GOVERNMENT COLLEGE OF ENGINEERING, SALEM – 636 011.
B.E – METALLURGICAL ENGINEERING (FULL TIME)

S. No.	Course Code	Course Title	Cat.	Hours / Week				Max. Marks		
				L	T	P	C	CA	FE	Total
SEMESTER I										
1	22MC101	Induction Program	MC	-	-	-	0	-	-	-
THEORY										
2	22EN101	Communicative English (Theory cum Practical)	HS	2	0	2	3	40	60	100
3	22MA101	Matrices, Calculus and Ordinary Differential Equations	BS	3	1	0	4	40	60	100
4	22PH101	Engineering Physics	BS	3	1	0	4	40	60	100
5	22CS101	Problem Solving and C Programming	ES	3	0	0	3	40	60	100
6	22CE201	Engineering Mechanics	ES	3	0	0	3	40	60	100
7	22MC102	Heritage of Tamil / தமிழர்மரபு	HS MC	1	0	0	1	100	-	100
PRACTICAL										
8	22CS102	Computer Practice and C Programming Laboratory	ES	0	0	3	1.5	60	40	100
9	22ME102	Workshop Manufacturing Practices	ES	0	0	4	2.0	60	40	100
TOTAL							**21.5**			**900**
SEMESTER II										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22MA201	Partial Differential Equation, Vector Calculus and Complex Variables	BS	3	1	0	4	50	50	100
2	22CY101	Engineering Chemistry	BS	3	1	0	4	40	60	100
3	22EE203	Basic Electrical Engineering for Metallurgy	ES	3	1	0	4	40	60	100
4	22ME101	Engineering Graphics & Design	ES	1	0	4	3	40	60	100
5	22HS201	Universal Human Values	HS	2	1	0	3	40	60	100
6	22MCIN01	Engineering Sprints	EE	0	0	2	1	100	-	100
7	22MC201	Tamils and Technology / தமிழரும் தொழில்நுட்பமும்	HS MC	1	0	0	1	100	-	100
8	22NC201	NCC COURSE – I (only for NCC Students)*	NC	3	0	0	3	40	60	100
PRACTICAL										
9	22EN102	Professional Skills Laboratory	HS	0	0	3	1	60	40	100
10	22PH103	Physics Laboratory	BS	0	0	3	1.5	60	40	100
11	22CY102	Chemistry Laboratory	BS	0	0	3	1.5	60	40	100
12	22EE204	Basic Electrical Engineering Laboratory for Metallurgy	ES	0	0	3	1	60	40	100
TOTAL							**24.5**			**900**

*Only for NCC students, it is not considered for CGPA calculation.

SEMESTER III										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22MA306	Linear Algebra & Transforms	BS	3	1	0	4	40	60	100
2	22MT301	Elements of Physical Metallurgy	PC	3	0	0	3	40	60	100
3	22MT302	Mineral Dressing, Fuels & Furnaces	PC	3	0	0	3	40	60	100
4	22MT303	Metallurgical Thermodynamics and Kinetics	PC	3	1	0	4	40	60	100
5	22PH102	Materials Science for Engineering	BS	3	0	0	3	40	60	100
6	22MCIN02	Innovation Sprints	EE	0	0	2	1	100	-	100
7	22CE310	Mechanics of Deformable bodies	ES	3	1	0	4	40	60	100
8	22NC301	NCC Course – II (Only for NCC Students)*	-	3	0	0	3	-	-	-
PRACTICAL										
9	22MT304	Metallography Laboratory	PC	0	0	3	1	60	40	100
10	22MT305	Chemical Metallurgy Laboratory	PC	0	0	3	1	60	40	100
TOTAL							**24**			**900**

SEMESTER IV										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22MA403	Probability and Statistical Methods	BS	3	1	0	4	40	60	100
2	22CY401	Non Metallic Materials	BS	3	0	0	3	40	60	100
3	22MT401	Mechanical Behaviour and Testing of Materials	PC	3	0	0	3	40	60	100
4	22MT402	Advanced Physical Metallurgy	PC	3	0	0	3	40	60	100
5	22MT403	Heat Treatment Technology	PC	3	0	0	3	40	60	100
6	22MT404	Iron Making	PC	3	0	0	3	40	60	100
7	22MCIN03	Design Sprints	EE	0	0	2	1	100	-	100
8	22CYMC01	Environmental Science	MC	0	0	3	0	100	-	100
PRACTICAL										
9	22MT405	Material Testing Laboratory	PC	0	0	3	1	60	40	100
10	22EN401	Placement and Soft Skills Laboratory	PC	0	0	4	2	60	40	100
TOTAL							**23**			**1000**

SEMESTER V										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22MT501	Forming Processes	PC	3	0	0	3	40	60	100
2	22MT502	Steel Making	PC	3	0	0	3	40	60	100
3	22MT503	Corrosion Engineering	PC	3	0	0	3	40	60	100
4	22MT504	Casting Engineering	PC	3	0	0	3	40	60	100
5	22MT505	Welding Engineering	PC	3	0	0	3	40	60	100
6	22MT506	Introduction to instrumentation	ES	3	0	0	3	40	60	100
7	22MC301	Indian Constitution	MC	3	0	0	0	40	60	100
8	22MCIN04	Ideation Sprints	EE	0	0	2	1	100	-	100
PRACTICAL										
9	22MT507	Heat Treatment Laboratory	PC	0	0	3	1	40	60	100
10	22MT508	Corrosion Science Laboratory	PC	0	0	3	1	40	60	100
11	22MT509	Machine Shop Practice	PC	0	0	3	1	40	60	100
TOTAL							**22**			**1100**
SEMESTER VI (Regular Stream)										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22MTPExx	Professional Elective - I	PE	3	0	0	3	40	60	100
2	22MTPExx	Professional Elective - II	PE	3	0	0	3	40	60	100
3	22MTPExx	Professional Elective - III	PE	3	0	0	3	40	60	100
4	22__OExx	Open Elective - I	OE	3	0	0	3	40	60	100
5	22__OExx	Open Elective - II	OE	3	0	0	3	40	60	100
6	22__OExx	Open Elective - III	OE	3	0	0	3	40	60	100
PRACTICAL										
7	22ME601	Mini Project	EE	0	0	6	3	60	40	100
TOTAL							**21**			**700**

SEMESTER VI (Protosem Stream)										
S. No.	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22MEPS11	Applied Design Thinking	Proto sem	2	0	2	3	100		100
2	22MEPS12	Start- up Fundamentals	Proto sem	2	0	2	3	100		100
3	22MEPS13	Computational Hardware	Proto sem	2	0	2	3	100		100
4	22MEPS14	Coding for Innovators	Proto sem	2	0	2	3	100		100
5	22MEPS15	Industrial Design & Rapid Prototyping Techniques	Proto sem	2	0	2	3	100		100
6	22MEPS16	Industrial Automation	Proto sem	2	0	2	3	100		100
7	22MEPS17	Robotics	Proto sem	2	0	2	3	100		100
PRACTICAL										
7	22GE601	Robotics/ML/MLOPs	EE	0	0	6	3	100	-	100
TOTAL							**21**			**700**
SEMESTER VII										
S. No	**Course Code**	**Course Title**	**Cat.**	**Hours / Week**				**Max. Marks**		
				L	**T**	**P**	**C**	**CA**	**FE**	**Total**
THEORY										
1	22MT701	Characterization of Materials	PC	3	0	0	3	40	60	100
2	22MT702	Introduction of Industrial Management	HS	3	0	0	3	40	60	100
3	22MT703	Non Ferrous Extractive Metallurgy	PC	3	0	0	3	40	60	100
4	22MTPExx	Professional Elective - V	PE	3	0	0	3	40	60	100
5	22__OExx	Open Elective - IV	OE	3	0	0	3	40	60	100
PRACTICAL										
6	22MT703	Materials Characterization Laboratory	PC	0	0	3	1	40	60	100
7	22MT704	Computer Application in Metallurgy Laboratory	PC	0	0	3	1	40	60	100
8	22MT705	Manufacturing Processes Laboratory	PC	0	0	3	1	40	60	100
9	22MT706	Casting & Forming Processes Laboratory	PC	0	0	3	1	40	60	100
TOTAL							**19**			**900**
SEMESTER VIII										

S. No	Course Code	Course Title	Cat.	Hours / Week				Max. Marks		
				L	T	P	C	CA	FE	Total
THEORY										
1	22MT801	Total Quality Management	HS	3	0	0	3	40	60	100
2	22MTPExx	Professional Elective - VI	PE	3	0	0	3	40	60	100
PRACTICAL										
3	22MT802	Project Work	EE	0	0	16	10			200
		TOTAL					**16**			**400**

CREDIT DISTRIBUTION SEMESTER WISE

SEMESTER	I	II	III	IV	V	VI	VII	VIII	TOTAL
CREDITS	21	24	24	23	22	21	19	16	170

BS	Basic Sciences
HS	Humanities and Social Sciences
ES	Engineering Sciences
MC	Mandatory Course
EEC	Employability Enhancement Course
PC	Professional Core
PEC	Professional Elective
OE	Open Elective

SUMMARY OF CREDIT DISTRIBUTION TABLE

B.E., METALLURGICAL ENGINEERING											
S.NO	Course Work subject Area	Credits Per Semester								Total Credit	Credits recommendedby AICTE
		I	II	III	IV	V	VI	VII	VIII		
1	Basic Sciences	8	11	4	7	-	-	-	-	30	25
2	Humanities andSocial Sciences	3	1	-	-	-	-	3	3	11	12
3	EngineeringSciences	8	8	4	-	3	-	-	-	23	24
4	Professional Core	-	-	16	12	12	14	5	-	57	48
5	Professional Elective	-	-	-	-	6	3	6	3	18	18
6	Open Elective	-	-	-	3	-	3	3	-	09	18
7	Employment Enhancement Course	-	-	-	-	-	-	-	10	10	15

8	Mandatory Course	0#	-	0#	-	-	0#	-	-	00	-
9	Proto Sem		1	1	1	1	21			25	
TOTAL		19	20	24	22	21	20	20	16	168	160*

0# - Non credit Course

*Minor variation is allowed as per need of the respective disciplines

PROFESSIONAL ELECTIVE COURSES (PEC)

S. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	22MTE01	Transport phenomena	PE	3	3	0	0	3
2.	22MTE02	Fractography and failure Analysis	PE	3	3	0	0	3
3.	22MTE03	Metallurgical kinetics	PE	3	3	0	0	3
4.	22MTE04	Solidification Processing	PE	3	3	0	0	3
5	22MTE05	Fracture Mechanics	PE	3	3	0	0	3
6.	22MTE06	Composite Materials	PE	3	3	0	0	3
7.	22MTE07	Ceramic materials	PE	3	3	0	0	3
8.	22MTE08	Metallurgy of tool Steels	PE	3	3	0	0	3
9.	22MTE09	Bio and smart materials	PE	3	3	0	0	3
10.	22MTE10	Continuous casting of steel	PE	3	3	0	0	3
11.	22MTE11	Ferrous and Non Ferrous alloys	PE	3	3	0	0	3
12.	22MTE12	Special casting Technology	PE	3	3	0	0	3
13.	22MTE13	Alternate routes of Ironmaking	PE	3	3	0	0	3
14.	22MTE14	Secondary steel making	PE	3	3	0	0	3
15	22MTE15	Powder Metallurgy	PE	3	3	0	0	3
16.	22MTE16	Non Destructive Evaluation	PE	3	3	0	0	3
17.	22MTE17	Severe plastic deformation	PE	3	3	0	0	3
18.	22MTE18	Metallurgical waste utilization and management	PE	3	3	0	0	3
19.	22MTE19	Computational Materials Engineering	PE	3	3	0	0	3
20.	22MTE20	Special welding processes	PE	3	3	0	0	3

21.	22MTE21	X- ray diffraction and Electron microscopy	PE	3	3	0	0	3
22.	22MTE22	Electrical ,Electronics and magnetic materials	PE	3	3	0	0	3
23.	22MTE23	Surface Engineering	PE	3	3	0	0	3
24.	22MTE24	Additive manufacturing	PE	3	3	0	0	3
25	22MTE25	Nano Materials	PE	3	3	0	0	3
26.	22MTE26	Thin films, coatings and applications	PE	3	3	0	0	3
27.	22MTE27	Aerospace materials	PE	3	3	0	0	3
28.	22MTE28	Modeling and simulation in material processes	PE	3	3	0	0	3
29.	22MTE29	Welding Metallurgy	PE	3	3	0	0	3
30.	22MTE30	Foundry Metallurgy	PE	3	3	0	0	3
31.	22MTE31	Nuclear materials	PE	3	3	0	0	3

OPEN ELECTIVE COURSES (OEC) – Courses offered to other departments

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	22MTOE01	Foundry and Welding Technology	OE	3	3	0	0	3
2	22MTOE02	Surface Engineering	OE	3	3	0	0	3
3.	22MTOE03	Design and Selection of Materials	OE	3	3	0	0	3
4.	22MTOE04	Nano science andTechnology	OE	3	3	0	0	3
5.	22MTOE05	Materials for automobile components	OE	3	3	0	0	3

VISION

To become a globally competent department in Metallurgical and Materials Engineering.

MISSION

- To achieve the vision, our diligent faculty will use effective, continually updated methodologies.
- To mould metallurgical and materials engineering graduates with professional excellence and social responsibility.
- To carry out quality research of national global relevance.
- To provide highest quality technical support and knowledge to industries.

PEO1. Apply Metallurgical Engineering knowledge to compete in the Engineering world.
PEO2. Have hands-on experimental skills and intellectual agility necessary for a productive professional life in highly technical and rapidly changing society.
PEO3. Develop physical intuition and mathematical expression of materials related phenomena.
PEO4. Acquire and generate innovative information for technical growth.
PEO5. Apply engineering knowledge in a global and societal context.
PEO6. Communicate technical information and knowledge in both written and oral form

PO1. Apply knowledge of mathematics, science and engineering for the solution of engineering problems

PO2. Investigate, design and analyze system component or process to meet the desire needs in metallurgical engineering

PO3. Design and conduct experiments to find solutions in the field of metallurgical engineering

PO4. Conduct investigation of complex engineering problems in the field of metallurgical engineering to provide valid conclusions

PO5. Use modern engineering tools necessary for engineering activities with an understanding of the limitations

PO6. Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.

PO7. Understand the impact of engineering solutions in societal and environmental context and explain the need for sustainable development

PO8. Understand and respect professional and ethical responsibility

PO9. Function on multi-disciplinary team as a leader or a team member

PO10. Communicate effectively both orally and in writing.

PO11. Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work

PO12. Recognize the need for, and have the preparation and ability to engage in life-long learning

PSO1: understand, analyze the theoretical foundations of Metallurgical Engineering and apply the various techniques and tools to solve the real-world problems.

PSO2: understand the concepts of metals and materials development and acquire the various skills under different platforms in the field of Metallurgical Engineering.

PSO3: use the knowledge in multiple domains to identify the research gap in the real-world environment providing link to innovate new ideas and helps to become a successful engineer and entrepreneur.

PSO4: work effectively as an individual or in a team having acquired leadership skills and manage in multi-disciplinary environments.

22MA306	LINEAR ALGEBRA AND TRANSFORMS	L	T	P	C
		3	1	0	4

Course Objectives:

- To understand the concepts of vector space and linear transformations.
- To apply the concept of inner product spaces in orthogonalization.
- To obtain the knowledge of solving second order ODE using Laplace transform techniques and inverse Laplace transform using convolution theorem.
- To familiarize with Fourier transform of a function and its sine and cosine transforms.
- To gain the skills to form difference equations and find its solution by using Z-transform method.

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UNIT I	VECTOR SPACES	9	+	3

Vector spaces – Subspaces – Linear independence and linear dependence – Bases and dimensions. Linear transformation - Null spaces and ranges - Dimension theorem - Matrix representation of a linear transformations.

UNIT II	INNER PRODUCT SPACES	9	+	3

Definition of Inner product, Inner product space- Examples- Gram Schmidt orthogonalization process - Adjoint of linear operations - Least square approximation.

UNIT III	LAPLACE TRANSFORM	9	+	3

Laplace Transform- Conditions for existence – Transform of elementary functions – Basic Properties – Transform of derivatives and integrals – Initial and Final value theorems- Transform of periodic Functions – Inverse Laplace Transform- solutions of linear ODE of second order with constant coefficient's using Laplace transformation techniques- statement and application of convolution theorem.

UNIT IV	FOURIER TRANSFORM	9	+	3

Statement of Fourier integral theorem – Fourier transform pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem - Parseval's Identity.

UNIT V	Z -TRANSFORM AND DIFFERENCE EQUATIONS	9	+	3

Z-transform of simple functions and properties – Inverse Z – transform –initial and final value theorems- Convolution theorem -Formation of difference equations – Solution of difference equations using Z – transform technique.

Total (L+T) = 60 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Use the concepts of vector space and linear transformations.
CO2	:	Illustrate the concept of inner product spaces in orthogonalization
CO3	:	Apply the knowledge of Laplace transforms method to solve second order differential equations.
CO4	:	Apply the knowledge of Fourier transform in engineering problems..
CO5		Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems

Text Books:

1.	Friedberg, A.H., Insel, A.J. and Spence, L., "Linear Algebra", Prentice Hall of India, New Delhi, 2004.
2.	Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, Khanna Publications, Delhi, 2015.
3.	Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, New Delhi, 3rd Edition, 2007.

Reference Books:

1.	Kumaresan, S., "Linear Algebra – A Geometric Approach", Prentice – Hall of India, New Delhi, Reprint, 2010.
2.	Strang, G., "Linear Algebra and its applications", Thomson (Brooks/Cole), New Delhi, 2005.
3.	Erwin Kreyszig, "Advanced Engineering Mathematics", 9th edition, John Wiley & Sons, 2006.

CO-PO ATTAINMENT:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO 1	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0
CO 2	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0
CO 3	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0
CO 4	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0
CO 5	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0

1- Faintly
2- Moderately
3- Strongly

22MT301	ELEMENTS OF PHYSICAL METALLURGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To develop an understanding of the basic principles of physical metallurgy and applications thoseprinciples to engineering applications.

UNIT I	CRYSTAL STRUCTURES	9	+	0

Review of atomic bonds, Lattice, unit cell, crystal systems and Bravais lattices; Principal crystal structures –BCC, FCC, HCP and its characteristics; Miller indices for crystallographic planes and directions, interplanarspacing;Volume, planar and linear atomic density;Polymorphism and allotropy;CsCl, NaCl, Diamond structures; single crystal and polycrystalline and amorphous materials;isotropy and anisotropy; Simple problems in the above topics.

UNIT II	CRYSTALLINE IMPERFECTIONS	9	+	0

Types of point defects, effect of temperature on vacancy concentration, interstitial sites-octahedral and tetrahedral sites;Line defects – dislocations – Edge, screw and mixed dislocations, Burger's vector, slip and twinning; Planar defects – grain boundaries, tilt boundaries, small angle grain boundaries; ASTM grain size number, grain size determinations; Volume defects;Simple problems in the above topics.

UNIT III	ATOMIC DIFFUSION IN SOLIDS AND SOLIDIFICATION OF METAL	9	+	0

Diffusion mechanisms, steady state diffusion and non-steady state diffusion-Fick's first law and second law; Kirkendall effect and Darken's equation; Factors affecting diffusion; Industrial applications of diffusion processes; Simple problems in the above topics; Basic principles of solidification of metals and alloys; Growth of crystals– Planar growth, dendritic growth, Solidification time, dendrite size; Cooling curves; Cast or Ingot structure, Solidification defects – Control of casting structure; Directional solidification – single crystal growth; Simple problems in the above topics.

UNIT IV	PHASE DIAGRAMS	9	+	0

Phases**,** solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Phase diagram determination; Binary isomorphous alloy systems – composition and amount of phases, development of microstructure – equilibrium and non-equilibrium cooling- Coring and its effects, homogenization; Binary eutectic system - composition and amount of phases, development of microstructure; Eutectoid, Peritectic and monotectic reaction, Phase diagrams with intermediate phases and compounds; Ternary phase diagrams. Simple problems in the above topics.

UNIT V	IRON-CARBON PHASE DIAGRAM, COLD WORKING AND HOT WORKING	9	+	0

Iron-carbon diagram, Phases in Fe-C system, Invariant reactions, Microstructure of slowly cooled steels, composition and amount of phases, Effect of Alloying elements on Fe-C system, Type, structure, properties and applications of Plain Carbon Steels and different types of Cast iron; IS Specification for Steels and Cast Irons, Simple problems in above topics.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the basic crystal structure, orientation and their influence on macroscopic properties.
CO2	:	Explain and relate the role of imperfections in strengthening the materials.
CO3	:	Apply the diffusion mechanism in solidification of materials under different conditions.
CO4	:	Understand and apply the concept of phase diagrams in equilibrium transformation of materialsphases.

CO5		Explain and apply the common strengthening processes viz. Cold working and Hot working andpost treatment process.

Text Books:	
1.	Donald R. Askeland,"The Science and Engineering of Materials", Thomson Learning, India Edition,2007.
2.	William D.Callister, "Materials Science and Engineering – An Introduction", 4th edition, John Wiley &Sons, New York, USA, 1997.
Reference Books:	
1.	Avner S H."An Introduction to Physical Metallurgy", McGraw Hill Book Co, New York, USA, 1997.
2.	Donald R Askeland," Essentials of Material Science and Engineering ", Thomson Learning, IndiaEdition, 2007.
3.	Raghavan V., "Physical Metallurgy – Principles and Practice", Prentice Hall of India Ltd., New Delhi,1996.
4.	William F.Smith, "Foundations of Materials Science and Engineering", Second Edition, McGraw-HillInc, New York, 1993.
E-Reference	
1.	www.matter.org
2.	www.doitpoms.ac.uk

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1	1	0	0	0	0	0	0	0	0	1	2	2	0	0
CO2	1	1	1	0	1	0	0	0	0	0	0	2	0	0	1	0
CO3	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CO4	1	1	2	1	2	0	0	0	0	0	0	2	0	2	0	1
CO5	1	1	2	2	3	0	0	0	0	0	0	2	0	0	2	0

1- Faintly
2- Moderately
3- Strongly

22MT302	MINERAL DRESSING, FUELS AND FURNACES	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To gain knowledge on the theoretical aspects of common mineral processing techniques and theassociated equipments used in extraction processes.
2.	To understand the fundamentals and applications of fuels, furnaces and refractories.

UNIT I	MINERAL DRESSING – I	9	+	0

Introduction to mineral dressing – Minerals, Ores, Physical characteristics of ores relevant to mineral dressing, industrially important minerals; Sampling of ores ; Comminution – Crushing and Grinding - Jaw, gyratory, cone and roll crushers – ball, rod, vibratory and hammer mills - Closed and open circuit grinding – dry and wet grinding. Power requirement calculations for crushing and grinding, Rittingers law; Sizing, Industrial screening.

UNIT II	MINERAL DRESSING – II	9	+	0

Chemical processing of ores – leaching, ion - exchange and liquid - solvent extraction. Classification – Principles and laws of classification – theory of settling; Types of classifiers – mechanical, hydraulic and hydrocyclone. Gravity concentration – Principles, Jigs, types of jigs, spirals, tables; Heavy media separation
– principles, different media used, static and dynamic separating vessels; Froth flotation – principle, operation and machines; Magnetic and electrostatic separation, Thickeners and filters.

UNIT III	FUELS AND THEIR PROPERTIES	9	+	0

Classification – solid, liquid and gaseous fuels; Coal – Classification, Manufacturing of metallurgical coke and its properties; Petroleum – classification, composition of crude petroleum; Gaseous Fuels - Natural gas, Coal gas, Producer gas, Water gas, Blast furnace gas – manufacture, properties and applications of above fuels; Testing of solid, liquid and gaseous fuels; Combustion calculations - Air requirements for combustion

UNIT IV	FURNACES:	9	+	0

Introduction, classification of furnaces; Measurement of Temperature and Pressure, Thermal efficiency, heat balance calculations – simple problems; Melting and Heat treatment furnaces – Constructional details and operation of Crucible furnaces, Reverberatory furnaces, Cupola, Rotary furnace, Induction furnaces (Core type and coreless type), Arc furnace (direct and indirect arc furnaces), Resistance furnaces, Batch and continuous type furnaces; Methods of heat recovery – recuperator and regenerators; Burners.

UNIT V	REFRACTORIES	9	+	0

Introduction, Classification – Acid, Basic, Neutral refractories; Properties and tests for refractories; Raw materials, manufacture, properties and applications of the following refractories – Silica, fire clay, alumina, magnesite, dolomite, chromite, chrome-magnesite, magnesite-chrome, carbon and graphite refractories, refractory cement, ramming mixes and castables.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Explain the basic mineral dressing principles, processes and equipment used in mineraldressing.
CO2	:	Understand the chemical processing of ores and gain knowledge on classification, frothfloatation and other mineral beneficiation processes.
CO3	:	Explain the different types of fuels, testing of the fuels and quality valuation of the fuels.
CO4	:	Understand and explain the basic operation of furnace, different types of furnaces and variousmethods of heat recovery.

CO5	:	Gain knowledge on the testing of refractories, explain the various refractories, their propertiesand applications

Text Books:	
1.	Gilchrist.J.D., "Extraction Metallurgy", 2nd Edition, Pergamon Press, London,1981.
2.	Gupta.O.P., "Elements of Fuels, Furnaces and Refractories", 4th Edition, Khanna Publishers, NewDelhi, 2000.
3.	Gaudin A.M. , "Principles of Mineral Dressing", TMH ,New Delhi,1986.
Reference Books:	
1.	Wills.B.A., Napier-Munn, T.J., "Mineral Processing Technology", 7th Edition, Pergamon Press, 2006.
2.	Feurstenau, M.C. and Han, K.N., "Principles of Mineral Processing", SME, USA, 2003.
3.	Jain.S.K. "Ore Processing", Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi, 1986.
E –References	
1.	https://nptel.ac.in/courses/113104008/
2.	https://nptel.ac.in/courses/113104060/10
3.	https://nptel.ac.in/courses/113104058/

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	1	1	0	0	0	0	0	0	0	0	1	2	2	0	0
CO2	1	1	1	0	1	0	0	0	0	0	0	2	0	0	1	0
CO3	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CO4	1	1	2	1	2	0	0	0	0	0	0	2	0	2	0	1
CO5	1	1	2	2	3	0	0	0	0	0	0	2	0	0	2	0

1- Faintly
2- Moderately
3- Strongly

22MT303	METALLURGICAL THERMODYNAMICS AND KINETICS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To learn the basic principles and concepts of thermodynamics, in the field of metallurgy and materials;and to learn about equations and their applications.

UNIT I	CONCEPTS AND FIRST LAW OF THERMODYNAMICS:	9	+	3

Introduction: System and surrounding, Classification of systems, Path and state properties, Thermodynamic processes, Thermodynamic equilibrium, Reversible and Irreversible processes. First law of thermodynamics: Heat and work, Internal energy, Heat capacity of materials, C_p-C_v relations, Nernst Equation, Enthalpy, Thermochemistry , Hess's law, Kirchoff's law, Maximum flame temperature.

UNIT II	SECOND AND THIRD LAW OF THERMODYNAMICS:	9	+	3

Second law of thermodynamics**:** Carnot cycle, Entropy - Statistical interpretation of entropy, Free energy,Combined statement of first and second laws, Thermodynamic functions - Maxwell's relations, Gibbs-Helmholtz equation. Third and Zeroth laws of thermodynamics : Definition, concept and applications

UNIT III	THERMODYNAMIC POTENTIALS AND PHASE EQUILIBRIA:	9	+	3

Thermodynamic potentials: Fugacity, Activity and Equilibrium constant. Clausius - Clayperon equation, Troutons rule. Le Chatelier's principle, Vant Hoff's equation. Equilibria in phase diagrams: Phase rule, Phase stability, Thermodynamics of surfaces, interfaces and defects, P-G-T diagrams, Application of free energy - composition diagrams to the study of alloy systems.

UNIT IV	THERMODYNAMICS OF SOLUTIONS:	9	+	3

Gibbs - Duhem equation, Partial and integral molar quantities, chemical potential, Ideal solutions - Raoult's law, Real solutions, Activity coefficient, Henry's law, Alternative standard states, Sievert's law, Mixing functions and excess functions, Regular solutions, Applications of Gibbs - Duhem equation.

UNIT V	ELECTRO CHEMICAL PROCESS AND KINETICS:	9	+	3

Electro chemical process: Cells, Inter conversion of free energy and electrical work, Determination of thermodynamic quantities using reversible cells, Solid electrolytic cells. Kinetics: First, Second and third order reactions, Arrhenius equation - activation energy, Determination of order of the reaction.

Total (L+T) = 60 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Explain the basic concepts of thermodynamics and the first law of thermodynamics
CO2	:	Understand the second and third laws of thermodynamics.
CO3	:	Know the thermodynamic potential and phase diagram.
CO4	:	Describe the thermodynamics of the solution and various important equations.
CO5	:	Discuss the concept of electrochemical processes and kinetics.

Text Books:

1.	Ahindra Ghosh, Text book of Materials & Metallurgical Thermodynamics, Prentice Hall India, 2002
2.	Upadhyaya G S and Dube R K., "Problems in Metallurgical Thermodynamics & Kinetics",Pergamon,1977.

3.	David R Gaskell, "Introduction to the Thermodynamics of Materials", Fifth Edition, Taylor & Francis,2008
Reference Books:	
1.	David V Ragone, "Thermodynamics of Materials - Volume-1", John Wiley & Sons, Inc. 1995.
2.	Dr S.K Dutta ,Prof A.B. Lele – Metallurgical thermodynamics kinetics and numericals, S.Chand & coLtd., New Delhi 2011
3.	Darken LS and Gurry R W ,"Physical Chemistry of Metals", CBS publications and distributors, 2002.
4.	Parker R H, "An introduction to chemical metallurgy", Pergamon press, New York, second edition,1978.
5.	Kapoor M.L., "Chemical and Metallurgical Thermodynamics Vol. I and II", Nem Chand, 1st Ed.,1981.
E-References:	
1.	**www.nptelvideos.in/2012/12/basicthermodynamics.html**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1	1	0	0	0	0	0	0	0	0	1	2	2	0	0
CO2	1	1	1	0	1	0	0	0	0	0	0	2	0	0	1	1
CO3	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CO4	1	1	2	1	2	0	0	0	0	0	0	2	0	2	0	0
CO5	1	1	2	2	3	0	0	0	0	0	0	2	0	0	2	0

1- Faintly
2- Moderately
3- Strongly

22PH102	MATERIALS SCIENCE FOR ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

- To introduce the theory of conducting materials and Fermi distribution function.
- To give the basic ideas of semiconductors and its Fermi level.
- To give an overview of Dielectric polarization, dielectric losses and application of dielectrics.
- To insight into the magnetic nature of materials, superconductors and their applications.

To introduce the synthesis and applications of metallic glasses, smart materials and nano phase materials

UNIT I	CONDUCTING MATERIALS	9	+	0

Conduction in metals - mobility and conductivity – Classical free electron theory of metals – Electrical and thermal conductivity – Wiedemann Franz law – Lorentz number – drawbacks of classical free electron theory – Quantum theory – Fermi distribution function - Effect of temperature on Fermi function – Density of states – Carrier concentration in metals – Band theory of solids - distinction between conductors, semiconductors and insulators.

UNIT II	SEMICONDUCTING MATERIALS	9	+	0

Properties of semiconductor - Bonds in semiconductors - Intrinsic semiconductors - Extrinsic semiconductors - N-type and P-type semiconductors – Carrier concentration in intrinsic semiconductors(derivation) –Electrical conductivity and band gap determination in intrinsic semiconductors - Carrier concentration in N-type semiconductor(derivation) – variation of Fermi level with temperature and doping concentration – Compound semiconductors –Direct and indirect band gap semiconductors - Hall effect - Determination of Hall coefficient – Applications.

UNIT III	DIELECTRIC MATERIALS	9	+	0

Electrical susceptibility – Dielectric constant – Dielectric polarization – Electronic , Ionic, Orientational and Space charge polarization – frequency and temperature dependence of polarization – Internal field – Classius – Mosotti relation (derivation) – dielectric loss – dielectric breakdown – Uses of dielectric materials (capacitor and transformer)-Polymeric dielectric materials.

UNIT IV	MAGNETIC AND SUPERCONDUCTING MATERIALS	9	+	0

Magnetic materials: Origin of magnetic moment – Bohr magneton – Dia, Para and Ferro magnetism – Domain theory of ferromagnetism – Hysteresis – Hard and soft magnetic materials – Antiferro magnetism.

Superconductivity: Properties – Type I & Type II superconductors - BCS theory - Applications – magnetic levitation – SQUID.

UNIT V	MODERN ENGINEERING MATERIALS	9	+	0

Metallic glasses - Preparation, properties, applications – Shape memory alloys(SMA) – Processing, characterization and applications.

Nanomaterials: Introduction – top down and bottom up approach – synthesis – Ball milling, Plasma arcing and Sol – Gel technique – properties – applications – Carbon nanotubes – Properties.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:		
CO1	:	The theory involved in conducting materials, carrier concentration in metals.
CO2	:	The basics of semiconductor and variation of Fermi level with respect to different parameters
CO3	:	The mechanism involved in dielectric polarization and the applications of dielectric materials.
CO4	:	The concept of the magnetic, superconducting nature of materials and their applications.
CO5		The preparation techniques, their distinct properties and applications of Metallic glasses, SMAs, nano phase materials.

Text Books:	
1.	P.K.Palanisamy, 'Materials Science', Scitech Publications (India) pvt. ltd. Chennai, Second edition, 2009.
2.	M. Arumugam, 'Materials Science', Anuradha Publications, Kumbakonam, 2018.
3.	Rajendran V and Marikani A, 'Materials Science', Tata McGraw Publications, New Delhi, 2012
4.	Jayakumar S, 'Materials Science', RK Publishers, Coimbatore, 2011.

Reference Books:	
1.	Charles Kittel, 'Introduction to Solid state Physics', John Wiley and Sons, 7th Edition, Singapore, 2019.
2.	Charles P. Poole and Frank J. Ownen, 'Introduction to Nanotechnology', Wiley India, 2007.
3.	M.S. Vijaya and G. Rangarajan, 'Materials Science', Tata McGraw Hill, New Delhi, 2012.

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	2	1	0	0	0	1	0	0	0	0	1	2	2	0	0
CO2	3	2	1	0	1	1	1	1	0	0	0	2	0	0	1	0
CO3	3	3	1	0	0	1	1	1	0	0	0	1	1	0	0	0
CO4	3	3	2	1	2	1	0	0	0	0	0	2	0	2	0	0
CO5	2	2	2	2	3	1	0	1	0	0	0	2	0	0	2	0

1- Faintly
2- Moderately
3- Strongly

22MT304	METALLOGRAPHY LABORATORY	L	T	P	C
		0	0	3	1.5

EXPERIMENTS

1.	Sample preparation and Mounting and Study of Metallurgical Microscope
2.	Microstructure of different types of cast iron in unetched condition
3.	Microstructure of different types of cast iron in etched condition
4.	Microstructure of pure iron, plain carbon steels
5.	ASTM grain size determination
6.	Microstructure of tool steels and stainless steels
7.	Microstructure of cast and wrought aluminium alloys
8.	Microstructure of copper alloys
9.	Sulphur and Phosphor printing
10	Inclusion rating

Total (P) = 45 Hours

Course Outcomes

After the successful completion of the practical session, the students will be able to

CO1	:	Observe and Explain the metallurgical microscope
CO2	:	Operate the process of sample preparation and mounting
CO3	:	View and analyze the microstructure of various samples
CO4	:	Conduct the process of sulphur printing and phosphor printing
CO5	:	Observe the unconventional structure in steel and determine the ASTM grain size.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1	1	0	0	0	0	0	0	0	0	1	2	2	0	0
CO2	1	1	1	0	0	0	0	0	0	0	0	2	0	0	1	1
CO3	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CO4	1	1	1	0	0	0	0	0	0	0	0	2	0	2	0	0
CO5	1	1	1	0	0	0	0	0	0	0	0	2	0	0	2	0

1- Faintly, 2- Moderately, 3- Strongly

22MT305	CHEMICAL METALLURGY LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To gain knowledge about the various properties of minerals and to become familiar with the equipments used in mineral processing, by means of experiments or demonstration of the laboratory scale equipments.

EXPERIMENTS

1.	Flash and Fire point of oils
2.	Red wood viscometer
3.	Size distribution using sieve analysis
4.	Screening efficiency
5.	Sampling of ores
6.	Jaw crusher
7.	Ball mill
8.	Proximate analysis of Coal.
9.	Settling velocity of $CaCO_3$ powder.
10.	Froth Flotation

Total (P) = 45 Hours

Course Outcomes

After the successful completion of the practical session, the students will be able to

CO1	:	Perform the mineral beneficiation operations.
CO2	:	Perform the comminution related experiments and necessary calculations.
CO3	:	Obtain the skills for physical observation of minerals / ores.

E- References

1.		https://www.youtube.com/watch?v=yLtuDv3GzWo
2.		https://www.youtube.com/watch?v=VzJ60uMdFe8
3.		https://www.youtube.com/watch?v=6kFONdchY0U

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1	1	0	0	0	0	0	0	0	0	0	2	2	0	0
CO2	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1
CO3	2	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0

1- Faintly, 2- Moderately, 3- Strongly

BE METALLURGY SEMESTER -IV

22MA403	PROBABILITY AND STATISTICAL METHODS	L	T	P	C
		3	1	0	4

Course Objectives:

- To familiar with basic concepts of probability and random variables.
- To obtain the knowledge about discrete and continuous distributions.
- To acquire knowledge of bivariate distributions and the problems related to coefficient of correlation.
- To understand the statistical averages and fitting of curve.
- To gain the knowledge of significance test for large and small samples.

UNIT I	PROBABILITY AND RANDOM VARIABLES	9	+	3

Axioms of Probability, Conditional Probability, Total Probability, Bayes' theorem- Random variables: Discrete and Continuous random variables - Moments – Moment generating functions and their properties.

UNIT II	STANDARD DISTRIBUTION	9	+	3

Binomial, Poisson, Exponential, Gamma and Normal Distributions and their properties - Chebyshev's inequality.

UNIT III	TWO DIMENSIONAL RANDOM VARIABLES	9	+	3

Joint distributions – Marginal and Conditional distributions – Correlation, Regression and rank correlation.

UNIT IV	BASIC STATISTICS	9	+	3

Measures of Central tendency: Moments, Skewness and Kurtosis, Curve fitting by the method of Least Squares –Fitting of straight lines, second degree parabolas and curves reducible to linear forms.

UNIT V	TEST OF HYPOTHESIS	9	+	3

Test of significance: Large Sample tests for Single proportion, difference of proportion, single mean and difference of means- Small Sample test for single mean, difference of means and correlation coefficients, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes

Total (L+T) = 60 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Learn the fundamental knowledge of the Probability concepts
CO2	:	Apply the standard distributions
CO3	:	Analyze the two-dimensional random variables.
CO4	:	Learn about statistical averages and fitting the curves by Least Square Method.

CO5		Use the Large and small sample tests

Text Books:	
1.	Veerarajan. T, "Probability and Random Process (With Queuing theory)", 4th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2016.
2.	Jay, L. Devore, "Probability and Statistics for Engineering and Sciences", Cengage Learning, New Delhi, 8th edition, 2012.
Reference Books:	
1.	Fruend John, E. and Miller, Irwin, "Probability and Statistics for Engineering", 5th Edition, Prentice Hall, 1994.
2.	Grewal, B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
3.	Gupta, S.C. and Kapoor, V.K. "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, New Delhi, 2015

CO-PO ATTAINMENT:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO 1	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0
CO 2	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0
CO 3	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0
CO 4	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0
CO 5	3	2	0	2	0	0	0	0	0	0	0	0	2	0	0	0

1- Faintly
2- Moderately
3- Strongly

22CY401	NON METALLIC MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives

To make the student acquainted with the

- Basic knowledge of polymer and their applications
- Understand the different methods processing of polymers
- Describe the various ceramics, glasses and explain their processing and properties.
- Describe the concept of composites and their types. Explain the uses of fiber composites in Commercial field.
- Explain the production, properties and uses of various Particulate and Laminar composites.

UNIT I	INTRODUCTION TO POLYMERS	9	+	0

Definition – Nomenclature of Polymers – Classification of Polymers (Source, structure, methods of synthesis, growth of polymer chain, molecular force) – Polymerization types – mechanism-degree of polymerization – Molecular mass of a polymer – polydispersity index (PDI) – Glass transition and melting temperatures – Additives for polymers – process aids, anti degradants, fillers, curing agents and coupling agents – special additives

UNIT II	POLYMER PROPERTIES AND PROCESSING	9	+	0

Properties: physical, mechanical, chemical, thermal, electrical, optical, magnetic, and biological properties Processing types: melt, rubbery stage, solution, emulsion, and suspension processing

Behavior of polymers: Viscoelasticity- Creep and stress relaxation in polymers- Yielding and fracture of polymers - Crazing of polymers Application of polymers in various fields- agriculture, space, automobile, electronics, medicine , construction and transport

UNIT III	CERAMICS	9	+	0

Introduction - important properties - Typical example of conventional and advanced ceramics. Comparison with metals and polymers. Preparation and properties: Boron Nitride, Silicon Carbide, Boron carbide, SlALON -Technical applications. Types of glasses - structure, properties and applications of various types of glasses manufacturing of glass – Blowing, pressing, drawing, rolling and casting, and Pilkington process.

UNIT IV	FIBER COMPOSITES	9	+	0

Composites: Introduction Classification Examples. Fiber composites: Constituents and functions of fiber composites Rule of Mixtures - Types of fibers and matrices. Production techniques (in brief) for fiber composites: Use of fiber composites in automobile, aerospace, sports and leisure applications.

UNIT V	PARTICULATE AND LAMINAR COMPOSITES	9	+	0

True particulate and Dispersion strengthened composites Production techniques Applications Functions and examples of dispersoids - particle size and inter particle spacing - examples of particulate composites. Laminar composites – types layered and honeycomb structures- examples, manufacture and applications.		
Total (L+T) = 45 Hours		
Course Outcomes:		
Upon completion of this course, the students will be able to:		
CO1	:	Explain the different types of polymers, polymerization mechanisms and polymer additives
CO2	:	Explain the properties, processing and behaviour of polymers.
CO3	:	Describe the various ceramics, glasses and explain their processing and properties.
CO4	:	Describe the concept of composites and their types. Explain the uses of fiber composites in commercial field.
CO5	:	Explain the production, properties and uses of various Particulate and Laminar composites.

Text Books:	
1.	Introduction to Polymers B - Robert J. Young, Peter A. Lovell Third edition, CRC press, 2011
2.	POLYMER CHEMISTRY - Pragati Prakashan , Global net publications.
3.	Introduction to composite materials design - Ever J. Barbero, second edition
4.	Composites Engineering handbook – P.K.Mallick, CRC press
Reference Books:	
1.	Polymer Science – V.R.Gowarikar – New age international Pvt Ltd., 2015
2.	Fundamentals of Polymers – Niranjan karak – PHI learning Private Ltd., 2009
3.	Ceramic Materials-Science and Engineering - C. Barry Carter, M. Grant Norton, C. Barry Carter, M. Grant Norton – Springer Newyork- 2013
4.	Composite Materials: Engineering and Sciencebooks - F. L. Matthews, Rees D. Rawlings · 1999

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	0	1	1	0	0	0	0	0	1	0	0	0	0
CO2	3	3	2	0	1	1	0	0	0	0	0	1	0	0	0	0
CO3	3	3	2	0	1	1	0	0	0	0	0	1	0	0	0	0
CO4	3	3	2	0	1	1	0	0	0	0	0	1	0	0	0	0
CO5	3	3	2	0	1	1	0	0	0	0	0	1	0	0	0	0

22MT401	MECHANICAL BEHAVIOUR AND TESTING OF MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To know the fundamental concepts of mechanical behavior of materials and to apply them to design the materials for various load-bearing structural engineering applications

Unit I	TENSILE BEHAVIOUR AND TESTS	9	+	0

Introduction: Types of testing, Introduction to material properties (structure sensitive and insensitive), ASTM testing standards. Engineering stress and strain, True stress - strain curves, Relationship between the tensile properties, Hollomon, Ludwig equation, Plastic Instability (Necking), Hot tensile tests, Testing machines – types, Testing procedures, specimen dimensions, Notch tensile test, Anisotropy of tensile properties. Bend test, torsion test & shearing test.

Unit II	HARDNESS TESTS AND IMPACT TESTS	9	+	0

Definition, Types of hardness tests- Vickers, Brinnell, Rockwell and Rockwell superficial hardness tests, Precautions - Relative merits and demerits, Hardness conversion, Rebound hardness test, Microhardness tests - Vickers and Knoop hardness tests, Concept of nano indentation. Izod and Charpy Impact tests, Instrumented Charpy test, Drop-weight Test and other large scale tests

Unit III	FRACTURE AND FRACTURE MECHANICS	9	+	0

Types of fracture – ductile and brittle fracture, Ductile to Brittle Transition Temperature (DBTT), Metallurgical factors affecting DBTT, determination of DBTT, Hydrogen embrittlement and other embrittlement, Theoretical cohesive strength of metals, Griffith's theory of brittle fracture, Orowan's modification. Fracture mechanics-introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and
determination of KIC, introduction to COD, J integral, R Curve. .

Unit IV	FATIGUE BEHAVIOUR AND TESTS	9	+	0

Fatigue: Stress cycles, S-N curves, effect of mean stress, factors affecting fatigue, structural changes accompanying fatigue, cumulative damage, low cycle fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines.

Unit V	CREEP BEHAVIOUR AND TESTS	9	+	0

Creep curve, stages in creep curve and explanation, structural changes during creep, creep mechanisms, metallurgical factors affecting creep, high temperature alloys, stress rupture testing, creep testing machines, Parameter methods of extrapolation. Introduction to remaining life assessment of high temperature structures and components, Creep-Fatigue
interaction.

Total = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand and explain the material properties, Testing machines – types, Testing procedures
CO2	:	Describe the Types of hardness tests viz Vickers, Brinnell etc...And concept of nano indentation, Izod and Charpy Impact tests.

CO3	:	: Explain the various fracture and mechanisms for different fractures, the fracture toughness and the various theories describing it.
CO4	:	Define and elaborate the Stress cycles, S-N curves, application of fracture
		mechanics and fatigue testing machines.
CO5	:	State the Creep curve, creep mechanisms, metallurgical factors affecting creep and explain about creep testing machines.

Text Books:

1.	George. E. Dieter, "Mechanical Metallurgy", McGraw-Hill, New York, SI Edition, 2001
2.	Reed Hill, R.E., "Physical Metallurgy Principles", Affiliated East West Press, New Delhi, 1992

Reference Books:

1.	Davis.H.E. Troxell G.E., Hauck.G.E.W. "The Testing of Engineering Materials", McGraw-Hill, 1982
2.	Thomas .H. Courtney, "Mechanical Behaviour of Materials", McGraw Hill Co., NY,1990.
3.	Wulff et al Vol. III "Mechanical Behavior of Materials", John Wiley and Sons, New York, USA, 1983
4.	1. Honeycombe R.W.K., "Plastic Deformation of Materials", Edward Arnold Publishers, 1984.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	0	0	0	0	0	0	0	0	1	2	2	0	0
CO2	1	1	1	0	1	0	0	0	0	0	0	2	0	0	1	0
CO3	2	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0
CO4	1	1	2	1	2	0	0	0	0	0	0	2	0	2	0	1
CO5	1	1	2	2	3	0	0	0	0	0	0	2	0	0	2	0

1- Faintly, 2- Moderately, 3- Strongly

22MT402	ADVANCED PHYSICAL METALLURGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To develop an understanding of the basis of physical metallurgy and correlate transformations of structure of materials with their properties for engineering applications.

UNIT I	SOLIDIFICATIONS	9	+	0

Driving force for solidification, Alloy solidification – Single phase binary alloy solidification, Cellular and dendritic solidification, constitutional super cooling, eutectic solidification, Solidification during quenching from melt, Concept of Activation energy and Arrhenius equation, Simple problems in above topics.

UNIT II	TRANSFORMATION KINETICS	9	+	0

Nucleation - Types of nucleation; Homogeneous nucleation - critical nucleus size, critical free energy change and nucleation rate; Heterogeneous nucleation - critical nucleus size, critical free energy change and nucleation rate; Rate of Heterogeneous nucleation, Growth Kinetics, Interface-Controlled growth, Diffusion-Controlled growth, Overall Transformation Kinetics – Empirical equations.

UNIT III	DIFFUSIONAL TRANSFORMATIONS	9	+	0

Diffusional transformation in solid; Homogeneous and heterogeneous nucleation in solids; Transformation kinetics for interface controlled growth and diffusion controlled growth, Johnson-Mehl-Avrami equation, simple numerical problems, Pearlitic Transformation, Experimental characteristics, Mechanism and kinetics of growth, Eutectoid transformation – nucleation and growth of pearlite, Interlamellar spacing, Bainite transformation; Spinodal decomposition - uphill diffusion, examples from metallic systems; Order-Disorder transformations; Precipitation.

UNIT IV	PARTICLE COARSENING AND RECOVERY RECRYSTALLIZATION AND GRAIN GROWTH	9	+	0

PARTICLE COARSENING – Driving force for coarsening, Kinetics of coarsening (Greenwood's model), RECOVERY RECRYSTALLIZATION AND GRAIN GROWTH – Recovery, Recrystallization, Grain growth mechanisms.
COLD WORKING – Structure and Properties of cold worked metals, Effect of mechanical properties and microstructures, Factors controlling recrystallization, Annealing textures.
HOT WORKING – Concept of hot working, Comparisons with cold working, warm working, Simple problems in above topics.

UNIT V	DIFFUSIONLESS TRANSFORMATIONS	9	+	0

Massive transformations; Martensite transformation – Definition, Characteristic features of martensitic transformation in steels; Morphology of martensite - lath and plate martensite; Crystallography of martensitic transformation; Kinetic characteristics of martensitic transformation; Martensite in Non-Ferrous systems;Thermo elastic Martensite; Shape Memory effect - Examples and applications of shape memory alloys.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand mechanism of solidification and transformation
CO2	:	Understand and explain the concept of growth and nucleation of crystal structures and phases in different materials.
CO3	:	Describe the phase transformation that is controlled by diffusion.

CO4	:	Describe the particle coarsening, recovery recrystallization and grain growth, cold and hot working
CO5	:	Describe the various phase transformations that occur due to diffusionless transformation.

Text Books:

1.	Raghavan , V."Solid State Phase Transformations", Prentice - Hall of India, New Delhi, 2004.
2.	Porter, D.A. and Easterling , K.E., "Phase Transformations in Metals and Alloys", 2nd ed., Chapman and Hall, London 1992.

Reference Books:

1.	Romesh C. Sharma, “Phase transformation in Materials”, CBS Publishers &Distributors, New Delhi, 2011.
2.	Reed Hill, R.E., "Physical Metallurgy Principles", Affiliated East West Press, New Delhi, 1992.
3.	R. E. Smallman A.H.W. Ngan, “Modern Physical Metallurgy”, Butterworth-Heinemann publication, 8th Edition, 2013.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	0	0	0	0	0	0	0	0	0	0	2	0	1	0	2
CO2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CO3	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	1
CO4	2	1	0	0	0	0	0	0	0	0	0	1	0	1	0	2
CO5	0	1	0	0	0	0	0	0	0	0	0	2	0	3	0	0

1- Faintly, 2- Moderately, 3- Strongly

22MT403	HEAT TREATMENT TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To study transformations in steels, various heat treatment processes and their equipments

Unit I	TRANSFORMATIONS IN STEELS	9	+	0

Iron - carbon equilibrium diagram**:** Transformations on heating and cooling, influence of alloying elements, general principles of heat treatment of steels, Isothermal and Continuous cooling transformations in steels. Continuous cooling curves TTT and CCT diagrams.

Unit II	HEAT TREATMENT PROCESSES	9	+	0

Annealing - types, Normalizing, Hardening - Retained austenite -measurement and methods of its elimination, Hardenability studies- Jominy end quench test, Grossman's experiments Tempering- Hollomon & Jaffe tempering correlations, Temper embrittlement, Austempering and Martempering, Precipitation hardening, Thermo mechanical treatment, , other heat treatment processes

Unit III	CASE HARDENING	9	+	0

Introduction, Carburising: Principle, carbon potential, application of Fick's law, depth of carburization and its control, methods of carburising, heat treatment after carburising, structure, properties and common problems in carburising. Nitriding: introduction, steels used, effect of microstructure, white layer, nitriding methods, ion nitriding and nitro-carburising. Induction and Flame hardening: principle, methods, operating variables. Measurement of case depth.

Unit IV	HEAT TREATMENT EQUIPMENTS	9	+	0

Various heating media used for heat treatment. Temperature and atmosphere control,carburising atmosphere and carbon potential measurement-simple problems, nitriding gas atmospheres. Quenching media and their characteristics. Various heat treatment furnaces, fluidized bed furnaces, cryo chamber, cryo treatment of steels, sealed-quenched furnace

Unit V	HEAT TREATMENT OF SPECIFIC ALLOYS	9	+	0

Heat treatment of carbon steels, stainless steels, tool steels. Heat treatment of gray cast irons, white cast irons, malleabilising and S.G.irons, austempering of S.G.Iron. Heat treatment of aluminium alloys and copper alloys. Defects in heat treated parts: causes and remedies.

Total (45+0)= 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Classify the different transformation processes that are taking place in steels with respect to parameter changes
CO2	:	: Describe the different process of heat treatment that influences the materials properties and also the combination of heat and mechanical properties.
CO3	:	Define the hardening property and hardenability of steels by applying variousdiffusion dependent laws and explain the process of carburizing, nitriding, nitro-carburizing etc.
CO4	:	Explain and analyze the various heat treatment equipment, heat treatingmedium, temperature for various heat treatment processes and also describe the heat treating furnaces

CO5	:	Describe and discuss the heat treatment processes for specific alloys like tool stee high speed steel and different varieties of cast iron.

Text Books:

1.	Rajan and Sharma "Heat Treatment Principles and Techniques" – Prentice Hall of India (P) Ltd, New Delhi, 2009
2.	Vijendra Singh,"Heat Treatment of Metals", Standard Publishers Distributors, Delhi, First edition 1998
3.	Romesh.C.Sharma, "Principles of Heat Treatment of Steels", New Age International Pvt. Ltd. Publishers, New Delhi, 2008**.**

Reference Books:

1.	Prabhudev, K H., "Handbook of Heat Treatment of Steels", Tata - McGraw Hill Publishing Co., New Delhi, 2000
2.	American Society for Metals, "Metals Handbook Vol.4", ASM Metals Parks, Ohio, USA, 2001

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	1	2		1						1		2	2	3	
CO2	2	2	3		2						2		1	1	2	
CO3			2		2						2		2			
CO4	2	3	2											2	2	
CO5	1				2						1		1		1	

1- Faintly, 2- Moderately, 3- Strongly

22MT404	IRON MAKING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the importance of the iron making and to apply them for the advancement of the production feasibilities in industries to compete with the modern day manufacturing routes.

UNIT I	RAW MATERIALS AND BURDEN PREPARATION:	9	+	0

Iron ore classification, Indian iron ores, characteristics of coal for coke making, selection of coals, coke quality, problems associated with Indian raw materials, Burden preparation: Iron Ore beneficiation, Agglomeration - Theory and practice of Sintering and Pelletizing, testing of burden materials, burden distribution on blast furnace performance.

UNIT II	PHYSICO-CHEMICAL-THERMAL PRINCIPLES:	9	+	0

Reduction of iron ores and oxides of iron by solid and gaseous reductions, C-O and Fe-C-O equilibria, thermodynamics and kinetics study of direct and indirect reduction, Gruner's theorem, physical chemistry of blast furnace reactions., Rist diagrams, material and heat balance.

UNIT III	BLAST FURNACE DESIGN, PRACTICE AND INSTRUMENTATION CONTROL:	9	+	0

Blast furnace parts, construction and design aspects ancillary equipments for charging, preheating the blast, gas cleaning equipments, pig casting, blast furnace instrumentation and control of furnace.

UNIT IV	BLAST FURNACE OPERATION:	9	+	0

Blast furnace operation, irregularities and remedies, Compositional control of metal and slag in blast furnace, Desulphurisation of Hot metal , Reichard's diagram, internal zones and gas flow in blast furnace, RAFT calculations, modern trends in blast furnace practice.

UNIT V	ALTERNATIVE ROUTES OF IRON MAKING:	9	+	0

Alternative routes of iron production – low shaft and charcoal furnace, electro-thermal processes, sponge iron production-coal based and gas based, sponge iron production in India. Ferro alloy furnaces, production of Fe-Si, Fe-Mn and Fe –Cr, Introduction to mathematical modeling in Iron making processes

Total (45+0) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand and define the feeding of raw materials that must be processed before loading into the blast furnace
CO2	:	Describe the various physical and chemical principles and study the different equilibria and establish the heat and mass balance
CO3	:	Design the blast furnace by describing the various parts of blast furnace and the reactions taking place in it
CO4	:	Describe the operational features of the blast furnace, the irregularities in operation
CO5	:	Alternate iron making process using different methods like low shaft and charcoal fired furnace, production of ferro alloys

Text Books:

1.	Ahindra Ghosh and Amit Chatterjee, "Iron Making and Steel Making – Theory and Practice", Prentice Hall of India Private Ltd., New Delhi 2008.

2.	Tupkary R J, "Introduction to Modern Iron Making", Khanna Publishers, Third edition, New Delhi, 2004.
Reference Books:	
1.	Biswas .A.K , " Principles of blast furnace iron making- theory and practice" , SBA Pub, Kolkata 1994
2.	David H Wekelin, "The Making, Shaping and Treating of Steel", AISE Steel Foundation, edition 11, 1999.
E-References:	
1.	https://nptel.iitm.ac.in

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2				2		2				1		1	2	2	2
CO2	2												2		2	1
CO3					2		1				2			1		2
CO4	1				1		3				2		2	3	1	
CO5	2				1		2				1				2	1

1- Faintly, 2- Moderately, 3- Strongly

22MT405	MATERIAL TESTING LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To learn about several of material testing principles, procedures and generating reports for quality control.

EXPERIMENTS

1.	Tensile testing of Metals and Alloys
2	Compression test
3	Impact testing of Metals (Charpy & Izod)
4	Bend Test of Metals
5	Hardness – Brinell / Rockwell
6	Hardness – Vickers
7	Microhardness test
8	Fatigue test
9	Wear test – Pin on disc
10	Creep test(using lead wire)

Total (P) = 45 Hours

Course Outcomes

After the successful completion of the practical session, the students will be able to

CO1	:	Gain knowledge in practical aspects of sample preparation for testing.
CO2	:	Hands on experience in operation of Material testing equipment.
CO3	:	Gain knowledge in various mechanical tests of metals

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2		2	2		2						1	2	2	
CO2	2					2							2		2	1
CO3		2	1	2	2		1							1		

1- Faintly, 2- Moderately, 3- Strongly

22EN401	PLACEMENT AND SOFT SKILLS LABORATORY	L	T	P	C
		1	0	3	2.5

Course Objectives:

1. To develop the students' confidence and help them to attend interviews successfully
2. To express opinions, illustrate with examplesand conclude in group discussions
3. To acquire knowledge to write error free letters and prepare reports
4. To enhance the employability and soft skills of students

EXPERIMENTS

UNIT I- WRITING SKILLS

Letter seeking permission to go on industrial visit, Letter of invitation,Resume and cover letter, Job application, E-mail writing, Report writing, progress in project work

UNIT II- SPEAKING SKILLS

Welcome address and vote of thanks, Analysing and presenting business articles, Power point presentation, Presenting the visuals effectively,Group discussion,Participating in group discussions, Understanding group dynamics, Brain-storming the topics

UNIT III - SOFT SKILLS

Employability and career skills,Self-introduction, Introducing oneself to the audience, introducing the topic, Interview skills, Interview etiquette, Dress code, Body language, Attending job interviews

UNIT IV- VERBAL ABILITIES

Error Spotting, Listening Comprehension, Reading comprehension,Rearranging Jumbled sentences, Vocabulary

UNIT V – REASONING ABILITIES

Series completion, Analogy, Classification, Coding-Decoding, Blood relations, Seating Arrangements, Directional Sense, Venn Diagram,Logical reasoning, Statements and Conclusions

Total (P) = 60 Hours

Course Outcomes

After the successful completion of the practical session, the students will be able to

CO1	:	To participate in group discussion and interview confidently
CO2	:	To develop adequate soft skills and career skills required for the workplace
CO3	:	To make effective presentations on given topics
CO4		To apply their verbal ability and reasoning ability in campus interviews

REFERENCE BOOKS:

1. Campus Recruitment Complete Reference, Praxis Groups (5th edition), Hyderabad, 2017.
2. John Seely, The Oxford Guide to Writing and Speaking, Oxford University Press, New Delhi, 2004.
3. R.S. Aggarwal. A Modern Approach to Verbal & Non-Verbal Reasoning. 2018 S Chand Publication, 2018

E-RESOURCES:

1. https://prepinsta.com/
2. https://www.indiabix.com/

List of Exercises:

1) Cover Letter and Resume
2) Letter Writing
3) Email Writing
4) Report Writing
5) Powerpoint Presentation
6) Self-Introduction
7) Job Interview
8) Group Discussion
9) Welcome Address
10) Vote of Thanks
11) Presentation of BusinessArticle
12) Jumbled Sentences
13) Error Spotting
14) Reading Comprehension
15) Series completion
16) Analogy
17) Coding-decoding
18) Blood relations
19) Seating arrangements
20) Logical reasoning

18EN401 - CO PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	0	0	0	1	0	0	0	0	2	3	0	1	0	0	1	0
CO2	0	0	0	2	0	0	0	0	2	3	0	1	0	0	2	0
CO3	0	0	0	2	0	0	0	0	1	3	0	1	0	0	1	0
CO4	0	0	0	1	0	0	0	0	2	3	0	1	0	0	2	0

1- Faintly, 2- Moderately, 3- Strongly

22CYMC01	ENVIRONMENTAL SCIENCE	L	T	P	C
		3	0	0	0

Course Objectives:

To learn the concept of non conventional energy systems.

To explore the environmental impact assessment and also to learn about the consequence of different types of pollutants

They are part of the environment

To have an ancient wisdom drawn from Vedas

Activities based knowledge to preserve environment

Conservation of water and its optimization

Environmental Awareness

Various types of traditional power Plant --Advantage and Disadvantage of conventional Power Definition of non-conventional energy sources Plants – Conventional vs. Non-conventional power generation.– types of non-conventional energy sources - India's current energy resources and their long-term viability – India’s Energy requirement and management

Solar Energy Basics- Solar Thermal Energy- Solar Photovoltaic Energy- Benefits and Drawbacks -Effects on the environment and safety. Wind turbine power and energy- India's wind energy potential- Wind turbine types. Environmental benefits and impacts of offshore wind energy

Air pollution- Sources, effects, control, air quality standards, air pollution act, air pollution measurement. Water Pollution-Sources and its remedy, Soil Pollution-Sources and its remedy, disposal of solid waste. Greenhouse gases – effect, acid rain. Noise pollution reduction. Aspects of pollution from various power plants

Environmental Activities

Group activity on water management – Group discussion on recycle of waste (4R’s)- Slogan making contest – Poster making event – Expert lecture on environmental awareness – Imparting knowledge on reduction of electricity usage

Identification and segregation of biodegradable and non-biodegradable waste – Campus cleaning activity – Plantation of trees in the college campus and local waste lands – Identification of varieties of plants and their usage – Shutting down the fans and ACs of the campus for an hour.

SEMESTER – V

22MT501	FORMING PROCESSES	L	T	P	C
		3	0	0	3

Course Objectives:

1.	Know the concepts of Metal forming and associates technologies
2.	Apply forming concepts in conventional and advanced manufacturing.
3.	Know the applications of forming processes in various manufacturing sectors.

UNIT I	FUNDAMENTALS OF METAL FORMING	9	+	0

Introduction to forming processes, Bulk forming Vs sheet metal forming, Classification of forming process based on loading conditions. Tensor Analysis, Yield criteria: Von Mises, Tresca yield criteria. Comparison of yield criteria, Octahedral shear stress and shear strain- Forming load calculations. Fundamentals of forming processes - variables in metal forming and their optimization, Flow stress determination, Temperature in metal forming, Hot, Cold and Warm working, Strain rate effects, Deformation zone geometry, Workability, Metallurgical structures, friction and lubrication, Residual stresses.

UNIT II	FORGING AND ROLLING	9	+	0

Classification of Forging, Types of presses and hammers, Open die forging ,Closed die forging, Die properties and design, Calculation of forging loads, Effect of forging on microstructure Forging defects, causes and remedies, Forging applications. Classification of Rolling Processes, Rolling of Blooms, billets, slabs and sheet, types of rolling mills. Forces and geometrical relationship in rolling. Analysis of rolling load. Defects causes and remedies.

UNIT III	EXTRUSION AND DRAWING	9	+	0

Extrusion: Direct and Indirect extrusion, equipments, container less extrusion port hole extrusion die, hydrostatic extrusion, defects and remedies. Analysis of extrusion, tube extrusion and production of seamless pipe and tube. Hydrostatic extrusion. Equal Channel Angular Extrusion. Defects causes and remedies, Drawing of rods, wires and tubes. Introduction to Super plasticity

UNIT IV	SHEET METAL WORKING AND HIGH VELOCITY FORMING	9	+	0

Sheet Metal Forming: Bending, spinning, stretch forming, deep drawing. Cutting methods - Shearing, blanking and Punching. Defects and applications. High velocity forming methods: Explosive forming, Electro hydraulic, Magnetic pulse forming and pneumatic method, Dynapak method. Formability tests: Effect of strain hardening coefficient (n value), strain rate sensitivity (m value), plastic strain ratio (r value) on formability. Introduction to formability limit diagram.

UNIT V	POWDER METALLURGY	9	+	0

Steps in P/M, advantages and disadvantages. Powder production methods-physical, chemical and mechanical methods. Compaction-Pressure and pressure-less compaction techniques. Hot and Cold isostatic pressing, Sintering- solid state and liquid phase sintering. Microwave sintering, Typical applications

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand and describe the fundamentals of metal forming – Yielding, workability

CO2	:	Exhibit the knowledge in Rolling and forging processes
CO3	:	Explain the Extrusion and Drawing processes, their defects and remedies
CO4	:	Understand the fundamentals of various sheet metal forming
CO5	:	Understand and describe the fundamentals of Powder metallurgy processes

Text Books:

1.	Dieter G.E ,Mechanical metallurgy , third edition ,McGraw hill company, SI edition 1995
2.	Sinha A.K ,Powder metallurgy, Dhanpat Rai & sons ,New Delhi,2001

Reference Books:

1.	ASM Metal handbook Volume 14 Forming and forging ,Metal park Ohio USA,2001
2	ASM Metal handbook Volume 14A: Metalworking: Bulk Forming Metal park Ohio USA,2005
3.	ASM Metal handbook Volume 14B: Metalworking: Sheet Forming Metal park Ohio USA,2005
4.	Metal forming Handbook – Springer
5.	P.C Angelo, R. Subramanian Powder Metallurgy Science, Technology and Applications , PHI Learning Private Ltd, New Delhi 2009

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	3	3	1	3	0	0	0	0	2	3	2	2	1
CO2	3	3	2	2	3	1	2	0	0	0	0	2	3	2	2	
CO3	3	2	2	2	3	1	2	0	0	0	0	2	3	2	2	
CO4	3	2	2	1	3	1	3	0	0	2	0	2	3	2	2	
CO5	3	2	2	2	3	2	0	0	0	2	0	2	3	2	2	1
Total	**3**	**2.4**	**2**	**2**	**3**	**1.2**	**2**	**0**	**0**	**0.8**	**0**	**2**	**3**	**2**	**2**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MT502	STEEL MAKING	L	T	P	C
		3	0	0	3

Course Objectives

1.	To know the importance of the steel making and to apply them for the advancement of the production feasibilities in steel industries to compete with the modern day manufacturing routes.

UNIT I	PHYSICAL CHEMISTRY OF STEEL MAKING	9	+	0

History & Development of Steel making processes. Raw materials for Steel making & plant layout. Physico Chemical Principles and Kinetic aspects of Steel making - Carbon reaction, Phosphorus reaction, Silicon reaction, Manganese reaction & Sulphur reaction, Reaction at slag-metal interface, Oxygen transport mechanism, Deoxidation of steel – Thermodynamics, Kinetics and Mechanism, Slag – Functions, Composition, Properties and Theories

UNIT II	OLDER STEEL MAKING & ELECTRIC STEEL MAKING PROCESS	9	+	0

Review of older Steel making process: Bessemer processes – Acid & Basic Bessemer Process, Open Hearth Process – Reasons for the decline, Electric Steel making process: Electric Arc Furnace and Induction furnace – Constructional features, Production practice for Plain Carbon Steels, Low Alloy Steels & Stainless Steels, Developments in Electric Arc Furnace technology – Furnace design, Operational features.
Modern approaches to Steel making – External treatments to remove Sulphur, Phosphorus & Silicon.

UNIT III	OXYGEN STEEL MAKING PROCESS	9	+	0

Review of older Steel making process: Bessemer processes – Acid & Basic Bessemer Process, Open Hearth Process – Reasons for the decline, Electric Steel making process: Electric Arc Furnace and Induction furnace – Constructional features, Production practice for Plain Carbon Steels, Low Alloy Steels & Stainless Steels, Developments in Electric Arc Furnace technology – Furnace design, Operational features.
Modern approaches to Steel making – External treatments to remove Sulphur, Phosphorus & Silicon.

UNIT IV	SECONDARY STEEL MAKING PROCESS	9	+	0

Introduction, Stirring techniques, Cleanliness improvement, Perrin Process, Decarburization techniques:
Stainless Steel making technology - AOD process, VOD process, CLU process, Nitrogen problem in Stainless Steel making. Injection Metallurgy, Plunging techniques, Post solidification treatments – VAR & ESR process. Tundish Metallurgy. Ladle furnace. Vacuum treatment – Principle & Function of Degassing, Degassing processes - Ladle degassing, Stream degassing, Recirculation degassing.

UNIT V	INGOT AND CONTINOUS CASTING OF STEEL	9	+	0

Casting Pit practice – Teeming Ladle, Ingot mould, Teeming methods. Solidification of Steel in Ingot moulds- Killed, Rimmed and Capped Steels. Ingot defects and their remedies. Gases in Steel. Continuous Casting of Steel – Introduction, Principles, Constructions features and Operation of a typical Continuous Casting Machine. Defects in Continues Casting products. Current status of Continuous Casting Technology. Quality Control in Continues casting. Metallurgical Defects and their remedies. Indian Steel Industry and global trends in steel making technology, Introduction to mathematical modelling in steel making processes

Total (45+0) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Specify the particular reactions taking place in the steel making process along with the thermodynamics, kinetics and the mechanism of reaction

CO2	**:**	Review the older steel making process and modern electric steel making processes
CO3	**:**	Discuss and describe the conventional steel making processes viz. oxygen steel making processes
CO4	**:**	Describe the secondary steel making processes, the process following the primary refining of raw pig iron
CO5	**:**	Specify the casting process for steel and discuss the ingot defects and their respective remedies

Reference Books:	
1.	Ahindra Ghosh and Amit Chatterjee, Iron Making and Steel Making – Theory and Practice, Prentice Hall of India Private Ltd., New Delhi, 2008.
2.	R.H.Tupkary and V.R. Tupkary, An Introduction to modern steel making, Khanna Publishers, 2000.
E-References:	
1.	https://nptel.ac.in/courses/113104013

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	3	3	1	3	0	0	0	0	2	3	2	2	
CO2	3	3	2	2	3	1	2	0	0	0	0	2	3	2	2	1
CO3	3	2	2	2	3	1	2	0	0	0	0	2	3	2	2	
CO4	3	2	2	1	3	1	3	0	0	2	0	2	3	2	2	
CO5	3	2	2	2	3	2	0	0	0	2	0	2	3	2	2	1
Total	**3**	**2.4**	**2**	**2**	**3**	**1.2**	**2**	**0**	**0**	**0.8**	**0**	**2**	**3**	**2**	**2**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MT503	CORROSION ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To know the concept of different types of corrosion and to understand the basic principles of corrosion engineering.

UNIT I	CORROSION PRINCIPLES	9	+	0

Electrochemical and thermodynamic principles, electrode potential of metals, EMF and galvanic series, merits and demerits, Pourbaix diagram and its importance to iron, aluminium and magnesium metals, corrosion rate expressions. Exchange current density, polarization - concentration, activation and resistance, Tafel equation, passivity, electrochemical behaviour of active-passive metals, flade potential, factors governing metals exhibiting passivity, Mixed potential theory and its application.

UNIT II	FORMS OF CORROSION	9	+	0

Atmospheric, galvanic, crevice, pitting, stress corrosion cracking, intergranular corrosion, corrosion fatigue, hydrogen damage, cavitation, fretting corrosion and high temperature oxidation-description, causes and remedial measures.

UNIT III	CORROSION TESTING	9	+	0

Purpose of testing - laboratory, semi-plant and field tests, susceptibility tests of IGC, stress corrosion cracking and pitting, ASTM standards for corrosion testing; Corrosion testing for Passivating metals.
Polarization methods to measure corrosion rate, Tafel extrapolation method, Linear Polarisation method.

UNIT IV	CORROSION PREVENTION	9	+	0

Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors

UNIT V	CORROSION IN INDUSTRIES	9	+	0

Corrosion in Boiler Plant: Corrosion on water-side of the boiler, fire-side of the boiler and their prevention. Scale formation in boilers and its prevention. Practical remedial treatments in boilers. Corrosion in automotive industry, chemical processing industries, corrosion in petroleum production operations and refining.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the electro chemical and thermodynamic principles and to discuss the pourbaix diagram.
CO2	**:**	Understand the different forms of corrosion and their causes and remedies.
CO3	**:**	Describe the processes of ASTM testing methods and polarization methods.
CO4	**:**	Understand the corrosion preventive methods such as mechanical and chemical methods.
CO5	**:**	Explain the corrosion in petroleum industries and pipe lines.

Text Books:	
1.	Mars G. Fontana, Corrosion Engineering, Tata McGraw Hill Education, 2005.
2.	Denny A. Jones, Principles and prevention of corrosion, 2nd Edition, Prentice Hall Inc.,1996.
Reference Books:	
1.	ASM hand book, Vol 13: Corrosion, ASM International, USA, 2001.
2.	Rajnarayan, Metallic corrosion and prevention, Oxford Publications, 2001.
3.	Trethewey, K.R., and Chamberlain, J., Corrosion – For science and engineering, 2nd Edition, Longman Inc., 1996.
4.	Uhlig, H.H., and R. Winston Revie, Corrosion and corrosion control – An introduction to corrosion science and engineering, Third edition, John Wiley & Sons, 1985.
E-References:	
1.	www.nptel.ac.in/courses/113108051/

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	2	2	2	3	1	0	0	0	0	1	1	3	2	3	1
CO2	2	3	3	2	1	0	0	0	0	0	1	1	2	3	3	1
CO3	2	2	3	1	1	0	0	0	0	0	1	2	2	2	2	1
CO4	1	3	3	3	3	1	2	0	0	0	0	1	1	2	2	1
CO5	1	3	2	2	2	0	0	0	0	0	1	2	3	2	2	1
Total	**1.6**	**2.6**	**2.8**	**2**	**2**	**0.4**	**0.4**	**0**	**0**	**0**	**0.8**	**1.4**	**2.2**	**2.2**	**2.4**	**1**

1- Faintly, 2- Moderately, 3- Strongly

22MT504	CASTING ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the basic concept of metal casting technology
2.	To apply the concept to produce new materials

UNIT I	MOULDING MATERIALS AND PATTERNS	9	+	0

Introduction to foundry operations, patterns - functions, types, allowances selection of pattern materials, colour codes, core boxes, moulding practice, ingredients of moulding sand and core sand, Testing of Moulding sands. Sand preparation.

UNIT II	MOULDING AND CASTING TECHNIQUES	9	+	0

Sand moulding: green sand moulding, dry sand moulding, skin dry sand moulding, shell moulding, carbon-di-oxide process, permanent mould casting, die casting, centrifugal casting, plaster mould casting, investment casting, squeeze casting, full mould process, Rheocasting, Thixo casting.

UNIT III	DESIGN OF CASTINGS	9	+	0

Elements of gating system, types, design of gating system with examples, functions of risers, types of risers, Chvorinov‟s rule, design and positioning of riser with examples, directional solidification, use of chills, exothermic compounds etc., riser efficiency, yield calculations. Solidification and shrinkage, inoculation in cast irons, modification in Al-Si system.

UNIT IV	MELTING PRACTICE	9	+	0

Types of furnaces used in foundry, Melting practice and special precautions for steels, alloy steels, cast irons, aluminium alloys, copper alloys and magnesium alloys, safety considerations, fluxing, degassing and inoculation.

UNIT V	QUALITY CONTROL, FETTLING, INSPECTION AND AUTOMATION	9	+	0

Quality control: composition control in steels and cast irons. Simple problems on charge calculations. Cleaning and repair of castings. Casting defects and remedies. Heat treatment of castings. Inspection of casting. Principles of mechanisation, automation and foundry layout. Sand reclamation and Pollution control in foundries.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the solidification of casting, effect of solidification range, fluidity and factors affecting fluidity
CO2	**:**	Discuss the cast iron categories, their types and different heat treatment methods like graphitization, spherodization etc and denote the ASTM standards for all the varieties
CO3	**:**	Discuss the alloying element effect on the steels and mention the precaution to be taken in moulding and melting of steels
CO4	**:**	Describe the casting methods employed for fabrication of non-ferrous alloys
C05	**:**	Mention the melting procedure that is adopted for the various alloys like steels, stainless steels, discuss the slag-metal reactions

Text Books:

1.	Heine R W., C.R., Loper, and P.C. Rosenthal, Principles of Metal Casting, Tata-McGraw Hill Publishing Co Ltd, New Delhi, 2018.
2.	Jain, P.L ., Principles of Foundry Technology, Tata McGraw Hill Publishing Co Ltd, New Delhi, 2013.
3.	Srinivasan, N.K., Foundry Engineering, Khanna Tech Publications, New Delhi, 2017.
Reference Books:	
1.	Ramana Rao, T.V., Metal Casting: Principles and Practice, New Age International Publishing Co., New Delhi, 2019.
2.	ASM Metals hand Book, Vol 15, Casting ASM International, 10th edition, 2010.
3.	Beeley, P.R., Foundry Technology, Butterworths, London, 2013.

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	2	3	2	1	0	0	0	0	0	0	3	2	3	
CO2	3	3	3	3	3	1	0	0	0	0	0	0	3	2	3	
CO3	3	3	3	3	3	1	0	0	0	0	0	0	3	2	3	1
CO4	3	3	2	2	3	1	2	0	0	0	0	2	3	2	2	
CO5	3	3	2	2	3	1	2	0	0	0	0	2	3	2	2	1
Total	**3**	**2.8**	**2.4**	**2.6**	**2.8**	**1**	**0.8**	**0**	**0**	**0**	**0**	**0.8**	**3**	**2**	**2.6**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MT505	WELDING ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the concepts of different materials joining and allied processes.
2.	To understand the metallurgical aspects of welding.

UNIT I	GAS, ARC AND OTHER WELDING PROCESSES:	9	+	0

Introduction to welding and allied processes. Overview of arc welding power sources, Open Circuit Voltage (OCV), duty cycle. Fusion welding processes – Principle, merits, demerits and applications of Oxy-acetylene welding (OAW), Shielded metal arc welding (SMAW), Submerged arc welding (SAW), Gas tungsten arc welding (GTAW), Gas metal arc welding (GMAW and FCAW). Introduction to welding consumables for these processes. Principle and applications of Electro slag welding (ESW), Thermit welding. Arc welding defects, their causes and remedies.

UNIT II	SOLID STATE AND SPECIAL WELDING PROCESSES:	9	+	0

Resistance welding processes (Spot and Seam welding). Principle, merits, demerits and applications of Cold pressure welding, hot pressure welding, induction pressure welding, friction welding, friction stir welding, ultrasonic welding, explosive welding, diffusion welding processes. Principle, merits, demerits and applications of Electron beam (EBW), Laser beam (LBW), Plasma arc welding (PAW) processes.

UNIT III	INTRODUCTION TO WELDING METALLURGY:	9	+	0

Heat flow in welding, Heat affected zone (HAZ), weld thermal cycles and their effects, simple problems, microstructural changes in the heat affected zone of carbon steels. Weld dilutiuon. Welding of carbon steels, low alloy steels, welding of cast irons, welding of stainless steels (Austenitic, Ferritic and Martensitic). Introduction to cracking phenomenon associated with welding - Hot cracking, Hydrogen induced cracking, Lamellar tearing, Reheat cracking. Welding of aluminium and its alloys, welding of copper and its alloys, welding of titanium and its alloys, welding of nickel and its alloys. Dissimilar welding. Concept of Weldability and its assessment for hot cracking and cold cracking.

UNIT IV	OTHER JOINING PROCESSES:	9	+	0

Introduction to Brazing and Soldering. Fundamentals - Capillary action and Wetting characteristics. Brazing: Principle, joint design, materials, merits, demerits and applications of Torch brazing, Furnace brazing, Induction brazing, Resistance brazing, Dip brazing processes. Filler alloys and fluxes for brazing. Soldering: Principle, joint design, materials, merits, demerits and applications of Iron soldering, Torch soldering, Infrared soldering, Laser soldering, Hot gas soldering, Wave soldering processes. Filler alloys and fluxes for soldering.

UNIT V	SURFACING AND CUTTING PROCESSES:	9	+	0

Surfacing: Dilution characteristics. Types of Surfacing – Cladding, Hardfacing, Build-up and Buttering. Surfacing by welding: OAW, SMAW, GTAW, GMAW, FCAW, SAW and PAW. Surfacing materials and their applications. Cutting processes: Principle of operation and applications of Oxy-fuel gas cutting, Metal powder cutting, Chemical flux cutting, Plasma arc cutting, Laser beam cutting and Air carbon arc cutting processes.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the working principle, merits and demerits of different arc welding processes.
CO2	**:**	Describe the working principle, merits and demerits of different solid state &special welding processes.

CO3	**:**	Solve welding heat flow related problems.
CO4	**:**	Demonstrate the working principle and importance of brazing and soldering in Joining processes.
CO5	**:**	Describe the working principle, merits and demerits of surfacing by welding and cutting processes.

Text Books:

1.	Srinivasan N K ,"Welding Technology", Khanna Publications, Delhi, 2001.
2.	Parmar, R.S., "Welding Processes and Technology", 3rd edition. Khanna Publishers, New Delhi, 2003.
3.	Parmar, R.S., "Welding Engineering and Technology", Khanna Publishers, New Delhi, 2003.

Reference Books:

1.	Davies A C , "Welding",10th edition, Cambridge University Press, UK, 1996.
2.	AWS Welding Handbooks, AWS, New York, 1995.
3.	Howard B. Cary, "Modern Welding Technology", Prentice Hall, New Jersey, USA, 2004.
4.	Sindo Kou, Welding Metallurgy, John Wiley & Sons, 1987.
5.	Norman Bailey, "Weldability of ferritic steels", Jaico Publishing House, 1997.
6.	Nadkarni S.V., "Modern Arc Welding Technology", Oxford & IBH Publishing Co., 1988.
7.	Schwartz M.M.,"Metals Joining Manual", McGraw- Hill Inc.,1979.
8.	ASM Metals Handbook, Vol. 6,"Welding Brazing & Soldering", ASM International, Metals park,Ohio, USA, 2001.

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	2	2	3	2	0	0	0	0	0	2	3	2	3	3	
CO2	1	2	3	1	2	0	0	0	1	0	2	2	2	2	2	
CO3	1	2	2	1	1	0	0	0	0	0	2	2	3	2	3	1
CO4	1	2	2	1	2	1	0	0	1	0	1	2	2	2	3	
CO5	3	1	1	1	2	0	0	0	0	0	1	1	2	2	2	1
Total	**1.4**	**1.8**	**2**	**1.4**	**1.8**	**0.2**	**0**	**0**	**0.4**	**0**	**1.6**	**2**	**2.2**	**2.2**	**2.6**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MT506	HEAT TREATMENT AND CORROSION LABORATORY	L	T	P	C
		0	0	3	1.5

Objective

1. To understand the various heat treatment process.

2. To gain knowledge about corrosion testing.

EXPERIMENTS: HEAT TREATMENT LABORATORY

1.	Annealing of carbon steels-Heat treatment practice and Analysis
2.	Normalising of carbon steels – Heat treatment practice and Analysis
3.	Effect of quenching media on hardening of steel – Heat treatment practice and Analysis
4.	Effect of tempering temperature on hardened steel – Heat treatment practice and Analysis
5.	Effect of tempering time on hardened steel- Heat treatment practice and Analysis

EXPERIMENTS: CORROSION LABORATORY

1.	Corrosion rate determination by weight loss method.
2.	Electroplating of Copper and Nickel.
3.	Effect of inhibitors on the rate of corrosion.
4.	Oxalic acid etch test for IGC ASTM A262 – Practice A.
5.	Carryout Polarization studies by using electrochemical workstation.

Total (P) = 45 Hours

Course Outcomes

After the successful completion of the practical session, the students will be able to

CO1	**:**	Conduct and explain the process of annealing and normalizing process on Carbon steels.
CO2	**:**	Determine the effect of Quenching and Tempering process of Hardened steel.
CO3	**:**	Determine the corrosion rate by weight loss method.
CO4	**:**	Analyze the effect of inhibitor on corrosion rate.
CO5	**:**	Perform electroplating of copper and nickel.

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	2	2	2	3	1	0	0	0	0	1	1	3	2	3	
CO2	2	1	3	2	1	0	0	0	0	0	1	1	2	3	3	
CO3	2	2	1	1	1	0	0	0	0	0	1	2	2	2	2	
CO4	1	3	3	3	3	1	1	0	0	0	0	1	1	2	2	
CO5	1	3	2	2	2	0	0	0	0	0	1	2	3	2	2	
Total	**1.6**	**2.2**	**2.2**	**2**	**2**	**0.4**	**0.2**	**0**	**0**	**0**	**0.8**	**1.4**	**2.2**	**2.2**	**2.4**	**0**

1- Faintly, 2- Moderately, 3- Strongly

22MT507	MACHINE SHOP PRACTICE	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To practice and know about various machining machine.

EXPERIMENTS

1.	Lathe
2.	Drilling
3.	Shaping
4.	Gear hobbing
5.	Keyway milling
6.	Study on cylindrical grinding, boring, and CNC machines.

Total (P) = 45 Hours

Course Outcomes

After the successful completion of the practical session, the students will be able to

CO1	:	Understand the machining concepts and also do the machining operations like facing and turning for the given components.
CO2	:	Practice the different methods of taper turning and do the taper turning operation using methods like tailstock set over and taper turning attachment.
CO3	:	Recognize performance and principle of basic drilling operation and also various successful machining of drilling, tapping, reaming and counter Sink by using radial drilling machine.
CO4	:	Practice the concept of milling and do the keyway milling.
CO5	:	Practice the various machining process like cylindrical grinding, boring and shaping.

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	1	0	0	3	2	1	0	3	1	2	2	3	2	2	
CO2	2	0	1	0	3	0	2	1	2	1	0	0	2	2	2	
CO3	3	1	2	2	1	0	2	3	0	0	1	1	0	0	0	
CO4	2	1	3	1	2	0	0	1	2	3	1	0	1	2	1	
CO5	1	2	1	0	2	3	1	2	1	0	0	0	1	1	1	1
Total	**2.2**	**1**	**1.4**	**0.6**	**2.2**	**1**	**1.2**	**1.4**	**1.6**	**1**	**0.8**	**0.6**	**1.4**	**1.4**	**1.2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

SEMESTER – VII

22MT701	CHARACTERIZATION OF MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To provide an understanding of the basic principles of various characterizations techniques
2.	To learn the uses of analytical instruments to carryout metallurgical characterization.

UNIT I	METALLOGRAPHIC TECHNIQUES:	9	+	0

Metallurgical microscope - principle, construction and working, metallographic specimen preparation, optical properties - magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources, lens aberrations and their remedial measures, various illumination techniques-bright field, dark field, phase-contrast, polarized light illuminations, interference microscopy, high temperature microscopy; quantitative metallography – Image analysis.

UNIT II	X-RAY DIFFRACTION TECHNIQUES :	9	+	0

Characteristic X-ray spectrum, Bragg's Law, Diffraction methods - Laue method, rotating crystal method, powder method, Principle, equipment and applications, X-ray diffractometer, filters and counters, Applications of X-ray diffraction in materials characterization – Determination of crystal structure, lattice parameter, measurement of stress, Introduction of GIXRD, SAX/WAX.

UNIT III	ELECTRON OPTICAL TECHNIQUES:	9	+	0

Electron optical instruments, electron-specimen interactions, Transmission electron microscopy(TEM) – principle, construction and working , specimen preparation, various imaging modes, selected area diffraction, applications, Scanning electron microscopy(SEM) – principle, equipment, various operating modes and applications, Electron probe microanalyser (EPMA)- principle, instrumentation, qualitative and quantitative analysis, HRTEM.

UNIT IV	SURFACE ANALYSIS TECHNIQUES:	9	+	0

Principle, instrumentation, working and applications of Auger Electron spectroscopy, X-ray photoelectron spectroscopy, Secondary ion mass spectroscopy / ion microprobe, Optical emission spectroscopy and X-ray fluorescence spectroscopy.

UNIT V	THERMAL ANALYSIS AND ADVANCED CHARACTERIZATION TECHNIQUES:	9	+	0

Advanced characterization techniques: Field ion microscopy including atom probe - principle, instrumentation and applications, Scanning probe microscopy - principle, instrumentation and applications, Atomic force microscopy - principle, instrumentation and applications. Thermal techniques: Principles of Differential thermal analysis, Differential scanning calorimetry and Thermogravimetric analysis – Instrumentation.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Describe the principle of various optical metallographic techniques.

CO2	**:**	Demonstrate the Bragg‟s law of diffraction and the principle of XRD.
CO3	**:**	Describe the principle of various electron optical techniques.
CO4	**:**	Describe the various surface analyzing techniques.
CO5	**:**	State the thermal analysis technique and apply them to determine various thermal events in materials.

Text Books:

1.	Angelo .P.C , “ Materials Characterization “, Reed Elsevier India Pvt Ltd, Haryana, 2016.
2.	Hebbar K R, “ Basics of X-Ray Diffraction and its Applications”, I.K. International Publishing House Pvt Ltd, New Delhi, 2011
3.	Khangaonkar. P.R., “An Introduction to Materials Characterization“, Penram International Publishing (India) Pvt. Ltd, Mumbai, 2010.

Reference Books:

1.	Phillips V A, “Modern Metallographic Techniques and their Applications”, Wiley Eastern, 1971.
2.	Cherepin and Malik, “Experimental Techniques in Physical Metallurgy”, Asia Publishing Co., Mumbai, 1968.
3.	Cullity B D., Stock S R "Elements of X-ray Diffraction", Prentice Hall, Inc 2001.
4.	ASM Handbook, Volume 10, “Materials Characterization“, 9th edition, ASM international, USA, 1986.
5.	Vander Voort, “Metallography: Principle and practice”, Mc Graw Hill Inc., 1984.
6.	Kehl G L., "The Principles of Metallographic Laboratory Practice", McGraw Hill Book Company, 1949.
7.	Small man R.E., „Modern Physical Metallurgy‟, 4th Edition, Butterworths, 1985.

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	2	0	2	3	1	2	1	3	1	1	0	1	3	3	1
CO2	2	1	3	0	2	3	3	0	2	0	1	2	2	2	0	1
CO3	0	3	2	1	0	0	0	3	2	2	2	0	0	3	1	1
CO4	3	0	1	3	1	2	1	2	1	3	3	3	2	0	3	1
CO5	1	2	3	0	2	1	0	1	1	0	2	0	1	1	2	1
Total	**1.4**	**1.6**	**1.8**	**1.2**	**1.6**	**1.4**	**1.2**	**1.4**	**1.8**	**1.2**	**1.8**	**1**	**1.2**	**1.8**	**1.8**	**1**

1- Faintly, 2- Moderately, 3- Strongly

22MT702	NON-FERROUS EXTRACTIVE METALLURGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To study the various ores of non ferrous metals and their extraction through Pyro, Hydro and Electro metallurgy routes
2.	To understand principles and gain knowledge on the processes used in the extraction of nonferrous metals
3.	To study the different refining techniques to purify the crude metal

UNIT I	PYROMETALLURGY	9	+	0

Introduction: Sources of metals, unit operations and unit processes of metal extraction. Principles of Pyrometallurgy, advantages, Pyrometallurgical Processes – Drying, Calcination, Sintering, Roasting – Roasting Techniques – Predominance Area Diagrams. Principles of Smelting and Converting. Ellingham diagrams – Carbothermic, Hydrothermic and Metallothermic reductions.

UNIT II	HYDROMETALLURGY	9	+	0

Principles of Hydrometallurgy, advantages, Leaching – Properties of good solvent. Preparation of ore for Leaching – Leaching methods, Recovery of metals from liquor – Solvent extraction, Ion exchange, Bio leaching, Gaseous reduction of metals in aqueous solutions, Cementaion, Recycling of leach liquor.

UNIT III	ELECTROMETALLURGY AND PURIFICATION METHODS	9	+	0

Principles of Electrometallurgy, advantages, Aqueous and Fused salt electrolysis, Electro refining and Electro winning of metals. Purification of Crude metals produced in bulk – Distillation, Liquation, Liquid-Liquid extraction. Fire refining, Electrolytic refining, Zone refining, VAR, EBM and ESR.

UNIT IV	EXTRACTION AND REFINING OF METALS FROM SULPHIDE AND OXIDE ORES	9	+	0

Extraction and Refining of metals from sulphide ores – Copper, Nickel, Lead and Zinc. Extraction and Refining of metals from oxide ores – Aluminium, Magnesium and Tin.

UNIT V	EXTRACTION OF PRECIOUS AND RARE EARTH METALS AND BYPRODUT METALS RECOVERY	9	+	0

Extraction and Refining of precious metals – Gold, Silver and Platinum. Extraction of metals rare earth metals from halides – Titanium, Zirconium and Uranium. Recovery of by-product metals and treatment of Metallurgical wastes, Material and Energy balance.

Total (45+0) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Exposure to different sources non ferrous metals and understand the process principles of pyrometallurgical extraction.
CO2	**:**	Understand the process principles of hydrometallurgical extraction.
CO3	**:**	Explain the process principles of electrometallurgical extraction and refining of metals.
CO4	**:**	Explain the extraction of metals from sulphide and oxide ores.
CO5	**:**	Explain the production of precious metals and rare earth metals. Recovery of metals from metallurgical wastes.

Text Books:

1.	Ray H.S, Sridhar R and Abraham K.P, Extraction of Non Ferrous Metals, Affiliated East-West Press Pvt Ltd, New Delhi, 2008.
2.	Ray H.S and Gosh A, Principles of Extractive Metallurgy, Prentice Hall of India, New Delhi, 1994

Reference Books:

1.	Terkel Rosenqvist, Principles of Extractive Metallurgy, 2nd Edition, McGraw-Hill International book Company, 1983

2.	Venkatachalam S, Hydrometllurgy, Narosa Publishing House, New Delhi, 1998
3.	R.Raghavan Extractive Metallurgy of Non - Ferrous Metals ,Vijay Nicole Imprints Private Limited, Chennai 2016
4.	Pehlke R.D, Unit Processes in Extractive Metallurgy, American Elsevier Publishing Company, New York, USA, 1977.
E-References:	
1.	https://nptel.ac.in/syllabus/113105021/

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 3
CO1	2	3	2	3	3	1	2	0	0	0	0	2	3	2	1	1
CO2	3	3	2	2	3	1	2	0	0	0	0	2	3	2	1	1
CO3	3	2	2	2	3	1	2	0	0	0	0	2	3	2	1	1
CO4	3	2	2	1	3	1	2	0	0	2	0	2	3	2	1	
CO5	3	2	2	2	3	2	2	0	0	2	0	2	3	2	1	
Total	**2.8**	**2.4**	**2**	**2**	**3**	**1.2**	**2**	**0**	**0**	**0.8**	**0**	**2**	**3**	**2**	**1**	**0.6**

1- Faintly, 2- Moderately, 3- Strongly

22MT703	INTRODUCTION TO INDUSTRIAL MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1.	On studying this course the students can contribute to the success of companies by understanding the basics of management.
2.	To provide an opportunity to learn basic management concepts essential for business.
3.	Gain knowledge on various factors of production in increasing the efficiency of the company.
4.	They can able to know better organizational behaviour and modern concepts of industrial management.

UNIT I	BASICS OF MANAGEMENT	9	+	0

Management – Definition – Functions – Evolution of Modern Management – Scientific Management Development of Management Thought. Approaches to the study of Management, Forms of Organization – Individual Ownership – Partnership – Joint Stock Companies – Co-operative Enterprises – Public Sector Undertakings, Corporate Frame Work – Share Holders – Board of Directors – Committees – Chief Executive –Trade Union.

UNIT II	FUNCTIONS OF MANAGEMENT	9	+	0

Planning – Nature and Purpose – Objectives – Strategies – Policies and Planning Premises – Decision Making – Organizing – Nature and Process – Premises – Departmentalization – Line and staff – Decentralization – Organizational culture, Staffing – selection and training – Placement – Performance appraisal – Career Strategy – Organizational Development. Leading – Managing human factor – Leadership – Communication, Controlling – Process of Controlling – Controlling techniques, productivity and operations management – Preventive control, Industrial Safety.

UNIT III	ORGANIZATIONAL BEHAVIOUR	9	+	0

Definition – Organization – Managerial Role and functions – Organizational approaches, Individual behaviour – causes – Environmental Effect – Behaviour and Performance, Perception – Organizational Implications. Personality – Contributing factors – Dimension – Need Theories – Process Theories – Job Satisfaction, Learning and Behaviour – Learning Curves, Work Design and approaches

UNIT IV	GROUP DYNAMICS	9	+	0

Group Behaviour – Groups – Contributing factors – Group Norms, Communication – Process – Barriers to communication – Effective communication, leadership – formal and informal characteristics – Managerial Grid – Leadership styles – Group Decision Making – Leadership Role in Group Decision, Group Conflicts – Types – Causes – Conflict Resolution – Inter group relations and conflict, Organization centralization and decentralization – Formal and informal – Organizational Structures – Organizational Change and Development – Change Process – Resistance to Change – Culture and Ethics.

UNIT V	MODERN CONCEPTS	9	+	0

Management by Objectives (MBO), Management by Exception (MBE), Strategic Management – Planning for Future direction – SWOT Analysis – Information technology in management – Decisions support system – Business Process Re-engineering (BPR) – Enterprises Resource Planning (ERP) – Supply Chain Management (SCM) – Activity Based Management (ABM).

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:		
CO1	**:**	Gain knowledge in Basics of the industrial management and the outline of industrial factors.
CO2	**:**	Gain knowledge on management functions and to apply it for different situations.
CO3	**:**	Develop their learning behaviour in an industrial set up.
CO4	**:**	Improve Personality skills, Major determination in profession in group behaviour.
CO5	**:**	Gain knowledge on modern concepts for better industrial management.

Text Books:	
1.	Herald Knottz and Heinz Weihrich, „Essentials of Management", Tata McGraw Hill Education Pvt. Ltd., 2010
2.	Stephen P. Robbins, „Organization Behaviour", Pearson Education Inc., 13 edition, 2010.

Reference Books:	
1.	Ties, AF, Stoner and R.Edward Freeman, „Management" Prentice Hall of India Pvt. Ltd. New Delhi 110 011, 1992.
2.	Joseph J, Massie, „Essentials of Management" Prentice Hall of India Pvt. Ltd. 1985.
3.	P.C. Tripathi & P.N. Reddy, „Principles of Management", Tata McGraw Hill, 2006.
4.	Ravi M. Kishore, "Project Management", Tata McGraw Hill, New Delhi, 2007.

E-References:	
1.	https://nptel.ac.in/courses/112107142/
2.	https://nptel.ac.in/courses/112107143/

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 3
CO1	2	3	2	3	0	3	2	3	2	2	1	2	1	2	3	1
CO2	3	2	1	2	1	2	3	2	1	1	2	3	2	3	2	
CO3	1	3	1	1	3	1	1	1	0	0	3	1	3	1	1	1
CO4	0	1	3	1	2	0	0	0	2	2	0	2	0	0	0	
CO5	1	2	0	0	0	2	1	2	0	3	2	0	1	1	1	1
Total	1.4	2.2	1.4	1.4	1.2	1.6	1.4	1.6	1	1.6	1.6	1.6	1.4	1.4	1.4	0.4

1- Faintly, 2- Moderately, 3- Strongly

22MT704	TOTAL QUALITY MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To give the student an overview of quality and TQM and explaining the salient contributions of Quality Gurus like Deming, Juran and Crosby. General barriers in implementing TQM.
2.	To make students to understand the TQM concepts like customer Focus, Employee Focus and their involvement, continous process improvement and Supplier Management.
3.	To provide exposure to students on the basic and new seven management tools, Quality concepts like Six sigma, Failure mode effect analysis.
4.	To explore industrial applications of Quality function deployment, Taguchi quality concepts and TPM.

UNIT I	PRINCIPLES AND CONCEPTS OF QUALITY	9	+	0

Basics of Quality Management - Development of Quality Management Systems - Quality Planning - Quality Policies and Objectives - Functional planning deployment from Strategic plans - Measurements and Benchmarking.

UNIT II	QUALITY AUDITS	9	+	0

Product, Process and System, Supplier Evaluation and Performance evaluation - Planning Quality Audits - QA plans - Quality Costs Prevention, Appraisal and Failure Costs - Quality Improvements - Corrective and Preventive actions - Role of Quality Control – Calibration.

UNIT III	CONCEPTS OF TQM	9	+	0

Business Excellence models (EFQM, Deming, Malcolm Balridge), TQM tools , Simple SQC tools to FMECA, New 7 tools, Business Process Reengineering, Cost/Time diagram, Quality Function Deployment - Business Excellence Awards and Case Studies - Six Sigma concepts

UNIT IV	STATISTICAL QUALITY CONTROL	9	+	0

Methods and Philosophy of statistical process control –Control Charts for Variables and Attributes – Cumulative sum and Exponential - weighted moving average control charts- other SPC techniques –Process Capability Analysis.

UNIT V	EMPLOYEE PARTICIPATION	9	+	0

Historical foundation of employee involvement programs classical and industrial engineering approaches, SQC, Behavioral management innovations, Quality circles Self managed teams- Implementing Employee Involvement programs.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Students will be able to gain basic knowledge in total quality management relevant to both manufacturing and service industry including IT sector.
CO2	**:**	Students will be able to implement the basic principles of TQM in manufacturing and service based organization.
CO3	**:**	The student would be able to apply the tools and techniques of quality management to manufacturing and services processes

CO4	**:**	The students will be able to gain the knowledge on various ISO standards and quality systems

Text Books:	
1.	Juran, J.M. and Gryna, 'Quality Control Hand Book', 2nd Ed., 1999.
2.	Evans R. J and Lindsay M. W, 'The Management and control of quality', 2nd Ed, 2011, Jaico Publishing house.
Reference Books:	
1.	James R. Evans and William M. Lindsay, "The Management and Control of Quality", 6th Edition, South-Western (Pg.Thomson Learning), 2005.
2.	Janakiraman,B and Gopal, R.K, "Total Quality Management – Text and Cases", Prentice Hall (Pg.India) Pvt. Ltd, 2006.
3.	Pathak ,"Total Quality Management- Macmillan publishers India Ltd.
4.	Suganthi,L and Anand Samuel, "Total Quality Management", Prentice Hall (Pg.India) Pvt. Ltd.,2006.
E-References:	
1.	https://onlinecourses.nptel.ac.in/noc17_mg18/preview
2.	https://onlinecourses.nptel.ac.in/noc18_mg04/preview

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	0	2	1	2	3	2	1	3	2	1	0	1	2	
CO2	2	1	1	1	0	3	0	3	3	2	1	2	1	2	3	
CO3	1	3	1	1	2	0	1	1	2	1	3	0	1	3	1	1
CO4	1	0	2	3	3	1	2	2	0	0	0	3	2	1	0	1
Total	**1.75**	**1.5**	**1**	**1.75**	**1.5**	**1.5**	**1.5**	**2**	**1.5**	**1.5**	**1.5**	**1.5**	**1**	**1.75**	**1.5**	**0.5**

1- Faintly, 2- Moderately, 3- Strongly

22MT705	MATERIALS CHARACTERIZATION AND COMPUTER APPLICATIONS LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To describe the various characterization methods and use of the tools.
2.	To become familiar with computational technique on thermodynamic and kinetics related mathematical background.
3.	Understanding the non-destructive testing principles and procedures for quality control.

EXPERIMENTS: Materials Characterization Laboratory

1.	(a) Determination of average grain size and volume fraction of phases using image analysis,, (b) nodularity and nodule count in cast iron using image analysis.
2.	(a) Determination of Structure Factor for BCC and FCC structure, (b) Indexing of XRD patterns.
3.	(a) Estimation of precise lattice parameter of cubic crystals, (b) Determination of crystallite size and r.m.s. strain for mechanically alloyed power.
4.	(a) Analysis of SEM & TEM images, (b) Interpretation of DSC curves.

EXPERIMENTS: Non-destructive Testing Laboratory

1.	(a) Visual inspection, (b) Liquid penetrant inspection.
2.	(a) Magnetic particle inspection, (b) Eddy current inspection,
3.	Identification of welding & casting defects in radiographs.
4.	Ultrasonic testing, use of IIW blocks and Reference Blocks.

EXPERIMENTS: Computer Applications Laboratory

1.	(a) Factorial computation of a given number, (b) Determine Parametric approaches in creep data, Larson miller parameter.
2.	(a) Solve and give Numerical solution for non-linear equations, (b) Determination of unsteady state heat for low-cooling of a slab.
3.	(a) Calculation of adiabatic flame temperatures, at the tuyers of a coke fueled shaft furnace, (b) Calculation of heat loss through furnace wall in transfer ladle,
4.	(a) Calculation of Enthalpy change using thermo-chemical data, (b) Determination of Enthalpy and free energy change of a reaction.

Total (P) = 45 Hours

E Reference

1.	https://materialsproject.org/

Course Outcomes		
After the successful completion of the practical session, the students will be able to		
CO1	**:**	Determine the volume fraction of phases, nodule count and nodularity.
CO2	**:**	Illustrate indexing, and calculate the residual stress and lattice parameter using XRD pattern.22
CO3	**:**	Analyze various fractographic SEM and TEM images/ DSC thermal images.
CO4	**:**	Calculate the adiabatic flame temperatures of shaft furnace through programming and exhibit the results ingraphical representation.
CO5	**:**	Demonstrate the usage of various numerical solutions for non-linear equations.
CO6	**:**	Create the concept of enthalpy and free energy change of reaction and heat loss through furnace walls.
CO7	**:**	Understanding the principles, procedures and perform surface, subsurface and Internal structure NDT inspection.
CO8		Surface preparation and hands on experience on operating the testing equipment.

CO PO MAPPING

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	1	2	2	3	2	0	0	0	0	0	2	3	2	3	3	1
CO2	1	2	3	1	2	0	0	0	1	0	2	2	2	2	2	1
CO3	1	2	2	1	1	0	0	0	0	0	2	2	3	2	3	
CO4	1	2	2	1	2	1	0	0	1	0	1	2	2	2	3	
CO5	3	1	1	1	2	0	0	0	0	0	1	1	2	2	2	
CO6	1	1	1	1	1	0	0	0	0	0	0	1	1			1
CO7	1	1	1	1	1	0	0	0	0	0	0	1	1	1		1
CO8	1	1	1	1	1	0	0	0	0	0	0	1	1		1	1

1- Faintly, 2- Moderately, 3- Strongly

22MT706	MANUFACTURING PROCESSES LABORATORY	L	T	P	C
		0	0	3	1.5

Course Objectives:

1.	To know and apply the concept of casting technology for green sand testing.
2.	To know and apply the concept of forming technology for various structural engineering applications.
3.	To know about the concepts of welding technology and apply them for the fabrication of components.

EXPERIMENTS: Casting Laboratory

1.	Determine Average grain fineness number.
2.	Conduct clay content, moisture content and mouldability of green sand.
3.	Determination of green hardness, compression and shear strength.
4.	Determine permeability and shatter index test of green sand.

EXPERIMENTS: Forming Laboratory

1.	Determine Tension Test - n and k value of rod/sheet.
2.	Determine Erichsen index and Cold rolling reduction percent of aluminium/brass sheets.
3.	Effect of Recrystallisation annealing temperature & time on cold worked alloys.
4.	Determination of Flow rate, Apparent and Tap densities of Powders.

EXPERIMENTS: Welding Laboratory

1.	Preparation of square butt joint and T-joint using Shielded Metal Arc Welding process.
2.	Effect of welding parameters on weld bead characteristics (using Profile projector) and Microstructural observation of weldments.
3.	Study and demonstration of GTA welding, GMA welding and Solid state welding processes.
4.	Practice for preparation of WPS and PQR.

Total (P) = 45 Hours

Course Outcomes

After the successful completion of the practical session, the students will be able to

CO1	**:**	Estimate the properties of the green sand.
CO2		Evaluate the formability behaviour of different sheet/rod/wire/powder materials.
CO3	**:**	Understand and prepare square butt joints for SMAW process and the effect of welding parameters on the weld bead by GTAW and GMAW processes.
CO4	**:**	Understand the microstructure and macrostructure analysis of weldment and preparation of WPS/PQR

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	0	0	2	2	0	0	0	0	0	1	2	3	2	2	1
CO2	1	1	1	2	1	0	0	0	0	0	2	1	3	3	3	
CO3	1	2	2	2	3	0	0	0	0	0	1	2	2	2	3	1
CO4	1	2	3	2	3	0	0	1	1	0	2	1	3	2	3	1

1- Faintly, 2- Moderately, 3- Strongly

PROFESSIONAL ELECTIVES COURSES (PEC)					
22MTE01	**TRANSPORT PHENOMENA**	**L**	**T**	**P**	**C**
(Use of HMT data book is permitted in University Examinations)		**3**	**0**	**0**	**3**

Course Objectives:

1.	To understand basic concepts related to heat flow, fluid flow, mass transfer, in the context of metallurgical processes; to become familiar with the mathematical treatment and equations related to above transport phenomena; to comprehend the science behind process modelling.

UNIT I	**MOMENTUM TRANSFER – I**	**9**	**+**	**0**

Properties of fluid – Dimensions and Units, Newton‘s law of viscosity, Types of fluids, Types of flow, Classical Reynold‘s experiment, Concept of pressure and its measurement, Steady state - Hagen-Poisulle equation, Laminar flow through circular pipe and flow over flat plate, Equation of Continuity, Concept of velocity boundary layer.

UNIT II	**MOMENTUM TRANSFER – II**	**9**	**+**	**0**

Creeping flow past a sphere – Stoke‘s law, Navier-Stokes equation, Bernoulli‘s equation and its applications of flow measurement by Venturimeter, Orifice meter and Pitot tube. Major and Minor head losses in fluid flow, Introduction - flow through packed bed of solids and fluidized beds, compressible flow and supersonic nozzles.

UNIT III	**HEAT TRANSFER – I**	**9**	**+**	**0**

Conduction: Fourier‘s law, Thermal conductivity of solids and fluids. General heat conduction equation, Steady state heat conduction in flat plates, cylinders, Composite walls – simple problems, Transient heat conduction system – lumped capacitance approach. Convection: Correlation for heat transfer with forced convection – flow through pipes, flow over plates (no derivations, simple problems only).

UNIT IV	**HEAT TRANSFER – II**	**9**	**+**	**0**

Correlation for heat transfer with natural convection – Heat transfer by natural convection from vertical plates, Natural convection over horizontal plates (no derivation, simple problems only), Concept of overall heat transfer coefficient and thermal boundary layer, Solidification heat transfer. Radiation: Fundamental laws, black body radiation, emissivity, absorptivity, reflectivity, transmissivity, Kirchhoff‘s law, view factors, radiation exchange between surfaces, radiation exchange between black bodies – simple problems.

UNIT V	**MASS TRANSFER**	**9**	**+**	**0**

Concept of mass diffusion, Factors affecting diffusivity in solids, liquids and gases. Fick‘s laws of diffusion and its applications, Darken‘s law. Steady state unidirectional diffusion: diffusion through a stagnant fluid. Introduction to Unsteady state diffusion. Mass transfer by forced and free convection in laminar flow, Mass transfer coefficients and concentration boundary layer. Dimensional Analysis- Rayleigh and Buckingham π method.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the mechanics of fluid and its basic properties and equation describing its motion and properties
CO2	**:**	Describe the flow of fluids through plates and pipes.
CO3	**:**	Understand and explain the modes and mechanism of heat conduction of a material
CO4	**:**	Describe the mode of conductive heat transfer and different flow types

CO5	**:**	Explain the method of radiative heat transfer and also the means of transfer of materials mass by different methods

Text Books:	
1.	Gaskell, D.R., An Introduction to Transport Phenomena in Materials Engineering, 2nd Edition, Momentum Press, New Jersey, 2012.
2.	Geiger, G.H., and D.R. Poirier, Transport Phenomena in Metallurgy, Addison-Wesley Publishing Company, Inc., Philippines, 1973
Reference Books:	
1.	Bansal R K, A text book of fluid mechanics and hydraulic machines, Eleventh Edition, Laxmi publication (p) Ltd., New Delhi, 2019.
2.	Sachdeva, R.C., Fundamentals of Engineering Heat and Mass Transfer, New Age International Publishers, 2017.
3.	Bird, R.B., W.E. Stewart, E.N. Lightfoot, and D.J. Klingenberg, Introductory Transport Phenomena, John Wiley & Sons, Inc., 2015
4.	Themelis, N.J., Transport and Chemical Rate Phenomena, Gordon & Breach Publishing Group, 1995.
E References:	
1.	https://archive.nptel.ac.in/courses/103/105/103105128/

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO 1	2	0	0	3	1	0	1	0	0	0	1	1	2	0	1	
CO 2	3	1	1	3	1	0	2	0	0	0	1	1	1	0	1	
CO 3	2	1	1	2	2	0	2	0	0	0	0	1	1	2	1	1
CO 4	2	1	1	3	2	0	3	0	0	0	0	1	1	2	1	1
CO 5	3	2	2	3	1	0	3	0	0	0	0	1	3	2	1	
Total	**2.4**	**1**	**1**	**2.8**	**1.4**	**0**	**2.2**	**0**	**0**	**0**	**0.4**	**1**	**1.6**	**1.2**	**1**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE02	FRACTOGRAPHY AND FAILURE ANALYSIS	L	T	P	C
		3	0	0	3

Course Objectives:

1	To learn about various types of failures and their mechanisms

UNIT I	SOURCES OF FAILURES	9	+	0

Deficiencies in Design, Material, Processing, Service and Maintenance. Stages of Failure Analysis, classification and identification of Various Types of Fracture-Overview of fracture mechanics concept. Ductile and Brittle Fracture, Fracture Origin, Initiators, characteristics of Ductile and Brittle Fracture.

UNIT II	FATIGUE AND CREEP FAILURE	9	+	0

General Concepts, fracture Characteristics Revealed by Microscopy, Factors Affecting Fatigue
Life Some Case Studies of Fatigue Failures. Creep, Stress Rupture, Elevated Temperature Fatigue, Metallurgical Instabilities, Environmental Induced Failure, Elevated Temperature Effects on Certain Gas Turbine Components and Petroleum Refinery Components.

UNIT III	WEAR AND CORROSION FAILURES	9	+	0

Types of Wear, Role of Friction in Wear, Lubricated and Non-Lubricated Wear, Analyzing Wear Failure. Corrosion Failures-Factors Influencing Corrosion Failures, Analysis of Corrosion Failures, overview of Various types of Corrosion Stress Corrosion Cracking, Sources. Characteristics of Stress Corrosion Cracking. Procedure for Analyzing Stress Corrosion Cracking, various types of Hydrogen Damage Failures.

UNIT IV	FAILURE OF FORGING, CASTING AND WELDMENTS	9	+	0

Causes of Failure in Forging like material characteristics, Deficiencies in design, Improper Processing, Fabrication or Deterioration resulting from service conditions, Failure of Iron and Steel Castings, effect of Surface Discontinuities, Internal Discontinuities, Microstructure, Improper Composition, Improper Heat Treatment, Stress Concentration and Service Conditions. Failure of Weldments-Reasons for Failure procedure for Weld Failure Analysis.

UNIT V	RELIABILITY	9	+	0

Reliability Concept and Hazard Function, Life Prediction, Condition Monitoring, Application of Poisson. Exponential and Weibull Distribution for Reliability, Bath Rub Curve, Parallel and Series system, Mean Time Between Failures and Life Testing.

Total(L+T)= 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Mention the different sources of failures and specify the deficiencies in design, material, processing, service and maintenance
CO2	**:**	Discuss the fatigue and creep failures that take place under cyclic loading and high temperature conditions
CO3	**:**	Investigate the failures occurring due to wear and corrosion damages
CO4	**:**	Discuss the failures occurring due to the process of forging, casting and at the weld joints
CO5	**:**	Describe the process of reliability and hazard function and the different systems

Text Books:

1.	Colangelo, V.J., and F.A. Heiser, Analysis of Metallurgical Failures, John Wiley and Sons Inc., New York, USA, 1974.
2.	Charlie R Brooks, Ashok Choudhury Metallurgical Failure Analysis, McGraW -Ilill Publishing Co. USA, 1993
Reference Books:	
1.	ASM Handbook, Vol. 10: Failure Analysis and Prevention, ASM Metals Park, Ohio, 1995
2.	Das, A.K., Metallurgy of 'Failure Analysis, Tata McGraw-Hill Publishing Co., New Delhi, 1996.

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	2	1	2	3	0	3	0	0	0	2	2	3	2	1	1
CO2	1	0	1	1	2	0	2	0	0	0	1	1	2	1	1	
CO3	2	0	1	1	0	0	2	0	0	0	1	1	2	3	1	
CO4	1	0	1	1	0	0	1	0	0	0	1	1	1	2	1	
CO5	2	0	2	1	1	0	1	0	0	0	1	1	1	1	1	1
Total	**1.6**	**0.4**	**1.2**	**1.2**	**1.2**	**0**	**1.6**	**0**	**0**	**0**	**1.2**	**1.2**	**1.8**	**1.8**	**1**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE03	METALLURGICAL KINETICS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To learn the basic principles and concepts of kinetics, in the domain of metallurgy and materials; and to learn about equations and their applications; and to appreciate that metallurgical kinetics is a knowledge base with abundant applications

UNIT I	INTRODUCTION	9	+	0

Introduction: Role of kinetics, heterogeneous and homogeneous kinetics, Role of heat and mass transfer in metallurgical kinetics, rate expression, Effect of Temperature and concentration on reaction kinetics: effect of temperature (Arrhenius Equation), Effect of concentration (order of a reaction), significance and determination of activation energy.

UNIT II	KINETICS OF SOLID-FLUID REACTION	9	+	0

Kinetics of solid-fluid reaction: kinetic steps, rate controlling step, definition of various resistances in series, shrinking core model, chemical reaction as rate controlling step, Product layer diffusion as rate controlling step, Mass transfer through external fluid film as rate controlling step, heat transfer as the rate controlling step, Concentration boundary layer, definition and significance of heat and mass transfer coefficient, Theoretical model for mass transfer coefficients, Correlations for heat and mass transfer coefficients.

UNIT III	KINETICS OF LIQUID-SOLID TRANSFORMATION	9	+	0

Kinetics of liquid-liquid reaction, Kinetics of liquid-solid transformation - driving force, homogeneous and heterogeneous nucleation kinetics, kinetics of growth, kinetics of alloy solidification. Solid state phase changes - classification, nucleation and growth processes.
Diffusion - driving force, classification, Ficks laws and diffusion coefficients.

UNIT IV	KINETICS OF SOLID-STATE PHASE TRANSFORMATION	9	+	0

Kinetics of solid-state phase transformation - scope and classification, kinetics of homogeneous and heterogeneous nucleation, interface growth velocity, kinetics of special transformations (Widmanstatten, massive, polymorphic, coarsening, recrystallization, age hardening), kinetics of invariant and moving boundary transformation,

UNIT V	OVERALL TRANSFORMATION KINETICS	9	+	0

Kinetics of phase transition in polymers, glass, ceramics. Overall transformation kinetics - Johnson-Mehl and Avrami s model, kinetics of non-random nucleation, kinetics of diffusion controlled, isothermal and non-isothermal kinetic analysis

Total (L+T)=45+0=45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Study about roles of kinematics, heat and mass transfer in metallurgy
CO2	**:**	Formulate kinematics of solid-fluid-gas reaction
CO3	**:**	Details about kinematics of solid-fluid transformation
CO4	**:**	Knowledge about solid phase transformation

Text Books:

1.	AhindraGhosh and SudiptoGhosh, A Text book of Metallurgical Kinetics, PHI learning Pvt. Ltd., New Delhi, 2014

2.	H.S. Ray, Kinetics of Metallurgical Reactions, International Science publisher, 1993
Reference Books:	
1.	F. Habashi, Kinetics of Metallurgical Processes, Métallurgie Extractive Québec, 1999
2.	Upadhyaya G S and Dube R K., "Problems in Metallurgical Thermodynamics &Kinetics", Pergamon, 1977.

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	2	1	1	2	2	0	1	0	1	1	2	1	3	2	1	1
CO 2	2	1	1	1	1	1	2	0	1	1	1	1	2	1	1	
CO 3	1	1	1	1	2	0	1	0	1	1	1	1	2	2	1	
CO 4	3	1	1	1	1	0	1	0	1	1	1	1	3	1	1	
Total	**2**	**1**	**1**	**1.25**	**1.5**	**0.5**	**1.25**	**0**	**1**	**1**	**1.25**	**1**	**2.5**	**1.5**	**1**	**.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE04	SOLIDIFICATION PROCESSING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To acquire basics knowledge on solidification, heat transfer, dendritic growth, runner, riser and fluid flow

UNIT I	PRINCIPLES OF SOLIDIFICATION	9	+	0

Thermodynamics of solidification: pure metal solidification i.e. G vs T curves for liquid and solid, alloy solidification. Scheil equation: Mathematical analysis of redistribution of solute during directional solidification Hierarchy of equilibrium, Local Interface equilibrium, Interface non-equilibrium.

UNIT II	THEORIES OF GRAIN GROWTH	9	+	0

Microsegregation, Constitutional undercooling, Theories of nucleation and growth: Mullins-Sekerka instability, Ivantsov's theory of dendritic growth. Macro scale Phenomena- Mathematics of diffusive transport, Macro mass Transport-solute diffusion controlled segregation, analysis of solute redistribution- Macro modelling of solidification.

UNIT III	SOLIDIFICATION AND TYPES OF CASTING	9	+	0

Multi phase solidification: regular and irregular eutectic solidification, Hunt-Jackson theory of eutectic growth, peritectic growth, Structure of casting and ingots, Types of casting, Heat transfer design of riser and gating.

UNIT IV	MELTING FURNACES AND KINETICS	9	+	0

Solidification, heat transfer, fluid flow during fusion welding. Casting Defects. Melting furnaces. Role of kinetics, heterogeneous and homogeneous kinetics- Kinetics of solid-fluid reaction-
Solid state diffusive transformation- Mechanism of transformation.

UNIT V	MELTING AND SOLIDIFICATION OF ALLOYS	9	+	0

Melting and solidification of cast irons and aluminium. Solidification, heat transfer and fluid flow during fusion welding.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the principles of solidification in metals and alloys
CO2	**:**	Correlate the morpho-genesis of solidification microstructures with the heat and mass transfer conditions
CO3	**:**	Describe the casting technique
CO4	**:**	Design the gating and risering of castings
CO5	**:**	Identify the melting furnaces for metals and alloys

Text Books:

1.	Kurz and Fisher: Solidification Processing, Trans Tech publications 1998.
2.	R. W. Heine, C. R. Loper, P. C. Rosenthal: Principles of metal casting, McGraw Higher Ed 1976.

Reference Books:	
1.	K. Easterling: Introduction to Physical metallurgy of welding, Butterworth-Hienemann 1992.
2.	P. K. Jain: Principles of foundry technology, McGraw-Hill 1987

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	2	1	1	2	2	0	1	0	1	1	2	1	3	2	1	
CO 2	2	1	1	1	1	1	2	0	1	1	1	1	2	1	1	
CO 3	1	1	1	1	2	0	1	0	1	1	1	1	2	2	1	
CO 4	3	1	1	1	1	0	1	0	1	1	1	1	3	1	1	1
CO 5	2	1	1	2	2	0	1	0	1	1	2	1	3	2	1	1
Total	**2**	**1**	**1**	**1.4**	**1.6**	**0.2**	**1.2**	**0**	**1**	**1**	**1.4**	**1**	**2.6**	**1.6**	**1**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE05	FRACTURE MECHANICS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To gain the knowledge of fracture mechanics and knowing the experimental measurements and applications of fracture mechanics

Unit I	TYPES OF FRACTURE	9	+	0

Ductile and brittle fracture, features of fracture surface for ductile, brittle and mixed modes, fractography Transition temperature approach: Notched bar impact tests. Ductile to brittle transition, influence of temperature, strain rate and multi-axial loading, limitations of charpy testing. Drop-weight test and other large scale tests – fracture analysis diagram.

Unit II	FRACTURE MECHANICS APPROACH	9	+	0

Stress distributions around discontinuities, stress analysis in simple cracked bodies, plane strain and plane stress conditions, stress intensity factor and fracture toughness.

Unit III	YIELDING FRACTURE MECHANICS	9	+	0

Concept of crack opening displacement, calculation of COD. The J contour integral- derivation of J from load – displacement diagram. The relationship between J and COD

Unit IV	EXPERIMENTAL MEASUREMENT OF FRACTURE TOUGHNESS	9	+	0

K_{IC} testing – test piece requirements and types, fatigue pre-cracking, determination of COD, estimation of critical COD from the test data. Measurement of J integral and R curve.

Unit V	APPLICATIONS OF FRACTURE MECHANICS	9	+	0

Concepts of tolerable defects, use of fracture mechanics in design and material selection.

Total = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Understand the concept of DBTT and various mechanical tests of materials
CO2	**:**	Analyze the crack, discontinuities and stress intensity factor
CO3	**:**	Know the concept of COD, J and displacement diagram
CO4	**:**	Use of fracture mechanics in design and selection of various materials

Reference Books:

1.	David Broek, Elementary Engineering Fracture Mechanics, SujthoffNoordhoof, 1978
2.	Hertzberg R.W. Deformation and Fracture Mechanics of Engineering Materials, 3rd edition, John Wiley 1989
3.	Rolfe T., Bassom J., Fracture and Fatigue Control of Structures – Applications of Fracture Mechanics, Prentice Hall, 1977

4.	Tetelmen A.S. and McEvily. A.J. Fracture of Structural Materials. John Wiley & Sons, 1967
5.	Gurney T.R., Fatigue of Welded Structures, Cambridge University Press, 1979

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	1	3	2	1	0	1	1	0	3	2	1	3	2	2	
CO2	1	1	3	3	2	0	2	0	0	2	1	2	3	2	2	
CO3	3	2	2	1	2	0	0	0	0	3	2	1	2	2	1	
CO4	2	3	3	2	3	0	2	2	1	1	3	2	3	3	2	1
Avg.	**2**	**1.75**	**2.75**	**2**	**0**	**0**	**1.25**	**0.75**	**0.25**	**2.25**	**2**	**1.5**	**2.75**	**2.25**	**1.75**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE06	COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To know manufacture of different type of Composite materials and develop for specific engineering applications

UNIT I	INTRODUCTION TO COMPOSITES	9	+	0

Fundamentals of composites - need for composites – enhancement of properties - classification of composites – Matrix- Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Reinforcement – particle reinforced composites, Fibre reinforced composites. Applications of various types of composites. Fiber production techniques for glass, carbon and ceramic fibers

UNIT II	POLYMER MATRIX COMPOSITES	9	+	0

Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibres – rovings– woven fabrics – non woven random mats – various types of fibres. PMC processes - hand layup processes – spray up processes – compression moulding – reinforced reaction injection moulding - resin transfer moulding – Pultrusion – Filament winding – Injection moulding. Fibre reinforced plastics (FRP), Glass Fibre Reinforced Plastics (GFRP). Laminates- different types.-applications of PMC in aerospace, automotive industries.

UNIT III	METAL MATRIX COMPOSITES	9	+	0

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement – volume Fraction – rule of mixtures. Processing of MMC – powder metallurgy process - diffusion bonding– stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface measurement of interface properties- applications of MMC in aerospace, automotive industries.

UNIT IV	CERAMIC MATRIX COMPOSITES AND SPECIAL COMPOSITES	9	+	0

Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics -need for CMC – ceramic matrix - various types of ceramic matrix composites- oxide ceramics – non oxide ceramics – aluminium oxide – silicon nitride – reinforcements – particles- fibres whiskers. Sintering - Hot pressing – Cold and Hot Iso-static pressing (CIP and HIP). Applications of CMC in aerospace, automotive industries- Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique Processing of Ceramic Matrix composites.

UNIT V	MECHANICS OF COMPOSITES	9	+	0

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke‘s Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations.
Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Classify the composites and know their properties.
CO2	**:**	Understand the details about the processing of polymer matrix composites and their applications.

CO3	**:**	Characterize the metal matrix composite, its processing and applications.
CO4	**:**	Understand the concept of ceramic matrix composite and some special composites.
CO5	**:**	Formulate the mechanics of composite and determine the lamina stresses within laminates.

Text Books:

1.	Mathews F. L. and Rawlings R. D., Composite Materials: Engineering and Science, Chapman and Hall, London, England, 1st edition, 1994.
2.	Chawla K. K., Composite materials, Springer – Verlag, Second Edition, 2006.

Reference Books:

1.	Clyne, T. W. and Withers, P. J., Introduction to Metal Matrix Composites, Cambridge University Press, 1993.
2.	Strong, A.B., Fundamentals of Composite Manufacturing, SME, 1989.
3.	Mallick P.K, Fibre-Reinforced Composites; materials, Manufacturing & Design, Third edition, CRC Press,2007.

CO PO MAPPING

CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO 1	1	1	1	0	1	0	1	1	1	0	1	2	1	3	1	
CO 2	2	1	2	3	2	0	1	0	0	0	1	3	2	3	3	
CO 3	3	2	2	3	3	1	2	0	0	0	0	1	2	2	3	
CO 4	2	3	2	2	1	3	2	1	1	0	1	2	3	2	3	1
CO 5	3	2	3	2	3	1	2	1	0	0	3	3	3	3	2	1
Total	**2.1**	**1.8**	**2**	**2**	**2**	**1**	**1.6**	**0.6**	**0.4**	**0**	**1.2**	**2.1**	**2.1**	**2.6**	**2.5**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE07	CERAMIC MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study about preparation, properties and applications of ceramic materials

UNIT I	INTRODUCTION	9	+	0

Review of bonding types in ceramics – calculation of percentage ionic character. Types of Ceramics, Ceramic crystal structures: Sodium chloride, cesium chloride, alumina, spinel and fluorite structures - examples. Co-ordination number and ionic radius ratio - Pauling's R

UNIT II	PROPERTIES AND APPLICATIONS OF ENGINEERING CERAMICS	9	+	0

Ceramics for mechanical functions: Abrasives - properties and applications SiC, Cubic Boron Nitride (CBN) - properties and applications. Ceramics for electrical and insulating functions - Barium Titanate and its modifications - insulating porcelains - properties and applications. Ceramics for magnetic functions - Normal and inverse spinel structure - Zinc, Nickel, Manganese and Iron ferrites - structure properties and applications Ceramics for thermal functions: Refractories - Desirable characteristics - applications - Ceramics for nuclear applications.

UNIT III	PREPARATION AND FORMING OF CERAMICS	9	+	0

Preparation of Alumina, Zirconia, Silicon carbide, Silicon Nitrides, Boron Nitride, Brief description of slip and slurry casting - applications. Powder processing equipment and rocess details of hot pressing, Hot Isostatic Pressing and Cold Isostatic Pressing. Liquid Phase sintering. shock wave compaction, reaction sintering, cermets

UNIT IV	GLASSES	9	+	0

Types of glasses - structure, properties and applications of various types of glasses. Silicate Glass ceramics- heat flow and precipitation from glasses – growth controlled by diffusion of solutes – crystalline glasses - enamels – photosensitive and photo chromic glasses; Blowing, pressing, drawing, rolling and casting - Pilkington process for float glass.

UNIT V	PROPERTY EVALUATION	9	+	0

Rupture strength; fracture Toughness, Elastic Constants, Hardness, Creep, Thermal Property Coefficient of thermal expansion, Electronic Property, Measurement of electro-optic properties Weibull Statistics of Strength Data for Fine Ceramics.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Know the structure and properties of different ceramic materials.
CO2	**:**	Understand the phase diagrams and comprehend the phase transformations in ceramic materials.
CO3	**:**	Understand the testing methods for evaluating the mechanical properties of ceramic materials
CO4	**:**	Select ceramic materials and to develop new ceramics for different engineering applications.
CO5	**:**	Understand and design the electrical, magnetic and optical properties of ceramic

Text Books:

1.	Michael Barsoum, Fundamentals of Ceramics, McGraw Hill Publishing Co. Inc, 1997.
2.	Kingery, W D, Introduction to Ceramics, John Wiley, USA, 1960
Reference Books:	
1.	William F.Smith, Foundations of Materials Science and Engineering, Second Edition, McGraw- Hill Inc, New York, 1993.
2.	VanVlack K H, Physical Ceramics for Engineers, Addison Wesley, 1964.

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	2	2	1	1	0	0	2	1	0	0	3	2	1	0	1	
CO 2	3	3	3	2	0	0	1	1	1	0	2	3	3	2	1	
CO 3	3	3	3	2	3	2	2	1	1	0	2	3	3	2	1	
CO 4	3	3	3	2	3	2	3	1	1	0	2	2	3	3	1	
CO 5	3	3	3	2	3	3	3	1	1	0	3	2	3	3	1	1
Total	**2.8**	**2.8**	**2.6**	**2**	**1.8**	**1.2**	**2.2**	**1**	**0.8**	**0**	**2.4**	**2.4**	**2.6**	**2**	**1**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE08	METALLURGY OF TOOL STEELS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To gain understanding of heat treatment of tool components based on geometry and understand the metallurgy of different tool steel and in the materials

UNIT I	FUNDAMENTALS OF HEAT TREATMENT AND TOOL STEELS	9	+	0

Classification of Tool steels-AISI system-composition of tool steels-Effect of alloying elements on Fe-C system, TTT diagrams, Formation of complex carbides, austenite formation, Hardenability and Tempering Effect of specific alloying elements. Heat Treatment of Tool steels: their characteristics and selection Distortion in tool steels during heat treatment, selection of tool steels for various application-Manufacturing methods of tool steels.

UNIT II	HEAT TREATMENT AND METALLURGY OF W, S, O, A & D TYPE TOOL STEELS	9	+	0

Water hardening tool steels, shock resistance tool steels, cold work tool steels-oil hardening, medium alloy and high carbon-high Cr(O,A&D types): Constitution, classification of principal types, heat treatment process, hardenability, distortion characteristics, properties and application.

UNIT III	HEAT TREATMENT AND METALLURGY OF H, T, M, SPECIAL PURPOSE TOOL STEELS	9	+	0

Hot work tool steels, high speed tool steels, maraging tool steels, special purpose tool steels: constitution, classification of principal types, heat treatment process, specific requirements and applications.

UNIT IV	ADVANCED TOOL MATERIALS	9	+	0

Sintered tungsten carbide tools-ISO classification-Uses of P, M and K grades-cermet-ceramics, mixed and reinforced grades-cubic boron nitride-poly crystalline diamond-Manufacturing techniques-properties.

UNIT V	SURFACE TREATMENTS AND COATINGS	9	+	0

Sulphidising of tool steels – Ti N coating by PVD - coating of carbide tools - mono and multi layer coatings of Ti C, Ti N, Alumina and DLC by PVD and CVD processes - selection of tool materials

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Classify the tool materials according to AISI systems and discuss the refining methods like VAR, ESR
CO2	**:**	Discuss the heat treatment methods adopted for tool steels
CO3	**:**	Describe properties and the testing methods that are adopted for tool steels

Text Books:

1.	Robert Wilson, ‑Metallurgy and Heat Treatment of Tool Steels‖, McGraw-Hill, New York, 1975.
2.	Payson, ―Metallurgy of Tool Steels‖, John Wiley and sons, New York, 1962.

Reference Books:	
1.	Davis.J.R. ―ASM Speciality Handbook-Tool Materials", American Society of Metals, Metals Park, Ohio, USA, 1995.
2.	George Roberts, George Krauss and Richard Kennedy, ‒Tool Steels", ASM International, 1998, Metals Park, Ohio, USA, 1998
3.	Roberts, Haymaker and Johnson, ‒Tool Steels‖, 3 rd edition, ASM, 1962.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	0	1	2	2	3	1	3	1	2	1	2	2	2	1	1	
CO 2	0	1	2	1	2	2	1	0	0	0	1	1	1	2	1	
CO 3	2	1	1	1	2	0	1	0	1	0	1	1	1	2	1	1
Total	**0.66**	**1**	**1.6**	**1.3**	**2.3**	**1**	**1.6**	**0.33**	**1**	**0.33**	**1.3**	**1.3**	**1.3**	**1.6**	**1**	**0.33**

1- Faintly, 2- Moderately, 3- Strongly

22MTE09	BIO AND SMART MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study about Bio and shape memory material, dental materials

UNIT I	INTRODUCTION	9	+	0

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

UNIT II	ELECTRO-RHEOLOGICAL AND PIEZOELECTRIC MATERIALS	9	+	0

The principal ingredients of smart materials–microsensors-hybrid smart materials-an algorithm for synthesizing smart materials–active, passive reactive actuator based smart structures suspensions and electro-rheological fluids–fluid actuators- design parameter–application of Electo-rheological fluids–Basics, Principles and instrumentation and application of Magnetorheological fluids–Piezoelectric materials: polymers and ceramics, mechanism, properties and application. Introduction to electro-restrictive and magneto-restrictive materials

UNIT III	SHAPE MEMORY MATERIALS	9	+	0

Nickel –Titanium alloy (Nitinol)–Materials characteristics of Nitinol–martensitic transformations– austenitic transformations–thermo elastic martensitic transformations–classification of SMA alloys- mechanism of magnetic SMA–applications of SMA–continuum applications of SMA fasteners–SMA fibers–reaction vessels, nuclear reactors, chemical plant, etc.–SMA memorization process (Satellite Antenna Applications) SMA blood clot filter–Impediments to applications of SMA–Shape memory polymers–mechanism of shape memory-Primary moulding–secondary moulding–types and applications.

UNIT IV	ORTHOPAEDIC AND DENTAL MATERIALS	9	+	0

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

UNIT V	BIO MATERIALS FOR CARDIOVASCULAR OPTHALMOLOGY AND SKIN REGENERATION	9	+	0

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

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Use of Bio materials for cardiovascular Opthalmology and Skin Regeneration
CO2	**:**	Use of Bio materials for Dental & Bone application
CO3	**:**	Use of shape memory alloys in engineering application
CO4	**:**	Explain the characteristics of Bio and smart materials

CO5	**:**	Use of smart materials as sensors, actuators.

Text Books:

1.	Sujata V., Bhat., Biomaterials, Narosa Publication House, New Delhi, 2002
2.	M. V. Gandhi and B. S. Thompson, Smart Materials and Structures, Chapman and Hall, London, First Edition, 1992

Reference Books:

1.	Duerig,T. W., Melton, K. N, Stockel, D. and Wayman, C.M., Engineering aspects of Shape memory Alloys, Butterworth – Heine
2.	Rogers, C. A., Smart Materials, Structures and Mathematical issues, Technomic Publishing Co., U.S.A, 1989.
3.	Mohsen Shahinpoor and Hans-Jo¨rg Schneider Intelligent Materials, RSC Publishing,2008
4.	Mel Schwartz (Ed), Encyclopaedia of Smart Materials Volume –I and II, John Wiley & Sons, Inc.2002

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	0	1	2	2	3	1	3	1	2	1	2	2	2	1	1	
CO2	0	1	2	1	2	2	1	0	0	0	1	1	1	2	1	
CO3	2	1	1	1	2	0	1	0	1	0	1	1	1	1	1	
CO4	0	0	0	1	1	0	2	0	0	1	1	2	3	1	1	1
CO5	1	1	1	1	2	0	1	0	0	0	1	1	1	1	2	1
Total	**0.75**	**1**	**1.25**	**1.5**	**2.5**	**0.75**	**2**	**0.25**	**0.75**	**0.5**	**1.5**	**1.75**	**2**	**1.5**	**1.5**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE10	CONTINUOUS CASTING OF STEEL	L	T	P	C
		3	0	0	3

Course Objectives:

1. To develop an understanding of the basic principles of continuous casting, impart modelling skills and to apply them for industrial problems to enable them to solve the problems encountered in the steel industries.

UNIT I	INTRODUCTION	09	+	0

Advantages- design of casters, metallurgical comparison of continuous casting with ingot casting.

UNIT II	HEAT TRANSFER IN MOULD AND SECONDARY ZONE	09	+	0

Heat transfer and solidification in continuous casting – heat transfer in mould- mould flux and heat transfer in secondary cooling zone.

UNIT III	TUNDISH DESIGN AND PRACTICE	09	+	0

Modern Tundish practice for clean steel production. Tundish design and operation-mould and its operation electromagnetic stirring use of sub merged entry nozzle (SEN) and water model study for funnel formation.
Vortex vs the drum funnels through rotational flow. Their characteristics and use of vortex buster to allow beller slag free teeming

UNIT IV	DEFECTS IN CONTINUOUS CASTING	09	+	0

Metallurgical defects and their remedies. Centre line micro segregation and porosity –cracks other defects – Oscillation marks.

UNIT V	ROLE OF INCLUSIONS AND RECENT DEVELOPMENTS	09	+	0

Inclusion distribution in cast products – inclusion modification. Application of Thermodynamics to deoxidation and inclusion formation. Deoxidation reaction. Modelling for inclusion prediction. Thin slab casting, Round casts and combination casts. High speed casting –breakouts and mould powder entrapments –Near net shape castings. Thin strip production of carbon steels and stainless steels and their characteristics. Recent studies on thin strip casting.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Design a continuous casting machine which has a wide advantage over ingot casting
CO2	**:**	Gain knowledge about transfer of heat in continuous casting machine
CO3	**:**	Design a proper metallurgical tundish for proper transferring of heat from ladle to the continuous caster and the use of Electromagnetic stirrer
CO4	**:**	Provide remedies for the common defects that are formed during the continuous casting of steel
CO5	**:**	Describe the role of inclusion in the steel, the modification of inclusion to derive at the required mechanical properties

Text Books:	
1.	Ahindra Ghosh Principles of Secondary Processing and Casting of liquid steel, , Oxford & IBA Publishers, 1990
2.	David H Wekelin,, The Making, Shaping and Treating of Steel, AISE Steel Foundation, 1999
Reference Books:	
1.	Chatterjee A and Govindarajan S, Monograph on Continuous Casting at TATA Steel, Jamshedpur, 1991.
2.	Brimacombe J K and Samarasekara (Eds)., Continuous Casting Vol.2, The Iron and Steel Institute, USA,1984.
3.	Ahindra Ghosh and Amit Chatterjee, Iron Making and Steel Making – Theory and Practice, Prentice Hall of India Private Ltd., New Delhi 2008.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO 4
CO1	1	2	3	1	2	0	1	0	0	0	0	2	1	1	1	
CO 2	3	1	3	3	1	0	0	0	1	0	1	1	2	2	3	
CO 3	3	3	3	2	1	1	1	1	1	0	1	2	3	2	3	
CO 4	2	3	2	3	2	2	3	2	1	0	1	2	2	3	2	1
CO 5	1	2	2	2	2	1	2	1	0	0	2	2	2	3	2	1
Total	**2**	**2.2**	**2.6**	**2.2**	**1.6**	**0.8**	**1.4**	**0.8**	**0.6**	**0**	**1**	**1.8**	**2**	**2.2**	**2.2**	**.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE11	FERROUS AND NON-FERROUS ALLOYS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study the fundamentals, properties and applications of Ferrous and Non Ferrous systems.

UNIT I	ALLOY STEELS	9	+	0

Introduction: Modern melting processes for making special steels; the effect of alloying elements on Steel. Maraging steels, HSLA, micro alloyed steels, silicon steels, CRGO (Cold Rolled Grain Oriented Sheet) steels and high manganese steels: structure, property, heat treatment and applications. Steels for special applications**:** Armour steel, steels for high temperature applications–High carbon steels, Ultra high strength steels, creep resistant steels.

UNIT II	STAINLESS STEELS	9	+	0

Types of stainless steels; ferritic, martensitic, austenitic, precipitation hardening, duplex, heat resisting, their properties, structure and applications; nickel free stainless steels high nitrogen stainless steels – their manufacture, structure, properties and applications. Sensitisation and the remedial measures for austenitic stainless steel.

UNIT III	COPPER ALLOYS	9	+	0

Properties and applications of copper, influence of alloying elements, Brasses: Cu-Zn alloys. Bronzes**:** Tin bronze, phosphor bronze, Al bronze, Be bronze- compositions, properties and uses; copper-nickel alloys, properties and applications; strengthening of copper alloys by mechanical alloying, OFHC copper and its applications. Heat Treatment of Copper Alloys.

UNIT IV	LIGHT METALS AND ALLOYS	9	+	0

Aluminium - Properties and uses of aluminium. Alloys of aluminium, Classification, Wrought and Cast alloys, Heat treatable and Non, heat treatable, Age hardening. Overaging –Al-Li alloys, super plastic forming of Al alloys. Magnesium - properties and uses of Magnesium alloys, influence of alloying elements – Al, Mn, Zn, Si, Ag, Th, Zr; classification – cast alloys and wrought alloys.. Titanium -Unique characteristics of the metal, Alloying elements – Alpha stabilisers; beta stabilisers. α, α-β and β Titanium alloys - major types, structure property correlations; thermo - mechanical processing; near-net shape processing; super plastic forming of titanium alloys. Titanium aluminides their properties and uses.

UNIT V	NICKEL AND OTHER ALLOYS	9	+	0

Properties of nickel and uses of nickel, Nickel base super alloys composition; solid solution alloys, precipitation hardenable alloys, ODS alloys - heat treatment, properties and applications; Nickel-iron base alloys - heat treatment, properties and applications; Ni base soft magnetic alloys, Ni base heating element alloys; Ni base controlled expansion alloys; nickel base DS alloys and single crystals. Nickel in special alloys and magnetic materials, Nickel aluminides. Zinc alloys, properties and uses, Die casting qualities. Use of zinc in corrosion protection of ferrous materials. Lead, Tin alloys. Major characteristics and applications, low melting nature solder alloys.

Total (L+T) = (45+0) 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Describe the different types of alloy steels.
CO2	**:**	Discuss the types of stainless steels, properties and their applications.
CO3	**:**	Discuss and describe the properties and applications of copper alloys.
CO4	**:**	Understand the light weight division of aluminium alloys, Magnesium and Titanium alloys.
CO5	**:**	Explain the importance and applications of Nickel, Lead, zinc and tin alloys

Text Books:

1.	William F Smith, Structure and Properties of Engineering Alloys, McGraw Hill India, 1993.
2.	P.C. Angelo, B.Ravisankar, —Non-Ferrous Alloys: Structure, Properties and Engineering applications, Cengage Learning India Pvt. Ltd., New Delhi, 2017.
3.	Brick, Gordon and Pense, Structure and Properties of Engineering Materials, McGraw Hill Book Co., New York, 1992.

Reference Books:

1.	K.G.Budinski and M.K.Budinski, Engineering Materials- Properties and Selection, PHI Learning Pvt Ltd, New Delhi, 2010.
2.	Clark and Varney, Physical Metallurgy for Engineers, Affiliated east West press, New York, 1987.
3.	Balram Gupta, Aerospace Materials, Vol.1,2 and 3, S.Chand & Co., New Delhi, 1996.

E-References:

1.	www.nptel.ac.in/courses/113105021/

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3	PSO4
CO1	1	1	0	1	0	0	0	1	0	0	1	1	2	2	2	
CO2	2	1	2	0	1	0	2	2	0	0	2	1	1	2	1	
CO3	1	2	1	2	2	0	1	1	1	1	3	1	2	3	1	1
CO4	0	1	2	0	3	2	0	0	2	1	1	2	2	2	3	1
CO5	2	2	1	3	0	3	2	1	3	1	0	3	3	1	1	
Total	**1.2**	**1.4**	**1.2**	**1**	**1.2**	**1**	**1**	**1**	**1.2**	**0.6**	**1.4**	**1.6**	**2**	**2**	**1.6**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE12	SPECIAL CASTING TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives

1.	knowledge on using economical design to give better quality castings to develop components of intricate shape and design by properly selecting the moulding and casting techniques

UNIT I	SHELL MOULDING	9	+	0

Various Special Casting Techniques-Shell Moulding Machines, Pattern Equipment, Sands, Resins and other Materials used for Shell Moulding, application of Shell Moulding, advantages of Shell Moulding over other Methods of Moulding.

UNIT II	CENTRIFUGAL CASTING	9	+	0

Types of Centrifugal Casting Processes-calculation of Mould Rotary Speeds, Techniques, equipments and Production Processes, advantages and limitations of Centrifugal Casting Methods.

UNIT III	INVESTMENT CASTING	9	+	0

Introduction, Pattern and Mould Materials used, Techniques and Production of Investment Moulds, Shaw Process, Full Mould Process, applications of Investment Casting Process.

UNIT IV	DIE CASTING	9	+	0

Die Casting Machines Gravity and Pressure Die Casting, Cold and Hot Chamber Operation and Details, Die Materials. Metals Cast by Die Casting Method, Casting of Aluminium, Magnesium and Zinc Alloys. Compo, Rheo and Thixo Processes, Advantages of Die Casting

UNIT V	ORGANIC AND OTHER PROCESSES	9	+	0

Cold Box, Hot Box and No Bake Processes, Fluid Sand Process, V Process, Graphite Moulding Process, Magnetic Moulding, Impulse Moulding, High Pressure Moulding, Metal Injection Moulding.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Describe the shell moulding process over the conventional processes of casting.
CO2	**:**	Provide the procedure for centrifugal casting of pipes and other hollow shafts.
CO3	**:**	Discuss the investment casting method with different processes like Shaw, full mould process and mention their applications.
CO4	**:**	Mention the modern die casting method and its type like and different operations performed in the chamber
CO5	**:**	Describe the organic processes that can be used to cast metals like metal injection moulding, magnetic moulding, impulse moulding.

Text Books:	
1.	Beeley, P.R., Foundry Technology, Butterworths, London, 1982.
2.	Clegg A.J., Precision Casting Processes, Pergamon Press, London,1991.
Reference Books:	
1.	Heine, Loper and Rosenthal, Principles of Metal Casting, Tata McGraw Hill Publishing Co., Ltd., New Delhi, 1995.
2.	Dumond, T.C., Shell Moulding and Shell Moulded Castings, Reinhold Publishing Corporation Inc., 1984.
3.	Doehler, E.H., Die Casting, McGraw Hill Book Co, New York, 1991.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	0	0	1	0	2	0	0	0	0	0	1	0	2	3	1	
CO2	1	1	3	3	2	0	2	0	0	1	2	0	2	2	2	
CO3	2	2	2	1	2	1	1	1	1	1	3	1	1	0	0	
CO4	1	0	0	0	3	2	0	1	2	2	1	1	1	0	0	1
CO5	0	2	1	2	2	1	3	1	1	1	0	1	0	1	3	
Total	**0.8**	**1**	**1.4**	**1.2**	**2.2**	**0.8**	**1.2**	**0.6**	**0.8**	**1**	**1.4**	**0.6**	**1.6**	**1.2**	**1.2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE13	ALTERNATE ROUTES OF IRON MAKING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the importance of the Iron making and to apply them for the advancement of alternative route for the production feasibilities in steel Industries to compete with the modern day manufacturing routes.

UNIT I	BLAST FURNACE AND ITS MODIFICATION	9	+	0

Blast furnace iron making. Low Shaft Furnace – Construction, Process and Advantages, Mini Blast Furnaces (MBF) – Special Features, Modern Blast Furnace, Charcoal blast Furnace.

UNIT II	ELECTRO THERMAL PROCESSES	9	+	0

Electro–Thermal Processes – Submerged Arc Furnace – Construction, Operation and Smelting practice. Modern trends & Special features. Irregularities in operation.

UNIT III	SPONGE IRON MAKING	9	+	0

Sponge Iron production – Introduction, Properties, Uses & Process of making Sponge Iron. Coal Based Sponge Iron process: Rotary Kiln (SL/RN, Krupp-Renn), Rotary Hearth (FASTMET) process. Gas Based Sponge Iron process: Finmet process, HYL-I, MIDREX, HYL-IV M process

UNIT IV	SMELTING REDUCTION AND OTHER PROCESSES	9	+	0

Smelting Reduction – Introduction, Raw materials & Fundamentals. Classification of Smelting Reduction process – Based on stages (Single stage , two stage operation), Based on Types of furnace –Vertical shaft furnace(COREX,FINEX), Electrical Furnace (INRED, ELRED),Converter type(HI-smelt), Rotary Hearth furnace(IT mk3).

UNIT V	IRON MAKING IN INDIA	9	+	0

Blast furnace design in India. Main problems in iron making in India. Sponge Iron making in India. India‘s role in Global steel trade. Future scope of Iron making processes in India.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Know about special features of blast furnace.
CO2	:	Details of modern trends in electro thermal process
CO3	:	Knowledge about sponge iron making
CO4	:	Describe about smelting reduction and other process
CO5	:	Analyse iron making in India

Text Books:

1.	Sarangi, A., and B. Sarangi, Alternative roots to Iron Making, 2nd Edition, Prentice Hall of India Pvt Ltd., New Delhi, 2016.

Reference Books:

1.	R.H. Tupkary and V.R. Tupkary., An Introduction to Modern Iron Making, Khanna Publishers, Fourth Edition.New Delhi, 2010
2.	Biswas .A.K , Principles of blast furnace iron making- theory and practice , SBA Pub, Kolkata 1994
3.	David H Wekelin,, The Making, Shaping and Treating of Steel, AISE Steel Foundation, 1999.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	2	0	2	0	0	1	1	2	1	1	0	2	
CO2	3	1	1	1	1	2	1	0	1	2	2	3	1	0	3	
CO3	1	2	1	1	2	2	0	0	0	2	2	3	1	1	1	
CO4	3	2	2	1	2	2	1	0	1	1	3	2	1	0	3	1
CO5	1	2	2	1	2	1	0	0	0	2	2	2	1	2	1	
Total	**2**	**1.6**	**1.4**	**1.2**	**1.4**	**1.8**	**0.4**	**0**	**0.6**	**1.6**	**2.2**	**2.2**	**1**	**0.6**	**2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE14	SECONDARY STEEL MAKING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To become familiar with a wide array of making special steels by various process an learn about impurities present in it

UNIT I	THERMODYNAMICS AND KINETICS OF DEOXIDATION	9	+	0

Oxygen in molten steel, Types of Deoxidation, Complex Deoxidisers, Kinetics of removal of Deoxidation products, Deoxidation on Industrial Scale.

UNIT II	METALLURGICAL PRINCIPLES IN SECONDARY STEEL MAKING	9	+	0

Thermodynamics of reactions during degassing, Fluid flow and mixing in ladle, Kinetics and mass transfer, Ladle injection metallurgy.

UNIT III	LADLE FURNACES AND SECONDARY STEEL MAKING	9	+	0

Introduction, Process variables, Stirring, Synthetic slag, Purging, Vacuum treatments, Injection metallurgy, Ladle furnaces.

UNIT IV	INCLUSIONS IN STEEL	9	+	0

Influence of inclusions on mechanical properties, Identification of inclusions, Origin of non-metallic inclusions, Inclusion control.

UNIT V	CONTINUOUS CASTING AND SEGREGATION	9	+	0

Solidification rate in ingot, Heat transfer in continuous casting, Segregation of solutes in plane front solidification, Dendritic solidification, Morphology of killed steel ingots, Defects in continuous cast products, Developments in continuous casting

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Discuss and explain the thermodynamics and kinetics of de-oxidation
CO2	**:**	Explain the basic metallurgical principles that govern the process of secondary steel making
CO3	**:**	Describe the metallurgical process taking place in the steel making ladle and also explain the ladle injection metallurgy
CO4	**:**	Mention modification of steel properties using steel inclusions
CO5	**:**	Specify and explain the process of continuous casting in steel and the common defects like segregation that are produced in casting and give a remedy

Text Books:

1.	Ahindra Ghosh, Principles of Secondary Processing and Casting of liquid steel, Oxford & IBH Publishers, 1991.
2.	Ahindra Ghosh, Secondary steel making- Principles and applications, CRC Press, USA, 2001.

Reference Books:	
1.	Chatterjee A and Govindarajan S, Monograph on Continuous casting at TATA Steel, Jamshedpur, 1991
2.	David H Wekelin, The Making, Shaping and Treating of Steel, AISE Steel Foundation, 1999
3.	Chow, C., et al., High speed continuous casting of steel billets Part 1 and Part 2, Iron making & Steelmaking, Vol.29, pp. 53-69, 2002

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	1	2	0	1	0	0	0	2	2	2	3	2	
CO2	1	2	2	2	3	0	2	0	0	0	2	2	1	1	1	
CO3	3	2	2	1	2	0	2	0	0	0	1	2	2	1	1	1
CO4	2	1	2	1	2	0	0	0	0	0	2	2	1	2	2	
CO5	2	1	2	1	3	0	0	0	0	0	2	3	1	1	1	
Total	**2.2**	**1.6**	**2.2**	**1.2**	**2.4**	**0**	**1**	**0**	**0**	**0**	**1.8**	**2.2**	**1.4**	**1.6**	**1.4**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE15	POWDER METALLURGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To introduce the importance non-conventional processing routes for different materials and its importance for advanced materials manufacturing.

UNIT I	CHARACTERISTICS AND TESTING OF METAL POWDERS	9	+	0

Sampling, chemical composition purity, surface contamination etc. Particle size and its measurement, Principle and procedure of sieve analysis, 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 and shrinkage.

UNIT II	POWDER MANUFACTURE AND CONDITIONING	9	+	0

Mechanical methods Machine milling, ball milling, atomisation. Shotting Chemical methods Condensation, thermal decomposition, carbonyl. Reduction by gas-hydride, dehydride process, electro deposition, precipitation from aqueous solution and fused salts, hydrometallurgical method. Physical methods: Electrolysis and atomisation processes, types of equipment, factors affecting these processes, examples of powders produced by these methods, applications,
Powder Conditioning, Heat treatment, blending and mixing, types of equipment, types of mixing and blending

UNIT III	POWDER COMPACTION	9	+	0

Pressure less Compaction: slip casting and slurry casting. Pressure compaction- lubrication, single ended and double ended compaction, Cold isostatic compaction, powder rolling, extrusion, explosive compaction, hot temperature compaction, continuous compaction

UNIT IV	SINTERING	9	+	0

Stage of sintering, property changes, mechanisms of sintering, liquid phase sintering and infiltration, activated sintering, Hot pressing and Hot Isostatic Pressing, vacuum sintering, sintering furnaces and sintering atmosphere, finishing operations – sizing, coining, repressing and heat treatment.

UNIT V	POWDER METALLURGY APPLICATIONS	9	+	0

Advantages and disadvantages of P/M, Major applications in aerospace. Nuclear and automobile industries. Bearing Materials-types, self lubrication and other types, methods of production, properties, applications. Sintered Friction Materials-clutches, brake linings, Tool Materials- cemented carbides, oxide ceramics, Cermets- Dispersion strengthened materials

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Describe the basic mechanism of powder production for variety of materials to meet the demand of the research and industrial needs
CO2	**:**	Characterize the various powders (materials) based on the engineering applications
CO3	**:**	Differentiate the processing routes for various powders (materials) and associated technology
CO4	**:**	Define modern day processing routes and apply them successfully to materials processing

Text Books:

1.	Sinha..A.K., Powder Metallurgy, DhanpatRai& Sons. New Delhi, 2001.
2.	Sands. R L. and Shakespeare. C.R. Powder Metallurgy, George Newes Ltd. London, 1966.
Reference Books:	
1.	ASM Handbook. Vol. 7, Powder Metallurgy, Metals Park, Ohio, USA, 1990.
2.	Animesh Bose., Advances in Particulate Materials, Butterworth - Heinemann. New Delhi, 1995.
3.	Kempton. H Roll., Powder Metallurgy, Metallurgical Society of AMlE, 1988.
4.	Ramakrishnan.P., Powder Metallurgy Opportunities for Engineering Industries, Oxford and IBH Publishing Co., Pvt. Ltd, New Delhi, 1987.
5.	Erhard Klar, Powder Metallurgy Applications, Advantages and Limitations, American Society for Metals, 1983.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO 4
CO1	1	1	1	3	1	0	0	0	0	0	1	1	2	3	2	
CO2	2	3	3	3	3	0	0	0	0	0	1	2	3	3	2	
CO3	1	2	3	3	3	0	1	0	0	0	1	1	3	2	2	
CO4	0	0	2	2	2	1	1	0	0	0	2	2	2	2	3	1
Total	**1**	**1.5**	**2.2**	**2.7**	**2.7**	**0.2**	**0.5**	**0**	**0**	**0**	**1.2**	**1.5**	**2.5**	**2.5**	**2.2**	**0.25**

1- Faintly, 2- Moderately, 3- Strongly

22MTE16	NON DESTRUCTIVE EVALUATION	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To understand the basic principles of various NDT techniques, its applications, limitations, codes and standards.

UNIT I	BASIC CONCEPTS AND SURFACE NDT METHODS	9	+	0

Concepts of Non-Destructive testing - Relative merits and limitations - NDT Versus Mechanical testing - Various physical characteristics of materials and their applications in NDT. Visual inspection: Unaided and Aided. Liquid penetrant inspection: Principle, applications, advantages and limitations, Dyes, developers and cleaners, Fluorescent penetrant test. Magnetic particle inspection: Principles, applications, magnetisation methods, magnetic particles, Dry technique and Wet technique, demagnetization, Advantages and limitations.

UNIT II	RADIOGRAPHY TESTING	9	+	0

X-rays and Gamma rays, Properties of X-rays relevant to NDE, Absorption of rays, scattering, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films - graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy-Xero-Radiography. Safety with X-rays and Gamma rays, Industrial computed tomography (ICT).

UNIT III	ULTRASONIC TESTING	9	+	0

Types of Ultrasonic waves, principles of wave propagation, characteristics of ultrasonic waves, Attenuation, couplants. Inspection methods - pulse echo, Transmission and resonance techniques, Thickness measurement. Types of scanning, Test block, IIW - reference blocks. Time of flight diffraction (TOFD), Phased array Ultrasonic Testing.

UNIT IV	OTHER NDT METHODS AND CODES	9	+	0

Eddy current testing: Principle, application and Instrumentation of Eddy current testing. Other NDT techniques: Principle, application and Instrumentation of Infrared and Thermal inspection methods, Holography and Acoustic emission. Pressure and Leak testing. Codes: Introduction to ANST standards and ASME codes related to NDT, certification of NDT Personnel level I, II & III

UNIT V	FAILUE ANALYSIS	9	+	0

Fundamental sources of failures- Deficiencies in design, material processing, service and maintenance. Stages of failure Analysis. Classification and identification of various types of fracture. Introduction to Fatigue failure Elevated Temperature failure, Wear failure, and Corrosion failure.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	To understand basic concepts of non-destructive testing and understanding the importance of Penetrant testing, the procedures involved in the magnetic methods.
CO2	**:**	To explain the techniques involved in the Radiographic testing and the various advancements in Radiography.
CO3	**:**	To evaluate and interpret the principles and calibrations in the Ultrasonic inspection.
CO4	**:**	To understand the basic principles and working of Thermographic technique, the Eddy current testing, and Acoustic emission.
CO5	**:**	To evaluate and explain the different types of fracture occurs in materials and processes.

Text Books:

1.	Barry Hull and Vernon John, Non Destructive Testing, ELBS / Macmillan, 2001.
2.	Baldev Raj, Jayakumar T. Thavasimuthu M, Practical Non-Destructive testing, Narosa Publishing House, NewDelhi, 1997.
Reference Books:	
1.	ASM Handbook, Vol.17: Non destructive Evaluation and Quality Control, ASM International, Metals Park, Ohio, USA, 1992.
2.	Louis Cartz, Non-Destructive Testing, ASM International, Metals Park Ohio, US, 1995.
3.	McGonnagle. W.J. Non-Destructive Testing, Gordon and Breach, 2nd Ed., 1971.
4.	ASM Handbook, Vol.11: Failure analysis and Prevention, ASM International, Metals Park, Ohio, USA, 1992.

CO/PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	2	0	2	0	0	1	1	2	1	1	0	2	
CO2	3	1	1	1	1	2	1	0	1	2	2	3	1	0	3	
CO3	1	2	1	1	2	2	0	0	0	2	2	3	1	1	1	
CO4	3	2	2	1	2	2	1	0	1	1	3	2	1	0	3	1
CO5	1	2	2	1	2	1	0	0	0	2	2	2	1	2	1	
Total	**2**	**1.6**	**1.4**	**1.2**	**1.4**	**1.8**	**0.4**	**0**	**0.6**	**1.6**	**2.2**	**2.2**	**1**	**0.6**	**2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE17	SEVERE PLASTIC DEFORMATION	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the fundamental concepts of mechanical behaviour of materials and to apply them to design the materials for various load-bearing structural engineering applications.

UNIT I	INTRODUTION AND ECAE	9	+	0

Severe plastic deformation processes (SPD), advantages over conventional metal forming processes. Concept of equal channel angular extrusion (ECAE), Plastic zone during ECAE. Material flow and stress distribution in ECAE.

UNIT II	ECAE – II	9	+	0

Multi-pass processing in ECAE, Processing parameters, defects associated with ECAE. Continuous ECAE. Concept of Incremental equal channel angular pressing (I-ECAP). Tooling of ECAP – Configuration of channel, die design, punch design, tool materials for punch and dies

UNIT III	HIGH PRESSHURE TORSION	9	+	0

Introduction to high pressure torsion (HPT) – advantages over other SPD techniques. Characteristic HPT microstructures. Principles of HPT-idealised, fully constrained, quasi-constrained HPT. Design criteria.

UNIT IV	CYCLIC EXTRUSION-COMPRESSION AND ARB	9	+	0

Concept cyclic extrusion-compression, microstructural evolution during CEC, grain refinement in aluminium alloys. Introduction to accumulative roll bonding, principle of ARB, nanostructure formation during ARB.

UNIT V	TWIST EXTRUSION AND OTHER PROCESSES	9	+	0

Introduction to twist extrusion, processing technique for TE, formation of nanostructure in TE. Applications and recent developments of TE. Friction stirs processing: principle and operating parameters. Applications of FSP.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Knowledge about material flow and stress distribution in ECAE
CO2	**:**	Details about different processing parameters of ECAE and its tooling
CO3	**:**	Formulate the design criteria for high pressure torsion
CO4	**:**	Know about the concepts of cyclic extrusion-compression and evolution of microstructure during CEC
CO5	**:**	Describes various applications of friction stir processing and its principle

Text Books:

1.	Rosochowski, A., Severe Plastic Deformation Technology, Whittles Publishing, UK, 2017.

Reference Books:

1.	Proceedings of the Conference ― Nanomaterials by Severe Plastic Deformation – NANOSPD2‖, December 9-13, 2002, Vienna, Austria, Edited by Zehetbauer, M and Z. Valiev.

CO/PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	2	1	2	1	0	1	1	2	2	2	2	1	1	
CO2	2	0	1	0	1	2	1	1	2	0	1	2	2	2	1	
CO3	1	2	2	2	1	2	1	1	0	1	1	2	2	1	2	
CO4	0	1	2	2	1	0	0	1	0	2	2	2	1	1	1	1
CO5	1	2	2	2	2	1	2	1	1	1	2	2	2	1	1	
Total	1	1.2	1.8	1.4	1.4	1.2	0.8	1	0.8	1.2	1.6	2	1.8	1.2	1.2	0.2

1- Faintly, 2- Moderately, 3- Strongly

22MTE18	METALLURGICAL WASTE UTILIZATION AND MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives:

1.	Student should be capable of understand various wastes in environment conditions and choose suitable materials for various conditions and to learn about utilization of metallurgical waste.

UNIT I	MINING AND METALLURGICAL WASTE	9	+	0

Environmental and health impacts of Mining and Metallurgical waste. Various kind of wastes: Mining and Beneficiation waste production. Ferrous metal waste production. Ferroalloys waste production.
Hydrometallurgical waste production. Metal manufacturing and finishing waste production. Post-consumer waste production.

UNIT II	UTILIZATION OF MINING AND BENEFICIATION WASTE	9	+	0

Utilization of mine overburden and waste rock. Potential utilization of mineral beneficiation tailings. Prevention and mitigation of acid mine drainage.

UNIT III	UTILIZATION OF FERROUS METAL WASTE	9	+	0

Recycling and reuse of blast furnace iron making slags, steel making dusts and sludges. Utilization of steel making dusts – Plasma based processing, hydrometallurgical processing, solidification and stabilization. Recycling and reuse of steelmaking slags

UNIT IV	UTILIZATION OF HYDROMETALLURGICAL AND METAL FINISHING WASTES	9	+	0

Utilization of Jarosite, goethite produced during extraction of zinc, Utilization of red mud produced in Bayer process: metallurgical utilization through metal recovery, utilization in building and construction, Glassceramics and Pigments. Recycling and utilization of surface oxide scale produced during metal forming operation. Metal recovery from pickling and plating sludges

UNIT V	WASTE MANAGEMENT	9	+	0

Waste management and utilization options: zero waste process approach, synergy between residue produces and residue end users. Process integration to mineral waste utilization. Process intensification.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Analyse various mining and metallurgical waste and their health impacts
CO2	**:**	Utilization of wastes of mining and prevention of acid rain drainage
CO3	**:**	Know about the ways of recycling and reuse of steel making slags
CO4	**:**	Analyse various routes of utilization of hydrometallurgical and metal finishing wastes
CO5	**:**	Implementing the approach of zero waste

Text Books:	
1.	Ndlovu, S., G.S. Simate and E. Matinde, Waste production and utilization in the Metal Extraction Industry, CRC Press, 2017

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	2	1	2	0	1	1	2	2	2	2	1	1	1	
CO2	2	0	1	0	1	1	1	2	0	1	2	2	2	1	2	
CO3	1	2	2	2	1	1	1	0	1	1	2	2	1	2	1	
CO4	0	1	2	2	1	0	1	0	2	2	2	1	1	1	0	1
CO5	1	2	2	2	2	2	1	1	1	2	2	2	1	1	1	
Total	**1**	**1.2**	**1.8**	**1.4**	**1.4**	**0.8**	**1**	**0.8**	**1.2**	**1.6**	**2**	**1.8**	**1.2**	**1.2**	**1**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE19	COMPUTATIONAL MATERIALS ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To become familiar with computational techniques including related mathematical background

UNIT I	Introduction To Computational Methods	9	+	0

Solving sets of equations – Gauss elimination method, Choleski method, Iterative methods, Relaxation method, System of non-linear equations- Newton Raphson method, Computer programs. Numerical Integration - Newton-Cotes integration formulae, Trapezoidal rule, Simpson's rule, Gaussian quadrature

UNIT II	Numerical solution of partial differential equations	9	+	0

Laplace's equations - Representations as a difference equation, Iterative methods for Laplace's equations, Poisson equation - Derivative boundary conditions, Irregular and non-rectangular grids, Matrix patterns, Sparseness, ADI method, Applications to heat, mass and momentum transfer problems, Computer programs

UNIT III	Finite Element Method	9	+	0

Weighted residue technique, variational approach, element types, plane triangular, quadrilateral curved isoparametric elements, three dimensional elements

UNIT IV	Analysis of production processes	9	+	0

Finite element analysis of metal casting - Special considerations, latent heat incorporation, gap element, time stepping procedures – crank – Nicholson algorithm, Prediction of grain structure. Basic concepts of plasticity– solid and flow formulation – small incremental deformation formulation

UNIT V	Curve fitting and approximation of functions	9	+	0

Least square approximation, fitting of non-linear curves by least squares, Regression analys Computer programs. Introduction to Artificial neural networks, various algorithms and CA studies Introduction to Genetic algorithms, GA for materials design and process optimization, case studies.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Understand the basics of the computational methods that can be used for numerical integration
CO2	**:**	Realize the utilization of finite element method
CO3	**:**	Recognize the appositeness of curve fitting and approximation of functions
CO4	**:**	Employing the usage of Artificial neural networks and Genetic algorithms.

Text Books:

1. Zoe Barber, Introduction to Materials Modelling, Maney Publishing, Institute of Materials, London, 2005.

2.	Rao S S, –The Finite element Method in Engineering‖, Pergaman Press, New York, 1989.
Reference Books:	
1.	Lewis R W, Morgan K, Thomas H R and Seetharamu K N, –The Finite Element method in Heat Transfer Analysis, John Wiley, 1994
2.	Malanie Mitchell, ―An introduction to genetic algorithms, MIT Press, 1998.
3.	Koenraad Janssens,Computational Materials Engineering, An introduction to microstructural evolution‖, Elsevier, 2007.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	3	2	2	0	0	0	0	0	1	1	2	3	3	
CO2	1	2	2	1	2	0	0	0	0	0	2	1	2	2	2	
CO3	2	2	3	1	1	0	0	0	0	0	1	1	3	3	2	1
CO4	2	3	2	3	1	1	1	1	1	1	1	2	2	3	1	
CO5	1	2	3	1	2	1	1	1	1	2	1	2	2	2	2	
Total	**1.4**	**2.2**	**2.6**	**1.6**	**1.6**	**0.4**	**0.4**	**0.4**	**0.4**	**0.6**	**1.2**	**1.4**	**2.2**	**2.6**	**2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE20	SPECIAL WELDING PROCESSES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the concepts of different welding process and various parameters for its applications

UNIT I	RADIANT ENERGY WELDING	9	+	0

Electron Beam Welding- Background of the Process, Guns, Weld Environment, Welding in Different Degrees of Vacuum, Equipment and Safety, Joint Design, Applications, Laser Beam Welding, Process Parameters, Applications and Limitations.

UNIT II	PLASMA ARC WELDING	9	+	0

Plasma Arc Welding- theory and Principles, Transferred arc and Non-Transferred arc Techniques, Equipment and Tooling, Joint Design Advantages, Disadvantages, Economics, Materials and Applications. Needle Arc Micro Plasma Welding - Characteristics of Process, Operating Characteristics, Fixturing and Joint Design, Shielding, Weld Penetration and Shape, Applications.

UNIT III	EXPLOSIVE WELDING	9	+	0

Explosive Welding- theory and Key Variables, Parameters, Weld Quality, Equipment and Tooling, Advantages and Limitations, Joint Design, Materials and Applications. Adhesive Bonding- theory and Key Parameters, Physical Characteristics, Metal Adhesive, Equipment, Design, Economics of Process, Materials and Applications.

UNIT IV	FRICTION AND FRICTION STIR WELDING	9	+	0

Friction Welding- Basic Principles, Process Variants, Different Stages of Friction Welding, Mechanism of Bonding, Influence of Process Parameters, Weld Quality and Process Control, Joining of Dissimilar Materials, Advantages, Limitations and Applications. Friction stir welding – process variables and applications

UNIT V	DIFFUSION WELDING AND VACUUM BRAZING	9	+	0

Diffusion Welding- theory and Principle of Process, Key Variables, Intermediate Materials, Deformation Welding, Equipment and Tooling, Joint Design, Economics, Advantages and Limitations, Materials and Applications. Vacuum Brazing- theory, mechanisms and Key Variables, Equipment and Tooling, Stop-off and Parting Agents, Advantages, Limitations, Economics Materials and Applications.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Apply radiant energy concepts using different process parameters
CO2	**:**	Characterization of plasma arc welding process and its associate technology
CO3	**:**	Know about the key variables and theory of explosive welding and their physical characteristics
CO4	**:**	Differentiate friction and friction stir welding process and its various applications
CO5	**:**	Describes the concepts of diffusion welding and vacuum brazing

Text Books:

1.	Schwartz M.M., Metals Joining Manual, McGraw-Hill Inc., 1979.
2.	Parmar R.S., Welding Processes and Technology, Khanna Publishers, New Delhi, 1998
Reference Books:	
1.	ASM Metals Hand Book Welding, Brazing and Soldering, Vol. 6, ASM, Ohio, 1988.
2.	Howard B. Cary, Modern Welding Technology, Prentice Hall, New Jersey, USA, 1989

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	0	0	2	2	0	0	0	0	0	1	2	3	2	2	
CO2	1	1	1	2	1	0	0	0	0	0	2	1	3	3	3	1
CO3	1	2	2	2	3	0	0	0	0	0	1	2	2	2	3	1
CO4	1	2	3	2	3	0	0	1	1	0	2	1	3	2	3	
CO5	1	1	2	1	0	0	0	0	0	2	1	3	3	3	1	
Total	**1**	**1.2**	**1.6**	**1.8**	**1.8**	**0**	**0**	**0.2**	**0.2**	**0.4**	**1.4**	**1.8**	**2.8**	**2.4**	**2.4**	**.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE21	X-RAY DIFFRACTION AND ELECTRON MICROSCOPY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study about X-ray diffraction methods and its uses, TEM, SEM

UNIT I	Fundamentals of X-ray Diffraction	9	+	0

Properties of X-rays: Continuous spectrum, characteristic spectrum, absorption, filters. Production of x-rays, Detection of x-rays. X-ray diffraction- Bragg‘s Law, diffraction direction

UNIT II	X-ray Diffraction	9	+	0

Diffraction methods – Laue, Rotating Crystal and Powder methods. Intensity of diffracted beams-Scattering by an electron, an atom and unit cell, Structure factor calculations. X-ray diffractometer – general features

UNIT III	Applications of X-ray Diffraction	9	+	0

X-ray diffraction application in determination of crystallite size, crystal structure, precise lattice parameter and residual stress. Chemical analysis by x-ray diffraction and x-ray spectroscopy

UNIT IV	Transmission Electron Microscopy	9	+	0

Transmission electron microscopy (TEM) instrumentation – electron sources, elements of electron optics, resolving power, image formation, contrast mechanism, bright field and dark field images, selected area diffraction, techniques of specimen preparation-mechanical thinning, electrochemical thinning and ion milling. Applications of TEM.

UNIT V	Scanning Electron Microscopy	9	+	0

Components of scanning electron microscope (SEM), electron beam – specimen interaction, Detection of secondary electrons, detection of back scattered electrons, image formation, methods of specimen preparation, Operational variables, Introduction to electron backscatter diffraction (EBSD) and Focused-Ion Beam microscopy

Total(L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Demonstrate the Bragg‘s law of diffraction and the principle of XRD.
CO2	**:**	Describe the principle of various electron optical techniques.
CO3	**:**	Ability to perform analysis of X ray diffraction and electron microscope images and the chemical and thermal analysis.

Text Books:

1.	Cullity, B.D., Elements of X Ray Diffraction, Addison-Wesley Publishing Company Inc, Philippines, 1978
2.	Brandon, D. and W.D. Kaplan, Microstructural Characterization of Materials, John Wiley & Sons Ltd, England, 2013
Reference Books:	
1.	Goldstein, J., et al., Scanning Electron Microscopy and X-ray Microanalysis, Kluwer Academic/Plenum Publishers, New York, 2003.
2.	Goodhew, P.J., J. Humphreys, and R. Beanland, Electron Microscopy and Analysis, Taylor & Francis, London, 2000
3.	Hebbar, K.R., Basics of X-Ray Diffraction and Its Applications, I.K. International Publishing House Pvt. Limited, India, 2007.
4.	Williams, D.B. and C.B. Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Springer Science+ Business Media, New York, 2009

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3	PSO4
CO1	3	1	1	1	2	0	0	0	0	0	1	1	2	2	2	
CO2	2	1	1	1	0	0	0	0	0	0	1	2	3	2	2	1
CO3	3	1	1	2	2	0	0	0	0	0	1	1	3	3	2	1
Total	**2.6**	**1**	**1**	**1.3**	**1.3**	**0**	**0**	**0**	**0**	**0**	**1**	**1.3**	**2.6**	**2.3**	**2**	**0.66**

1- Faintly, 2- Moderately, 3- Strongly

22MTE22	ELECTRICAL, ELECTRONICS AND MAGNETIC MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives

1. To study super conductors, magnetic materials, semiconductors, optoelectronic materials.

UNIT I	DIELECTRIC AND PIEZO ELECTRIC MATERIALS	9	+	0

Free electron theory - Band theory - discussion on specific materials used as conductors - Dielectric phenomena - concept of polarization- frequency and temperature dependence - dielectric loss - dielectric breakdown - ferro electricity - piezo electricity and pyro electricity – $BaTiO_3$ – structure and properties

UNIT II	SUPERCONDUCTORS	9	+	0

Concept of superconductivity – BCS theory of super conductivity – Types of super conductors –YBCO- structure and properties – specific super conducting materials – Fabrication and engineering applications.

UNIT III	MAGNETIC MATERIALS	9	+	0

Origin of Magnetism - Introduction to dia, para, ferri and ferro magnetism – Curie temperature – Magnetic anisotropy - hard and soft magnetic materials- iron based alloys - ferrites and garnets – rare earth alloys - fine particle magnets.

UNIT IV	OPTOELECTRONIC MATERIALS	9	+	0

Principles of photoconductivity, luminescence- - photo detectors – Optical disc and optoelectronic materials –LCD, LED and diode laser materials - electro optic modulators - Kerr and Pockel's effect – $LiNbO_3$.

UNIT V	SEMICONDUCTORS	9	+	0

Semiconducting materials and types; simple, compound and oxide semiconductors – semiconducting materials in devices – Production of silicon starting materials – methods for crystal growth for bulk single crystals- zone melting – Czochralski method – Epitaxial films by VPE, MBE and MOCVD techniques – Lithography .

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Understand the theory for Dielectric and Piezo electric materials
CO2	**:**	Understand concepts, theory and approach.
CO3	**:**	Study various kinds of magnetism principles, various types of magnetic materials exhibiting.
CO4	**:**	Learn about photoconduction phenomenon, optical materials and various optical devices and their performances.
CO5	**:**	Study the theory of superconductivity recent advancements, methods of producing semiconductors and their processing methods used in the semiconducting materials industry.

Text Books:

1. Kittel C., _Introduction to Solid State Physics', 7th Edition, Wiley Eastern, New International Publishers, 2004
2. Dekker A. J., _Electrical Engineering materials, Prentic Hall, 1995

Reference Books:

1. Dekker. A.J, Solid state Physics, Mac Millan India, 1995

2.	Van Vlack L.H, Elements of Materials Science and Engineering, 6th edition, Addison Wiley, 1989
3.	Kasap and Capper, Handbook of electronic and photonic materials, 2006, NY

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	3	2	2	0	0	0	0	0	1	1	2	3	3	
CO2	1	2	2	1	2	0	0	0	0	0	2	1	2	2	2	
CO3	2	2	3	1	1	0	0	0	0	0	1	1	3	3	2	
CO4	2	3	2	3	1	1	1	1	1	1	1	2	2	3	1	1
CO5	1	2	3	1	2	1	1	1	1	2	1	2	2	2	2	
Total	**1.4**	**2.2**	**2.6**	**1.6**	**1.6**	**0.4**	**0.4**	**0.4**	**0.4**	**0.6**	**1.2**	**1.4**	**2.2**	**2.6**	**2**	**.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE23	SURFACE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1.	Analyze the various concepts of surface engineering and comprehend the design difficulties

UNIT I	TRIBOLOGY AND PLATING PROCESSES	9	+	0

Introduction to tribology, Wear: Types of wear-adhesive, abrasive, oxidative, corrosive, erosive and trotting wear, roles of friction and lubrication and wear testing. Plating Processes: fundamentals of electro deposition, plating of nickel, chromium, tin and copper, pulsed plating, hydrogen embrittlement, plating adhesion, electroless plating, electro chemical conversion coating, selective plating for repair, plating properties, hard anodizing.

UNIT II	HARD FACING PROCESSES	9	+	0

SMAW,GTAW, GMAW, FCAW, SAW, PAW, Oxy-Acetylene Welding, Furnace fusing, Thermal-spray, name spray processes-HVOF, Detonation gun and jet kote processes, hardfacing consumables.

UNIT III	SPECIAL DIFFUSION PROCESSES	9	+	0

Principle of diffusion processes-Boriding, Aluminising, Siliconising, Chromising Selection of diffusion processes-Characteristics of diffused layer-micro structure and micro hardness evaluation-properties and applications.

UNIT IV	THIN FILM COATINGS	9	+	0

Physical vapour deposition processes-Thermal evaporation-sputter coating-Ion plating Chemical vapour deposition-reactive sputtering-TiC, TiN, Alumina, CBN, Diamond and DLC coatings. Structure, properties and applications.

UNIT V	HIGH ENERGY MODIFICATION AND SPECIAL PROCESSES	9	+	0

Electron beam hardening, glazing, Laser beam hardening glazing ion implantation,
Composite surface created by laser and Electron beam. Surface cements, Wear tiles, Electro spark deposition, fused carbide cloth, thermal/chemical. Ceramic coatings, centrifugal cast wear coatings, Wear sleeves and Wear plates.

Total(L+T)= 45+0 = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Understand the influence of the tribological characteristics and improvise the material property by the plating process
CO2	**:**	Explain the various hard facing processes
CO3	**:**	Enhance surface properties with diffusion of foreign atoms into the outer surface of the material such as boriding, aluminizing, etc
CO4	**:**	Describe the various vapour deposition processes of different materials on the surface of native materials using the Chemical, Physical and Thermal vapour deposition processes.
CO5	**:**	Describe the Modern processes and high energy processes like electron beam hardening, laser beam hardening.

Text Books:

1.	Chattopadhyay R., Surface Wear: Analysis, Treatment, Prevention, ASM International, USA, 2001
2.	Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prentice Hall, Englewood Cliff, 1990.

Reference Books:

1.	ASM Metals Handbook, Vol 5: Surface Engineering, ASM International, Ohio, 1994.
2.	Ernest Rabinowicz, Friction and Wear of Materials, 2nd ed., John Wiley & Sons, NY, 1995.
3.	Davis J.R., Surface Engineering for Corrosion and Wear resistance, ASM International, 2001.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	0	1	2	0	0	0	0	0	1	2	2	2	1	
CO2	2	3	2	1	3	1	0	2	1	0	1	2	2	3	1	
CO3	0	1	1	0	2	1	2	3	1	0	1	2	1	1	2	
CO4	1	2	3	3	2	1	0	0	0	1	3	2	1	1	0	1
CO5	2	1	1	1	2	0	1	0	2	1	1	0	0	0	1	
Total	**1.2**	**1.8**	**1.4**	**1.2**	**2.2**	**0.6**	**0.6**	**1**	**0.8**	**0.4**	**1.4**	**1.6**	**1.2**	**1.4**	**1**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE24	ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

Course Objectives

1.	To Understand the fundamentals of various Additive Manufacturing Technologies and STL file formations for application to various industrial needs.
2.	Able to understand various method of manufacturing of liquid based, powder based and solid based Additive Manufacturing techniques.

UNIT I	INTRODUCTION	9	+	0

Prototyping fundamentals, Historical development, Advantages of AMT, Commonly used terms, process chain, 3D modelling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of AMT process, Applications to various fields.

UNIT II	LIQUID BASED SYSTEMS	9	+	0

Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.

UNIT III	SOLID BASED SYSTEMS	9	+	0

Laminated object manufacturing (LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies, practical demonstration.

UNIT IV	POWDER BASED SYSTEMS	9	+	0

Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Three dimensional printing (3DP):Models and specification, process, working principle, applications, advantages and disadvantages, case studies

UNIT V	APPLICATION OF ADDITIVE MANUFACTURING	9	+	0

Artificial Heart, Prosthetic Cardiac Valves, Artificial lung (oxygenateor), Artificial Kidney (Dialyser membrane), Dental Implants, Orthopaedic Implants and Biomaterials in Ophthalmology - Aerospace, automobile, Agricultural, Oil and gas industries.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Understand the fundamentals of AdditiveManufacturing Technologies for engineeringapplications.
CO2	**:**	Understand the methodology to manufacture theproducts using SLA and SGC technologies and study their applications, advantages and case studies.
CO3	**:**	Understand the methodology to manufacture theproducts using LOM and FDM technologies and study their applications , advantages and case studies.
CO4	**:**	Understand the methodology to manufacture theproducts using SLS and 3D Printing technologies and study their applications , advantages and case studies.
CO5	**:**	Understand the fundamentals of AdditiveManufacturing Technologies for engineeringapplications.

Text Books:

1.	Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.
2.	Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010
Reference Books:	
1.	D.T. Pham and S.S. Dimov, “Rapid Manufacturing”, Springer, 2001
2.	Paul F. Jacobs, “ Rapid Prototyping and Manufacturing”–, ASME Press, 1996
3.	Terry Wohlers, “ Wholers Report 2000”, Wohlers Associates, 2000.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	2	3	2	1	1	0	0	0	2	2	3	3	2	
CO2	2	3	2	2	1	0	1	2	0	0	2	3	3	2	1	
CO3	2	2	2	2	2	1	3	2	0	0	3	3	2	2	3	
CO4	2	2	3	3	2	1	0	0	0	1	3	2	1	1	0	
CO5	2	3	1	1	2	0	1	0	2	1	1	0	0	0	1	1
Total	**2**	**2.2**	**2**	**2.3**	**1.6**	**0.6**	**1.6**	**1.3**	**0**	**0**	**1.6**	**2.6**	**2.6**	**2.3**	**2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE25	NANO MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	Describe the various synthesis methods
2.	Identidy the various types and forms of nano materials
3.	Know the application of nano materials in various fields

UNIT I	INTRODUCTION AND SYNTHESIS BY MECHANICAL METHODS:	9	+	0

Introduction: Definition, classification of nanomaterials- Structure of nanomaterials - Effect of nanoscale dimensions on various properties – Structural, thermal, chemical, mechanical, magnetic, optical and electronic properties. Comparison nanomaterials with conventional materials. Synthesis: Basic approaches- top down and bottom up approaches- various methods for producing nanomaterials. Solid State (Mechanical methods): Mechanical Alloying (MA) and Mechanical Milling (MM)- Severe Plastic deformation – ECAP,HPT,ARB

UNIT II	SYNTHESIS BY PHYSICAL& CHEMICAL	9	+	0

Top down approach, Nanolithography,Bottom up approach:Chemicalmethods:CVD – Steps and reactions involved for various types of CVD, Sol-gel method and co-precipitation techniques. Physical methods: PVD - Evaporation, Sputtering & Laser ablation .Consolidation of nanomaterials: Problems, Shockwave consolidations, Spark plasma sintering .

UNIT III	CHARACTERIZATION OF NANOMATERIALS	9	+	0

Application of X-ray diffraction in nanomaterial characterization. Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscope, Field Ion Microscope – Construction, working principle, different modes of operation and application in nanomaterial characterization. Nano indentation technique. Introduction to 3D Atom Probe Tomography.

UNIT IV	APPLICATIONS OF NANOMATERIALS - I	9	+	0

Nano-electronics, Micro and Nano Electromechanical systems, nanosensors, Electrical and optical applications. Quantum dots: Fabrication and applications. Nanofluids and their applications.

UNIT V	APPLICATIONS OF NANOMATERIALS - II	9	+	0

Energy applications: energy storage devices, fuel cells, solar cells, Biomedical applications. Structural applications. Carbon nanotubes: Types, structures, synthesis and applications. Health and environmental issues related to nanomaterials.

Total (L+T) =45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Distinguish synthesis of nanomaterial‘s using different methods such as mechanical alloying and mechanical milling
CO2	**:**	Describe the various deposition processes of nanomaterial‘s like physical ,chemical and thermal methods
CO3	**:**	Demonstrate the various nano material characterization techniques such as AFM, XRD, SEM and TEM.
CO4	**:**	Demonstrate the electronic and optical applications of nonmaterial‘s in semiconductor industries
CO5	**:**	Demonstrate the applications of nano materials in energy storage devices and biomedical industries

Text Books:	
1.	B.S Murthy ,P.Shankar, Baldevraj, B.BRath, JamesMurday – Text book nano science and nanotechnology, University press(India)Pvt Ltd, Hyderabad 2012
2.	Dieter vollath , Nanomaterials : An introduction to Synthesis, Properties and applications, Second edition, Wiley – VCH verlag Gmbh& co ,Germany 2013
Reference Books:	
1.	Pradeep T, ―Nano : The essentials‖, Tata McGraw Hill Publishing Company Limited, New Delhi, 2007
2.	B. S. Murty et al., Textbook of Nanoscience and Nanotechnology, Universities Press (India) Private Limited 2013
3.	Bharath Bhushan, Springer Handbook of Nanotechnology, Springer – Verlag, New York, 2004.
4.	Charles P. Poole and Frank J Owens, Introduction to Nanotechnology, John Wiley and Sons Inc, New York, 2003.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO 4
CO1	2	1	2	2	3	2	0	3	3	2	3	2	3	3	3	
CO2	2	3	2	3	3	2	2	0	2	1	3	2	3	3	3	
CO3	2	2	3	3	2	1	0	0	0	3	3	2	2	2	3	
CO4	2	2	0	0	3	3	3	2	0	2	3	3	3	1	3	1
CO5	2	3	3	3	3	0	1	0	1	2	3	2	3	3	3	1
Total	**2**	**2.2**	**2.2**	**2.2**	**2.8**	**1.6**	**1.2**	**1**	**1.2**	**2**	**3**	**2.2**	**2.8**	**2.4**	**3**	**.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE26	THIN FILMS, COATINGS AND APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study about thin films, coatings and application techniques.

UNIT I	INTRODUCTION	9	+	0

Need for miniaturization, Basics of thin film, Brief review of kinetic theory of adsorption, desorption, film growth: nucleation and growth kinetics. Vacuum science and technology, Vacuum pumps, surface: role of substrate surface, substrate cleaning. Epitaxy, thin film growth control,

UNIT II	TECHNIQUES OF COATING	9	+	0

Physical vapor deposition (PVD) processes, evaporation: thermal and e-beam. Principles of glow discharge and various sputtering processes. Fundamentals of Chemical Vapor Deposition (CVD) processes.

UNIT III	OTHER TECHNIQUES	9	+	0

Pulsed laser deposition (PLD), other techniques: electro-deposition, spin Coating, sol-gel, Langmuir Blodgett (LB) techniques, SILAR technique, Doctor blade technique, printing.

UNIT IV	HARD COATINGS	9	+	0

Hard coating: physical, mechanical and protective properties, basic thin film thickness measurement, microstructural characterization of films/coating.

UNIT V	APPLICATIONS	9	+	0

Thin film devices: opto electronic devices, photo-detectors, solar cells. Applications: high hardness, corrosion resistance, biocompatibility and high temperature stability.

Total (L+T)=45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the basics of adsorption, desorption and need of vacuum
CO2	**:**	Describe the principles, process and advantages of different techniques
CO3	**:**	Know about various hard coating techniques
CO4	**:**	Identify thin film devices and applications of it.

Text Books:

1.	Milton Ohring, Materials Science of Thin Films, 2nd Edition, Academic Press, 2001
2.	Hartmut Frey and Hamid R Khan, Handbook of Thin Film Technology, Springer,2016

Reference Books:

1.	K. L. Chopra & L. K. Malhotra, Thin film Technology and Application, Tata McGraw-Hill, 1985
2.	Peter M. Martin, Handbook of Deposition Technologies for Films and Coatings, Elsevier, 1994
3.	Sam Zhang, Nanostructured Thin Films and Coating, CRC Press, 2010

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	3	3	3	2	0	0	0	0	0	1	2	3	2	2	
CO2	2	1	3	2	0	1	2	3	0	0	2	2	2	3	2	
CO3	2	3	3	3	3	0	1	0	0	0	3	3	3	3	3	
CO4	2	3	3	3	3	0	0	0	0	3	3	3	3	3	3	1
Total	**1.4**	**2**	**3**	**2.2**	**1.6**	**0.2**	**0.6**	**0.6**	**0**	**0.6**	**1.8**	**2**	**2.2**	**2.2**	**2**	**0.25**

1- Faintly, 2- Moderately, 3- Strongly

22MTE27	AEROSPACE MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To analyze the materials for aerospace.

UNIT I	MECHANICAL BEHAVIOUR OF ENGINEERING MATERIALS	9	+	0

Knowledge of various type of hardness testing machines and various types of hardness number linear and non – linear elastic properties – stress and strain curves – yielding and strain hardening toughness- modulus of resilience- bauchinger effect- effect of notches – testing and flaw detection of materials and components.

UNIT II	MATERIALS IN AIRCRAFT CONSTRUCTION-01	9	+	0

Aluminium and its alloys: types and identification. Properties-casting-heat treatment processes-surface treatments Magnesium and its alloys: cast and wrought alloys-aircraft applications, future specification, fabrication problems, special treatments. Titanium and its alloys: application, forming, machining, welding and heat treatment.

UNIT III	MATERIALS IN AIRCRAFT CONSTRUCTION-02	9	+	0

Steels: plain and low carbon steels, various low alloy steels. Aircraft steel specification, corrosion and heat resistant steels, structural applications. Maraging steels: Properties and applications Copper alloys: Monel, K-monel Superalloys: use –Ni base-Co base-Fe base- forging and casting of superalloys -welding, heat treatment.

UNIT IV	ADHESIVE AND SEALANTS FOR AIRCRAFTS	9	+	0

Advantages of bonded structure in airframes, crack arresting-weight saving- technology of adhesive bonding structural adhesive materials- test for bonding structure Typical bonded joints &non destructive tests for bonded joint bonded sandwich structures- materials – methods of construction of honeycombs

UNIT V	NON METALS IN AIRCRAFT CONSTRUCTION	9	+	0

Wood and fabric in aircraft construction and specifications- Glues use of glass, plastics and rubber in aircrafts, introduction to glass and carbon composites

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the properties of aerospace materials.
CO2	**:**	Describe the light alloys and special materials for aircraft construction.
CO3	**:**	Explain the on metallic materials used in aircraft joining
CO4	**:**	Explain the Non metallic materials used in the aircraft industries.

Text Books:

1. H. Buhl, Advanced Aerospace Materials, Springer Verlag, Berlin 1992.

Reference Books:

1. Balram Gupta et.al Aerospace Materials Vol 1, 2, 3 ARDB, S. Chand & Co. 1996.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	3	3	3	2	0	0	0	0	0	1	2	3	2	2	
CO2	2	1	3	2	0	1	2	3	0	0	2	2	2	3	2	
CO3	2	3	3	3	3	0	1	0	0	0	3	3	3	3	3	
CO4	2	3	3	3	3	0	0	0	0	3	3	3	3	3	3	1
Total	**1.4**	**2**	**3**	**2.2**	**1.6**	**0.2**	**0.6**	**0.6**	**0**	**0.6**	**1.8**	**2**	**2.2**	**2.2**	**2**	**.25**

1- Faintly, 2- Moderately, 3- Strongly

22MTE28	MODELING AND SIMULATION IN MATERIAL PROCESSES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study about available softwares for modelling of different processes.

UNIT I	INTRODUCTION	9	+	0

Introduction to modelling, simulation models and Casting process: modelling of heat transfer, direct heat conduction modelling, one-dimensional and multidimensional inverse modelling, fluid flow and heat transfer model.

UNIT II	CASTING MODELING	9	+	0

Thermodynamics of solidification, metal/mold interfacial heat transfer, deformation and stresses in castings, thermo-mechanical modelling in casting, determination of heat transfer coefficient and air gap width in permanent mould castings, continuous casting and DC casting process.

UNIT III	WELDING AND HEAT TREATMENT SIMULATION	9	+	0

Welding process: weld heat -source models, thermal analysis with-microstructure, transient fluid flow, residual stresses in welds, Heat treatment: metal quenchant, interfacial heat transfer, diffusion model, microstructure model, carburization model, quench crack simulation, creep simulation.

UNIT IV	MODELLING	9	+	0

Modelling of rolling, forming and extrusion processes, Artificial Neural Net works in materials processing, Phase-field modelling and Monte-Carlo simulations.

UNIT V	SOFTWARES	9	+	0

Introduction to commercially available softwares - Solid Cast, FIow Cast, OptiCast, Deform HT, ProCast, Magma Soft, Design of experiments and factorial designs.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Explain the basics of modelling.
CO2	:	Describe the principles in casting modelling.
CO3	:	Know about welding and heat treatment simulation
CO4	:	Identify commercially available softwares for modelling

Text Books:

1.	Modelling in Welding, Hot Powder Forming and Casting (Eds. L. Koarlsson), ASM, MaterialsPark, OH, 1997.
2.	Szekely,J., Evans, J.E .and Brimacombe, J.K., The Mathematical and Physical Modelling of Primary Metal processing Operations, Wiley, 1988.

Reference Books:	
1.	Numerical Recipes: The Art of Scientific Computing, Cambridge Univ. Press, N.Y., 1988.
2.	D.R. Poirier and G.H. Geiger: Transport Phenomena in Materials Processing, TMS, warrendale 1994.
3.	R.I. L. Guthrie: Engineering in Process Metallurgy, Oxford Science Publications (1989)

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3	PSO 4
CO1	0	3	2	1	3	3	2	3	2	2	2	3	3	3	3	
CO2	0	2	2	3	2	2	1	2	2	2	3	2	3	3	3	
CO3	0	2	2	2	2	2	3	2	3	3	3	3	3	2	2	
CO4	0	2	2	2	2	2	1	0	1	1	1	2	3	2	1	1
Total	**0**	**2.2**	**2**	**2**	**2.2**	**2.2**	**1.7**	**1.7**	**2**	**2**	**2.5**	**2.5**	**3**	**2.5**	**2.2**	**.25**

1- Faintly, 2- Moderately, 3- Strongly

22MTE29	WELDING METALLURGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the concepts of different materials joining and allied processes.
2.	To understand the metallurgical aspects of welding.

UNIT I	WELDING METALLURGY PRINCIPLES	9	+	0

Thermal cycles in welding: basic heat transfer equations, temperature distributions and cooling curves, dependence of cooling rate on heat input, joint geometry, preheat and other factors. Comparison of welding processes based on these considerations.

UNIT II	PHYSICAL METALLURGY OF WELDING:	9	+	0

Welding of ferrous materials: Iron-carbon diagram, TTT and CCT diagrams, effects of steel composition, formation of different microstructural zones in welded plain-carbon steels. Welding of C-Mn and low-alloy steels, phase transformations in weld and heat-affected zones, cold cracking, role of hydrogen and carbon equivalent, formation of acicular ferrite and effect on weld metal toughness.

UNIT III	WELDING OF ALLOY STEELS	9	+	0

Welding of stainless steels, types of stainless steels, overview of joining ferritic and martensitic types, welding of austenitic stainless steels, hot cracking, sigma phase and chromium carbide formation, ways of overcoming these difficulties, welding of cast iron.

UNIT IV	WELDING OF NON-FERROUS METALS	9	+	0

Welding of non-ferrous materials: Joining of aluminium, copper, nickel and titanium alloys, problems encountered and solutions. Dissimilar welding: Metallurgical problems – Calculation of dilution – methods of controlling dilution – techniques of dissimilar welding.

UNIT V	WELDABILITY AND TESTS	9	+	0

Concepts of weldability, carbon equivalent, and concept of preheat and post weld heat treatment, cold cracking, and role of hydrogen. Phenomenon of hot cracking, reheat cracking and lamellar tearing. Weldability tests – cold cracking and hot cracking tests. Defects in welded joints: Defects such as arc strike, porosity, undercut, slag entrapment and hot cracking, causes and remedies in each case.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Understand the working principle, merits and demerits of different conventional welding processes.
CO2	**:**	Understand the working principle, merits and demerits of different solid state welding processes.
CO3	**:**	Understand the working principle, merits and demerits of different special welding processes.
CO4	**:**	Understand the working principle and importance of allied processes in metals joining.
C05	**:**	Solve welding heat flow related problems. Learn weldability and welding related problems of different materials.

Text Books:	
1.	Parmar, R.S., –Welding Engineering and Technology‖, Khanna Publishers, New Delhi, 2003.
2.	Lancaster J.F. –Metallurgy of Welding‖, George Allen & Unwin. Boston. 1980.
Reference Books:	
1.	Linnert. G.E. –Welding Metallurgy‖. Vol. 1 and 2. 4th edition. A W S. USA, 1994.
2.	Sindo Kou, Welding Metallurgy, John Wiley & Sons, 1987.
3.	Granjon. H, –Fundamentals of Welding Metallurgy‖, Jaico Publishing House, New Delhi, 1994.
4.	Nadkarni S.V., "Modern Arc Welding Technology", Oxford & IBH Publishing Co., 1988.
5.	Schwartz M.M.,"Metals Joining Manual", McGraw- Hill Inc.,1979.
6.	ASM Metals Handbook, Vol. 6,"Welding Brazing & Soldering", ASM International, Metals park, Ohio, USA, 2001.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	2	2	3	2	0	3	3	2	3	2	3	3	3	
CO2	2	3	2	3	3	2	2	0	2	1	3	2	3	3	3	
CO3	2	2	3	3	2	1	0	0	0	3	3	2	2	2	3	
CO4	2	2	0	0	3	3	3	2	0	2	3	3	3	1	3	
CO5	2	3	3	3	3	0	1	0	1	2	3	2	3	3	3	1
Total	**2**	**2.2**	**2.2**	**2.2**	**2.8**	**1.6**	**1.2**	**1**	**1.2**	**2**	**3**	**2.2**	**2.8**	**2.4**	**3**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE30	FOUNDRY METALLURGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the basic concept of metal casting technology
2.	To apply the concept to produce new materials

UNIT I	SOLIDIFICATION OF METALS AND ALLOYS:	9	+	0

Solidification of Castings, Effect of Solidification Range on Freezing Pattern, effect of Moulding Materials and Cooling Rate on Freezing Pattern, Shrinkage of Casting and Directional Solidification of Castings, Fluidity, Definition, Factors Affecting and Measurement Fluidity.

UNIT II	CAST IRONS	9	+	0

Graphitization, types and Sizes of Graphite for Grey Cast Iron and S.G.Iron, effect of normal elements and Alloying Elements in Cast Irons, Compositional Aspects and Properties of Austenitic Cast Irons, High Silicon Cast Irons, High Chrome Cast Iron and Ni-Hard Cast Irons, Production of S.G Iron, Austempered SG Iron, CG Iron, Malleable Cast Iron and Alloy Cast Irons, brief introduction on Indian and ASTM Standards for Grey Cast Iron and SG Iron.

UNIT III	METALLURGY OF STEELS:	9	+	0

Effect of Alloying Elements on Castability of Steels, Compositional Aspects and Properties of Alloy Steels, Specifications of Cast Steels, Low Alloy Steels and Stainless Steels. Stresses - Origin, Effects and Stress Relieving Operations, Precautions to be taken in Moulding and Melting of Steels, Gating and Riser Design for Steel Casting, Grain Refinement of Steels. Defects in Castings- appearance, their Causes and Remedies.

UNIT IV	METALLURGY OF NON-FERROUS CAST ALLOYS:	9	+	0

Specifications, Composition, Properties and Phase Diagrams of Copper, Aluminium, Magnesium, Zinc Alloys and Nickel base Alloys, Modification and Grain Refinement -Defects in Castings- appearance, their Causes and Remedies.

UNIT V	MELTING PROCEDURE ANDCOMPOSITION CONTROL	9	+	0

Cast Irons Plain Carbon Steels, Stainless Steels, Al Alloys. Mg alloys, Nickel alloys. Zinc alloys and Copper alloys, Slag-Metal Reactions, Desulphurization, Dephosphorisation, inoculation and inoculating techniques-Gases in Metals and Degassing Technique.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the solidification of casting, effect of solidification range, fluidity and factors affecting fluidity
CO2	**:**	Discuss the cast iron categories, their types and different heat treatment methods like graphitization, spherodization etc and denote the ASTM standards for all the varieties
CO3	**:**	Discuss the alloying element effect on the steels and mention the precaution to be taken in moulding and melting of steels
CO4	**:**	Describe the casting methods employed for fabrication of non-ferrous alloys
C05	**:**	Mention the melting procedure that is adopted for the various alloys like steels, stainless steels, discuss the slag-metal reactions

Text Books:	
1.	Heine R W., Loper, C.R.Rosenthal, P.C., "Principles of Metal Casting" ,Tata-McGraw Hill Publishing Co Ltd, New Delhi, 2018.
2.	Beeley,P.R., Foundry Technology, Butterworths, London, 2016.
3.	Srinivasan N K.,"Foundry Engineering", Khanna Tech Publications, New Delhi, 2018.
Reference Books:	
1.	ASM Metals hand Book, Vol 15, "Casting" ASM International, 10th edition, 2001.
2.	Flinn,R.A., Fundamentals of Metal Casting, Addison Wesley Inc., 1983.
3.	Murphy,A.J., Ed., Non Ferrous Foundry Metallurgy, 1984
4.	The Foseco Foundryman's Hand book, Pergamon Press, 10th edition, 1995.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	2	2	3	2	0	3	3	2	3	2	3	3	3	
CO2	2	3	2	3	3	2	2	0	2	1	3	2	3	3	3	
CO3	2	2	3	3	2	1	0	0	0	3	3	2	2	2	3	
CO4	2	2	0	0	3	3	3	2	0	2	3	3	3	1	3	
CO5	2	3	3	3	3	0	1	0	1	2	3	2	3	3	3	1
Total	**2**	**2.2**	**2.2**	**2.2**	**2.8**	**1.6**	**1.2**	**1**	**1.2**	**2**	**3**	**2.2**	**2.8**	**2.4**	**3**	**.2**

1- Faintly, 2- Moderately, 3- Strongly

22MTE31	NUCLEAR MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study about materials required for nuclear applications.

UNIT I	INTRODUCTION	9	+	0

Structure of a nuclear power plant, requirements of reactor materials, fuel materials, plutonium uranium and thorium and their alloys & compounds.

UNIT II	CORE MATERIALS	9	+	0

Core materials: beryllium, graphite, control and shielding materials, magnesium & its alloys, aluminium & its alloys, zirconium & its alloys, austenitic stainless steel; materials for reactor vessel and other components, pearlitic steels, ferritic, chromium stainless steels, copper alloys, titanium and its alloys, coolants used in reactors: radiation embrittlement, corrosion of reactor materials, mechanical properties of materials.

UNIT III	REACTOR INSTRUMENTATION	9	+	0

Reactor Instrumentation — general considerations — Reactor Nuclear Instrumentation systems — an overview — pressurized water nuclear instrumentation, boiling water reactor nuclear instrumentation, Encore detectors, self-powered detectors, detectors based on beta decay, detectors based on secondary electrons from gamma decay.

UNIT IV	NUCLEAR TECHNIQUES FOR MATERIAL ANALYSIS	9	+	0

Nuclear techniques for materials analysis — basic principles of materials analysis, basic requirements for the technique, nuclear techniques for elemental analysis, main nuclear processes useful for materials analysis, the quantitative estimate, Rutherford back scattering (RBS) and elastic recoil detection analysis(ERDA). Nuclear reaction analysis — principle of the technique and required instrumentation, nuclear reactions suitable for nuclear reaction analysis, neutron activation analysis. PIXE and XRF techniques.

UNIT V	NUCLEAR WASTE MANAGEMENT	9	+	0

Nuclear Waste Management: Introduces scientific and engineering aspects of the management of spent fuel, reprocessed high-level waste, low-level wastes, and decommissioning wastes. Characteristics and classification of nuclear wastes and waste forms. Fundamental processes and governing equations of radionuclide transport in the environment. Discussion of performance assessment for repositories. Design principles and evaluation methods for geologic waste disposal systems.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Know about the structure of a nuclear power plant
CO2	**:**	Identify the reactor core materials
CO3	**:**	Classify various reactor vessel materials
CO4	**:**	Identify corrosion of reactor materials and mechanical properties of materials.
CO5	**:**	Understand the waste management of nuclear materials.

Text Books:

1.	V.Gerasimov& A. Monakhov, Nuclear Engineering Materials, Mir Publishers, Moskow, 1983.
2.	D.S.Clark& W.R Varney, Physical Metallurgy for engineers, East West Press, New Delhi, 1987
Reference Books:	
1.	C.M. Srivatsava & C.Srinivasan, Science of engineering Materials, 1997, New Age International.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	3	3	2	2	2	2	0	1	1	1	2	1	
CO2	2	3	3	3	2	3	3	2	2	0	2	1	3	2	1	
CO3	1	0	1	2	2	2	1	1	1	0	1	2	2	2	2	
CO4	2	2	2	3	3	2	2	0	0	0	2	2	2	2	2	1
CO5	2	2	2	1	3	3	2	0	1	0	2	2	2	2	2	1
Total	**1.7**	**2**	**2.2**	**2.7**	**2.5**	**2.2**	**2**	**1.2**	**1.2**	**0**	**1.5**	**1.5**	**2**	**2**	**1.5**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MTE32	INTRODUCTION TO INSTRUMENTATION	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To acquire basic knowledge on measurements using different tools and skills to implement measurement techniques to control the system.

UNIT I	GENERAL CHARACTERISTICS OF A MEASUREMENT SYSTEM	9	+	0

Three stages generalized measurement system(sensing and modifying and terminative stages) Sensors and transducers - displacement and velocity transducers - potentiometer strain gauge LVDT - variable inductance transducers, capacitance transducers - Static and dynamic characteristics - Errors in measurement - Error analysis and classification - statistical treatment of data.

UNIT II	GEOMETRICAL MEASUREMENT	9	+	0

Linear measurements- limit gauges (types and design) - mechanical Comparators, slip gauge, Instruments for angular measurement - vernier and optical protractors, Sine bar. Flatness, parallelism and roundness measurement, Measurement of surface finish: direct and indirect methods.

UNIT III	FORCE, TORQUE AND STRAIN MEASUREMENT	9	+	0

Elastic elements for force measurement, torque measurements, electrical resistance. Strain gauges and measuring circuit, temperature compensation, strain gauge rosettes. Instrument calibration - calibration standards - test procedures.

UNIT IV	TEMPERATURE AND PRESSURE MEASUREMENT	9	+	0

Temperature scales, thermometers, thermocouples, resistance thermometers, thermisters, pyrometers. Manometers, mechanical pressure sensors - electrical pressure measuring devices, pressure transmitters- low and vacuum pressure measurement systems.

UNIT V	MICRO PROCESSOR AND CONTROLS	9	+	0

Basics of open loop and closed loop system, classification of variables, ON/OFF, P, PI, PID controllers and their applications. Introduction to Micro Processor and its architecture. Instruction sets.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Understanding the general characterization of a measurement system
CO2	**:**	Select Tools suitable for linear, angular and surface measurements
CO3	**:**	Understanding force, torque and strain measurements
CO4	**:**	Choose instruments for different temperature and pressure measurements.
CO5	**:**	Understanding the basics of microprocessors and micro controllers

Text Books:	
1.	Radhakrishnan V.R., Instrumentation and control for the Chemical, Mineral and Metallurgical processes, Allied publishers pvt. limited, New Delhi 1997
2.	Beckwith T.G. and Buck N.L., Mechanical Measurements, Addition Wesley Publishing Company Limited, 1995.
Reference Books:	
1.	Rangan Mani. and Sharma, Instrumentation, Tata McGraw Hill Publications Co. Ltd., New Delhi, 1985.
2.	Jain R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1984.
3.	Microprocessor Architecture, Programming, and Applications with the 8085, Ramesh S Gaonkar Penram International Publications (Pvt) Ltd, 2013.
4.	Nakra B.C., Theory and Applications of Automatic Controls, New Age International (Pvt) limited Publishers, 1998.
E- references	
1.	https://nptel.ac.in/courses/112106138/

CO PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	1	1	1	2	0	0	0	0	0	1	1	3	2	1	
CO2	2	1	1	1	3	0	0	0	0	0	1	2	2	2	2	0
CO3	1	1	1	2	2	0	0	0	0	0	1	1	3	3	3	0
CO4	1	1	1	1	2	0	0	0	0	0	1	1	2	2	1	
CO5	2	1	1	1	0	0	0	0	0	0	1	2	3	2	1	1
Total	**1.4**	**1**	**1**	**1.4**	**1.3**	**0**	**0**	**0**	**0**	**0**	**1**	**1.3**	**2.6**	**2.2**	**1.6**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

OPEN ELECTIVE COURSES OFFERED TO OTHER DEPARTMENTS

22MTOE01	FOUNDRY AND WELDING TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the basic concepts of metal casting technology and to apply them to produce of new materials.
2.	To know the concepts of different materials joining technology and emphasis on underlying science and engineering principle of every processes.

UNIT I	MOULDING MATERIALS AND PATTERNS	9	+	0

Introduction to foundry operations, patterns - functions, types, allowances, selection of pattern materials, colour codes, core boxes, moulding practice, ingredients of moulding sand and core sand, Testing of Moulding sands. Sand preparation, Sand reclamation in foundries

UNIT II	MOULDING AND CASTING TECHNIQUES	9	+	0

Sand moulding: green sand moulding, dry sand moulding, skin dry sand moulding, shell moulding, carbon- di-oxide process, permanent mould casting, die casting, centrifugal casting, , investment casting, squeeze casting, full mould process, Rheocasting, Thixo casting.

UNIT III	MELTING PRACTICE	9	+	0

Melting practice and special precautions for steels, alloy steels, cast irons, aluminium alloys, copper alloys and magnesium alloys, Cleaning and repair of castings. Casting defects and remedies

UNIT IV	WELDING AND OTHER JOINING PROCESSES	9	+	0

Classification of welding processes- oxy-acetylene welding, arc welding-manual, submerged arc welding, gas tungsten arc and gas metal arc welding, electro slag and electro gas welding. Brazing, soldering and cutting processes

UNIT V	SPECIAL WELDING PROCESSES	9	+	0

Principle, equipment, process variables, merits, limitations and applications of Electron beam, plasma arc and laser beam welding processes. Friction, friction stir welding, ultrasonic explosive and diffusion welding.

Total (45+0) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Discuss the alloying element effect on the steels and mention the precaution to be taken in moulding and melting of steels.
CO2	**:**	Mention the melting procedure that is adopted for the various alloys like steels, stainless steels, discuss the slag-metal reactions
CO3	**:**	Understand and describe the gas and arc Welding processes such as Fusion welding process, Arc welding-manual process and Gas metal arc welding etc. and their heat sources.
CO4	**:**	Describe the Brazing, Soldering and cutting processes and their advantages, limitations and applications.
CO5	**:**	Explain the pressure welding processes such as cold, hot pressure welding, friction, friction stir welding processes, and special welding process such as Electron beam, plasma arc and laser beam welding.

Text Books:

1.	Heine R W., Loper, C.R.Rosenthal, P.C.,"Principles of Metal Casting",Tata-McGraw Hill Publishing Co Ltd, New Delhi, 2008.
2.	Srinivasan N K.,"Foundry Engineering", Khanna Tech Publications, New Delhi, 2005.
3.	Parmar, R.S., –Welding Processes and Technology‖, 2nd edn. Khanna Publishers, New Delhi, 2001

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4.	Srinivasan N K ,"Welding Technology", Khanna Publications, Delhi, 2000
Reference Books:	
1.	Beeley P R., "Foundry Technology", Butterworths, London, 1982.
2.	Howard B. Cary, "Modern Welding Technology", Prentice Hall, New Jersey, USA, 1998.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	0	0	2	2	0	0	0	0	0	1	2	3	2	2	
CO2	1	1	1	2	1	0	0	0	0	0	2	1	3	3	3	
CO3	1	2	2	2	3	0	0	0	0	0	1	2	2	2	3	
CO4	1	2	3	2	3	0	0	1	1	0	2	1	3	2	3	
CO5	1	1	2	1	0	0	0	0	0	2	1	3	3	3	1	1
Total	**1**	**1.2**	**1.6**	**1.8**	**1.8**	**0**	**0**	**0.2**	**0.2**	**0.4**	**1.4**	**1.8**	**2.8**	**2.4**	**2.4**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

1.

22MTOE02	SURFACE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. Analyze the various concepts of surface engineering and comprehend the design difficulties

UNIT I	TRIBOLOGY AND PLATING PROCESSES	9	+	0

Introduction to tribology, Wear: Types of wear - adhesive, abrasive, oxidative, corrosive, erosive and trotting wear, roles of friction and lubrication and wear testing. Plating Processes: Fundamentals of electrode position, plating of nickel, chromium, tin and copper, pulsed plating, hydrogen embrittlement, plating adhesion, electroless plating, electrochemical conversion coating, selective plating for repair, plating properties, hard anodizing.

UNIT II	HARD FACING PROCESSES	9	+	0

SMAW, GTAW, GMAW, FCAW, SAW, PAW, Oxy-Acetylene Welding, Furnace fusing, Thermal-spray, name spray processes - HVOF, Detonation gun and jet kote processes, hard facing consumables.

UNIT III	SPECIAL DIFFUSION PROCESSES	9	+	0

Principle of diffusion processes - Boriding, Aluminising, Siliconising, Chromising - Selection of diffusion processes - Characteristics of diffused layer - micro structure and micro hardness evaluation - properties and applications.

UNIT IV	THIN FILM COATINGS	9	+	0

Physical vapour deposition processes - Thermal evaporation - sputter coating - Ion plating - Chemical vapour deposition - reactive sputtering - TiC, TiN, Alumina, CBN, Diamond and DLC coatings. Structure, properties and applications.

UNIT V	HIGH ENERGY MODIFICATION AND SPECIAL PROCESSES	9	+	0

Electron beam hardening, glazing, Laser beam hardening glazing ion implantation, Composite surface created by laser and Electron beam. Surface cements, Wear tiles, Electro spark deposition, fused carbide cloth, thermal / chemical. Ceramic coatings, centrifugal cast wear coatings, Wear sleeves and Wear plates.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Understand the influence of the tribological characteristics and improvise the material property by the plating process
CO2	**:**	Explain the various hard facing processes
CO3	**:**	Enhancement of surface properties with diffusion of foreign atoms into the outer surface of the material such as boriding, aluminizing, etc
CO4	**:**	Describe the various vapour deposition processes of different materials on the surface of native materials using the Chemical, Physical and Thermal vapour deposition processes.
CO5	**:**	Describe the Modern processes and high energy processes like electron beam hardening, laser beam hardening.

Text Books:

1. Chattopadhyay R., Surface Wear: Analysis, Treatment, Prevention, ASM International, USA, 2001
2. Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prentice Hall, Englewood Cliff, 1990.

Reference Books:

1. ASM Metals Handbook, Vol 5: Surface Engineering, ASM International, Ohio, 1994.

1.

2.	Ernest Rabinowicz, Friction and Wear of Materials, 2nd ed., John Wiley & Sons, NY, 1995.
3.	Davis J.R., Surface Engineering for Corrosion and Wear resistance, ASM International, 2001.

CO PO MAPPING

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	2	0	1	2	0	0	0	0	0	1	2	2	2	1	
CO2	2	3	2	1	3	1	0	2	1	0	1	2	2	3	1	
CO3	0	1	1	0	2	1	2	3	1	0	1	2	1	1	2	
CO4	1	2	3	3	2	1	0	0	0	1	3	2	1	1	0	
CO5	2	1	1	1	2	0	1	0	2	1	1	0	0	0	1	1
Total	**1.2**	**1.8**	**1.4**	**1.2**	**2.2**	**0.6**	**0.6**	**1**	**0.8**	**0.4**	**1.4**	**1.6**	**1.2**	**1.4**	**1**	**.2**

1- Faintly, 2- Moderately, 3- Strongly

1.

22MTOE03	DESIGN AND SELECTION OF MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know different types of materials and properties and to select better materials for Different applications.

UNIT I	DESIGN PROCESS	9	+	0

Materials in Design, Evolution of Engineering Materials, Design process, Types of design, Design flow chart-tools and material data, Interaction between Function, Material, Shape and Process

UNIT II	MATERIAL PROPERTIES	9	+	0

Revision of engineering materials and properties, Material properties interrelationship charts such as Young"s modulus-density, Strength-density, Young"s modulus-Strength, wear rate-hardness, Young's modulus – relative cost, strength relative cost and others.

UNIT III	MATERIAL SELECTION	9	+	0

Materials selection, selection strategy: material attributes, attribute limits, selection procedure, computer aided selection, structural index; Case studies: table legs, flywheel, springs, pressure vessels, bearings, heat exchangers, airframes, ship structures, automobile structures

UNIT IV	PROCESSES AND PROCESS SELECTION	9	+	0

The processes: shaping, joining and finishing, Process selection, ranking processes, cost, computer based process selection, Case studies: fan, pressure vessel, optical table, economical casting.

UNIT V	MULTIPLE CONSTRAINS AND OBJECTIVES	9	+	0

Selection under multiple constraints, conflicting objectives, penalty-functions, exchange constants, Case studies: connecting rods for high performance engines, windings of high field magnets.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Explain the physical, chemical and electrical properties of metals and their selection criterion
CO2	**:**	Suggest the materials for corrosion and wear resistance process.
CO3	**:**	Suggest the materials for auto and aero industry.
CO4	**:**	Suggest the materials for high and low temperature process.
CO5	**:**	Suggest the materials for nuclear and mining industries.

Text Books:

1.	Michael F. Ashby, Materials Selection in Mechanical Design, third edition, Butterworth-Heinemann, 2005
2.	J. Charles, F.A.A. Crane, J. A.G. Furness, Selection and Use of Engineering Materials, third edition, Butterworth-Heinemann, 2006

Reference Books:

1.	ASM Metals Handbook, Vol.20: Materials Selection and Design, ASM International,1997
2.	Myer Kutz, Handbook of Materials Selection, John Wiley & Sons, Inc., New York, 2002

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CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	0	0	1	0	2	0	0	0	0	0	1	0	2	3	1	
CO2	1	1	3	3	2	0	2	0	0	1	2	0	2	2	2	
CO3	2	2	2	1	2	1	1	1	1	1	3	1	1	0	0	
CO4	1	0	0	0	3	2	0	1	2	2	1	1	1	0	0	
CO5	0	2	1	2	2	1	3	1	1	1	0	1	0	1	3	1
Total	**0.8**	**1**	**1.4**	**1.2**	**2.2**	**0.8**	**1.2**	**0.6**	**0.8**	**1**	**1.4**	**0.6**	**1.6**	**1.2**	**1.2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

1.

22MTOE04	NANOSCIENCE AND TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study about nanomaterials and its application

UNIT I	INTRODUCTION	9	+	0

Definition, Length scales, surface area/volume ratio of micron to nanoscale materials, Importance of Nanoscale and Technology, Top down and bottom up approaches, Classification of nanomaterials, Properties of selected nanomaterials including carbon nanotubes (CNT), graphene, metal nanoparticles, clays, nanowires, quantum dots (QDs), effect of size on thermal, mechanical and electrical properties of nanomaterials.

UNIT II	SYNTHESIS OF NANOMATERIALS	9	+	0

Fabrication of Nanomaterials: Top-down approaches-lithography, Mechanical alloying milling, Severe Plastic Deformation, Bottom-up approaches-chemical vapour deposition, physical vapour deposition, atomic layer deposition (ALD), and Sol-gel method, Synthesis and purification of CNT, synthesis of expanded graphite (EG) or graphene.

UNIT III	NANOCOMPOSITES	9	+	0

Fabrication of nanocomposites: Fabrication of Clay-rubber, Clay-polymer, CNT-polymer, EG-polymer, magnetic particle-polymer, CNT-metal, trade off between the composites and nanocomposites etc. Consolidation of nanomaterials.

UNIT IV	CHARACTERIZATION OF NANOMATERIALS	9	+	0

Characterization of Nanomaterials:, X-ray diffraction (XRD), Dynamic Light Scattering, Scanning electron microscope (SEM), Transmission Electron Microscope (TEM), UV-Visible spectroscopy, Scanning probe microscopy- Atomic force microscope (AFM) and scanning tunneling microscope (STM). Nanoindentation.

UNIT V	APPLICATIONS OF NANOMATERIALS	9	+	0

Applications of nanomaterials: Electronics, structural, biomedical, sensors nanofluids, optical, magnetic, biomedical fields, solar cells, LED, LCD, electrically conducting polymers, batteries, fuel cells, SMART Materials. Environmental and health issues related to nanomaterials.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Define and differentiate engineering materials on the basis of structure and properties for engineering applications.
CO2	**:**	Various applications of nanomaterials
CO3	**:**	Select a material for a particular application based on the requirements.
CO4	**:**	Predict and apply the necessary protection mechanism to prevent corrosion
CO5	**:**	Understanding details about SEM,TEM

Text Books:

1.	B.S. Murty, P. Shankar, Baldev Raj, B BRath, James Murday, Textbook of Nanoscience and Nanotechnology, University Press (I) Pvt. Ltd., 2013.
2.	Bharat Bhushan (Ed), Springer Handbook of Nanotechnology, Springer-Verlag Berlin Heidelberg, 2004

Reference Books:

1.

1.	Charles P Poole and Frank J Owens, –Introduction to Nanotechnology‖, John Wiley and Sons, New York, 2003.
2.	Michael Wilson, KamaliKannagara and Geoff Smith, ―Nanotechnology: Basic Science and Emerging Technology‖, Chapman and Hall, New York, 2002.
3.	Pradeep T, –Nano: The Essentials‖, Tata McGraw Hill, New Delhi, 2007.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3	PSO4
CO1	1	2	0	1	2	0	0	0	0	0	1	2	2	2	1	
CO2	2	3	2	1	3	1	0	2	1	0	1	2	2	3	1	
CO3	0	1	1	0	2	1	2	3	1	0	1	2	1	1	2	
CO4	1	2	3	3	2	1	0	0	0	1	3	2	1	1	0	
CO5	2	1	1	1	2	0	1	0	2	1	1	0	0	0	1	1
Total	**1.2**	**1.8**	**1.4**	**1.2**	**2.2**	**0.6**	**0.6**	**1**	**0.8**	**0.4**	**1.4**	**1.6**	**1.2**	**1.4**	**1**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

1.

22MTOE05	MATERIALS FOR AUTOMOTIVE APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To give an overview of material properties, use of materials selection chart and considerations for material selection
2.	To impart knowledge about the basis of materials selection
3.	To give insight about the factors that influence materials selection for engines and transmission system
4.	To instill the knowledge required for the selection of materials for automotive structures
5.	To render the basis of material selection for electronics devices in the automobile.

UNIT I	ENGINEERING MATERIALS AND THEIR PROPERTIES	9	+	0

Classes of engineering materials - the evolution of engineering materials, Definition of materials properties, Displaying material properties using materials selection charts, Forces for change in materials selection and design, Materials and the environment. Selection of materials for automotive, aerospace, marine and defence applications.

UNIT II	BASIS OF MATERIAL SELECTION	9	+	0

Selection strategy, Attribute limits and Material indices, structural index Selection procedure: Design process - types of design, design requirements, Function, Material attributes, Shape and Manufacturing processes - Materials processing and design processes and their influence on design, Process attributes, Systematic process selection, Process selection diagrams, Process cost, Energy consumption for production, Material costs, Availability, Recyclability, Environmental consideration. Computer aided selection.

UNIT III	MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS	9	+	0

Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.

UNIT IV	MATERIALS FOR AUTOMOTIVE STRUCTURES	9	+	0

Materials selection for bearings, leaf springs, chasis& frames, Bumper, shock absorbers, Damping fluid, wind screens, panels, brake shoes, Disc, wheels, differentials , damping and Antifriction fluids, Tyres and tubes.

UNIT V	ELECTRONIC MATERIALS FOR AUTOMOTIVE APPLICATIONS	9	+	0

Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, Temperature sensors for climate control, anti-collision, Anti-fog, Head lamps.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	**:**	Identify the criteria and forces that cause the changes in materials selection.
CO2	**:**	Investigate the influence of structural index, manufacturing process, design and Functional requirements on selection strategies.
CO3	**:**	Recognize the temperature regime, nature of load and property requirements of materials for engines and transmission system.
CO4	**:**	Analyse the various stresses acting on the structural members of automobile under Dynamic loading and select suitable material.
CO5	**:**	Adjudicate the apt material for electronic devices used in automobiles

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Text Books:	
1.	Charles J A and Crane. F A. A., –Selection and Use of Engineering Materials‖, 3rd Edition, Butterworths, London UK, 1996.
2.	Jason Rowe, ―Advanced Materials in Automotive Engineering‖, Wood Head Publishing, 2012.
Reference Books:	
1.	Ahmed E, ―Advanced composite materials for Automotive applications, Wiley, 2013
2.	Don H Wright,‖ Testing Automotive Materials and Components‖, SAE 1993.
3.	Geoff Davis, ― Materials for Automobile bodies‖, Butter Worth Heinemann, 2012
4.	Hiroshi Yamagata, –The Science and Technology of Materials in Automotive Engines‖, Elsvier, 2005
5.	Mstislav A M, Valentin N A, Gleb V M, ―Automotive materials: a handbook for the mechanical engineer‖, NTIS, 1972.

CO PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	0	1	2	0	0	0	0	0	1	2	2	2	1	
CO2	2	3	2	1	3	1	0	2	1	0	1	2	2	3	1	
CO3	0	1	1	0	2	1	2	3	1	0	1	2	1	1	2	
CO4	1	2	3	3	2	1	0	0	0	1	3	2	1	1	0	
CO5	2	1	1	1	2	0	1	0	2	1	1	0	0	0	1	1
Total	**1.2**	**1.8**	**1.4**	**1.2**	**2.2**	**0.6**	**0.6**	**1**	**0.8**	**0.4**	**1.4**	**1.6**	**1.2**	**1.4**	**1**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

1.

HONOURS DEGREE for Metallurgical Engineering Students

VERTICAL 2 : MATERIALS AND PROCESSING

22HMTMP201	ELECTRICAL, MAGNETIC AND OPTICAL MATERIALS	L	T	P	C
		3	0	0	3

Course Objective:

- To study the basic electrical, magnetic and optical properties of different materials.

ELECTRICAL AND DIELECTRIC MATERIALS: (9)

Review of electrical conduction - resistivity and dielectric phenomena - concept of polarization - effects of composition, frequency and temperature on these properties - discussion on specific materials used as conductors (OFHC Copper, Al alloys, Fe-Si alloys, amorphous metals) - discussion on specific materials used as dielectrics (ceramics and polymers) - dielectric loss, dielectric breakdown – ferroelectricity, piezo and pyroelectricity.

MAGNETIC MATERIALS: (9)

Introduction to dia, para, ferri and ferro magnetism - hard and soft magnetic materials - iron-silicon alloys – iron, nickel alloys - ferrites and garnets - (Ag - Mn - Al) alloys - (Cu - Ni- Co) alloy - fine particle magnets - applications of hard and soft magnetic materials - Giant magneto resistance- Nanomaterials

SEMICONDUCTING AND SUPERCONDUCTING MATERIALS: (9)

Review of semiconducting materials - concept of doping - simple and compound semiconductors - amorphous silicon, oxide semiconductors; amorphous semiconductors - FER, MOSFET and CMOS - Concept of superconductivity.

PRODUCTION OF ELECTRONIC MATERIALS: (9)

Review of electronic materials - methods of crystal growth for bulk single crystals - zone melting-refining, leveling - synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques - lithography; production of silicon - starting applications.

OPTICAL PROPERTIES OF MATERIALS: (9)

Introduction to electromagnetic radiation, atomic and electronic interactions with electromagnetic radiation, optical properties of metals, optical properties of nonmetals, opacity and translucency in insulators, color of materials, applications of optical phenomena-luminescence, photoconductivity, lasers, optical fibers in communications

Total : 45 hours

REFERENCES :

1. Raghavan V, Materials Science and Engineering, 4th Edition, Prentice Hall of India, 1998.
2. Pradeep fuley, Electrical, magnetic, and Optical Materials, 1st edition, CRC press, 2010

3. Kittel C, Introduction to Solid State Physics, 6th Edition, Wiley Eastern, New International Publishers, 1997.
4. Dekker A.J, Solid State Physics, MacMillan India, 1995

COURSE OUTCOME:

After the completion of this course, the student will be able to:

CO1. Understand the conducting, semiconducting, superconducting, dielectric, ferro-electric and piezoelectric behavior of materials

CO2. Differentiate between diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, and antiferromagnetic behavior of materials

CO3. Study the effect of composition, structure and temperature on the properties of the materials.

CO4. Understand the working principles of solid state devices, etc.

CO5. Describe the interactions of light with materials and its effects at the interface.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3	PSO4
CO1	1	0	0	2	2	0	0	0	0	0	0	1	2	3	2	2	1
CO2	1	1	1	2	1	0	0	0	0	0	0	2	1	3	3	3	1
CO3	1	2	2	2	3	0	0	0	0	0	0	1	2	2	2	3	1
CO4	1	2	3	2	3	1	0	0	1	1	0	2	1	3	2	3	1
CO5	1	1	2	1	0	0	0	0	0	0	2	1	3	3	3	1	1
Total	1	1.2	1.6	1.8	1.8	0.2	0	0	0.2	0.2	0.4	1.4	1.8	2.8	2.4	2.4	1

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP202	MATERIALS TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Objective:

- To develop an understanding of the basic principles of physical metallurgy and apply those principles to engineering materials.

CONSTITUTION OF ALLOYS AND PHASE DIAGRAMS **(9)**

Phases, solid solutions, compounds - Concept of phase diagram – phases and microconstituents in steels and cast irons – equilibrium and non-equilibrium cooling of various Fe-C alloys – Fe-C Equilibrium diagram - effects of alloying elements and cooling rate on structure and properties of steels and cast irons.

HEAT TREATMENT **(9)**

Introduction to heat treatment; TTT diagram and CCT diagram – hardenability measurement, annealing – normalizing – hardening and tempering – heat treatment atmospheres – quenching media – case hardening techniques.

STEELS **(9)**

Introduction to specifications – plain carbon steels – low alloy and Q and T steels dual phase steels – Ultra high strength steels – maraging steels – HSLA steels – steels for magnetic and electrical applications, processing, properties & applications

STAINLESS STEELS AND CAST IRONS **(9)**

Stainless steels – phase diagrams – effects of chromium and nickel – Ferritic and Austenitic, martensitic, duplex and precipitation hardened stainless steels. Types of Cast Irons- Gray Cast iron, white iron, malleable iron, S.G. Iron and alloy cast irons – physical metallurgy, composition of cast irons, properties and applications. Heat treatment of cast irons.

NON-FERROUS ALLOYS **(9)**

Brasses, bronzes, Cu-Ni alloys – High Strength Al Alloys, Ti alloys, Ni alloys and Mg alloys - Physical metallurgy, composition, properties and applications.

Total : 45 hours

TEXT BOOKS:

1. Raghavan V. “Physical Metallurgy – Principles and Practice”, Prentice Hall of India, 1993.
2. Brick Garden Phillips. “Structure and Properties of Alloys", McGraw Hill, 1976.
3. Flinn. R.A. and Trojan. P.K. “Engineering Materials and their Applications”, 4th Edition, Jaico, 1999

REFERENCES

1. Leslie. W.C., “The Physical Metallurgy of Steels”. McGraw Hill. 1983.
2. Metals Hand book. 10th edition. Volume 2. ASM. 1995.

3. Askeland. D.R. "The Science and Engineering of Materials". PWT Kent Publishing Company, Boston, 1989
4. Pickering F.B. "Physical Metallurgy and Design of Steels". Applied Science Publishers Limited. London.

COURSE OUTCOME:

After the completion of this course, the student will be able to:

- Understand and explain the concept of growth and nucleation of crystal structures and phases in different materials.
- Understand the various heat treatment process and its techniques.
- Describe the different types of steel and alloy steels properties and their applications.
- Discuss the types of stainless steels and cast iron properties and their applications.
- Understand various non-ferrous materials properties and its applications.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3	PSO4
CO1	1	2	0	1	2	0	0	0	0	0	1	2	2	2	1	
CO2	2	3	2	1	3	1	0	2	1	0	1	2	2	3	1	
CO3	0	1	1	0	2	1	2	3	1	0	1	2	1	1	2	1
CO4	1	2	3	3	2	1	0	0	0	1	3	2	1	1	0	1
CO5	2	1	1	1	2	0	1	0	2	1	1	0	0	0	1	1
Total	1.2	1.8	1.4	1.2	2.2	0.6	0.6	1	0.8	0.4	1.4	1.6	1.2	1.4	1	0.6

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP203	POLYMERS AND COMPOSITES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To make the student to acquire knowledge in fundamentals of polymers, bio and inorganic polymers.
- To enable students know about various additives and to make the student to acquire knowledge about polymers meant for various engineering applications and special applications.
- To understand the fundamentals of composite material strength and its mechanical behavior

UNIT I: BIO AND INORGANIC POLYMERS **(9)**

Naturally occurring polymers – starch, proteins, cellulose – Derivatives of cellulose polymers – rayon, cellophane, cellulose acetate, butyrate and nitrate – ethyl cellulose – carboxymethyl cellulose- preparation, properties- application organo metallic polymers - co-ordination polymers - polyamides- Inorganic polymers - phosphorous and nitrogen containing polymers, – silicones - hybrid polymers.

UNIT II: INTRODUCTION TO ADDITIVES **(9)**

Introduction-Technological Requirements-Classification-Chemistry and Mechanism- Selection Criteria-General effect on Properties-Evaluation and functions of additives – Antioxidants - Stabilizers (Heat & UV)-carbon black-its types, manufacture and characteristics- mechanism of reinforcement of a rubber, non black fillers in rubbers

UNIT III: POLYMERS IN ENGINEERING & SPECIALITY POLYMERS **(9)**

Polymers for electrical and electronics applications - polymers for high temperature applications - polymer blends, alloys and liquid crystals - polymers in lithography and water treatment - polymers for biomedical applications. Liquid crystalline polymers (LCP) - conducting polymers - heat resistant polymers - photosensitive polymers and polymers as coating additives - polymers in miscellaneous specialty applications.

UNIT IV: COMPOSITES – INTRODUCTION & LAMINA CONSTITUTIVE EQUATIONS **(9)**

Definition –Need – General Characteristics, Applications. Fibers – Glass, Carbon, Ceramic and Aramid fibers. Matrices – Polymer, Graphite, Ceramic and Metal Matrices

– Characteristics of fibers and matrices. Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness..

UNIT V: **LAMINATES & TESTING OF COMPOSITES**	**(9)**

Mechanics of composites - Fracture and damage mechanics - laminates –delamination - Measurement of physical and mechanical properties: density- fibre volume fraction-void content, test for tensile-compression- flexural in fiber direction –Non- Destructive Evaluation Methods for Composites – Visual Inspection, Ultrasonic Methods, X-Ray Imaging.

Total :	**45 hours**

TEXT BOOKS:

1. H.F. Mark (Ed), Encyclopedia of Polymer Science and Engineering, Wiley – Interscience, New York, 1991

2. Manas Chanda, Salil K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, CRC Press, 2008.

3. Robert William Dyson, Specialty Polymers, 2nd ed., Springer Verlag, 2011.

4. S.T.Peters, "Handbook of Composites", Chapmun & hall, 2nd Edition 1998.

5. F.L. Matthews and R.D. Rawlings, 'Composite materials: engineering and science', Chapman and Hall, 1994.

COURSE OUTCOMES:

Upon completing this course, the students

- Will understand the utility of bio and inorganic polymers
- Will understand about various additives for rubbers and plastics – their needs, their functions and the mechanisms by which they act
- Will understand the uses of polymers in various fields of engineering and methodically discuss the applications of specialty polymers.

• Will familiarize about the fibers, matrices and lamina constitutive equations in composites

• Will develop the knowledge about laminates and testing of composites

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3	PSO4
CO1	**0**	**0**	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**3**	**1**	
CO2	**1**	**1**	**3**	**3**	**2**	**0**	**2**	**0**	**0**	**1**	**2**	**0**	**2**	**2**	**2**	
CO3	**2**	**2**	**2**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**3**	**1**	**1**	**0**	**0**	**1**
CO4	**1**	**0**	**0**	**0**	**3**	**2**	**0**	**1**	**2**	**2**	**1**	**1**	**1**	**0**	**0**	
CO5	**0**	**2**	**1**	**2**	**2**	**1**	**3**	**1**	**1**	**1**	**0**	**1**	**0**	**1**	**3**	
Total	**0.8**	**1**	**1.4**	**1.2**	**2.2**	**0.8**	**1.2**	**0.6**	**0.8**	**1**	**1.4**	**0.6**	**1.6**	**1.2**	**1.2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP204	DESIGN AND SELECTION OF MATERIALS	L	T	P	C
		3	0	0	3

Course Objective:

To know different types of materials and properties to select better materials for different applications.

UNIT 1 **(9)**

Technologically important properties of materials - Physical, chemical, mechanical, thermal, optical, environmental and electrical properties of materials. Material property charts - Modulus – density, strength-density, fracture toughness-strength.

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UNIT 2 **(9)**

Types of design, Design tools and materials data – Materials and shape – microscopic and micro structural shape factors – limit to shape efficiency Comparison of structural sections and material indices – case studies.

UNIT 3 **(9)**

Service, Fabrication and economic requirements for the components – Methodology for selection of materials – Collection of data on availability, requirements and non-functional things- its importance to the situations – case studies.

UNIT 4 **(9)**

Classifying process - systematic selection of process – Selection charts - Ranking of processes – case studies - Influence of manufacturing aspects and processing route on properties of materials and its influence on selection of materials.

UNIT 5 **(9)**

Selection of materials for automobile, nuclear, power generation, aerospace, petrochemical, electronic and mining industries.

Total : 45 hours

TEXT BOOKS :

1. M.F. Ashby, “Materials Selection in Mechanical Design’ – Third edition, Elsevier publishers, Oxford, 2005.
2. Gladius Lewis, “Selection of Engineering Materials", Prentice Hall Inc, New Jersey, USA, 1995.
3. Charles.J.A. andCrane,F.A.A., "Selection and Use of Engineering Materials", Butterworths, London, UK, 1989.
4. Angelo P C and Ravisankar B, “Introduction to Steel- Processing, Properties and Applications”, CRC Press, Taylor & Francis Group, Florida, U.S.A., 2019.
5. ASM Handbook. “Materials Selection and Design”, Vol.20- ASM Metals

Park Ohio. USA, 1997.

COURSE OUTCOMES: Upon completion of the course, the student will be able to:

CO1. Understand the types of materials and properties
CO2. Know the different methods for materials selection
CO3. Know the different methods for process selection
CO4. Selection of materials for Specific engineering applications and processes.
CO5. Suggest the materials for nuclear and mining industries.

CO/ PO	PO 1	PO 2	P O3	P O4	P O5	P O6	P O7	P O8	P O9	PO 10	PO 11	PO 12	PSO 1	PSo2	PSO 3	PSO 4
CO1	1	2	0	1	2	0	0	0	0	0	1	2	2	2	1	
CO2	2	3	2	1	3	1	0	2	1	0	1	2	2	3	1	
CO3	0	1	1	0	2	1	2	3	1	0	1	2	1	1	2	
CO4	1	2	3	3	2	1	0	0	0	1	3	2	1	1	0	1
CO5	1	2	3	3	2	1	0	0	0	1	3	2	1	1	0	1

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP205	HIGH TEMPERATURE MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on requirements for materials for high temperature use and the Behavior of materials at high temperatures.

Unit I	INTRODUCTION	9

Need for high temperature materials, historical development of high temperature materials, and equipment for material testing at high temperatures, requirements of high temperature materials (mechanical properties and preferred microstructure, environmental resistance, erosion and wear).

Unit II	PRINCIPLES FOR HIGH TEMPERATURE STRENGTHENING	9

Metallic materials (solid solution strengthening, precipitation strengthening, dispersion strengthening grain size and grain boundary effects) Ceramic materials (phase control, defect tolerance, thermal shock resistance) composite materials.

Unit III	CREEP AND STRESS RUPTURE	9

Creep test, stress rupture test, structural changes during creep, mechanism of creep deformation, fracture at elevated temperatures - fatigue interaction: Modes of high temperature fracture and fatigue fracture, creep-fatigue interaction (creep accelerated by fatigue), fatigue-creep interaction (fatigue accelerated by creep), micro-mechanism of damage, fracture criterion for creep fatigue, creep-fatigue failure mapping, creep-fatigue testing, influence of environment.

Unit IV	MATERIALS FOR HIGH TEMPERATURE	9

Metals / alloys, super alloys, steels, titanium and its alloys, ceramics (Alumina, Zirconia, Silicon carbide, Silicon nitride, Glass ceramics) composites (Metal matrix composites, ceramic matrix composites) carbon – carbon composites.

Unit V	COATINGS FOR PROTECTION AGAINST HIGH TEMPERATURE CORROSION AND EROSION AND APPLICATIONS	9

Corrosion / oxidation resistant coatings (metallic, ceramic, rare and reactive metal reinforced coatings), high temperature erosion and wear, thermal barrier coats - Applications in industry, aerospace, defense and nuclear industry.

Total = 45 hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	Understand the materials behavior at high temperature.
CO2	Discuss the oxidation mechanisms of metallic and ceramic materials.
CO3	Explain mechanisms of creep, thermal fatigue.
CO4	Classify materials for high temperature applications.
CO5	Select the materials and/or coatings for high temperature applications.

Reference Books:

1. Meetham, G. W., Van de Voorde, M. H., "Materials for High Temperature Engineering Applications (Engineering Materials)", 1st 2000 Ed., Springer., 2013.

2.	Chan R. W., “High temperature structural materials”, Chapman & Hall, 1996.
3.	Reed R. C., “The Super-alloys: Fundamentals and Applications”, Cambridge University Press, 2008.
4.	Birks, N., Meier, G. H., and Pettit, F. S., “Introduction to the High Temperature Oxidation of Metals”, Cambridge University Press, 2009.
5.	Bose, S., “High Temperature Coatings” , Butterworth-Heinemann, 2007.

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**2**	**1**	**2**	**2**	**3**	**2**	**0**	**3**	**3**	**2**	**3**	**2**	**3**	**3**	**3**	
CO2	**2**	**3**	**2**	**3**	**3**	**2**	**2**	**0**	**2**	**1**	**3**	**2**	**3**	**3**	**3**	
CO3	**2**	**2**	**3**	**3**	**2**	**1**	**0**	**0**	**0**	**3**	**3**	**2**	**2**	**2**	**3**	
CO4	**2**	**2**	**0**	**0**	**3**	**3**	**3**	**2**	**0**	**2**	**3**	**3**	**3**	**1**	**3**	**1**
CO5	**2**	**3**	**3**	**3**	**3**	**0**	**1**	**0**	**1**	**2**	**3**	**2**	**3**	**3**	**3**	**1**
Total	**2**	**2.2**	**2.2**	**2.2**	**2.8**	**1.6**	**1.2**	**1**	**1.2**	**2**	**3**	**2.2**	**2.8**	**2.4**	**3**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP206 PROCESSING OF NON METALLIC MATERIALS

L P T C

3 0 0 3

COURSE OBJECTIVES:

- To introduce the student to the range of non-metallic materials available for engineering.
- To get an exposure to the techniques associated with the synthesis and processing of these materials.

UNIT - I INTRODUCTION TO NON METALLIC MATERIALS 9

Definition and classification of nonmetallic materials, comparison of properties of metals and nonmetallic materials. Introduction to Polymers: Concept of polymers, types of polymers reactions, Mechanism of polymerization, Ceramics: Introduction, classification, structure, and applications of ceramics. Glasses: Introduction, classification, structural features and applications of glasses. Composites: Introduction, classification, and applications of composite materials.

UNIT – II PROCESSING OF POLYMERS 9

Extrusion - single screw and twin screw extrusion, Film blowing, Pipe extrusion, extrusion of sheet, Calendaring, Thermoforming. Molding - Injection molding, Blow molding, Compression molding, Injection stretch blow molding, Resin transfer molding, Gas and water assisted injection molding, Reaction Injection Molding, Pultrusion, Pull winding.

UNIT – III PROCESSING OF CERAMICS 9

Powder Preparation Techniques: Sol-gel technology – Precipitation, Coprecipitation and Hydrothermal precipitation techniques. Preparation of Al_2O_3, ZrO_2, SiC, Si_3N_4 BN & B_4C.

Ceramic Processing Techniques: Hot Pressing, Hot Isostatic Pressing, (HIP). Spark Plasma Sintering. Sintering, Sinter / HIP, Injection moulding, Slip casting, Tape casting, Gel casting, Extrusion.

UNIT – IV PROCESSING OF GLASSES 9

Glass Melting Process: Process leading to glass formation – Volatilization – Effect of pre-sintering-refining - Physico - chemical reactions taking in glass batch- Homogenization and

devitrification - Tempering – Annealing. Glass Forming Process: Hand operation – Laboratory ware and Bulb making, Tube making – Danner process – Up draw process, down draw process, pressing – Hand press, Flat glass - Pitts berg process, Foucault process, Float process.

UNIT – V PROCESSING OF COMPOSITES 9

Processing of PMC: Processing of Thermoset Matrix Composites - Hand Lay-Up and Spray Techniques, Filament winding, Pultrusion, Resin Transfer Molding (RTM), Bag molding processes. Processing of Thermoplastic Matrix Composites - Film Stacking Technique, Diaphragm Forming, Commingled fibers, Injection molding, Sheet Molding Compound (SMC). **Processing of CMC** Cold Pressing & Sintering, Hot Pressing, Reaction Bonding Processes, Infiltration, Directed Oxidation, In Situ Chemical Reaction Technique, Sol-Gel, Polymer Infiltration & Pyrolysis.

Total = 45 hours

COURSE OUTCOMES:

After completing this course, the students will be able to:

- list the prominent non-metallic materials available for engineering applications.
- understand the various processing techniques of polymers.
- understand the various manufacturing techniques of ceramic materials.
- Indicate the various glass melting and forming techniques.
- Understand the various manufacturing techniques of PMCs and CMCs.

TEXT BOOKS:

1. Textbook of Polymer Science; Fred W. Billmeyer, Wiley 2007
2. Introduction to Ceramics; Kingery, Bowen, Uhlman. Wiley India Pvt Limited, 2012
3. Composite Materials: Science and Engineering; Krishan K. Chawla, Springer, 2012

REFERENCE BOOKS:

1. W.S. Smith: Principles of Materials Science and Engineering, McGraw-Hill.
2. Manufacturing Processes for Engineering Materials : S. Kalpakjian, 3rd edition Addison - Wesley, 1997
3. Plastic Materials and Processing : A. Brent Strong, Prentice Hall, ISBN 0-13-021626-7

4. Handbook of Glass Manufacture - F.V. Tooley

5. Composite Materials: Engineering and Science: F.L. Mathews and R.D. Rawlings, CRC press, 084930251X

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**2**	**1**	**2**	**2**	**3**	**2**	**0**	**3**	**3**	**2**	**3**	**2**	**3**	**3**	**3**	
CO2	**2**	**3**	**2**	**3**	**3**	**2**	**2**	**0**	**2**	**1**	**3**	**2**	**3**	**3**	**3**	
CO3	**2**	**2**	**3**	**3**	**2**	**1**	**0**	**0**	**0**	**3**	**3**	**2**	**2**	**2**	**3**	
CO4	**2**	**2**	**0**	**0**	**3**	**3**	**3**	**2**	**0**	**2**	**3**	**3**	**3**	**1**	**3**	
CO5	**2**	**3**	**3**	**3**	**3**	**0**	**1**	**0**	**1**	**2**	**3**	**2**	**3**	**3**	**3**	**1**
Total	**2**	**2.2**	**2.2**	**2.2**	**2.8**	**1.6**	**1.2**	**1**	**1.2**	**2**	**3**	**2.2**	**2.8**	**2.4**	**3**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP207	BIOMATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. Learn characteristics and classification of Biomaterials
2. To understand the importance of Biomaterials in medical applications

UNIT I	INTRODUCTION TO BIOMATERIALS	9	+	0

Definitions, Types of materials – Ceramics, metals, polymers and composites. Basic properties of materials - Tensile testing, Compressive testing, Shear testing, Bend or flexural tests, Ductile and brittle fracture, Stress concentration, Fracture toughness and Fatigue.

UNIT II	METALLIC AND CERAMIC MATERIALS	9	+	0

Metallic implants – Stainless steels, co-based alloys, Ti-based alloys, shape memory alloy, nanostructured metallic implants, degradation and corrosion, ceramic implant – bio inert, biodegradable or bioresorbable, bioactive ceramics, nanostructured bio ceramics.

UNIT III	POLYMERIC IMPLANT MATERIALS	9	+	0

Polymerization, factors influencing the properties of polymers, polymers as biomaterials, biodegradable polymers, Bio polymers: Collagen, Elastin and chitin. Medical Textiles, Materials for ophthalmology: contact lens, intraocular lens. Membranes for plasma separation and Blood oxygenation, electro spinning: a new approach.

UNIT IV	TESTING OF BIOMATERIALS	9	+	0

Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, Invitro and Invivo testing; Sterilisation of implants and devices: ETO, gamma radiation, autoclaving. Effects of sterilization.

UNIT V	APPLICATION OF BIOMATERIALS	9	+	0

Artificial Heart, Prosthetic Cardiac Valves, Artificial lung (oxygenator), Artificial Kidney (Dialyser membrane) , Dental Implants, Orthopaedic Implants and Biomaterials in Ophthalmology.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the testing standards applied for biomaterials.
CO2	:	Identify significant gap required to overcome challenges and further development in metallic and ceramic materials
CO3	:	Identify significant gap required to overcome challenges and further development in polymeric materials
CO4	:	To demonstrate purpose of Biomaterials in various applications

Text Books:	
1.	C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford and Gopinath Mani, Introduction to Biomaterials Basic Theory with Engineering Applications, Cambridge University Press 2014
2.	Sujata V. Bhatt, “Biomaterials”, Second Edition, Narosa Publishing House, 2005
Reference Books:	
1.	Donglu Shi, Introduction to Biomaterials, Tsinghua University Press 2006
2.	Sreeram Ramakrishna, MuruganRamalingam, T. S. Sampath Kumar, and Winston O. Soboyejo, “Biomaterials: A Nano Approach”, CRC Press, 2010.
3.	Myer Kutz, “Standard Handbook of Biomedical Engineering & Design”, McGraw Hill, 2003.

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	1	2	2	3	2	0	3	3	2	3	2	3	3	3	
CO2	2	3	2	3	3	2	2	0	2	1	3	2	3	3	3	
CO3	2	2	3	3	2	1	0	0	0	3	3	2	2	2	3	
CO4	2	2	0	0	3	3	3	2	0	2	3	3	3	1	3	1

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP208	ADVANCES IN NUCLEAR MATERIALS	L	T	P	C
		3	0	0	3

Course Objective:

- To understand nuclear energy sources, its reactions and materials for energy applications.
- To understand its safety and current scenario in world level.

UNIT-1	**(9)**
Introduction to nuclear energy / reactors – comparison of different modes of energy generation – ecological and environmental aspects	
UNIT-2	**(9)**
Nuclear reactions – concept of half-life, nuclear minerals – related exploration and processing	
UNIT-3	**(9)**
Material requirements – structural materials, rare earth materials coolants, shielding materials and fuel rods – fabrication requirements	
UNIT-4	**(9)**
Nuclear irradiation effects on structural materials – safe guards, safety and health protection	
UNIT-5	**(9)**
Strategic issues – current status and major needs, overview of nuclear scenario in India, nuclear scenario at international level.	
Total: 45 Hours	

TEXT BOOKS

1. Benjamin M. M., Van Nostrand "Nuclear Reactor Materials and Applications", Reinhold Company Inc, 1983
2. Henley E.J., & Herbert Kouts, "Advances in Nuclear Science and Technology".

COURSE OUTCOMES:

At the end of this course, the students would be able to:

1. Learn different modes to generate nuclear energy.
2. Learn the concept of half-life of nuclear materials.
3. Understand properties of nuclear materials.
4. Learn and understand the safety precautions of nuclear radiation and protection.
5. Current scenario of nuclear materials.

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**2**	**1**	**2**	**2**	**3**	**2**	**0**	**3**	**3**	**2**	**3**	**2**	**3**	**3**	**3**	
CO2	**2**	**3**	**2**	**3**	**3**	**2**	**2**	**0**	**2**	**1**	**3**	**2**	**3**	**3**	**3**	
CO3	**2**	**2**	**3**	**3**	**2**	**1**	**0**	**0**	**0**	**3**	**3**	**2**	**2**	**2**	**3**	
CO4	**2**	**2**	**0**	**0**	**3**	**3**	**3**	**2**	**0**	**2**	**3**	**3**	**3**	**1**	**3**	**1**
CO5	**2**	**3**	**3**	**3**	**3**	**0**	**1**	**0**	**1**	**2**	**3**	**2**	**3**	**3**	**3**	**1**
Total	**2**	**2.2**	**2.2**	**2.2**	**2.8**	**1.6**	**1.2**	**1**	**1.2**	**2**	**3**	**2.2**	**2.8**	**2.4**	**3**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP209 **AUTOMOTIVE AND AEROSPACE MATERIALS** **L T P C**
3 0 0 3

Course Objectives:

To know the details of electrodes for various materials used for different welding processes

Unit I MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS 9

Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.

Unit II MATERIALS FOR AUTOMOTIVE STRUCTURES 9

Materials selection for bearings, leaf springs, chasis & frames, Bumper, shock absorbers, wind screens, panels, brake shoes, Disc, wheels, differentials , damping and antifriction Fluids, Tyres and tubes.Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, anti-collision, Anti-fog, Head lamps.

Unit III NON-FERROUS MATERIALS IN AIRCRAFT CONSTRUCTION 9

Aluminum and its alloys: Types and identification. Properties - Castings - Heat treatment processes - Surface treatments.

Magnesium and its alloys: Cast and Wrought alloys - Aircraft application, features specification, fabrication problems, Special treatments.

Titanium and its alloys: Applications, machining, forming, welding and heat treatment, Copper Alloys.

Wood and fabric in aircraft construction and specifications - Glues Use of glass, plastics & rubber in Aircraft, Introduction to glass & carbon composite.

Unit IV FERROUS MATERIALS IN AIRCRAFT CONSTRUCTION 9

Steels: Plain and low carbon steels, various low alloy steels, aircraft steel specifications, corrosion and heat resistant steels, structural applications.

Maraging Steels: Properties and Applications.

Super Alloys: Use - Nickel base - Cobalt base - Iron base - Forging and Casting of Super alloys - Welding, Heat treatment

Unit V CERAMICS AND COMPOSITES 9

Introduction, modern ceramic materials, cermets, glass ceramic, production of semi-fabricated forms, Carbon/Carbon composites, Fabrication processes and its aerospace applications involved in metal matrix composites, polymer composites

Total = 45 hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1 Understand the use of Materials selection criteria for engine and transmission systems.
CO2 Understand the Different materials used for automotive structures and Different electronic materials for automotive applications
CO3 Explain mechanical behavior and heat treatment of aerospace nonferrous materials.
CO4 Understand the properties and heat treatment of ferrous materials for aircraft materials.

CO5 Understand the properties of ceramics and composites for aircraft materials.

Reference Books:

1. **ASM Handbook, "Selection of Materials Vol. 1 and 2", ASM Metals Park, Ohio. USA, 1991.**
2. Materials Science and Engineering, Willium D. Callister, Jr. John Wiley & Sons publications
   Or Callister's Materials Science and Engineering Adapted By R. Balasubramaniam, Wiley
   India, Edition -2010.
3. Material Science and Engineering, V. Raghavan, Prentice Hall of India, 4th Edition.
4. H Buhl, Advanced Aerospace Materials, Springer, Berlin 1992, ISBN-13: 978-3540558880
5. Balram Gupta, Aerospace material Vol. 1,2,3,4ARDB, S Chand & Co ,2009, ISBN-13: 978-
   8121922005.
6. Parker E R, Materials for Missiles and Space, McGraw-Hill Inc., US, 1963, ISBN-13: 978 0070485013
7. ASM Handbook. "Materials Selection and Design", Vol. 20- ASM Metals Park Ohio.USA, 1997.
8. Cantor," Automotive Engineering: Lightweight, Functional, and Novel Materials", Taylor & Francis Group, London, 2006

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3	PSO4
CO1	1	2	0	1	2	0	0	0	0	0	1	2	2	2	1	
CO2	2	3	2	1	3	1	0	2	1	0	1	2	2	3	1	
CO3	0	1	1	0	2	1	2	3	1	0	1	2	1	1	2	1
CO4	1	2	3	3	2	1	0	0	0	1	3	2	1	1	0	1
CO5	2	1	1	1	2	0	1	0	2	1	1	0	0	0	1	1
Total	1.2	1.8	1.4	1.2	2.2	0.6	0.6	1	0.8	0.4	1.4	1.6	1.2	1.4	1	0.6

1- Faintly, 2- Moderately, 3- Strongly

22HMTMP210	PROCESSING OF NON FERROUS METAL ORES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study the processing of non ferrous metals ores.
2. To understand the fundamental principles and operations of non ferrous ores.

UNIT I	FUNDAMENTALS OF EXTRACTION METALLURGY	9	+	0

Principles of Pyrometallurgy - Drying, Calcination, Sintering, Roasting – Predominance Area Diagrams. Smelting and Converting.

Principles of Hydrometallurgy, Leaching – Properties of good solvent - Leaching methods – Solvent extraction, Ion exchange, Bio leaching, Gaseous reduction of metals in aqueous solutions.

Principles of Electrometallurgy - Aqueous and Fused salt electrolysis, Electro refining and Electro winning of metals. Purification of Crude metals produced in bulk – Distillation, Liquation, Fire refining, Electrolytic refining, Zone refining.

UNIT II	EXTRACTION AND REFINING OF METALS FROM SULPHIDE ORES	9	+	0

COPPER: Principal Ore and Minerals; Matte smelting – Blast furnace, Reverberatory, Electric furnace, Flash; Converting; Continuous production of blister Copper; Fire refining; Electrolytic refining; Hydro-Metallurgical copper extraction; Leaching processes, Recovery of copper from leach solutions; Electrowinning - NICKEL: Simplified flow sheets for the extraction of nickel,- LEAD: Blast furnace smelting, Refining of lead bullion and ZINC: General Principles: Horizontal and vertical retort processes: Production in a Blast furnace: Leaching purification: Electrolysis, Refining.

UNIT III	EXTRACTION AND REFINING OF METALS FROM OXIDE ORES	9	+	0

MAGNESIUM: Production of a hydrous Magnesium chloride from seawater and magnesite. Electro-winning practice and problem, refining, Pidgeon and Handspring processes - ALUMINIUM: Bayer process: Hall – Heroult process: Anode effect: Efficiency of the process: Refining, Alternative processes of aluminum production and TIN: Smelting of Tin concentrates, Refining of Tin-Fire refining of Tin and Electrolytic refining. TUNGSTEN: Flow sheets for the extraction of Tungsten.

UNIT IV	EXTRACTION AND REFINING OF METALS FROM HALIDE ORES	9	+	0

Extraction of metals rare earth metals from halides – TITANIUM: Upgrading of ilmenite, chlorination of titania, Kroll's process. Refining. ZIRCONIUM - Treatment of Zircon, Method for separating HF from Zirconium, Reduction of Zr compound to metal and URANIUM, Acid and alkali processes for digestion of uranium ores, Purification of crude salt, Production of reactor grade UO2 and uranium.

UNIT V	EXTRACTION OF PRECIOUS METALS AND BYPRODUCT FROM METALS RECOVERY	9	+	0

Extraction and Refining of precious metals – GOLD: Amalgamation process, Chlorination process and Cyandiation process, SILVER: Chloridizing roasting, Cyandiation, Parke's process and recovery from base material ores, and PLATINUM: INCO process.

Recovery of by-product metals and treatment of Metallurgical wastes - Secondary refining of Copper, Lead, Zinc, Aluminium, Non scrap sources of Aluminium, Tin, Vanadium – Utilization of metallurgical wastes.

Total (L+T) = 45 Hours

Course Outcomes:		
Upon completion of this course, the students will be able to:		
CO1	:	Understand the principles of extraction processes.
CO2	:	Explain the extraction of metals from sulphides ores.
CO3	:	Explain the extraction of metals from Oxides ores.
CO4	:	Explain the extraction of metals from halide ores.
CO5	:	Explain the extraction of precious metals and secondary refining processes.

Text Books:	
1.	Ray H.S, Sridhar R and Abraham K.P, Extraction of Non Ferrous Metals, Affiliated East-West Press Pvt Ltd, New Delhi, 2008.
2.	Ray H.S and Gosh A, Principles of Extractive Metallurgy, Prentice Hall of India, New Delhi, 1994
3.	Principles of Extractive Metallurgy-Gosh

Reference Books:	
1.	Text book of Metallurgy-A.R. Bailey.
2.	Terkel Rosenqvist, Principles of Extractive Metallurgy, 2nd Edition, McGraw-Hill International book Company, 1983
3.	Venkatachalam S, Hydrometllurgy, Narosa Publishing House, New Delhi, 1998
4.	R.Raghavan Extractive Metallurgy of Non - Ferrous Metals ,Vijay Nicole Imprints Private Limited, Chennai 2016.
5.	Pehlke R.D, Unit Processes in Extractive Metallurgy, American Elsevier Publishing Company, New York, USA, 1977.

CO/ PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	**2**	**1**	**2**	**2**	**3**	**2**	**0**	**3**	**3**	**2**	**3**	**2**	**3**	**3**	**3**	
CO2	**2**	**3**	**2**	**3**	**3**	**2**	**2**	**0**	**2**	**1**	**3**	**2**	**3**	**3**	**3**	
CO3	**2**	**2**	**3**	**3**	**2**	**1**	**0**	**0**	**0**	**3**	**3**	**2**	**2**	**2**	**3**	
CO4	**2**	**2**	**0**	**0**	**3**	**3**	**3**	**2**	**0**	**2**	**3**	**3**	**3**	**1**	**3**	
CO5	**2**	**3**	**3**	**3**	**3**	**0**	**1**	**0**	**1**	**2**	**3**	**2**	**3**	**3**	**3**	**1**
Total	**2**	**2.2**	**2.2**	**2.2**	**2.8**	**1.6**	**1.2**	**1**	**1.2**	**2**	**3**	**2.2**	**2.8**	**2.4**	**3**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

HONOURS DEGREE for Metallurgical Engineering Students

VERTICAL 1 : WELDING

22HMTW101	Advanced Metal Joining Processes	L T PC
		3 0 0 3

Course Objectives:

- To understand the various special/ advanced welding processes.
- To gain knowledge on the principle of operation, advantages, limitations and applications of various special/ advanced welding processes.

ELECTRON BEAM AND LASER BEAM WELDING (9)

Heat generation and regulation, equipment details in typical set-up, electron beam welding in different degrees of vacuum, advantages, disadvantages and applications.

Laser Beam Welding: Laser sources for welding, Principles of operation, advantages, limitations, and applications.

Introduction to Hybrid Welding Process.

ELECTRO SLAG WELDING AND RESISTANCE WELDING (9)

Electro slag welding - Heat generation, principles of operations, wire and consumable guide techniques, selection of current, voltage and other process variables, nature of fluxes and their choice, applications, variants of electro slag welding, Electrogas welding.

Resistance welding - Principles of contact resistance, surface preparation, calculation of current, time and voltage for spot welding – Temperature distribution, spot welding cycle, inter-relationship between process variables, choice of electrode material, seam welding, projection welding. Flash welding, Upset welding, Percussion welding, High frequency welding.

SOLID STATE WELDING PROCESSES (9)

Advantages of solid state welding processes over conventional welding processes. High temperature solid state welding, Low temperature solid state welding, Fundamental principles, Overview of various solid state welding processes. and principles of operation, applications.

Cold pressure welding, Induction pressure welding, Explosive welding, Diffusion welding, Ultrasonic welding, Forge welding, Roll welding– Principles of operation, equipment, process characteristics advantages, limitations and applications.

FRICTION AND FRICTION STIR WELDING (9)

Friction Welding- Theoretical considerations, Process characteristics, Friction Welding machines and equipments, welding variables, weld properties, Joint design, Applications.

Friction Stir Welding - Principles of operation, Important welding parameters - tool rotation and traverse speeds, tool tilt and plunge depth, tool design. Generation and flow of heat. Advantages, limitations and applications. Flaws and defects in FSW. Friction surfacing and friction processing.

OTHER JOINING PROCESSES, CUTTING AND SURFACING (9)

Adhesive bonding – Concept, Procedure, Testing of Adhesive bonded joints, types of adhesive bonded joints, Sandwich Construction, selection and types of adhesives. Welding of plastics, Underwater Welding. Thermit Welding, Brazing and Soldering -Fundamentals, Types, brazing and soldering alloys and their classification. Thermal cutting – Oxy-fuel cutting, arc cutting, plasma arc cutting, laser cutting. Surfacing.

Total: 45 hours

Course Outcomes: Upon completion of this course, the students will be able to:

CO1. Explain the principle of operation, advantages, limitations and applications of various solid state welding processes.
CO2. Explain the principle of operation, advantages, limitations and applications of FRW and FSW processes.
CO3. Explain the principle of operation, advantages, limitations and applications of EBW and LBW processes.
CO4. Explain the principle of operation, advantages, limitations and applications of ESW and Resistance welding processes.
CO5. Explain the principle and features of various special joining techniques and thermal cutting methods.

RECOMMENDEDBOOKS:

1. AWS Welding Handbook. 9th edition. Volume 2, Welding Processes,2013.
2. Schwartz M.M., "Metals Joining Manual", McGraw Hill Books.1979.
3. Metals Handbook (Welding, Brazing and Soldering) Vol. 6, 10th Edition. ASM1995.
4. Howard B.Cary, "Modern Welding Technology", Prentice Hall, 6th Ed.,2017.
5. Tylecote R.F., "The Solid Phase Welding of Metals", Edward Arnold Publishers Ltd. London.1968.
6. Christopher Davis, "Laser Welding - Practical Guide", Jaico Publishing House,1994.
7. Parmar R.S. "Welding Processes and Technology" Khanna Publishers, 2nd Ed.,2005.
8. ASM Handbook, "Welding Fundamentals and Processes" Vol. 6A, ASM2017

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**0**	**0**	**0**	**1**	**3**	**3**	**3**	**3**	
CO2	**3**	**3**	**2**	**1**	**2**	**1**	**0**	**0**	**1**	**2**	**0**	**0**	**3**	**3**	**3**	
CO3	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**3**	**1**	**1**	**0**	**0**	**3**	**3**	**3**	
CO4	**3**	**3**	**3**	**2**	**3**	**1**	**0**	**0**	**0**	**0**	**1**	**3**	**3**	**3**	**3**	**1**
CO5	**3**	**2**	**2**	**2**	**1**	**1**	**2**	**0**	**0**	**0**	**0**	**2**	**3**	**3**	**3**	**1**
Avg.	**2.8**	**2.2**	**2.2**	**1.8**	**2.2**	**1**	**1**	**0.6**	**0.4**	**0.6**	**0.4**	**1.6**	**3**	**3**	**3**	**.4**

1- Faintly, 2- Moderately, 3- Strongly

22HMTW102 METALLURGY OF WELDING L T PC
3 0 0 3

Course Objectives:

- To gain understanding of heat flow and temperature distribution on weld components based on weld geometry
- To understand the solidification structure and growth morphology on weld joins in relation to the welding parameters
- Study phase transformations in weld joints with aid of CCT, Schaffler and Delong diagrams and welding of alloy steels, carbon steels and stainless steels.

HEAT FLOW IN ARC WELDING (9)

Heat flow-Basic heat transfer equations, temperature distributions and cooling curves- Influence of heat input, Joint Geometry, plate thickness, preheating and other factors. Comparison of welding processes based on these considerations. Solidification – Epitaxial growth – weld metal solidification – cellular and columnar structures – effect of welding parameters – absorption of gases – gas/metal and slag/metal reactions.

WELDABILITY AND WELDABILITY TESTING (9)

Concept of Weldability, Factors affecting Weldability, Welding Defects, Causes and remedies,Crackingphenomenainwelding,Characterizationofweldments,Weldabilitytests – cold cracking tests, hot cracking tests, Internal restraint tests, External restraint tests, Mechanical tests for weldments-Tension tests and Bendtests.

WELDABILITY OF CARBON STEELS AND LOW ALLOYSTEELS (9)

Formation of different microstructural zones in welded plain-carbon steels, C-Mn and low alloysteels.Phasetransformationinweldmetalandheataffectedzones.Hydrogeninduced cracking, Carbon equivalent, preheating, Post heating and post weld heat treatment, Hot cracking – compositional features – Effect of S and P, Reheat cracking and Lamellar cracking.

WELDABILITY OF STAINLESS STEEL (9)

Introduction to stainless steel classification, effect of alloying elements, Austenitising elements, Ferritising elements, Weldability of austenitic stainless steels – Hot cracking – constitution diagrams – Schaffler, Delong, WRC diagrams, Mode of solidification, Sensitisation, Sigma embrittlement. Metallurgical difficulties in welding of ferritic, martensitic and duplex stainless steels, selection of filler metals.

WELDABILITY OF OTHER ALLOYS AND DISSIMILAR WELDING (9)

Welding of cast irons, High Cr steels, Maraging Steels – Process, procedure and filler metal selection, weldability problems encountered and solutions.

Weldability of Al alloys, Cu Alloys, T iAlloys and Ni Alloys – Selection of welding process and procedure appropriate for each material.

Dissimilar welding: Metallurgical problems in dissimilar welding- calculation of dilution- methods of controlling dilution - techniques of dissimilar welding.

Total: 45 hours

COURSE OUTCOMES: Upon completion of this course, the students will be able to:

CO1. To understand heat flow in welding, structures formed and effect of various parameters.
CO2. To gain knowledge in various types of weld ability tests.
CO3. To know about weldability of carbon steels and low alloy steels and weldability issues.
CO4. To understand welding of stainless steels.
CO5. To get familiar in the area of welding of castiroN and dissimilar welding..

RECOMMENDED BOOKS:

1. Parmar R.S., "Welding Engineering and Technology", Khanna Publishers.1997.
2. Lancaster J.F., "Metallurgy of Welding", George Allen & Unwin. Boston.1980.
3. Kou. S., "Welding Metallurgy", John Wiley & Sons.1987.
4. Granjon. H., "Fundamentals of Welding Metallurgy", Jaico Publishing House. New Delhi1994.
5. Norman Bailey, "Weldability of Ferritic Steels", Jaico Publishing House.1997

AWS Welding Hand book. 8thedition. Vol-1. Welding

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**3**	**2**	**3**	**2**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**3**	**1**	**0**	
CO2	**3**	**2**	**1**	**2**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**2**	**1**	**3**	
CO3	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**2**	**2**	**3**	
CO4	**3**	**2**	**2**	**2**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**2**	**3**	
CO5	**3**	**2**	**2**	**1**	**2**	**2**	**0**	**0**	**0**	**0**	**1**	**1**	**3**	**3**	**3**	**1**
Avg.	**2.8**	**2**	**2**	**1.8**	**2.2**	**1.2**	**0.6**	**0**	**0**	**0**	**0.4**	**1**	**2.6**	**1.8**	**2.4**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22HMTW103	WELDING EQUIPMENTS AND CONSUMABLES	L	T	P	C
		3	0	0	3

Course Objectives:

1. To know the basic knowledge of equipment's and accessories of various welding process.
2. To gain knowledge on selection of consumables for different welding processes.

UNIT I	EQUIPMENTS AND ACCESSORIES FOR VARIOUS WELDING PROCESS	9	+	0

Gas welding process – Compressed gas cylinders, Cylinder valves, Pressure valves, Gas hoses, Welding torches, Torch tips, Tip cleaner and spark lighter.

Arc welding process – Shielded metal arc welding (SMAW): Equipment and operating accessories.Gas tungsten arc welding (GTAW): Power source, GTAW torch, wire feed mechanism, materials.Gas metal arc welding (GMAW): power source, wire feed units, GMAW gun and wire feed conduit assembly, shielding gas and cooling water systems, materials used.Submerged Arc Welding (SAW): Equipment and materials.

UNIT II	EQUIPMENTS AND ACCESSORIES FOR OTHER WELDING PROCESS	9	+	0

Electron Beam Welding – Cathode, Electron accelerating system, Beam focusing system, Weld viewing system, Vaccum chamber, Work traversing system, Seam tracking methods. Laser welding – Principle and mechanism of laser operation, ruby laser equipment and setup. Thermit Welding – Equipment setup and operation. Solid-State Welding Processes – Friction welding machines and equipment. Resistance Welding – Rocker-Arm Type Machines, Press Type Machines, Portable Welder.

UNIT III	ARC WELDING POWER SOURCES	9	+	0

A.C. Welding Power Sources – Operating Principles of a Welding Transformer, Requirements of a Welding Transformer, Basic Types of Welding Transformers. D.C. Welding Power Sources – Opposition Series Generator (Sparately Excited), Opposition Series Generator (Self Excited), Split-Pole D.C. Welding Generator, Output Volt-Ampere Characteristics of Welding Generators, Multi-Operator D.C. Welding Power Sources. Rectified D.C. Welding Power Sources – General Theory of Rectifier Design, Solid-State Welding Rectifiers, SCR Welding Power Source, Pulsed Arc Welding Power Sources, Transistor Welding Power Sources.

UNIT IV	AUTOMATION IN WELDING	9	+	0

Introduction to automation in welding, Welding sequence and classification of processes, Manual welding, Semi-Automatic welding, Automatic welding, Automated welding, Adaptive controls, Automatic welding versus Automated welding, remote welding, Robotic welding and Selecting a welding system.

UNIT V	WELDING CONSUMABLES.	9	+	0

Coated Electrodes- Electrode Coating, classification and coding of covered (heavy coated), Classification and coding of electrodes for SMAW/MMAW of low and medium alloy steels. Welding Rods and Wires – Specifications for solid Wires and Rods and Tubular Electrodes or Flux-Cored Wires. Welding Fluxes – Composition and chemical classification of SAW Fluxes, Roles of flux ingredients, Physical classification of SWA fluxes and Shielding gases – inlet and activated shielding gases.

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	:	Understand the basic knowledge on handling welding equipments and accessories.
CO2	:	Describe and understand the appropriate power sources for welding operations.
CO3	:	Gain knowledge on advancements of automations in welding processes.
CO4	:	Demonstrate and select suitable consumables for different welding processes.

Text Books:	
1.	Welding Engineering and Technology by Dr. R.S. Parmar, Khanna Publishers, 2013.
2.	Welding Technology by Dr. N.K.Srinivasan, Khanna Publishers, 2001.
Reference Books:	
1.	Text Book Of Welding Technology by Bruce Stirling, DhanpatRai Publications, 2011.
2.	AWS Welding Handbook. 9th editionVolume1, "Welding Science and Technology", 2013
3.	AWS Welding handbook, 3rd edition, WeldingConsumablesGases and GasMixtures for FusionWelding and AlliedProcesses, 2021

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**2**	**1**	**2**	**2**	**2**	**1**	**1**	**0**	**0**	**0**	**1**	**3**	**3**	**3**	**3**	
CO2	**3**	**3**	**2**	**1**	**2**	**1**	**0**	**0**	**1**	**2**	**0**	**0**	**3**	**3**	**3**	
CO3	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**3**	**1**	**1**	**0**	**0**	**3**	**3**	**3**	**1**
CO4	**3**	**3**	**3**	**2**	**3**	**1**	**0**	**0**	**0**	**0**	**1**	**3**	**3**	**3**	**3**	

1- Faintly, 2- Moderately, 3- Strongly

22HMTW104 WELDING CODES AND STANDARDS L T PC

3 0 03

Overview and Introductory treatment of codes and standards in the reference–No numerical problems, written document procedures and qualification

Course Objective: To acquire knowledge on various welding codes and standards related to various engineering applications.

STRUCTURAL WELDING CODES (9)

Design requirements, allowable stress values, workmanship and inspection, introduction to welding codes and standards

PETROLEUM PIPING FABRICATION (9)

Process and product standards for manufacturing of pipe – welding procedure and welder qualifications, field welding and inspection, API 1104 and API 5L

PRESSURE VESSEL FABRICATION (9)

Design requirements fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydro testing.

WELDING PROCEDURE AND WELDER QUALIFICATION (9)

Welding procedure specification, procedure qualification records, performance qualification, variables

MATERIALS AND CONSUMABLES (9)

Introduction to materials standards and testing of materials, consumables testing and qualification as per ASME/AWS requirements

Total: 45 hours

Course outcomes: Upon completion of this course, the students will be able to:

CO1. Identify various design requirements and applicability of AWS D1.1.
CO2. Apply API 1104 and AP15L for pipe welding applications.
CO3. Apply ASME II, V, VIII and IX for boiler fabrication.
CO4. Understand and apply WPS, PQR and performance qualification variables for a specific welding application.
CO5. Understand different materials standard, testing methods and consumable testing.

RECOMMENDED BOOKS:

1. AWS D1.1 Structural Welding Code 2.
API 1104
3. ASME Section VIII – Division 1
4. ASME SectionIX
5. ASME Section II Part A andC
6. API6A

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**2**	**3**	**3**	**3**	
CO2	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**1**	**3**	**3**	**3**	
CO3	**3**	**2**	**3**	**3**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**3**	**3**	**3**	
CO4	**1**	**1**	**2**	**2**	**1**	**2**	**1**	**0**	**0**	**0**	**2**	**2**	**3**	**3**	**3**	**1**
CO5	**1**	**2**	**2**	**2**	**2**	**1**	**0**	**0**	**1**	**1**	**0**	**2**	**3**	**3**	**3**	
Avg.	**2.2**	**1.8**	**2.2**	**2.2**	**1.4**	**1.2**	**1**	**.4**	**.8**	**.8**	**1**	**1.6**	**3**	**3**	**3**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22HMTW105 AUTOMATION AND ROBOTICS L T PC

3 0 03

Course Objectives:

- To compile and work with the automated equipments and its processing are Automation of arc welding processes and other related welding processes.
- To emulate the Automated welding equipment, Arc and work motion and standardized arc welding machines, controls and sensors and gain knowledge on operations using the robots.

AUTOMATION OF ARC WELDING PROCESSES (9)

Need for automation in welding, introduction to semi-automatic mechanized, automatic, robotic and adaptive control welding. Automatic welding system – factors affecting welding productivity– advantages and disadvantages of welding automation - Arc welding processes suitable for automation and degree of automation possible in different welding processes like GMAW, FCAW, SAW, GTAW, PAW and Stud welding.

AUTOMATION OF OTHER RELATED PROCESSES (9)

Automation of Resistance welding, EBW, and Laser beam Welding, Solid State welding. Automation of oxygen cutting- Arc and Plasma cutting - Laser beam cutting, thermal spraying.

AUTOMATED WELDING EQUIPMENT, ARC AND WORK MOTION DEVICES (9)

Welding power sources, type of electrode wire feeders and electrode wire dispersing system – spools, coils, rods, drums, pay off packs, typical adaptors and spiders. Types of welding torches used in automated welding and functions of torches. Types of standardized arc motion devices – Tractor, carriages, side beam carriages, manipulators and Gantry carriages. Work motion devices – Universal positioners, turning rolls, head and tail stock positioners. Combination of arc and work motion devices.

STANDARDIZED ARC WELDING MACHINES, CONTROLS AND SENSORS (9)

Standardized arc welding equipment, types of standardized welding machines – seamers, welding lathes, weld – around machines, nozzle welders and bore welders. I beam welders and strip welders. Standardized welding machines for maintenance work. Automatic welding of pipes and tubes Introduction to some dedicated arc welding machines. Temporary portable automated tooling for welding control functions involved in a mechanized total welding system sensor systems – introduction and classification.

ROBOTIC ARC WELDING (9)

Introduction to flexible automatic welding. Robotic arc welding system, types of welding Robots – Revolute, Cartesian, Spherical, Cylindrical and Scara – Hybrid robots far welding, features of welding robot, robotic part – holding positioners, Teaching the robot, some case studies of robotic application in welding.

Total: 45 hours

COURSE OUTCOME: Upon completion of this course, the students will be able to:

CO1. Gain knowledge on automation of the arc welding processes.
CO2. Gain knowledge on the different kinds of welding processes.
CO3. Gain knowledge on the welding equipments and work motions of the automated devices.
CO4. Gain detailed knowledge on standardized arc welding machines, controls and sensors.
CO5. Get familiarized in the area of Robotic Arc welding.

RECOMMENDED BOOKS:

1. Howard B. Cary "Arc welding Automation"- Marcel Dekker, New York1995
2. AWS Welding Handbook, Vol. 3, 9th edition, A W S.,2015.
3. AWS Welding Handbook, vol.5, "Engineering Costs, Quality and Safety", 9th edition, AWS,2015.
4. The Procedure Handbook of Arc Welding, 13th Edition, Lincoln Electric, USA,1994
5. Proceedings of the International Conference on Assembly Automation, British Welding Institute,1985. Kozyrev, Industrial Robots Handbook, Mir Publishers, Moscow.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**3**	**3**	**3**	**2**	**3**	**1**	**1**	**0**	**1**	**0**	**1**	**2**	**3**	**2**	**2**	
CO2	**3**	**2**	**2**	**3**	**3**	**1**	**1**	**0**	**1**	**0**	**0**	**3**	**3**	**2**	**3**	
CO3	**2**	**2**	**2**	**3**	**3**	**1**	**1**	**0**	**1**	**0**	**0**	**2**	**1**	**2**	**1**	
CO4	**2**	**3**	**3**	**2**	**3**	**1**	**1**	**0**	**1**	**0**	**0**	**2**	**1**	**2**	**1**	
CO5	**2**	**2**	**2**	**2**	**3**	**1**	**1**	**0**	**1**	**0**	**0**	**2**	**3**	**2**	**2**	**1**
Avg.	**2.4**	**2.4**	**2.4**	**2.4**	**3**	**1**	**1**	**0**	**1**	**0**	**0.2**	**2.2**	**2.2**	**2**	**1.8**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22HMTW106 WELDING APPLICATION TECHNOLOGY

L T PC
3 0 0 3

Course Objective:

- To understand the materials, process, fabrication techniques used in welding of pressure vessels, piping and pipelines, shipyards, railways, chemical plants and structural.
- To gain knowledge of the materials, processes, fabrication, inspection and stringent quality control procedures used in oil and gas industries and chemical plants.
- To learn about welding economics such as weldment deposition rates for different welding processes, welding cost estimation, standard data for cost estimation and comparative cost study for various welding procedure.

WELDING OF STRUCTURALS AND PRESSURE VESSELS (9)

STRUCTURALS: Types of structural elements and their welding, materials used in bridges and welding of bridges.

PRESSURE VESSELS: Material selection and factors affecting it, fabrication of conventional pressure vessels – welding processes used, nozzle welding, tube to tube plate welds, flanges, vessel ends, fabrication of clad pressure vessels. Weldability aspects of pressure vessel steels.

WELDING OF STORAGE TANKS AND PIPINGS (9)

Welding of vertical storage tanks and Horton sphere.

WELDING OF PIPING AND PIPELINES: pipe steels and electrodes, types of joints and welding, backing welds rings, fittings, alloys used for piping, pipe welding procedures, preheating and PWHT, offshore pipework, pipelines and pipeline welding, under water pipeline welding.

WELDINGIN CHEMICAL PLANTS, CRYOGENICS & MICRO JOINING TECHNIQUES (9)

CHEMICAL PLANTS: Welding of oil-refinery components and fertilizer plant components. CRYOGENICS: Materials used for cryogenic applications, problems of welding. Welding processes and procedures used for welding cryogenic materials.

MICRO JOINING TECHNIQUES: Various techniques used for joining of electronic circuits and other micro joining applications**.**

WELDING OF SHIP STRUCTURE AND RAILWAYS (9)

SHIP STRUCTURE: Main parts of ship structure, materials for ship building, unit and block method of ship construction, welding of submarine steels, welding of offshore structures.

RAILWAYS: Materials used for locomotive subassemblies, rail coaches, wagons and its subassemblies, rails and welding processused

WELDING OF AEROSPACE AND AUTOMOBILE (9)

AEROSPACE: Main parts of aerospace structure, materials for aircrafts building, method of aircraft construction, welding of aircraft structures.

AUTOMOBILE: Main parts in Automobiles, Materials used for automobile subassemblies, welding of automobile components.

Total: 45 hours

COURSE OUTCOMES: Upon completion of this course, the students will be able to:

CO1. Select the suitable welding procedures for the fabrication of structural elements and conventional pressure vessels and solve the difficulties in welding of pressure vessel steels.
CO2. Choose the correct materials, electrodes, type of joint, welding processes and fittings for the fabrication of storage tanks, piping as well as pipe lines.
CO3. Solve the problems involved in welding of oil refinery components, fertilizer components and cryogenic materials.
CO4. Explain the shipbuilding activities and solve the problems involved in welding of submarine steels and railway materials.
CO5. Gain knowledge on materials used in Aerospace and Automobile components and their weldments.

RECOMMENDED BOOKS:

1. S.V.Nadkarni, "Modern Arc Welding Technology", Oxford-IBH Publishers, New Delhi, 7th edition1996.
2. R.S.Parmar, "Welding Engineering and Technology", Khanna Publishers, New Delhi, 1st edition1997.
3. AWS Welding Handbook, Sec.5 – Applications of Welding, 5th Edition,1967.
4. AWS Welding Handbook, Vol.4, 7th Edition,1991.
5. ASM Metals Handbook, Vol.6, Welding, Brazing and Soldering, ASM, New York, 1998.
6. Howard B. Cary, "Modern Welding Technology", Prentice Hall, New Jersey, USA, 1989.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**3**	**2**	**2**	**2**	**3**	**2**	**1**	**0**	**1**	**0**	**0**	**2**	**2**	**2**	**3**	
CO2	**3**	**2**	**2**	**3**	**2**	**1**	**1**	**0**	**1**	**0**	**1**	**1**	**2**	**3**	**3**	
CO3	**2**	**2**	**2**	**2**	**3**	**1**	**1**	**0**	**1**	**1**	**1**	**2**	**1**	**2**	**3**	
CO4	**2**	**3**	**2**	**3**	**2**	**1**	**2**	**0**	**1**	**0**	**1**	**2**	**1**	**2**	**3**	**1**
CO5	**2**	**2**	**2**	**2**	**3**	**1**	**2**	**0**	**1**	**0**	**1**	**2**	**2**	**2**	**3**	**1**
Avg.	**2.4**	**2.2**	**2**	**2.4**	**2.6**	**1.2**	**1.4**	**0**	**1**	**0.2**	**0.8**	**1.8**	**1.6**	**2.2**	**3**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22HMTW107 BRAZING, SOLDERING, SURFACING AND CUTTING L T PC

3 0 0 3

Course Objective: To understand the fundamental concepts, applications, advantage sand limitations of brazing, soldering, surfacing and cutting

FUNDAMENTALS OF BRAZING AND SOLDERING (9)

Wetting and spreading characteristics, surface tension and contact angle concepts. Filling of horizontal and vertical capillary joints. Capillary dams.

FLUXES AND ATMOSPHERES FOR BRAZING AND SOLDERING (9)

Role of flux and characteristics constituents of flux, grouping and applications Fluxes used for specific braze metal flux removal and related corrosion problem. Atmosphere for brazing and atmosphere for brazing specific base metal metallurgy of filler metal for brazing and soldering - joint design and fixturing for brazing.

SOLDERING AND BRAZING PROCESSES (9)

Hand soldering, flame soldering furnace soldering, hot gas blanket soldering, wave soldering, etc., torch brazing furnace brazing, induction brazing, dip brazing resistance brazing, vaccum brazing, etc., applications of brazing soldering-brazing and soldering defects.

SURFACING (9)

Thermal spraying, plasma spraying, laser surface alloying and modification. Surfacing spraying to improve wear resistance and corrosion resistance. CVD, PVD and ion implantation. Cladding and its applications.

THERMAL CUTTING PROCESSES (9)

Oxygen cutting-oxy fuel gas, metal powder, chemical flux and oxygen arc cutting. Arc cutting processes- carbon arc, air carbon arc cutting. Metal and plasma arc cutting, High energy beam cutting, laser beam cutting, water jet cutting and under water cutting.

Total: 45 hours

COURSE OUTCOME: Upon completion of this course, the students will be able to:

CO1. Explain the concepts of brazing and soldering.
CO2. Understand the fluxes and atmosphere for brazing and soldering.
CO3. To gain knowledge on brazing and soldering processes.
CO4. To understand surfacing techniques.
CO5. To get familiar in the areas of thermal cutting processes.

RECOMMENDED BOOKS

1. Schwartz. M., “Brazing – for the Engineering Technologies”, Champan and Hall, 1995.
2. Manko. H.H., “Solders and Soldering”.2nd Edition, McGraw Hill1979..
3. Udin, Funk, and Wulf ., “Welding for ENGINEERS”.
4. ASM Metals Hand Book Vol. 6 “Welding and Brazing”,1988.
5. Lancaster .J .F . “Metallurgy of Welding, Brazing and Soldering” 3rd edition. George Allen & Unwin.1980.

6. Brooke, “Indusrial Brazing”, Bcton.1975.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**0**	**0**	**1**	**0**	**3**	**3**	**2**	**2**	
CO2	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**0**	**1**	**1**	**0**	**2**	**1**	**2**	**2**	
CO3	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**2**	**1**	**0**	**0**	**3**	**1**	**3**	**1**	**1**
CO4	**2**	**2**	**2**	**2**	**2**	**1**	**0**	**0**	**1**	**1**	**0**	**2**	**1**	**1**	**1**	**1**
CO5	**3**	**2**	**2**	**3**	**3**	**1**	**1**	**0**	**1**	**0**	**0**	**2**	**0**	**2**	**2**	**1**
Avg.	**2.8**	**2.4**	**2.2**	**2.4**	**2.4**	**1**	**.8**	**0.4**	**0.8**	**0.6**	**0**	**2.4**	**1.2**	**2**	**1.6**	**0.6**

1- Faintly, 2- Moderately, 3- Strongly

22HMTW108 DESIGN OF WELDMENTS L T PC
3 0 0 3

Course Objective:

To design a system, a component, or a process to meet desired needs within realistic constraints such as design basics, weld design for static loading, weld design for dynamic loading, distortion and residual stresses and failure analysis of the manufacturing.

DESIGN BASICS (9)

Types of joints, Types of welds, variants of joints, selection of weld type, weld joints for structural tubular connections, welding symbols, weld dimensions, NDT symbols. Principles of weld joint design – General and specific design principles.

WELD DESIGN FOR STATIC LOADING (9)

Material or section properties, Weld design stress calculation for welds, design under different types of loading like tension, compression, bending, shear, torsion and shock

WELD DESIGN FOR DYNAMIC LOADING (9)

Basic details of fatigue and fatigue failure, S-N curve, Goodman diagram, factors affecting fatigue life of welded joint, methods of improving fatigue life of welded structures, design for fatigue loading, weld design using fracture toughness value (KIC).

DISTORTION AND RESIDUAL STRESSES (9)

Welding residual stresses–causes, occurrence, effects–thermal and mechanical stress relieving. Types of distortion – factors affecting distortion –distortion control methods – prediction- correction, jigs, fixtures and positioners.

FRACTURE MECHANICS (9)

Concept of stress intensity factor - LEFM and EPFM concepts - brittle fracture- transition temperature approach - fracture toughness testing, application of fracture mechanics to fatigue, weldments design for high temperature applications.

Total: 45 hours

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1. Gain knowledge on design basics of the welding operations.
CO2. Gain knowledge on the weld design for static loading processes.
CO3. Gain knowledge on the weld design for dynamic loading processes.
CO4. Gain detailed knowledge on factors influencing the distortion and residual stresses.
CO5. Get familiarized in the failure analysis sector.

RECOMMENDED BOOKS:

1. Blodgett. O. W., Design of Weldments, James F. Lincoln Arc Welding Foundation, 1991.
2. R.S.Parmar, Welding Engineering and Technology 2ndedition,2010.
3. Gurney T.R. Fatigue of Welded Structures. Cambridge University Press,1980.
4. Rolfe. T., Barsom. J., Fracture and Fatigue Control of Structures – Applications of Fracture Mechanics, Prentice Hall,1987.
5. ASM Metals Hand Book. Failure Analysis and Prevention. Vol. 11. ASM2002.
6. Das, A.K., Metallurgy of Failure Analysis, Tata McGraw Hill, New Delhi,1997.
7. Donald J. Wulpi, Understanding how components fail, ASM International, 3rdEdition, 2013.
8. Colangelo.V.J. and Heiser.F.A., “Analysis of Metallurgical Failures”, John Wileyand Sons Inc. New York, USA,1987.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**3**	**2**	**2**	**2**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**1**	**2**	
CO2	**3**	**3**	**2**	**2**	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**2**	**3**	**1**	**1**	
CO3	**3**	**2**	**2**	**1**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**2**	**1**	**1**
CO4	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**2**	
CO5	**3**	**2**	**2**	**1**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**3**	
Avg.	**3**	**2.2**	**2**	**1.6**	**2.4**	**1.2**	**.4**	**0**	**0**	**0**	**0**	**1.2**	**2**	**1.6**	**1.8**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22HMTW109 FAILURE ANALYSIS IN WELDMENTS L T PC

3 0 0 3

Course Objective:

To understand the concepts on failure and fracture analysis of weldments and to design new materials that can withstand catastrophic failures of weldments at different environment.

INTRODUCTION TO FAILURE ANALYSIS (9)

Stages of failure analysis, classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture.

WELDMENT SURFACE FAILURES (9)

Types of wear, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, overview of various types of corrosion stress corrosion cracking, sources, characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, various types of hydrogen damage failures.

WELDMENT CREEP AND FATIGUE FAILURES (9)

General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life, Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies on weldment failures.

FAILURE OF WELDED PRODUCTS (9)

Causes of failure in forge weldments, failure of welded iron and steel castings, improper heat treatment of weldments, stress concentration by weldments, in-service weldment failures. Procedure for weld failure analysis and data extraction.

RELIABILITY (9)

Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, exponential and Weibull distribution for reliability, bathtub curve, parallel and series system, mean time between failures and life testing.

Total: 45 hours

COURSE OUTCOMES: Upon completion of this course, the students will be able to:

CO1. Understand the concepts of types of failures and analysis
CO2. Learn the various factors affecting/causing failures of weldments
CO3. Design new materials that can withstand failures, especially considering weldments in different environment.
CO4. To understand failure in welded products.
CO5. To learn various concepts in reliability.

RECOMMENDED BOOKS

1. Colangelo.V.J. and Heiser.F.A., "Analysis of Metallurgical Failures", John Wiley and Sons Inc. New York, USA,1987.
2. Das, A.K., "Metallurgy of Failure Analysis", Tata McGraw Hill, New Delhi,1992.
3. DonaldJ.Wulpi,"Understandinghowcomponentsfail",ASMInternational,3rdEdition, 2013.
4. ASM Metals Handbook "Failure Analysis and Prevention", ASM Metals Park. Ohio, Vol.10, 10thEdition,1995.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**3**	**2**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**2**	**3**	
CO2	**3**	**2**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**2**	
CO3	**2**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	
CO4	**3**	**2**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**1**	**2**	**1**
CO5	**2**	**1**	**2**	**1**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	
Avg.	**2.6**	**1.8**	**1.6**	**1**	**1.2**	**0.8**	**0**	**0**	**0**	**0**	**0.6**	**1.2**	**0.8**	**0.8**	**1.8**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22HMTW110 FINITE ELEMENT ANALYSIS IN WELDING L T PC

3 0 0 3

Course Objective:

To provide the basic FEM modeling and to analyze and solve metallurgical problems using those methods.

TWO DIMENSIONAL PROBLEMS (9)

Poisson equation – Laplace equation – Weak form – Element matrices for triangular and rectangular elements – Evaluation of integrals – Assembly – Axi-symmetric problems – Applications – Conduction and convection heat transfer – Torsional cylindrical member – Transient analysis - Theory of elasticity – Plane strain – Plane stress – Axi-symmetric problems– Principle of virtual displacement

ISOPARAMETRIC ELEMENTS AND ITS APPLICATIONS (9)

Introduction – Bilinear quadrilateral elements – Quadratic quadrilaterals – Hexahedral elements - Numerical integration – Gauss quadrature – Static condensation – Load considerations – Stress calculations – Examples of 2D and 3D applications

NON-LINEAR PROBLEMS AND ERROR ESTIMATES (9)

Introduction-Iterative Techniques-Material non-Linearity-Elasto Plasticity-Plasticity-Visco plasticity-Geometric Non linearity-large displacement Formulation-Application in Metal Forming Process and contact problems- Error norms and Convergence rates- high refinement with adaptivity-Adaptive refinement

DYNAMIC PROBLEM (9)

Direct Formulation-Free-Transient and Forced Response-Solution Procedures-Subspace Iterative Technique -Houbolt- Wilson- Newmark - Methods –Examples

FLUID MECHANICS (9)

Governing Equations of Fluid Mechanics-Inviscid and Incompressible Flow-Potential Formulations-Slow Non- Newtonian Flow-Navier Stokes Equation-Steady and Transient Solutions.

Total: 45 hours

Course outcomes: Upon completion of this course, the students will be able to:

CO1. Demonstrate understanding of FE formulation for axi- symmetric problems in heat transfer and elasticity

CO2. To identify the primary and secondary variables of the problem and choose correct nodal degrees of freedom and develop suitable shape functions for an iso parametric element.

CO3. Able to solve contact problems by using the techniques of non-linear equations of equilibrium

CO4. Understand to solve the dynamic flow problems by iterative methods

CO5. Solve non Newtonian Flow-Navier Stokes Equation by FE equations.

RECOMMENDED BOOKS:

1. Cook, Robert Davis et al "Concepts and Applications of Finite Element Analysis", Wiley, John & Sons,1981.
2. Desai C.S. and Abel J.F., "Introduction to Finite Element Method", Affiliated East- West Press,1972.
3. Chandrupatla, Belagundu, "Finite Elements in Engineering", Prentice Hall of India Private Ltd.,2002.
4. O.C. Zienkiewicz and R.L. Taylor, Finite element methods Vol I &Vol II, McGraw Hill,1989,1992.
5. K.J. Bathe, Finite element procedures, PHI Ltd.,1996.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	**2**	**3**	**2**	**3**	**1**	**0**	**0**	**0**	**1**	**0**	**1**	**3**	**2**	**3**	**0**	
CO2	**3**	**3**	**3**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**3**	**0**	
CO3	**3**	**2**	**3**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**3**	**0**	
CO4	**3**	**2**	**3**	**3**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**2**	**2**	**3**	**0**	**1**
CO5	**3**	**3**	**3**	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**3**	**0**	
Avg.	**2.6**	**2.6**	**2.8**	**3**	**1.4**	**.4**	**0**	**0**	**0.4**	**0**	**0.2**	**2**	**2**	**3**	**0**	**.2**

1- Faintly, 2- Moderately, 3- Strongly

MINOR DEGREE : METALLURGICAL ENGINEEING for other Branch Students
VERTICAL :1

22MDMT101 **ADVANCED PHYSICAL METALLURGY**

L	T	P	C
3	0	0	3

Course Objectives:

To impart knowledge on the crystal structure, diffusion, phase diagrams for various engineering materials.

UNIT-1 CRYSTAL STRUCTURES (9)

Review of atomic bonds, Lattice, unit cell, crystal systems and Bravais lattices; Principal crystal structures – BCC, FCC, HCP and its characteristics; Miller indices for crystallographic planes and directions, interplanar spacing; Volume, planar and linear atomic density; Polymorphism and allotropy; CsCl, NaCl, Diamond structures; single crystal and polycrystalline and amorphous materials; isotropy and anisotropy; Simple problems in the above topics

UNIT-2 CRYSTALLINE IMPERFECTIONS (9)

Types of point defects, effect of temperature on vacancy concentration, interstitial sites-octahedral and tetrahedral sites; Line defects – dislocations – Edge, screw and mixed dislocations, Burger's vector, slip and twinning; Planar defects – grain boundaries, tilt boundaries, small angle grain boundaries; ASTM grain size number, grain size determinations; Volume defects; Simple problems in the above topics.

UNIT-3 ATOMIC DIFFUSION IN SOLIDS AND SOLIDIFICATION OF METAL (9)

Diffusion mechanisms, steady state diffusion and non-steady state diffusion-Fick's first law and second law; Kirkendall effect and Darken's equation; Factors affecting diffusion; Industrial applications of diffusion processes; Simple problems in the above topics; Basic principles of solidification of metals and alloys; Growth of crystals– Planar growth, dendritic growth, Solidification time, dendrite size; Cooling curves; Cast or Ingot structure, Solidification defects – Control of casting structure; Directional solidification – single crystal growth; Simple problems in the above topics.

UNIT-4 PHASE DIAGRAMS (9)

Phases, solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Phase diagram determination; Binary isomorphous alloy systems – composition and amount of phases, development of microstructure – equilibrium and non-equilibrium cooling- Coring and its effects, homogenization; Binary eutectic system - composition and amount of phases, development of microstructure; Eutectoid, Peritectic and monotectic reaction, Phase diagrams with intermediate phases and compounds; Ternary phase diagrams. Simple problems in the above topics.

UNIT-5 IRON-CARBON PHASE DIAGRAM (9)

Iron-carbon diagram, Phases in Fe-C system, Invariant reactions, Microstructure of slowly cooled steels, composition and amount of phases, Effect of Alloying elements on Fe-C system, Type, structure, properties and applications of Plain Carbon Steels and different types of Cast iron; IS Specification for Steels and Cast Irons, Simple problems in above topics.

Total (L) 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1 : Understand the basic crystal structure, orientation and their influence on macroscopic properties.

CO2 : Explain and relate the role of imperfections in strengthening the materials.

CO3 : Apply the diffusion mechanism in solidification of materials under different conditions.

CO4 : Understand and apply the concept of phase diagrams in equilibrium transformation of materials phases.

CO5 Explain the Fe-Fe_3C system and properties of steel and cast iron.

Text Books:

1. Donald R. Askeland,"The Science and Engineering of Materials", Thomson Learning, India Edition, 2007.

2. William D.Callister, "Materials Science and Engineering – An Introduction", 4th edition, JohnWiley & Sons, New York, USA, 1997.

Reference Books:

1. Avner S H."An Introduction to Physical Metallurgy", McGraw Hill Book Co, New York, USA, 1997.

2. Donald R Askeland," Essentials of Material Science and Engineering ", Thomson Learning, India Edition, 2007.

3. Raghavan V., "Physical Metallurgy – Principles and Practice", Prentice Hall of India Ltd., New Delhi, 1996.

4. William F.Smith, "Foundations of Materials Science and Engineering", Second Edition, McGraw-Hill Inc,

New York, 1993.

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3	PSO 4
CO1	**3**	2	**0**	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**1**	
CO2	**2**	3	**1**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**1**	**2**	**3**	**0**	
CO3	**2**	2	**1**	**1**	**0**	**1**	**0**	**3**	**0**	**0**	**2**	**1**	**2**	**3**	**1**	
CO4	**3**	2	**2**	**1**	**3**	**2**	**1**	**2**	**0**	**0**	**1**	**3**	**3**	**2**	**3**	
CO5	**3**	2	**2**	**3**	**2**	**1**	**0**	**2**	**2**	**0**	**1**	**2**	**2**	**3**	**3**	**1**
AVG	**2.6**	2.2	**1.2**	**1.4**	**1**	**1.4**	**0.2**	**1.6**	**0.4**	**0**	**0.8**	**1.4**	**2.4**	**2.2**	**1.6**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MDMT102 METALLURGICAL THERMODYNAMICS AND KINETICS

L	T	P	C
3	0	0	3

Course objectives:

To introduce the basic knowledge of thermodynamics required for understanding various alloy systems, phase transformations and interpreting properties

UNIT-1 FUNDAMENTAL CONCEPT AND INTERNAL ENERGY (9)

Introduction: System and surrounding, Classification of systems, Path and state properties, Thermodynamic processes, Thermodynamic equilibrium, Reversible and Irreversible processes. First law of thermodynamics: Heat and work, Internal energy, Heat capacity of materials, Cp-Cv relations, Nernst Equation, Enthalpy, Thermochemistry Hess's law, Kirchoff's law, Maximum flame temperature.

UNIT-2 ENTROPY AND AUXILARY FUNCTIONS (9)

Second law of thermodynamics: Carnot cycle, Entropy - Statistical interpretation of entropy, Free energy, Combined statement of first and second laws, Thermodynamic functions - Maxwell's relations, Gibbs Helmholtz equation. Third and Zeroth laws of thermodynamics : Definition, concept and applications

UNIT-3 THERMODYNAMIC POTENTIALS AND PHASE EQUILIBRIA: (9)

Thermodynamic potentials: Fugacity, Activity and Equilibrium constant. Clausius - Clayperon equation, Troutons rule. Le Chatelier's principle, Vant Hoff's equation. Equilibria in phase diagrams: Phase rule, Phase stability, Thermodynamics of surfaces, interfaces and defects, P-G-T diagrams, Application of free energy - composition diagrams to the study of alloy systems.

UNIT-4 THERMODYNAMICS OF SOLUTIONS: (9)

Gibbs - Duhem equation, Partial and integral molar quantities, chemical potential, Ideal solutions - Raoult's law, Real solutions, Activity coefficient, Henry's law, Alternative standard states, Sievert's law, Mixing functions and excess functions, Regular solutions, Applications of Gibbs - Duhem equation.

UNIT-5 THERMODYNAMICS OF REACTIONS AND KINETICS: (9)

Electro chemical process: Cells, Interconversion of free energy and electrical work, Determination of thermodynamic quantities using reversible cells, Solid electrolytic cells. Kinetics: First, Second and third order reactions, Arrhenius equation - activation energy, Determination of order of the reaction.

Total (L) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1 : To remember the fundamental concepts of thermodynamics and internal energy

CO2 : Understand the thermodynamics entropy and auxilary functions.

CO3 : Apply the basic laws and derive chemical potential and phase equilibria.

CO4 : Describe the thermodynamics of the solution and various important equations.

CO5 : understand and apply to solve problems related to electrochemical processes and kinetics.

Text Books:

1. Upadhyaya G S andDube R K., "Problems in Metallurgical Thermodynamics & Kinetics",Pergamon, 1977.
2. Ahindra Ghosh, Text book of Materials & MetallurgicalThermodynamics, Prentice Hall India, 2002
3. David R Gaskell, "Introduction to the Thermodynamics of Materials", Fifth Edition, Taylor & Francis, 2008

Reference Books:

1. David V Ragone, "Thermodynamics of Materials - Volume-1", John Wiley & Sons, Inc. 1995. 2. .Dr S.K Dutta,Prof A.B.Lele – Metallurgical thermodynamics kinetics and numericals,S.Chand& co Ltd.,New Delhi 2011
3. Darken LS and Gurry R W,"Physical Chemistry of Metals", CBS publications and distributors, 2002.
4. Parker R H, "An introduction to chemical metallurgy", Pergamon press, New York, second edition, 1978.
5. Kapoor M.L., “Chemical and Metallurgical Thermodynamics Vol. I and II”, Nem Chand, 1st Ed., 1981.

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3	PSO 4
CO1	**2**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**1**	**0**	**0**	**1**	**3**	**3**	**3**	
CO2	**2**	**3**	**0**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**1**	**0**	
CO3	**2**	**2**	**1**	**2**	**1**	**2**	**0**	**0**	**1**	**2**	**1**	**1**	**3**	**3**	**1**	**1**
CO4	**2**	**3**	**1**	**1**	**1**	**2**	**0**	**1**	**1**	**0**	**1**	**2**	**2**	**3**	**2**	
CO5	**1**	**3**	**0**	**3**	**0**	**1**	**1**	**0**	**2**	**1**	**0**	**0**	**3**	**2**	**1**	
AVG	**1.8**	**2.2**	**0.4**	**1.6**	**0.4**	**1.6**	**0.4**	**0.4**	**1**	**0.6**	**0.4**	**1.2**	**0.8**	**0.8**	**0.6**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MDMT103	MECHANICAL BEHAVIOUR OF MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

To know the fundamental concepts of deformation behaviour for structural engineering applications.

UNIT-1 DISLOCATIONS AND PLASTIC DEFORMATION (9)

Strength of perfect crystal and need for dislocations; Characteristics of dislocations – Edge dislocation, Screw dislocation, Burger's vector, mixed dislocation, dislocation loops; Movement of dislocation – Pierls stress, Cross slip, Climb; Dislocations in FCC, HCP and BCC lattice; Stress fields and energies of dislocations, forces on and between dislocations; Dislocation density; Intersections of dislocations – Jogs and kinks; Dislocation multiplication; Dislocation pile-ups; Deformation by slip and twinning; Critical resolved shear stress; Deformation bands and kink bands.

UNIT-2 STRENGTHENING MECHANISMS (9)

Strain hardening; Grain boundary strengthening; Solid solution strengthening - yield-point phenomenon, strain ageing; Precipitation hardening - Conditions for precipitation hardening, Ageing, Formation of precipitates, coarsening of precipitates, Mechanism of strengthening; Dispersion strengthening; Fiber strengthening; Martensite strengthening - examples for above strengthening mechanisms from ferrous and non-ferrous systems, Bauschinger effect; Preferred orientation; Sever plastic deformation.

UNIT-3 FRACTURE AND FRACTURE MECHANICS: (9)

Types of fracture – ductile and brittle fracture, Ductile to Brittle Transition Temperature (DBTT), Metallurgical factors affecting DBTT, determination of DBTT, Hydrogen embrittlement and other embrittlement, Theoretical cohesive strength of metals, Griffith's theory of brittle fracture, Orowan's modification. Fracture mechanics - introduction, modes of fracture, stress intensity factor, strain energy release rate, fracture toughness and determination of KIC, introduction to COD, J integral.

UNIT-4 FATIGUE BEHAVIOUR AND TESTS: (9)

Fatigue: Stress cycles, S-N curves, effect of mean stress, factors affecting fatigue, structural changes accompanying fatigue, cumulative damage, HCF / LCF, thermo-mechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines.

UNIT-5 CREEP BEHAVIOUR AND TESTS: (9)

Creep curve, stages in creep curve and explanation, structural changes during creep, creep mechanisms, metallurgical factors affecting creep, high temperature alloys, stress rupture testing, creep testing machines, parametetric methods of extrapolation. Deformation Mechanism Maps.

Total (L) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1 : Understand and explain the mechanical behaviour of materials.

CO2 : Understand the various types of fractures and their mechanisms, fracture mechanics and various theories describing fracture mechanics.

CO3 : Understand and explain the fatigue behaviour and the mechanism of fatigue, SN curve and fatigue testing machines.

CO4 : Explain the creep behaviour and mechanism, factors affecting creep and creep testing machines.

Text Books:

1. George. E. Dieter, "Mechanical Metallurgy", 3rd Edition, McGraw-Hill Publications, New York, SI Edition, 2004

2. Marc Andr´e Meyers, Krishan Kumar Chawla, "Mechanical Behavior of Materials", Cambridge University Press, UK, 2009.

Reference Books:

1. Reed Hill, R.E., "Physical Metallurgy Principles", Affiliated East West Press, New Delhi, 1992.

2. Davis.H.E. Troxell G.E., Hauck.G.E.W. "The Testing of Engineering Materials", McGraw-Hill, 1982.

3. Wulff et al Vol. III "Mechanical Behavior of Materials", John Wiley and Sons, New York, USA, 1983.

4. Honeycombe R.W.K., "Plastic Deformation of Materials", Edward Arnold Publishers, 1984

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 10	PO 11	PO 12	PS O 1	PS O2	PS O3	PS O 4
CO1	**2**	**0**	**2**	**0**	**3**	**1**	**0**	**0**	**2**	**1**	**1**	**3**	**2**	**1**	**0**	
CO2	**2**	**1**	**3**	**2**	**2**	**1**	**0**	**0**	**2**	**1**	**2**	**2**	**1**	**2**	**1**	
CO3	**1**	**2**	**1**	**0**	**3**	**1**	**1**	**0**	**0**	**0**	**1**	**2**	**1**	**0**	**1**	**1**
CO4	**3**	**0**	**3**	**2**	**3**	**1**	**0**	**1**	**0**	**0**	**2**	**3**	**2**	**1**	**0**	**1**
AVG	**2**	**0.15**	**2.25**	**1**	**2.75**	**1**	**0.25**	**0.25**	**1**	**0.5**	**1.5**	**2.5**	**1.4**	**1.2**	**0.4**	**0.5**

1- Faintly, 2- Moderately, 3- Strongly

22MDMT104	RATE PROCESSES IN METALLURGY	L	T	P	C
		3	0	0	3

Course Objectives:

To impart knowledge on requirements for materials for high temperature use and the behavior of materials at high temperatures.

Unit I	INTRODUCTION	9

Introduction: Role of kinetics, heterogeneous and homogeneous kinetics, Role of heat and mass transfer in metallurgical kinetics, rate expression, Effect of Temperature and concentration on reaction kinetics: effect of temperature (Arrhenius Equation), Effect of concentration (order of a reaction), significance and determination of activation energy.

Unit II	KINETICS OF SOLID-FLUID REACTION	9

Kinetics of solid-fluid reaction: kinetic steps, rate controlling step, definition of various resistances in series, shrinking core model, chemical reaction as rate controlling step, Product layer diffusion as rate controlling step, Mass transfer through external fluid film as rate controlling step, heat transfer as the rate controlling step, Concentration boundary layer, definition and significance of heat and mass transfer coefficient, Theoretical models for mass transfer coefficients, Correlations for heat and mass transfer coefficients

Unit III	LIQUID-SOLID PHASE TRANSFORMATION	9

Principles of Solidification in metals and alloys: thermodynamics involved, eutectic and peritectic Solidification, Homogeneous and heterogeneous nucleation, Mechanisms of growth. Rapid Solidification Processing.

Unit IV	SOLID STATE PHASE TRANSFORMATIONS	9

Nucleation and growth Kinetics, homogeneous and heterogeneous transformation, Precipitation: Coherency, age hardening, particle Coarsening. Ostwald ripening, Order-disorder transformation, spinodal decomposition, massive transformations

Unit V	SOLID STATE PHASE TRANSFORMATIONS IN STEEL	9

Reconstructive and displacive transformations; Pearlitic transformation: mechanism and kinetics: Johnson-Mehl equation, morphology of pearlite; Bainitic transformation: mechanism and kinetics; morphology of upper bainite and lower bainite; Martensitic transformation: Mechanism- diffusionless displacive nature; morphology of high carbon and low carbon martensite.

Total = 45 hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1	Learn the thermodynamic aspects of phase changes.
CO2	Discuss the fundamentals of solid –fluid reactions.
CO3	Derive mathematical expressions of diffusion in order to interpret industrial processes such as carburizing, homogenizing annealing etc.
CO4	Understand the fundamentals of solidification in order to apply it in Foundry industry.
CO5	Learn solid state phase transformations in steel

Text Books:

1.	Ahindra Ghosh and Sudipto Ghosh, A Text book of Metallurgical Kinetics, PHI learning Pvt. Ltd., New Delhi, 2014
2.	H.S. Ray, Kinetics of Metallurgical Reactions, International Science publisher, 1993.
3.	F. Habashi, Kinetics of Metallurgical Processes, Metallurgy Extractive Québec, 1999.
4.	Upadhyaya G S and Dube R K., "Problems in Metallurgical Thermodynamics & Kinetics", Pergamon, 1977.

Reference Books:

1.	Phase transformations in metals and alloys- D.A. Potter and K.E. Easterling, CRC Press, 1992. 2. Transformations in Metals, P.G. Shewmon, Mc-Graw Hill, 1969.
2.	Introduction to Physical Metallurgy – S. N. Avner, Tata McGraw Hill, 1997.
3.	Physical Metallurgy Principles, R. E. Reed-Hill and R. Abbaschian, 3rd ed, PWS-Kent Publishing, 1992.
4.	Modern Physical Metallurgy, R. E. Smallman, Butterworths, 1963

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3	PSO 4
CO1	**1**	**0**	**0**	**2**	**3**	**1**	**0**	**0**	**2**	**1**	**3**	**0**	**1**	**1**	**1**	
CO2	**1**	**3**	**2**	**3**	**2**	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**2**	**1**	**0**	
CO3	**2**	**3**	**0**	**2**	**1**	**0**	**0**	**1**	**0**	**1**	**2**	**0**	**2**	**2**	**1**	**1**
CO4	**3**	**1**	**2**	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**0**	**2**	**0**	**1**	**0**	**1**
CO5	**2**	**3**	**3**	**2**	**1**	**2**	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**2**	**0**	
AVG	**1.8**	**2**	**1.4**	**2**	**2**	**1**	**0.6**	**0.6**	**0.8**	**0.8**	**1.2**	**0.8**	**1.2**	**1.4**	**0.4**	**0.4**

1- Faintly, 2- Moderately, 3- Strongly

22MDMT105 CORROSION AND SURFACE ENGINEERING LT P C
3 0 0 3

Course Objective:

To provide a practical knowledge about corrosion and surface engineering, with its application in engineering field.

MECHANISMS AND TYPES OF CORROSION **9**

Principles of direct and Electro chemical Corrosion, Hydrogen evolution and Oxygen absorption mechanisms – Galvanic corrosion, Galvanic series-specific types of corrosion such as uniform, Pitting, Intergranular, Cavitations, Crevice Fretting, Erosion and Stress Corrosion, corrosion fatigue, hydrogen damage –Factors influencing corrosion

TESTING AND PREVENTION OF CORROSION **9**

Corrosion testing techniques and procedures- Corrosion Testing ASTM Standards, Pitting Corrosion Test, Hydrogen Induced Cracking Test, Sulphide Stress Corrosion Cracking Test- Prevention of Corrosion-Design against corrosion –Modifications of corrosive environment –Inhibitors – Cathodic Protection –Special surfacing processes.

CORROSION OF INDUSTRIAL COMPONENTS **9**

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

SURFACE ENGINEERING FOR WEAR AND CORROSION RESISTANCE **9**

Diffusion coatings –Electro and Electroless Plating –Hot dip coating –Hard facing-Metal spraying, Flame and Arc processes- Conversion coating –Selection of coating for wear and Corrosion resistance.

THIN LAYER ENGINEERING PROCESSES **9**

Laser and Electron Beam hardening –Effect of process variables such as power and scan speed - Physical vapor deposition, Thermal evaporation, Arc vaporization, Sputtering, Ion plating - Chemical vapor deposition – Coating of tools, TiC, TiN, Al_2O_3 and Diamond coating-Properties and applications of thin coatings.

Total(L+T) = 45 hours

Course outcomes:

Upon completion of this course, the students will be able to:

CO1: Know the different types of corrosion and their mechanism.
CO2: Estimate corrosion resistance by different tests.
CO3: Understand corrosion behavior of different metals at different industries.
CO4: Define different forms of processing techniques of surface engineering materials.
CO5: Select the type of deposition and spraying technique with respect to application.

RECOMMENDED BOOKS:

1. Fontana. G., Corrosion Engineering, McGraw Hill,1985.
2. Kenneth G. Budinski, Surface Engineering for Wear Resistance, Prenticehall,1992.
3. ASM Metals Hand Book –Vol. 5, Surface Engineering,1996.
4. Denny A Jones, “Principles and prevention of corrosion”, 2nd edition, Prentice Hall, New Jersey,1995.
5. ASM International, Surface Engineering for Corrosion and Wear Resistance,2005.
6. Schweitzer. P.A., Corrosion Engineering Hand Book, 3rd Edition, Marcel Decker, 1996.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3	PSO 4
CO1	**3**	**2**	**1**	**2**	**2**	**1**	**2**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**2**	
CO2	**3**	**2**	**3**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**3**	**2**	**0**	**2**	
CO3	**3**	**3**	**2**	**3**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**2**	**2**	**1**	**2**	**1**
CO4	**3**	**2**	**2**	**3**	**2**	**1**	**1**	**0**	**1**	**0**	**0**	**3**	**1**	**1**	**2**	
CO5	**3**	**2**	**2**	**2**	**2**	**1**	**0**	**0**	**3**	**0**	**0**	**3**	**1**	**2**	**2**	
AVG	**3**	**2.2**	**2**	**2.2**	**1.6**	**1**	**1**	**0**	**0.8**	**0**	**0**	**2.4**	**1.4**	**1**	**2**	**0.2**

1- Faintly, 2- Moderately, 3- Strongly

22MDMT106 CHARACTERIZATION OF MATERIALS

L	T	P	C
3	0	0	3

Course Objectives:

To acquire knowledge on various characterization, chemical and thermal analysis of metallurgical components using those analysis tools.

OPTICAL MICROSCOPY (9)

Metallographic specimen preparation. Macro-examination -applications. Metallurgical microscope - principle, construction and working, , Optic properties - magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources, lens aberrations and their remedial measures, Various illumination techniques-bright field , dark field, phase-contrast, polarized light illuminations, interference microscopy, high temperature microscopy; Quantitative metallography – Image analysis.

X-RAY DIFFRACTION (9)

Characteristic X-ray spectrum, Bragg's Law, Diffraction methods - Laue method, rotating crystal method and powder method. Diffraction intensity – structure factor calculation. X-ray diffractometer -general features, filters and counters. Applications of X-ray diffraction in materials characterisation – Determination of crystallite size, crystal structure, precise lattice parameter, measurement of stress.

ELECTRON MICROSCOPY (9)

Electron beam - specimen interactions. Construction and operation of Transmission Electron Microscopy – Diffraction effects and image formation, various imaging modes, selected area diffraction, applications, specimen preparation techniques. Scanning electron microscopy – principle, equipment, various operating modes and applications, Electron probe microanalyser (EPMA)- principle, instrumentation, qualitative and quantitative analysis. Introduction to HRTEM, FESEM, EBSD.

SPECTROSCOPIC TECHNIQUES (9)

X-ray spectroscopy – EDS and WDS. Principle, instrumentation, working and applications of Auger Electron spectroscopy, X-ray photoelectron spectroscopy and Secondary ion mass spectroscopy / ion microprobe. Optical emission spectroscopy, Atomic Absorption spectroscopy and X-ray fluorescence spectroscopy - principle, construction, working and applications. UV-Vis, FTIR and Raman spectroscopy.

THERMAL ANALYSIS AND ADVANCED CHARACTERIZATION TECHNIQUES (9)

Thermal Analysis: Principles of differential thermal analysis, differential scanning calorimetry and thermo-graviometric analysis – Instrumentation and applications. Advanced characterization techniques: Scanning probe microscopy - STM and AFM - principle, instrumentation and applications. Field ion microscopy including atom probe - principles, instrumentation and applications.

Total : 45 hours

Upon completion of this course, the students will be able to:

CO1 Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer.

CO2 Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitative metallography

CO3 Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis using XRD

CO4 Analyze the material in lattice level by using different modes of TEM like bright and dark field imaging, selected area diffraction and microchemical analyses.

CO5 Evaluation of the specimen chemical and thermal analysis using advanced methods.

TEXT BOOKS :

1. Cullity, B.D., Elements of X Ray Diffraction, Addison-Wesley Publishing Company Inc, Philippines, 1978
2. Brandon, D. and W.D. Kaplan, Microstructural Characterization of Materials, John Wiley & Sons Ltd, England, 2013.
3. Leng, Y., Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, Singapore, 2008

REFERENCES :

1. ASM Handbook, Volume 10, Materials Characterization, ASM international, USA, 1986.
2. Vander Voort, G.F., Metallography: Principle and practice, ASM International, 1999.
3. Phillips V A, Modern Metallographic Techniques and their Applications, Wiley Eastern, 1971.
4. Angelo, P.C., Materials Characterization, Reed Elsevier India Pvt Ltd, Haryana, 2013.

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3	PSO 4
CO1	2	0	0	2	3	2	0	0	0	0	1	0	2	2	0	
CO2	3	2	2	3	3	1	1	1	1	2	0	0	2	2	1	1
CO3	2	3	1	1	3	0	0	0	2	1	2	0	2	2	1	1
CO4	2	1	2	0	3	0	0	0	1	1	1	2	1	2	1	
CO5	3	0	2	0	3	0	1	1	0	1	2	2	1	0	2	
AVG	2.4	1.2	1.4	1.2	3	0.6	0.4	0.4	0.8	1	1.2	0.8	1.6	1.6	1	0.4

1- Faintly, 2- Moderately, 3- Strongly

22MDMT107 Automotive, Aerospace and Defence Materials

L	T	P	C
3	0	0	3

Course Objectives:

To know the details of electrodes for various materials used for different welding processes

Unit I MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS **9**

Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, Connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.

Unit II MATERIALS FOR AUTOMOTIVE STRUCTURES **9**

Materials selection for bearings, leaf springs, chasis & frames, Bumper, shock absorbers, wind screens, panels, brake shoes, Disc, wheels, differentials , damping and antifriction fluids, Tyres and tubes. Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, anti-collision, Anti-fog, Head lamps.

Unit III AEROSPACE METALS AND ALLOYS **9**

Types of corrosion – Effect of corrosion on mechanical properties – Stress corrosion cracking – Corrosion resistance materials used for space vehicles. Heat treatment of carbon steels – aluminium alloys, magnesium alloys and titanium alloys – Effect of alloying treatment, heat resistance alloys – tool and die steels, magnetic alloys, powder metallurgy-application of materials in Thermal protection systems of Aerospace vehicles – super alloys

Unit IV CERAMICS AND COMPOSITES **9**

Introduction – physical metallurgy – modern ceramic materials – cermet - cutting tools – glass ceramic –production of semi-fabricated forms - Plastics and rubber – Carbon/Carbon composites, Fabrication processes involved in metal matrix composites - shape memory alloys – applications in aerospace vehicle design.

Unit V NUCLEAR WASTE AND RADIATION PROTECTION, IRRADIATION EFEFCTS **9**

Introduction-unit of nuclear radiation-Types of waste –disposal –ICRP recommendations-radiation hazards and prevention –radiation dose units - Irradiation Examination of Fuels, Irradiation behaviour of metallic uranium – irradiation growth, thermal cycling, swelling, adjusted uranium, blistering in uranium rods. Irradiation effects in ceramic oxide and mixed oxide fuels, definition and units of burn up, main causes of fuel element failure in power reactors and remedies to avoid failures.

Total = 45 hours

Course Outcomes:

Upon completion of this course, the students will be able to:

CO1 Understand the use of Materials selection criteria for engine and transmission systems.
CO2 Understand the Different materials used for automotive structures and Different electronic materials for automotive applications
CO3 Explain various topics such as elements of aerospace materials, mechanical behaviour of materials,
CO4 Deploy the skills effectively in understanding the ceramics and composites aerospace materials
CO5 Ability to examine the fuels for nuclear materials.

Reference Books:

1. **ASM Handbook, "Selection of Materials Vol. 1 and 2", ASM Metals Park, Ohio. USA, 1991.**
2. Materials Science and Engineering, Willium D. Callister, Jr. John Wiley & Sons publications Or Callister's Materials Science and Engineering Adapted By R. Balasubramaniam, Wiley India, Edition -2010.
3. Material Science and Engineering, V. Raghavan, Prentice Hall of India, 4th Edition.
4. Engineering Metallurgy Applied Physical Metallurgy, R. A. Higgins, 6th Edition.
5. Gladius Lewis, "Selection of Engineering Materials", Prentice Hall Inc. New Jersey USA, 1995.
6. Charles J A and Crane. F A. A., "Selection and Use of Engineering Materials", 3rd Edition, Butterworths, London UK, 1996

7. ASM Handbook. “Materials Selection and Design”, Vol. 20- ASM Metals Park Ohio.USA, 1997.
8. Cantor,“ Automotive Engineering: Lightweight, Functional, and Novel Materials”, Taylor & Francis Group, London, 2006

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3	PSO 4
CO1	2	0	0	1	1	1	2	0	1	1	0	0	1	2	0	1
CO2	2	1	1	0	3	1	2	0	3	2	1	3	1	0	1	1
CO3	1	0	3	0	3	2	2	0	1	0	3	3	1	1	2	1
CO4	3	0	2	0	3	0	2	1	2	3	2	3	2	1	2	1
CO5	3	0	0	0	0	3	3	0	2	1	2	0	0	2	3	1
AVG	2.2	0.2	1.2	0.2	2	1.4	2.2	0.2	1.8	1.4	1.6	1.8	1	1	1.6	1

1- Faintly, 2- Moderately, 3- Strongly