GOVERNMENT COLLEGE OF ENGINEERING SALEM – 636001
(An Autonomous Institution, Affiliated to Anna University, Chennai)

Regulations 2018A

B.E. METALLURGICAL ENGINEERING – FULL TIME

Course code	Name of the Course	Hours/week						Maximum Marks		
		Category	Contact periods	Lecture	Tutorial /Demo*	Practical	Credits	CA	FE	Total
SEMESTER I										
THEORY										
I8EN101	Professional English	HS	2	2	0	0	2	40	60	100
I8MA101	Matrices and Calculus	BS	4	3	1	0	4	40	60	100
I8CY101	Chemistry	BS	4	3	1	0	4	40	60	100
I8CS101	Fundamentals of Problem solving and Programming	ES	3	3	0	0	3	40	60	100
PRACTICAL										
I8EN102	Professional English Laboratory	HS	2	0	0	2	1	60	40	100
I8CS102	Computer Practice Laboratory	ES	4	0	0	4	2	60	40	100
I8ME102	Workshop Manufacturing Practices	ES	5	1	0	4	3	60	40	100
18MC101	Induction Program	MC	0	0	0	0	0			
TOTAL			24	12	2	10	**19**	-	-	700
SEMESTER II										
THEORY										
18MA201	Differential Equations and Complex variables	BS	4	3	1	0	4	40	60	100
18PH101	Physics - Mechanics	BS	4	3	1	0	4	40	60	100
18EE203	Basic Electrical Engineering for Metallurgy	ES	4	3	1	0	4	40	60	100
18ME101	Engineering graphics and Design	ES	5	1	0	4	3	40	60	100
PRACTICAL										
18PH103	Physics Laboratory	BS	3	0	0	3	1.5	60	40	100
18CY102	Chemistry Laboratory	BS	3	0	0	3	1.5	60	40	100
18EN103	Professional Communication Laboratory	HS	2	0	0	2	1	60	40	100
18EE204	Basic Electrical Engineering Laboratory for Metallurgy	ES	2	0	0	2	1	60	40	100
TOTAL			27	10	3	14	**20**	-	-	800

Course code	Name of the Course	Hours/week						Maximum Marks		
		Category	Contact periods	Lecture	Tutorial /Demo*	Practical	Credits	CA	FE	Total
SEMESTER III										
THEORY										
18MA204	Fourier Series & Transforms	BS	4	3	1	0	4	40	60	100
18MT301	Elements of Physical Metallurgy	PC	4	3	1	0	4	40	60	100
18MT302	Mineral Dressing, Fuels & Furnaces	PC	3	3	0	0	3	40	60	100
18MT303	Metallurgical Thermodynamics & Kinetics	PC	4	3	1	0	4	40	60	100
18MT304	Testing of Materials	PC	3	3	0	0	3	40	60	100
18CE305	Engineering Mechanics	ES	4	3	1	0	4	40	60	100
PRACTICAL										
18MT305	Metallography Laboratory	PC	3	0	0	3	1	60	40	100
18MT306	Chemical Metallurgy Laboratory	PC	3	0	0	3	1	60	40	100
18CYMC01	Environmental Sciences	MC	1	0	0	1	0			
TOTAL			29	18	4	7	**24**	-	-	800
SEMESTER IV										
THEORY										
18MA302	Statistics and Numerical Methods	BS	4	3	1	0	4	40	60	100
18CY301	Biology for Engineers	BS	3	2	1	0	3	40	60	100
18MT401	Mechanical Behaviour of Materials	PC	3	3	0	0	3	40	60	100
18MT402	Phase Transformation	PC	3	3	0	0	3	40	60	100
18MT403	Iron Making	PC	3	3	0	0	3	40	60	100
18XXXXX	Open Elective Course I	OE	3	3	0	0	3	40	60	100
PRACTICAL										
18MT404	Material Testing Laboratory	PC	3	0	0	3	1	60	40	100
18MT405	Machine shop Practice	PC	3	0	0	3	1	60	40	100
TOTAL			25	17	2	6	**21**	-	-	800

Course code	Name of the Course	Hours/week						Maximum Marks		
		Category	Contact periods	Lecture	Tutorial /Demo*	Practical	Credits	CA	FE	Total
SEMESTER V										
THEORY										
18MT501	Heat treatment and Surface Engineering	PC	3	3	0	0	3	40	60	100
18MT502	Steel Making	PC	3	3	0	0	3	40	60	100
18MT503	Corrosion Engineering	PC	3	3	0	0	3	40	60	100
18MT504	Introduction to Instrumentation	ES	3	3	0	0	3	40	60	100
18MTXXX	Professional Elective course I	PE	3	3	0	0	3	40	60	100
18MTXXX	Professional Elective course II	PE	3	3	0	0	3	40	60	100
18MCIN01	Ideation Sprits	EEC	3	3	0	0	1	-	-	100
PRACTICAL										
18MT505	Heat treatment Laboratory	PC	3	0	0	3	1	60	40	100
18MT506	Corrosion Science Laboratory	PC	3	0	0	3	1	60	40	100
TOTAL			24	18	0	06	**21**	-	-	800
SEMESTER VI (Regular Stream)										
THEORY										
18MTXXX	Professional Elective Course III	PE	3	3	0	0	3	40	60	100
18MTXXX	Professional Elective Course IV	PE	3	3	0	0	3	40	60	100
18MTXXX	Professional Elective Course V	PE	3	3	0	0	3	40	60	100
18MTXXX	Professional Elective Course VI	PE	3	3	0	0	3	40	60	100
18XXXXX	Open Elective Course II	OE	3	3	0	0	3	40	60	100
18XXXXX	Open Elective Course III	OE	3	3	0	0	3	40	60	100
18XXXXX	Open Elective Course IV	OE	3	3	0	0	3	40	60	100
	TOTAL						**21**			

SEMESTER VI (Protosem Stream)										
THEORY										
18MEPS11	Applied Design Thinking	Proto sem	3	3	0	0	3	100	-	100
18MEPS12	Startup Fundamentals	Proto sem	3	3	0	0	3	100	-	100
18MEPS13	Computational Hardware	Proto sem	3	3	0	0	3	100	-	100
18MEPS14	Coding for Innovators	Proto sem	3	3	0	0	3	100	-	100
18MEPS15	Industrial Design & Rapid Prototyping Techniques	Proto sem	3	3	0	0	3	100	-	100
18MEPS16	Industrial Automation/ Data Life Cycle Management	Proto sem	3	3	0	0	3	100	-	100
18MEPS17	Robotics /ML& MLOps	Proto sem	3	3	0	0	3	100	-	100
TOTAL			21	21	0	0	**21**			700
SEMESTER VII										
THEORY										
18MT701	Characterization of Materials	PC	3	3	0	0	3	40	60	100
18MT702	Introduction to Industrial Management	HS	3	3	0	0	3	40	60	100
18MT601	Non Ferrous Extractive Metallurgy	PC	3	3	0	0	3	40	60	100
18MT602	Forming Processes	PC	3	3	0	0	3	40	60	100
18MT603	Foundry Processes and Metallurgy	PC	3	3	0	0	3	40	60	100
18MT604	Welding Processes and Metallurgy	PC	3	3	0	0	3	40	60	100
PRACTICAL										
18MT703	Materials Characterization Laboratory	PC	3	0	0	3	1	60	40	100
18MT704	Computer application in Metallurgy Laboratory	PC	3	0	0	3	1	60	40	100
18MT605	Welding & NDT Laboratory	PC	3	0	0	3	1	60	40	100
18MT606	Foundry & Forming Processes Laboratory	PC	3	0	0	3	1	60	40	100
TOTAL			30	18	0	12	**22**	-	-	1000
SEMESTER VIII										
THEORY										
18MT801	Total Quality Management	HS	3	3	0	0	3	40	60	100
18MTXXX	Mandatory Course	MC	2	2	0	0	0	0	0	0
18EN501	Communication Skills Laboratory	HS	4	0	0	4	2	60	40	100
18MT802	Project Work	EEC	16	0	0	16	10	80	120	200
TOTAL			25	5	0	20	**15**	-	-	400
Grand Total							**163**			

CREDIT DISTRIBUTION SEMESTER WISE

SEMESTER	I	II	III	IV	V	VI	VII	VIII	TOTAL
CREDITS	19	20	24	21	21	21	22	15	163

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

PROFESSIONAL ELECTIVE COURSES (PEC)

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PROFESSIONAL ELECTIVE I								
1.	18MTE11	Transport phenomena	PE	3	3	0	0	3
2.	18MTE12	Fractography and failure analysis	PE	3	3	0	0	3
3.	18MTE13	Metallurgical kinetics	PE	3	3	0	0	3
4.	18MTE14	Solidification Processing	PE	3	3	0	0	3
5	18MTE15	Fracture Mechanics	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE II								
1.	18MTE21	Ferrous and Non Ferrous alloys	PE	3	3	0	0	3
2.	18MTE22	Composite Materials	PE	3	3	0	0	3
3.	18MTE23	Ceramic materials	PE	3	3	0	0	3
4.	18MTE24	Metallurgy of tool Steels	PE	3	3	0	0	3
5.	18MTE25	Bio and smart materials	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE III								
1.	18MTE31	Nonmetallic Materials	PE	3	3	0	0	3
2.	18MTE32	Continuous casting of steel	PE	3	3	0	0	3
3.	18MTE33	Special casting Technology	PE	3	3	0	0	3
4.	18MTE34	Alternate routes of Iron making	PE	3	3	0	0	3
5.	18MTE35	Secondary steel making	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE IV								
1.	18MTE41	Particulate processing Technology	PE	3	3	0	0	3
2.	18MTE42	Severe plastic deformation	PE	3	3	0	0	3
3.	18MTE43	Metallurgical waste utilization and management	PE	3	3	0	0	3
4.	18MTE44	Computational Materials Engineering	PE	3	3	0	0	3
5.	18MTE45	Special welding processes	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE V								
1.	18MTE51	Physics of Engineering Materials	PE	3	3	0	0	3
2.	18MTE52	X- ray diffraction and Electron microscopy	PE	3	3	0	0	3
3.	18MTE53	Electrical ,Electronics and magnetic materials	PE	3	3	0	0	3
4.	18MTE54	Surface engineering	PE	3	3	0	0	3
5.	18MTE55	Additive manufacturing	PE	3	3	0	0	3
PROFESSIONAL ELECTIVES VI								
1.	18MTE61	Nano Materials	PE	3	3	0	0	3
2.	18MTE62	Thin films, coatings and applications	PE	3	3	0	0	3
3.	18MTE63	Aerospace materials	PE	3	3	0	0	3
4.	18MTE64	Modeling and simulation in material processes	PE	3	3	0	0	3
5.	18MTE65	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.	18MTOE01	Foundry and Welding Technology	OE	3	3	0	0	3
2	18MTOE02	Surface Engineering	OE	3	3	0	0	3
3.	18MTOE03	Design and Selection of Materials	OE	3	3	0	0	3
4.	18MTOE04	Nano science and Technology	OE	3	3	0	0	3

SUMMARY OF CREDIT DISTRIBUTION TABLE

B.E., METALLURGICAL ENGINEERING											
S.NO	Course Work subject Area	Credits Per Semester								Total Credit	Credits recommended by AICTE
		I	II	III	IV	V	VI	VII	VIII		
1	Basic Sciences	8	11	4	7	-	-	-	-	30	25
2	Humanities and Social Sciences	3	1	-	-	-	2	3	3	11	12
3	Engineering Sciences	8	8	4	-	3	-	-	-	23	24
4	Professional Core	-	-	16	11	11	14	5	-	57	48
5	Professional Elective	-	-	-	-	6	3	6	3	18	18
6	Open Elective	-	-	-	3	-	3	6	-	12	18
7	Employment Enhancement Course	-	-	-	-	-	-	-	10	10	15
8	Mandatory Course	$0^{\#}$	-	$0^{\#}$	-	-	$0^{\#}$	-	-	00	-
TOTAL		19	20	24	21	21	22	22	15	163	160*

$0^{\#}$ - Non credit Course *Minor variation is allowed as per need of the respective disciplines.

SEMESTER - III

18MA204	FOURIER SERIES AND TRANSFORMS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To impact analytical skills in the areas of boundary value problems and transform techniques.
2.	To obtain the knowledge of solving second order ODE using Laplace transform techniques and inverse Laplace transform using convolution theorem.
3.	To familiarize with Fourier transform of a function and its sine and cosine transforms.
4.	It serves as a prerequisite for post graduate and specialized studies and research.
5.	To gain the skills to form difference equations and find its solution by using Z-transform method.

UNIT I	FOURIER SERIES	9	+	3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Parseval's Identity – Harmonic Analysis.

UNIT II	BOUNDARY VALUE PROBLEMS	9	+	3

Classification of second order quasi linear partial differential equations – Solutions of one dimensional wave equation – One dimensional heat equation – Steady state solution of two-dimensional heat equation (Insulated edges excluded) – Fourier series solutions in Cartesian coordinates.

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) =45L+15T=60 Hours

Course Outcomes:

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

CO1	:	Acquire the knowledge about Fourier series
CO2	:	Learn the techniques of solving boundary value problems
CO3	:	Familiar with the transform techniques.

Text Books:

1.	Veerarajan T, “Engineering Mathematics (For Semester III)”, 3rd Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
2.	P.Kandasamy, K.Thilagavathy and K.Gunavathy, “Engineering Mathematics, Volume III”, S. Chand & Company ltd., New Delhi, 1996.
Reference Books:	
1.	Grewal, B.S., “Higher Engineering Mathematics”, 43rd Edition, Khanna Publishers, Delhi, 2014.
2.	Wylie C. Ray and Barrett Louis, C., “Advanced Engineering Mathematics”, Sixth Edition, McGraw-Hill, Inc., New York, 1995.
3.	Andrews, L.A., and Shivamoggi B.K., “Integral Transforms for Engineers and Applied Mathematicians”, MacMillan, New York, 1988.
4.	Narayanan, S., Manicavachagom Pillai, T.K. and Ramaniah, G., “Advanced Mathematics for Engineering Students”, Volumes II and III, S. Viswanathan (Printers and Publishers) Pvt. Ltd. Chennai, 2002.

18MT301	ELEMENTS OF PHYSICAL METALLURGY	L	T	P	C
		3	1	0	4

Course Objectives:

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

UNIT I	CRYSTAL STRUCTURES	9	+	3

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 II	CRYSTALLINE IMPERFECTIONS	9	+	3

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	+	3

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	+	3

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	+	3

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) = 60 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 and apply the common strengthening processes viz. Cold working and Hot working and post 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, 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.
E-Reference	
1.	www.matter.org
2.	www.doitpoms.ac.uk

18MT302	MINERAL DRESSING, FUELS & 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 the associated 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 equipments used in mineral dressing.
CO2	:	Understand the chemical processing of ores and gain knowledge on classification, froth floatation 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 tyes of furnaces and various methods of heat recovery.
CO5	:	Gain knowledge on the testing of refractories, explain the various refractories, their properties and 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, New Delhi, 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/

18MT303	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 lawsof 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, 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+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 & MetallurgicalThermodynamics, Prentice Hall India, 2002
2.	Upadhyaya G S andDube 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 & 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.
E-References:	
1.	www.nptelvideos.in/2012/12/basicthermodynamics.html

18MT304	TESTING OF MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To gain knowledge on the mechanical behaviour of materials and to apply them to design the materials for various engineering applications.
2.	To gain knowledge on various mechanical tests carried out on the materials.
3.	To develop the fundamental knowledge about various non-destructive techniques in order to control the quality in manufacturing and production engineering components.

UNIT I	**TENSILE TESTS**:	9	+	0

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

UNIT II	**HARDNESS TESTS AND IMPACT TESTS:**	9	+	0

Definition, Types of hardness tests- Vickers, Brinell, 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	**LIQUID PENETRANT, MAGNETIC PARTICLE AND EDDY CURRENT INSPECTION**	9	+	0

Visual inspection, Liquid penetrant inspection: Principle, applications, advantages and limitations, Dyes, developers and cleaners, Fluorescent penetrant test. Magnetic particle inspection: Principles, applications, magnetisation methods, magnetic particles, demagnetisation. Advantages and limitations. Eddy current testing: Principle, application and Instrumentation of Eddy current testing.

UNIT IV	**RADIOGRAPHY TESTING:**	9	+	0

X-rays and Gamma rays, Production of X-rays, properties. Gamma ray sources, characteristics of Gamma rays. Absorption of rays, scattering, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films – grain fineness, 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 V	**ULTRASONIC TESTING AND OTHER NDT METHODS:**	9	+	0

Types of Ultrasonic waves, principles of wave propagation, characteristics of ultrasonic waves, Inspection methods - pulse echo, Transmission and resonance techniques, Types of scanning, Test block, IIW - reference blocks. Introduction to Time of flight diffraction (TOFD) and Phased array Ultrasonic Testing.
Other NDT techniques: Principle, application and Instrumentation of Infrared and Thermal inspection methods, Holography and Acoustic emission testing. Pressure and Leak testing. LASER shearography.

Total (L+T) = 45 Hours

Course Outcomes:

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

CO1	:	Understand and explain the material properties, testing machines – their types and testing procedures.

CO2	:	Explain the different types of hardness test and impact tests and their uses.
CO3	:	Understand the basic concepts of NDT and the principle of techniques like Visual inspection, Liquid penetrant inspection, Magnetic particle inspection and Eddy current testing.
CO4	:	Explain the principles of radiography and ultrasonics.
CO5	:	Explain the principle of NDT methods like, Thermal inspection, Holography, Acoustic emission testing, Pressure testing, Leak testing and LASER shearography
Text Books:		
1.	George. E. Dieter, “Mechanical Metallurgy”, 3rd Edition, McGraw-Hill Publications, New York, SI Edition, 2004	
2.	Suryanarayana, “Testing of Metallic Materials”, Prentice Hall India, 1979.	
3.	Baldev Raj, Jayakumar T. Thavasimuthu M, “Practical Non-Destructive testing”, Narosa Publishing House, NewDelhi, 1997.	
4.	Barry Hull and Vernon John, "Non Destructive Testing", ELBS / Macmillan, 2001.	
5.	Mc Gonnagle, W T ,"Non-Destructive Testing", McGraw Hill Book Co., 2003.	
Reference Books:		
1.	Davis.H.E. Troxell G.E., Hauck.G.E.W. “The Testing of Engineering Materials”, McGraw-Hill, 1982.	
2.	Wulff et al Vol. III “Mechanical Behavior of Materials”, John Wiley and Sons, New York, USA, 1983.	
3.	Honeycombe R.W.K., “Plastic Deformation of Materials”, Edward Arnold Publishers, 1984	

18CE305	ENGINEERING MECHANICS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To explain the importance of mechanics in the context of engineering and conservation equations.
2.	To explain the significance of centroid, centre of gavity and moment of inertia
3.	To apply the different principles to study the motion of a body, and concept of relative velocity and acceleration

UNIT I	BASICS & STATICS OF PARTICLES	9	+	3

Introduction – Units and Dimensions – Laws of Mechanics – Lame's theorem, Parallelogram and triangular Law of forces – Vectors – Vectorial representation of forces and moments – Vector operations: additions, subtraction, dot product, cross product – Coplanar Forces – Resolution and Composition of forces – Equilibrium of a particle – Forces in space – Equilibrium of a particle in space – Equivalent systems of forces – Principle of transmissibility – Single equivalent force.

UNIT II	EQUILIBRIUM OF RIGID BODIES	9	+	3

Free body diagram – Types of supports and their reactions – requirements of stable equilibrium – Moments and Couples – Moment of a force about a point and about an axis – Vectorial representation of moments and couples – Scalar components of a moment – Varignon's theorem – Equilibrium of Rigid bodies in two dimensions – Equilibrium of Rigid bodies in three dimensions – Examples

UNIT III	PROPERTIES OF SURFACES AND FRICTION	9	+	3

Determination of Areas and Volumes – Theorms of Pappus - Guildinus – First moment of area and the Centroid of sections – second and product moments of plane area of various sections–Parallel axis theorem and perpendicular axis theorem - Polar moment of inertia – Principal moments of inertia of plane areas – Principal axes of inertia-Frictional force – Laws of Coulomb friction – simple contact friction – Rolling resistance – Belt friction.

UNIT IV	KINEMATICS AND KINETICS OF PARTICLES	9	+	3

Equations of motion- Rectilinear motion-curvelinear motion- Relative motion- D'Alembert's Principle-work-Energy equation-Conservative forces and principle of conservation of energy-Impulse- momentum- Impact-Direct central impact and oblique central impact

UNIT V	KINEMATICS AND KINETICS OF RIGID BODIES	9	+	3

Plane motion- Absolute motion- Relative motion- translating axes and rotating axes- work and energy-impulse and momentum

Total (L+T) = 60 Hours

Course Outcomes:

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

CO1	:	Understand the basics and statics of the particle
CO2	:	Establish the equilibrium of rigid bodies and draw the free body diagram and mention the supports and the reactions for the diagram
CO3	:	Determine the areas and volumes of the surfaces using the various theorems and find the moment of inertia of different body shapes
CO4	:	Comprehend the frictional forces acting on a rolling and the resting body
CO5	:	Understand the laws of motion, the kinematics of motion and the interrelationship.

Text Books:

1.	Rajasekaran S and Sankarasubramanian G., Fundamentals of Engineering Mechanics, Vikas Publishing House Pvt. Ltd., 2000.
2.	Palanichamy M.S. and Nagan S., Engineering Mechanics – Statics &Dynamics, Tata McGraw-Hill, 2001.
Reference Books:	
1.	Bansal R.K., Engineering Mechanics, Laxmi Publications (P) Ltd., 2007.
2.	Kumar K.L., Engineering Mechanic, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
3.	Beer F.P and Johnson Jr. E.R. Vector Mechanics for Engineers, Vol. 1 Statics and Vol. 2 Dynamics, McGraw-Hill International Edition, 1997.
4.	Hibbeller R.C., Engineering Mechanics, Vol. 1 Statics, Vol. 2 Dynamics, Pearson Education Asia Pvt. Ltd., 2000.
5.	Irving H. Shames, Engineering Mechanics – Statics and Dynamics, IV Edition – Pearson Education Asia Pvt. Ltd., 2003.
6.	Ashok Gupta, Interactive Engineering Mechanics – Statics – A Virtual Tutor (CDROM), Pearson Education Asia Pvt., Ltd., 2002.

18MT305	METALLOGRAPHY LABORATORY	L	T	P	C
		0	0	3	1

EXPERIMENTS	
1.	Sample preparation and mounting
2.	Study of metallurgical microscope
3.	Microstructure of different types of cast iron in unetched condition
4.	Microstructure of different types of cast iron in etched condition
5.	Microstructure of pure iron, plain carbon steels
6.	Overheated structure and banded structure in steel
7.	ASTM grain size determination
8.	Microstructure of tool steels and stainless steels
9.	Microstructure of cast and wrought aluminium alloys
10	Microstructure of copper alloys
11.	Sulphur and Phosphor printing
12	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.

18MT306	CHEMICAL METALLURGY LABORATORY	L	T	P	C
		0	0	3	1

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.	Muffle Furnace temperature calibration
9.	Proximate analysis of Coal.
10.	Settling velocity of $CaCO_3$ powder.
11.	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

18CYMC01	ENVIRONMENTAL SCIENCE	L	T	P	C
		0	0	1	0

Course Objectives:

1.	To impart awareness to the student that they are separate from the environment and should not control the environment.
2.	They are part of the environment
3.	To have an ancient wisdom drawn from Vedas
4.	Activities based knowledge to preserve environment
5.	Conservation of water and its optimization.

ENVIRONMENTAL AWARENESS **6 Hours**

1.	Group activity on water management
2.	Group discussion on recycle of waste (4R's)
3.	Slogan making contest.
4.	Poster making event.
5.	Expert lecture on environmental awareness.
6.	Imparting knowledge on reduction of electricity usage

ENVIRONMENTAL ACTIVITIES **8 Hours**

1.	Identification and segregation of biodegradable and non biodegradable waste
2.	Campus cleaning activity
3.	Plantation of trees in the college campus and local waste lands.
4.	Identification of varieties of plants and their usage
5.	Shutting down the fans and ACs of the campus for an hour
6.	Field work on growing of kitchen garden for mess

SEMESTER – IV

18MA302	STATISTICS AND NUMERICAL METHODS	L	T	P	C
		3	1	0	4

Course Objectives:

1.	To understand the statistical averages and fitting of curves.
2.	To gain the knowledge of significance test for large and small samples.
3.	To obtain the knowledge about numerical interpolation, differentiation and integration.
4.	To acquire knowledge of numerical solution to first order ordinary differential equations using single step and multi step methods.
5.	To gain the knowledge of numerical solution to second order partial differential equations by using explicit and implicit methods.

UNIT I	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 II	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 co-efficient, test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

UNIT III	INTERPOLATION, NUMERICAL DIFFERENTIATION AND INTEGRATION	9	+	3

Solution of Algebraic and Transcendental equations by Newton-Raphson method- Solution of system of equations by Gauss Elimination and Gauss Seidal iterative methods - Interpolation using Newton's Forward and Backward formulae. Interpolation with unequal intervals: Newton's divided difference and Lagrange's formulae Numerical Differentiation and Integration: Trapezoidal rule and Simpson's 1/3 rule, Simpson's 3/8 rule.

UNIT IV	NUMERICAL SOLUTION FOR ORDINARY DIFFERENTIAL EQUATIONS	9	+	3

Ordinary differential equations: Taylor series method- Euler and modified Euler's method- Runge-Kutta method of fourth order for solving first and second order differential equations- Milne's and Adam's predictor - corrector methods.

UNIT V	NUMERICAL SOLUTION FOR PARTIAL DIFFERENTIAL EQUATION	9	+	3

Partial differential equations: Finite difference solution of two dimensional Laplace and Poisson equations- Implicit and Explicit methods for one dimensional heat equation (Bender Schmidt and Crank-Nicholson methods) - Finite difference explicit method for wave equation.

Total (L+T) =60 Hours

Course Outcomes:

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

CO1	:	Learn about statistical averages and fitting the curves by Least Square Method.
CO2	:	Acquire the techniques of interpolation.
CO3	:	Familiar with the numerical differentiation and integration
CO4	:	Solve the initial value problems for ordinary differential equations.

CO5	:	Learn to find the numerical solution of partial differential equation by using Finite difference method.

Text Books:	
1.	Veerarajan T, “Probability and Random Process (With Queuing theory)”, 4th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2016.
2.	Kandasamy.P, Thilagavathy.K, Gunavathi.K, “Numerical Methods” S.Chand & Co., New Delhi, 2005.
3.	Gupta, S.C. and Kapur, V.K., “Fundamentals of Mathematical Statistics”, S.Chand and Sons, New Delhi, 11th Edition 2014
Reference Books:	
1.	Fruend John, E. and Miller Irwin, “Probability and Statistics for Engineers”, 8thEdition, Prentice Hall India (P) Ltd, 2010.
2.	Gerald, C. F. and Wheatley, P.O., “Applied Numerical Analysis” , Sixth Edition , Pearson Education Asia , New Delhi – 2002
3.	M.K.Venkataraman, “Numerical Methods”, National Publishing Company,2000
4.	Jain M.K.Iyengar, K & Jain R.K., “Numerical Methods for Scientific and Engineering Computation ”, New Age International (P) Ltd, Publishers 2003
5.	Manish Goyal, “Numerical Methods and Statistical techniques Using “C” ”, 1st Edition, Laxmi Publications (P) Ltd, 2009.

18CY301	BIOLOGY FOR ENGINEERS	L	T	P	C
		2	1	0	3

Course Objectives:

To introduce students to modern biology with an emphasis on evolution of biology as a multi-disciplinary field and to make them aware of biological principles. The course will facilitate the students to:

1.	Realize that all forms of life have the same building blocks.
2.	Convey that without catalysis life would not have existed on earth.
3.	Know the analysis of biological processes at the reduction level
4.	Comprehend the fundamental principles of energy transactions are the same in physical and biological world.
5.	Understand the fundamentals about the molecular basis of coding and decoding

UNIT I	BIOMOLECULES	6	+	3

Carbohydrates- classification - Glucose properties and structural elucidation –fructose, sucrose, starch - structure only; Amino acids- classification- amphoteric nature of amino acids - zwitter ion - isoelectric point reactions of amino acids; Vitamins - general characteristics- classification- function and deficiency diseases

UNIT II	ENZYMES	6	+	3

Nomenclature - structure of enzymes – enzyme cofactors- properties of enzymes(catalytic properties, specificity, reversibility, sensitiveness to heat and inhibitors, colloidal nature)- mechanism of the enzyme action- lock and key mechanism and koshland induced fit mechanism -Factors affecting rate of enzyme reaction(temperature, pH, substrate concentration, enzyme concentration, water inhibitors, end product accumulation)- enzyme kinetics –michaelis-menten equation.

UNIT III	MACROMOLECULES	6	+	3

Proteins- classification- structure of proteins- primary, secondary, tertiary and quaternary structure- properties of proteins- physical and chemical properties- colour reaction of proteins (biuret reaction, millions reaction, xanthoproteic reaction, ninhydrin reaction, azo dye reaction Hopkins Cole reaction) -Protein synthesis- mechanism of protein synthesis.

UNIT IV	METABOLISM	6	+	3

Thermodynamics as applied to biological systems - exothermic and endothermic versus endergonic and exergonic reactions- concept of equilibrium constant and its relation to standard free energy- spontaneity - structure of ATP; Glycolysis- definition- flow chart- steps involved in glycolysis- preparatory phase and pay off phase- kinds of reactions in glycolysis; Photosynthesis- definition- significance photosynthetic- pigments types- structure of pigments factors affecting photosynthesis- external and internal factors.

UNIT V	NUCLEIC ACIDS	6	+	3

Types-Structural components of nucleic acids- acid, pentose sugar and nitrogenous base- nucleoside – nucleotide and its functions - single and double helical structure of DNA-comparison between DNA and RNA- types of RNA- transcription -mRNA, tRNA and rRNA and their function - replication of DNA- genetic code characteristics

Total (L+T) = 45 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:		
CO1	:	Appreciate that all types of life have the identical structural units.
CO2	:	Highlight the idea that without catalysis, living beings would not have existed on earth.
CO3	:	Be familiar with the investigation of biological processes at the reduction level.
CO4	:	Figure out that the primary principles of energy transactions are alike in physical and chemical
Text Books:		
1.		FJ.L.Jain, Sanjay jain and Nitin jain- “Fundamentals of Biochemistry” - Sixth edition, S.Chand and company Ltd., Ram nagar, 2005.
2.		Dr.A.V.S.S.Rama Rao-“ Text book of Biochemistry”- Text book of Biochemistry- First edition- UBS Publishers' Distributors Pvt. Ltd., 2008.
3.		U. Satyanarayana –“ Biochemistry”-5th edition – Sri Padmavathi Publications Ltd.,2017.
Reference Books:		
1.		Campbell, N. A.; Reece, J. B.; Urry, Lisa; Cain, M,L.; Wasserman, S. A.; Minorsky, P. V.; Jackson, R. B.-“ Biology: A global approach”- Pearson Education Ltd
2.		Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H-“ Outlines of Biochemistry”- John Wiley and Sons
3.		By Nelson, D. L.; and Cox- “Principles of Biochemistry”- V Edition- M. M.W.H. Freeman and Company
4.		Stent, G. S.; and Calender-“ Molecular Genetics”- Second edition - R. W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher

18MT401	MECHANICAL BEHAVIOUR OF MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To gain knowledge on the mechanical behaviour of materials and to apply them to design the materials for various engineering applications.
2.	To gain knowledge on fracture, fatigue and creep behaviour of materials

UNIT I	DISLOCATION THEORY AND PLASTIC DEFORMATION	9	+	0

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 II	STRENGTHENING MECHANISMS	9	+	0

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,simple problems; Bauschinger effect; Preferred orientation; Sever plastic deformation.

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 K_{IC}, 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 (L+T) = 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	

18MT402	PHASE TRANSFORMATION	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.

18MT403	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	

18MT404	MATERIALS TESTING LABORATORY	L	T	P	C
		0	0	3	1

Course Objectives:

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

EXPERIMENTS

1.	Tensile testing of base materials(Sample – Round,Flat,pipe)
2	Tensile testing of base materials by tensometer
3	Tensile testing of weldments (Longitudinal/Transverse)
4	Compression test - Base material
5	Impact testing of base materials (Charpy & Izod)
6	Impact testing of weldments (Charpy & Izod)
7	Bend Test 0f base material / Weldment
8	Hardness – Brinell / Rockwell
9	Hardness – Vickers
10	Microhardness test
11	Fatigue test
12	Wear test – Pin on disc
13.	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 base materials and weldments

18MTE405		MACHINESHOP PRACTICE	L	T	P	C
			0	0	3	1
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) = 60 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	:	Explain 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	:	Understand the fundamentals of casting and molding principles and its emerging applications and explain the steps for making green sand molding and also build the core by using different types of pattern like split pattern and loose piece pattern.				
CO5	:	Explain the fundamentals of welding process and to make the joints like butt joint, lap joints and tee joints by using arc welding equipment for industrial applications.				

SEMESTER – V

18MT501	HEAT TREATMENT AND SURFACE ENGINEERING	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, Various heating media used for heat treatment, furnaces, temperature and atmosphere control. Quenching media and their characteristics.

UNIT III	HEAT TREATMENT OF SPECIFIC ALLOYS	9	+	0

Heat treatment of carbon steels, various types of tool steels, high speed steels, and die 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.

UNIT IV	CASE HARDENING	9	+	0

Carburising. Nitriding, Cyaniding, Carbonitriding, Boriding, Aluminising, Siliconising, Chromising Induction, Flame hardening, Electron beam hardening, Laser beam hardening: principle, methods, operating variables. Measurement of case depth.

UNIT V	SURFACE ENGINEERING	9	+	0

Introduction to Lubrication and tribology, Physical vapour deposition processes - Thermal evaporation - sputter coating -Ion plating - Chemical vapourdeposition - reactive sputtering - TiC,TiN,Alumina, CBN,Diamond andDLCcoatings. Principle and applications of surfacing, Principle and applications of Electroplating

Total (L+T) = 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 various diffusion dependent laws and explain the process of carburizing, nitriding, nitro-carburizing etc.
CO4	:	Explain and analyze the various heat treatment equipments, heat treating medium, 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 steels, 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, 2011.
2.	Vijendra Singh,"Heat Treatment of Metals", Standard Publishers Distributors, Delhi, 2007.
3.	Romesh.C.Sharma, “Principles of Heat Treatment of Steels”, New Age International Pvt. Ltd. Publishers, New Delhi, 2009.
4.	Kenneth G.Budinski, "Surface Engineering for Wear Resistance", Prentice Hall, Englewood Cliff,1998.
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.
3.	Karl-Erik Thelning, "Steel and its Heat Treatment", Butterworths London, second edition 1984.
4.	ASMMetals Handbook, Vol.5,"Surface Engineering", Metals Park,Ohio, 2001.

18MT502	STEEL MAKING	L	T	P	C
		3	0	0	3

Course Objectives:

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

Top blown process, LD process – LD vessel design & Lance design, Charge material, Operational feature, Characteristics of LD process & Reactions in LD converter. LDAC, Kaldo process, Rotor process. Bottom blown basic Oxygen conventional process (Q-BOP/OBM/LWS),EOF. Principles & Mechanism of refining only.

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 modeling 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

Text Books:	
1.	Chakrabarti, A.K., Steel Making, Prentice Hall of India Pvt. Ltd. New Delhi, 2010.
2.	Tupkary, R.H., and V.R. Tupkary, Introduction to Modern Steel Making, 7th Edition, Khanna Publications, New Delhi, 2012.
Reference Books:	
1.	Fruchan, R.J., The Making, Shaping and Treating of Steel, AISE Steel Foundation, 11th Ed., 1998.
2.	Ghosh, A., and A. Chatterjee, Iron Making and Steel Making – Theory and Practice, Prentice Hall of India Private Ltd., New Delhi, 2008.
E-References:	
1.	https://nptel.iitm.ac.in

18MT503	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, corrosion of pipelines.

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

18MT504	INTRODUCTION TO INSTRUMENTATION	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To acquire basics 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	FLOW, LEVEL AND VIBRATION MEASUREMENT	9	+	0

Flow and level measurements: Variable head flow meters, variable area flow meters, positive displacement flow meters, hot wire anemometer, open channel flow meters, mass flow measurement - thickess, liquid and continuous level measurement. Vibration measurement: Elementary Accelerometer and Vibrometer- seismic instruments for absolute displacement – velocity seismic accelerometer, Piezo electric accelerometer.

UNIT V	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.

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	:	Familiarize the various flow, level and vibration measuring instruments
CO5		Choose instruments for different temperature and pressure conditions

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.	Nakra B.C., Theory and Applications of Automatic Controls, New Age International P. Limited, Publishers, 1998.
3.	Holmon J.P., Experimental methods for Engineers, Tata McGraw Hill Publications Co. Ltd., New Delhi, 2004.
4.	Jain R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1984.
E- references	
1.	https://nptel.ac.in/courses/112106138/

18MT505	HEAT TREATMENT LABORATORY	L	T	P	C
		0	0	3	1

Objective

1. To understand the various heat treatment process and their equipment's

EXPERIMENTS

1.	Annealing of carbon steels-Heattreatment practice and Analysis
2.	Normalising of carbon steels - Heattreatment practice and Analysis
3.	Effect of quenching media on hardening of steel - Heattreatment practice and Analysis
4.	Effect of tempering temperature on hardened steel - Heattreatment practice and Analysis
5.	Effect of tempering time on hardened steel- Heattreatment practice and Analysis
6.	Carburizing of steel
7.	Case hardness depth measurements
8.	Heat treatment of cast iron - Heattreatment practice and Analysis
9.	Age hardening of aluminium alloys.- Heattreatment practice and Analysis
10.	Identification of defects in heat treated materials

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	:	Conduct the process of carburizing of steels.
CO4	:	Observe and determine the defects in Heat treated steels
CO5	:	Determine the Age hardening of aluminium alloys

18MT506	CORROSION SCIENCE LABORATORY	L	T	P	C
		0	0	3	1

Course Objectives:

1.	To gain knowledge about corrosion and its applications in the engineering field.

EXPERIMENTS

1.	Corrosion rate determination by weight loss method.
2.	Effect of inhibitors on rate of corrosion.
3.	Oxalic acid etch test for IGC ASTM A262 – Practice A
4.	Investigation of pitting corrosion in steel by indicator test.
5.	Carryout Polarization Studies by using electrochemical workstation.
6.	Carry out Impedance studies by electrochemical workstation.
7.	Determination of pitting potential of steel by polarization technique.
8.	Salt spray test.
9.	Electroplating of Copper
10.	Electroplating of Nickel

Total (P) = 45 Hours

Course Outcomes

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

CO1	:	Determine the corrosion rate by weight loss method.
CO2	:	Analyze the effect of inhibitor on corrosion rate.
CO3	:	Investigate galvanic corrosion and pitting corrosion.
CO4	:	Perform electroplating of copper and nickel.

Reference books

1.		Mars G. Fontana, Corrosion Engineering, Third Edition, Mc Graw Hill Inc., 1987.
2.		Rajnarayan, Metallic corrosion and prevention, Oxford Publications, 2001.
E- References		
1.		https://www.youtube.com/watch?v=Wo99UhTpbi8
2.		https://www.youtube.com/watch?v=OxhCU_jBiOA

18EN501	COMMUNICATION SKILLS LABORATORY	L	T	P	C
		0	0	4	1

Course Objectives:	
1.	Communicate effectively with interviewers
2.	Express opinions, illustrate with examples, elucidate and conclude in group discussions
3.	Write error free letters and prepare reports
EXPERIMENTS	
1.	**WRITING SKILLS (5 hours)**
	• Letter seeking permission to go on industrial visit
	• Letter of invitation
	• Resume and Cover Letter
	• Report Writing – Progress in project work
2.	**SPEAKING SKILLS (5 hours)**
	• Welcome Address and Vote of Thanks
	• Analysing and presenting business articles
	• Power Point Presentation
	• Group Discussion
3.	**SOFT SKILLS (5 hours)**
	• Psychometric profile
	• Self-Introduction
	• Interview skills
	• Conducting a board meeting
4.	**VERBAL ABILITIES (5 hours)**
	• Error Spotting

	• Listening Comprehension		
	• Rearranging Jumbled sentences		
	• Vocabulary		
5.	**Lab Record**		
	1. Group Discussion - Literature survey		
	2. Group Discussion - Transcripts		
	3. Group Discussion - Assessment forms		
	4. Interview Skills – Psychometric profile		
	5. Interview Skills - Self-introduction		
	6. Interview Skills – Resume and Cover Letter		
	7. Interview Skills - Transcription of interview		
	8. Interview Skills - Assessment sheet signed by interview panel		
	9. Power Point Presentation		
	10. Error spotting worksheet		
	11. Jumbled sentences worksheet		
	12. Welcome Address		
	13. Vote of Thanks		
	14. Letter seeking permission to go on industrial visit		
	15. Report Writing – Progress in project work		
	16. Presentation of business articles – Transcription		
Total (P) = 20 Hours			
Course Outcomes			
After the successful completion of the practical session, the students will be able to			
CO1	:	Write error free letters and prepare reports	

CO2	:	Deliver welcome address and vote of thanks
CO3	:	Speak coherently with proper pronunciation and accent
CO4	:	Avoid common Indianisms and grammatical errors
CO5	:	Improve repertoire of passive vocabulary
CO6	:	Answer questions posed by interviewers confidently
CO7	:	Participate in group discussion effectively
CO8	:	Undertake online psychometric and IQ test to understand their strengths and weaknesses

Reference Books:

1.	Anderson, P.V, Technical Communication, Thomason Wadsworth, Sixth Edition, New Delhi, 2007.
2.	Prakash, P, Verbal and Non-Verbal Reasoning, Macmillan India Ltd., Second Edition, New Delhi, 2004.
3.	John Seely, The Oxford Guide to Writing and Speaking, Oxford University Press, New Delhi, 2004.
4.	Evans, D, Decision maker, Cambridge University Press, 1997.
5.	Thorpe, E, and Thorpe, S, Objective English, Pearson Education, Second Edition, New Delhi, 2007.
6.	Turton, N.D and Heaton, J.B, Dictionary of Common Errors, Addision
7.	Wesley Longman Ltd., Indian reprint 1998.
8.	Ready,Steaady, Go. Deepak Mehra, Jaico Publishing House, Delhi,2015

E-References:

1.	http://www.seemypersonality.com (Personality Test and IQ Test).
2.	http://www.humanmetrics.com/cgi-win/jtypes2.asp

SEMESTER – VI

18MT601	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, Electrorefining and Electrowinning 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 BYPRODUCT 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/

18MT602	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, 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

C05		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 Vol 14 Forming and forging ,Metal park Ohio USA,2001	
2	ASM Metal handbook Volume 14A: Metalworking: Bulk FormingMetal park Ohio USA,2005	
3.	ASM Metal handbook Volume 14B: Metalworking: Sheet FormingMetal park Ohio USA,2005	
4.	Metal forming Handbook – Springer	
5.	P.C Angelo ,R.Subramaninan Powder Metallurgy Science,Technology and Applications ,PHI Learning Private Ltd,New Delhi 2009	

18MT603	FOUNDRY PROCESSES AND 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	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 mouldprocess,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, use of chills, exothermic compounds etc., riser efficiency, yield calculations. Use of softwares for foundry applications

UNIT IV	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.

UNIT V	FOUNDRY METALLURGY	9	+	0

Melting practice and Metallurgy of steels, alloy steels, cast irons, aluminium alloys, copper alloys and magnesium alloys, Solidification of Castings, Fluidity, Definition, Factors affecting and Measurement of Fluidity, inoculation in cast irons, modification in Al-Si system, Slag-Metal Reactions , 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, 2011.
2.	Jain P.L ,"Principles of Foundry Technology", Tata McGraw Hill Publishing Co Ltd, New Delhi, 2004.

3.	Srinivasan N K.,"Foundry Engineering", Khanna Tech Publications, New Delhi, 2009.
Reference Books:	
1.	RamanaRao T V.,"MetalCasting : Principles and Practice", New Age International Publishing Co., New Delhi, 2004.
2.	ASM Metals hand Book, Vol 15, "Casting" ASM International, 10th edition, 2001.
3.	Beeley P R.,"Foundry Technology", Butterworths, London, 2005.

18MT604	WELDING PROCESSES AND 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	GAS, ARC AND OTHER WELDING PROCESSES:	9	+	0

Introduction to welding and allied processes. Overview of arc welding power sources, open circuit voltage, duty cycle. Fusion welding processes–Principle, merits, demerits and applications of oxy-acetylene welding, shielded metal arc welding, submerged arc welding, gas tungsten arc welding, gas metal arc welding, electro slag welding. Consumables for these processes. Thermit welding process, Resistance welding processes.

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

Principle, merits, limitations and applications of Cold pressure welding, hot pressure welding, friction welding, friction stir welding, ultrasonic welding, induction pressure welding, explosive welding and diffusion welding processes. Principle, merits, limitations and applications of Electron beam, plasma arc and laser beam welding processes.

UNIT III	OTHER JOINING AND ALLIED PROCESSES:	9	+	0

Principle, techniques, joint design, materials, merits, limitations and applications of Brazing, Soldering. Principles of Cutting processes and Hard facing techniques.

UNIT IV	WELDING METALLURGY:	9	+	0

Heat flow in welding, weld thermal cycles and their effects, simple problems, structural changes in weld metal and heat affected zone, slag-metal reactions, gas-metal reactions, solidification of weld metal. Concept of weldability and its assessment.

UNIT V	WELDING AND WELDABILITY OF ALLOYS:	9	+	0

Welding of plain carbon steels, C-Mn steels, low alloy steels, welding of cast irons, welding of stainless steels, welding of aluminium and its alloys, welding of copper and its alloys, welding of titanium and its alloys, welding of Ni and its alloys. Dissimilar welding. Arc welding defects, their causes and remedies.

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.	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.

18MT605	WELDING AND NON-DESTRUCTIVE TESTING LABORATORY	L	T	P	C
		0	0	3	1

Course Objectives:

1.	To know about the concepts of welding technology and apply them for the fabrication of components.
2.	To provide an understanding on the concepts of NDT and apply them for assessing the quality of components.

EXPERIMENTS: Welding Laboratory

1.	Preparation of square butt joint using Shielded metal arc welding process.
2.	Effect of welding parameters on weld bead characteristics (using Profile projector).
3.	Study and demonstration of GTA welding, GMA welding and Solid state welding processes.
4.	Microstructural observation of weldments.
5.	Practice for preparation of WPS and PQR.
6.	Study and demonstration of weldability testing methods related to cold cracking and hot cracking.

EXPERIMENTS: Non-Destructive Laboratory

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

Total (P) = 45 Hours

Course Outcomes

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

CO1	:	Prepare square butt joints
CO2	:	Analyze the weld bead characteristics using profile projector
CO3	:	Understand the basics of GTA and GMA processes
CO4	:	Perform liquid penetrant, magnetic particle and eddy current inspection
CO5	:	Interpret the radiograph and study of IIW block

18MT606	FOUNDRY & FORMING PROCESSES LABORATORY	L	T	P	C

	0	**0**	**3**	**1**

Course Objectives:

1.	To know the concept of material forming technology
2.	To apply them for the advanced manufacturing processing for various structural engineering applications

EXPERIMENTS:

1.	AFS Grain Fineness Number.
2.	Moisture Content determination and Mouldability Test.
3.	Sand Strength Tests. and Mould Hardness Test
4.	Permeability Test and Shatter Index Test
5.	Tension Test- Finding n and k value.
6.	Cupping test.
7.	Cold rolling of aluminium/brass sheets.
8.	Effect of Recrystallisation annealing temperature & time on cold worked alloys.
9.	Determination of particle size and shape of metal powders.
10.	Determination of Flow rate, Apparent and Tap densities of Powders.

Total (P) = 45 Hours

Course Outcomes

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

CO1	:	Determine the strength, collapsibility of the moulding sand
CO2	:	Roll the different sheets to obtain a reduced thickness of given sheets
CO3	:	Vary the material properties of cold worked alloys by changing the recrystallisation annealing temperature and time
CO4	:	Understanding the effect of Recrystallisation annealing temperature & time on cold worked alloys
CO5	:	Simulating metal flow using a model material

SEMESTER – VII

18MT701	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 Thermograviometric 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.

C05	:	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.

18MT702	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 bheaviour 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 – Behavior and Performance, Perception – Organizational Implications. Personality – Contributing factors – Dimension – Need Theories – Process Theories – Job Satisfaction, Learning and Behavior – Learning Curves, Work Design and approaches

UNIT IV	GROUP DYNAMICS	9	+	0

Group Behavior – 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 behavior.
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/

18MT703	MATERIAL CHARACTERIZATION LABORATORY	L	T	P	C
		0	0	3	1

Course Objectives:

1.	To develop the understanding of the various characterization tools and use of the tools.

EXPERIMENTS

1.	Determination of volume fraction of phases using image analysis.
2.	Determination of nodularity and nodule count in cast iron using image analysis.
3.	Study of Wulff net diagram, Stereographic projection & Pole Figure.
4.	Structure Factor determination.
5.	Indexing of XRD patterns.
6.	Estimation of precise lattice parameter of cubic crystals.
7.	Determination of crystallite size and r.m.s.strain for mechanically alloyed power.
8.	Analysis of SEM fractographs.
9.	Analysis of TEM images
10.	Interpretation of DSC curves

Total (P) = 45 Hours

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	:	Index the XRD patterns
CO3	:	Analyze SEM and TEM images
CO4	:	Interpret DSC curves

18MT704	COMPUTER APPLICATION IN METALLURGY LABORATORY	L	T	P	C
		0	0	3	1

Course Objectives:

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

EXPERIMENTS

	Note : Compute the following experiments through programming and exhibit the results in graphical mode
1	Parametric approaches in creep data, Larson miller parameter.
2	Statistical quality control, use of various charts
3	Numerical solution for non-linear equations
4	Calculation of adiabatic flame temperatures, at the tuyers of a coke fueled shaft furnace.
5	Cooling of pig iron in transfer ladle
6	Thermo chemical data calculation – enthalpy increment
7	Predicting the scrap requirement of oxygen steel making process.
8	Heat loss through furnace roof.
9	Unsteady state heat flow-cooling of a slab.
10	Enthalpy and free energy change of a reaction.

Total (P) = 45 Hours

Course Outcomes

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

CO1	:	Calculate the adiabatic flame temperatures of shaft furnace through programming and exhibit the results in graphical representation.
CO2	:	Demonstrate the usage of various control charts
CO3	:	Create the concept of enthalpy and free energy change of reaction.
CO4	:	Predict the scrap requirement of oxygen steel making process

SEMESTER – VIII

18MT801	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

PROFESSIONAL ELECTIVES - I					
18MTE11	**TRANSPORT PHENOMENA**	**L**	**T**	**P**	**C**
(Use of HMT databook 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 modeling.

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

Dimensions and units, Properties of fluid, Concept of pressure and its measurement. Newton's law of viscosity, types of fluids. Types of flow.Conservation of momentum in steady state - Fluid flow in a circular tube, Hagen-Poisulle equation, Equation of continuity, Conservation of Momentum - Navier-Stokes equation. Creeping flow past a sphere – Stoke's law. Classical Reynold's experiment,

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

Turbulent flow – Friction factor and turbulent flow in cylindrical pipes, Moody diagram. Flow over a flat plate – concept of velocity boundary layer. Flow past a submerged sphere. Energy balance – Bernoulli's equation. Friction loss, Influence of bends, fittings and changes in the pipe radius, Concept of head, Pitot tube, Orifice plate. 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 and cylinders through composite walls – simple problems. Transient heat conduction system – lumped capacitance approach, semi-infinite systems and one dimensional finite system (no derivations and only simple problems). Convection: Correlation for heat transfer with forced convection – flow through pipes, flow over plates, spheres and cylinders (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 and vertical cylinders, Natural convection over horizontal plates, horizontal cylinders and spheres (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, diffusion through porous media. Unsteady state diffusion: diffusion of gas (like hydrogen) in a plate of finite thickness. Mass transfer by forced and free convection in laminar flow, Mass transfer coefficients and concentration boundary layer. Introduction to mass transfer correlations. Basics of Dimensional Analysis.

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.	Themelis, N.J., Transport and Chemical Rate Phenomena, Gordon & Breach Publishing Group, 1995
2.	Bird, R.B., W.E. Stewart, E.N. Lightfoot, and D.J. Klingenberg, Introductory Transport Phenomena, John Wiley & Sons, Inc., 2015
3.	Mohanty, A.K., Rate Processes in Metallurgy, PHI Learning, India, 2009.
4.	Sachdeva, R.C., Fundamentals of Engineering Heat and Mass Transfer, New Age International Publishers,

18MTE12	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.Ductileand 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 andhigh temperature conditions
CO3	:	Investigate the failures occurring due to wear and corrosional damages
CO4	:	Discuss the failures occurring due to the process of forging, casting and at theweld joints
CO5	:	Describe the process of reliability and hazard function and the different systems

Text Books:

1.	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.

18MTE13	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, 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=45Hours

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.	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
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.

18MTE14	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 electrodeposition, plating of nickel, chromium, tin and copper, pulsed plating, hydrogen embrittlement, plating adhesion, electroless plating,electrochemicalconversion 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 ofdiffusion processes-Boriding, Aluminising, Siliconising, Chromising-Selection of diffusion processes-Characteristics of diffused layer-micro structureandmicro hardness evaluation-properties and applications.

UNIT IV	THIN FILM COATINGS	9	+	0

Physicalvapourdeposition processes-Thermal evaporation-sputtercoating-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 Wearplates.

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	:	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.	
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.	

18MTE15	FRACTURE MECHANICS	L	T	P	C
		3	0	0	3

Course Objectives:

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

Unit I	TYPES OF FRACTURE	9

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

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

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

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

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, Sujthoff Noordhoof, 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

18MTE21	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, microalloyed 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 aluminum. Alloys of aluminium, Classification, Wrought and Cast alloys, Heat treatable and Non, heat treatable, Age hardening. Overaging –Al-Li alloys, superplastic 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; thermomechanical processing; near-net shape processing; superplastic forming of titanium alloys.Titaniumaluminides their properties and uses.

UNIT V	NICKEL AND OTHER ALLOYS	9	+	0

Properties of nickel and uses of nickel, Nickel base superalloys 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 and Titanium alloys.
CO5	:	Explain the roll 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/

18MTE22	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 lay up 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 isostatic 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 techniqueProcessing 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+15)= 60 Hours

Course Outcomes:

Upon completion of this course, the students will be able to:		
CO1	:	classify the composites and know about their properties
CO2	:	details about the processing of polymer matrix composites and their application
CO3	:	characterize the metal matrix composite and study about its processing and application
CO4	:	understanding the concept of ceramix matrix composite and some special composites
CO5	:	formulate the mechanics of composite and the determination of lamina stress with 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, 1998
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.	Broutman, L.J. and Krock,R.M., Modern Composite Materials, Addison-Wesley, 1967.

18MTE23	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 ceramcis, 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 proc ess 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 photochromic 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+0) 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	:	CO2: Understand the phase diagrams and comprehend the phase transformations in ceramic materials.
CO3	:	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, Mc Graw 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.

18MTE24	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 - TiN coating by PVD - coating of carbide tools - mono and multi layer coatings of Ti C, TiN, Alumina and DLC by PVD and CVD processes - selection of tool materials

Total (L+T) = (45+0) 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 Wsiley 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.

18MTE25	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–Polyfunctional 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 evaluationofbiomaterials.

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 andmagneto-restrictive materials

UNIT III	SHAPE MEMORY MATERIALS	9	+	0

Nickel –Titanium alloy (Nitinol)–Materials characteristics of Nitinol–martensitic transformations–austenitic transformations–thermoelastic 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–mechanismofshapememory-Primarymoulding–secondarymoulding–typesandapplications.

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 tissueengineering.

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-skingrafts-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	:	Discuss the implant material's properties and manufacturing methods
CO2	:	Explain the polymeric biomaterials and describe the techniques used formanufacturing, sterilization and improving properties
CO3	:	Discuss ceramic and composite biomaterials used for implantation and its properties and explain manufacturing methods
CO4	:	Explain the biomedical applications of the smart materials with its detailed Properties
CO5	:	Discuss the instruments used for surface and chemical analysis of implant materials and explain material selection for implantation
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 Shapememory 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	

18MTE31	NON METALLIC MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives

1.	To gain basic knowledge about the various non - metallic materials like polymers, ceramics and composites and apply them in the advance engineering applications

UNIT I	INTRODUCTION TO POLYMERS	9	+	0

Classification- thermoset, thermoplastics and elastomers. Structure of polymers-crystalline and amorphous polymers-concept of Glass Transition Temperature (Tg). Polymerization-types and mechanisms with examples Degree of polymerization -molecular weight of polymers- problems. Polymer additives. Example, properties.

UNIT II	POLYMER PROPERTIES AND PROCESSING	9	+	0

Applications of engineering plastics. Elastomers- types, properties, examples and application. Processing of polymers: Processing of thermoset and thermoplastic polymers. Applications. Behaviour of polymers: Viscoelasticity- creep and stress relaxation in polymers. Yielding and fracture of polymers. Crazing of polymers.

UNIT III	CERAMICS	9	+	0

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

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.	Bhargava A K, Engineering Materials - Polymers, Ceramics and Composites, Prentice Hall of India Ltd., New Delhi, 2012.
2.	Pahari A K and Chauhan B S, Engineering Chemistry, Laxmi Publications, New Delhi, 2006.
3.	Van Vlack L K Physical Ceramics for Engineers, Addison Wesley, Massachusetts, 1964.
4.	Mallick P K, Fiber Reinforced Composites: materials, manufacturing and design, CRC Press, Taylor & Francis group, London, 2010.
Reference Books:	
1.	Jacobs, J A and Kilduff T F, Engineering Materials Technology, Prentice Hall Inc., N.J., 1988.
2.	Krishnan K Chawla, Composite materials: Science and Engineering, Springer, 1998.
E- Reference	
1.	https://nptel.ac.in/courses/Webcourse.../Composite%20Materials/pdf/.../LNm1.pdf
2.	web.eng.fiu.edu/wangc/EGN3365-16.pdf
3.	https://nptel.ac.in/courses/112107086/6
4.	https://nptel.ac.in/courses/104103071/pdf/mod16.pdf

18MTE32	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 modeling 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 funnel 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. Modeling 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.	Brima combe 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.

18MTE33	SPECIAL CASTING TECHNIQUE	L	T	P	C
		3	0	0	3

Course Objectives:

1.	To know the raw materials casting procedures and parameters of various special casting processes to gain knowledge on designing appropriate processes to produce for different applications to gain 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 (45+0) = 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.

18MTE34	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.	

18MTE35	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 deoxidation
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, 1990	
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, Ironmaking & Steelmaking, Vol.29, pp. 53-69, 2002	
4.		

18MTE41	PARTICULATE PROCESSING TECHNOLOGY	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, 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

Pressureless 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 HIP, 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 strength hened 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, Dhanpat Rai& 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 AMIE, 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.

18MTE42	SEVERE PLASTIC DEFORMATION	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	INTRODUTION AND ECAE	9	+	0

Severe plastic deformation processes (SPD), advantages over conventional metal forming processes. Concept of qual 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 stir 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.

18MTE43	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 ironmaking 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, Glass-ceramics 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 steelmaing 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

18MTE44	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	:	Use of plasma arc for the welding of two metals

CO3	:	: Safe use of domestic explosive materials for the joining of the weld metals
CO4	:	Employing the advantage of frictional force in generating heat which can be used to join dissimilar metals

Text Books:	
1.	Zoe Barber, Introduction to Materials Modeling, 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.

18MTE45	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, 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 PartingAgents, 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

18MTE51	PHYSICS OF ENGINEERING MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the several types of materials and their principles.

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

Elemental semiconductors : Study of intrinsic and extrinsic semiconductors with energy band structure – Carrier concentration in intrinsic semiconductors (derivation) – Carrier concentration in extrinsic semiconductors (qualitative) – variation of Fermi level with temperature and doping concentration – Compound semiconductors – importance of compound semiconductors – Physics of pn junction diode : formation of pn junction – barrier potential – forward and reverse biased VI characteristics – Photovoltaic effect – Solar cell: Parameters (qualitative study) – Hall effect : determination of hall coefficient – applications

UNIT III	DIELECTRIC MATERIALS	9	+	0

Dielectrics: 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).

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 – Ferrites – application of ferrites.
Superconductivity: Properties – Type I& Type II superconductors – applications – magnetic levitation – SQUID.

UNIT V	MODERN ENGINEERING MATERIALS:	9	+	0

Metallic glasses: Preparation, properties, applications – Shape memory alloys: (SMA) – Processing, characterization and applications.
Nano – materials: Introduction – top down and bottom up approach – synthesis – Ball milling, Plasma arcing and Sol – Gel technique – properties – applications.
CNTs: Structure – Structure – properties – Synthesis – Carbon arc method, Pulsed vapour deposition, Chemical vapour deposition – properties – applications.

Total (L+T) = 45 Hours

Course Outcomes:

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

CO1	:	Classify the conducting and semiconducting materials and mention the theories relating the conductivity and apply Fermi distribution function to calculate carrier concentration in metals
CO2	:	Discuss the optical properties of materials like polarization and photo elastic effect and the directions of stress as isoclinic and isochromatic fringes
CO3	:	Mention the magnetic and superconducting materials and the special application of superconducting materials like maglev and SQUIDS

CO4	:	Discuss the dielectric materials and different equations that can be used to describe the electronic characteristics of the dielectric material
C05	:	Explain and mention the modern engineering materials

Text Books:	
1.	P.K.Palanisamy, ‘Materials Science’, Scitech Publications (India) pvt.ltd. Chennai, Second edition, 2007.
2.	M. Arumugam, ‘Materials Science’, Anuradha Publications, Kumbakonam, 2006
3.	Rajendran V and Marikani A, ‘Materials Science’, Tata McGraw Publications, New Delhi, 2004
4.	Jayakumar S, ‘Materials Science’, RK Publishers, Coimbatore, 2008.
Reference Books:	
1.	Charles Kittel, ‘Introduction to Solid state Physics’, John Wiley and Sons, 7th Edition, Singapore, 2007.
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.

18MTE52	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	:	Learn to obtain the numerical solutions of linear and non-linear equations
CO2	:	Acquired the techniques of interpolation and approximations
CO3	:	Familiarize with the numerical differentiation and integration, will know to solve the initial value problems for ordinary differential equations.

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

18MTE53	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 band gap theory for conducting, semiconducting and insulating materials.
CO2	:	Understand various electrical phenomenon such as ferro electricity, piezo electricity
CO3	:	Learn about photoconduction phenomenon, optical materials and various optical devices and their performances

CO4	:	Study various kinds of magnetism principles, various types of materials exhibiting
CO5	:	Study the theory of superconductivity phenomenon and superconducting materials and their applications along with recent advancements Understand the fundamentals of semiconducting materials and operational principles of solid state devices made of these semiconducting materials. To learn various 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

18MTE54	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 modeling 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

UNIT IV	MELTING FURNACES AND KINETICS	9	+	0

design of riser and gating.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 techniques

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	

18MTE55	ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To know about additive manufacturing and rapid prototyping technologies.

UNIT I	INTRODUCTION	9	+	0

General overview, need of additive manufacturing (AM), reverse engineering (RE), and computer aided design (CAD), computer aided manufacturing (CAM) and AM, AM tooling and uses.

UNIT II	ADDITIVE MANUFACTURING SYSTEMS	9	+	0

Principle, process, advantages and applications of (i) Stereo lithography (ii)3-D Printing (iii) Fused Deposition Modelling (FDM) (iv) Laminated Object Manufacturing (LOM) (v) Selective Laser Sintering (SLS) (vi) Laser Engineered Net Shaping (LENS) (vii) Direct Metal Deposition (DMD).

UNIT III	MATERIALS AND MECHANISMS	9	+	0

Polymer, photo polymerization and SLS, ceramics for SLS and Laser chemical vapour deposition (LCVD), Metals used in DMD and SLS, effect of rapid solidification and non-equilibrium structure.

UNIT IV	APPLICATIONS	9	+	0

Design and production of Customized implants and prosthesis using AM, Computer Aided Tissue Engineering (CATE).

UNIT V	OTHER APPLICATIONS	9	+	0

Reactive and Lightweight, Wear and Corrosion resistant and improved thermal properties suitable for Aerospace, Automobile, Oil and Gas and Agriculture.

Total (L+T) = 45 Hours

Course Outcomes:

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

CO1	:	Explain the need for Additive Manufacturing (AM) and Rapid Prototyping Technologies
CO2	:	Describe the principles, process and advantages of different AM systems
CO3	:	Design and apply AM for customized implants and industrial products

TEXT BOOKS	
1.	A. Gebhardt, “Rapid prototyping”, Hanser Gardener Publications, 2003.
2.	L.W. Liou and F.W. Liou, “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007.
Reference Books:	
1.	A.K. Kamrani and E.A. Nasr, “Rapid Prototyping: Theory and Practice”, Springer, 2006.
2.	P.D. Hilton and P.F. Jacobs, “Rapid Tooling: Technologies and Industrial Applications”, CRC press, 2000.

18MTE61	NANO MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1.	Able to describe the various methods synthesis
2.	Able to characterize the 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 nanomaterialswith 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:Chemical methods:CVD – Steps and reactions involved for various types of CVD, Sol-gel method and co-precipitation techniques.Physicalmethods:PVD - Evaporation,Sputtering &Laser ablation .Consolidation of nanomaterials : Problems ,Shockwave consolidations, Spark plasma sintering .

UNIT III	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 IV	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.

UNIT V	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.

Total (L+T) = 45 Hours

Course Outcomes:

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

CO1	:	Explain the fabrication 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	:	Describe the electronic and optical applications of nanomaterial's

CO4	:	Describe the energy storage devices and explain the applications related to biomedical and bioactive fields
CO5	:	Demonstrate the various nano material characterization techniques such as AFM,XRD –andTEM

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 verlagGmbh& 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.	BharathBhushan, 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.

18MTE62	THIN FLIMS,COATINGS AND APPLICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study about thin flims, 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: optoelectronicdevices, 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 flim 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

18MTE63	AEROSPACE MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To analyse 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 production, properties and application of composites
CO2	:	Describe the metal matrix composites
CO3	:	Know about Ti. Ni based composites
CO4	:	Identify materials for engines and plasma engines

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.

18MTE64	MODELING AND SIMULATION IN MATERIAL PROCESSES	L	T	P	C
		3	0	0	3

Course Objectives:

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

UNIT I	INTRODUCTION	9	+	0

Introduction to modeling, simulation models, Casting process: modeling of heat transfer, direct heat conduction modeling, one-dimensional and multidimensional inverse modeling, 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 modeling 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

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

UNIT V	SOFTWARES	9	+	0

introduction to commercially available softwares - Solid Cast, FlowCast, OptiCast,.Deform HT, ProCast, MagmaSoft, 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 modeling.
CO2	:	Describe the principles in casting modeling.
CO3	:	Know about welding and heat treatment simulation
CO4	:	Identify commercially available softwares for modeling

Text Books:	
1.	Modeling in Welding, Hot Powder Forming and Casting (Eds. L. Koarlsson), ASM, MaterialsPark,OH,1997.
2.	Szekely,J.,Evans, J.E.andBrimacombe, 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)

18MTE65	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 uraniumand 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.
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.	

OPEN ELECTIVE COURSES OFFERED TO OTHER DEPARTMENTS

18MTOE01	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
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.

18MTOE02	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 electrodeposition, 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.
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.

18MTOE03	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, strengthrelative 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 high and low temperature process.
CO4	:	Suggest the materials for auto and aero industry

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	

18MTOE04	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 alloyin/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 B Rath, 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.	Charles P Poole and Frank J Owens, “Introduction to Nanotechnology”, John Wiley and Sons, New York, 2003.
2.	Michael Wilson, Kamali Kannagara and Geoff Smith, “Nanotechnology: Basic Science and Emerging Technology”, Chapman and Hall, New York, 2002.
3.	Pradeep T, “Nano: The Essentials”, Tata Mc Graw Hill, New Delhi, 2007.

PROTOSEM COURSES SYLLABUS

18MEPS11	APPLIED DESIGN THINKING		Semester			VI
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	The course enables product innovators and early-stage startup founders to learn the customer development process
2	To familiarize with the tools & techniques & validate the inherent risks by linking their progress to customer-motivation, customer-commitment & customer-acceptance.
3	To learn the system thinking concepts by reverse engineering technique.

Unit I	**DESIGN THINKING PRINCIPLES**	**9**	**0**	**0**	**9**

Exploring Human – Centered Design – Understanding the innovation process, discovering areas of opportunity, interviewing &empathy –building techniques, Mitigate validate risk with FIR(Forge Innovation Rubric) – Case Studies.

Unit II	**CUSTOMER-CENTRIC INNOVATION**	**9**	**0**	**0**	**9**

Importance of customer-centric innovation – Problem Validation and Customer Discovery – Understanding problem significance and problem incidence- Customer Validation. Target user, User persona & user stories. Activity : Customer development process – Customer interviews and field visit.

Unit III	**APPLIED DESIGN THINKING TOOLS**	**9**	**0**	**0**	**9**

Concept of Minimum Usable Prototype(MUP) – MUP challenge brief – Designing & Crafting the value proposition – Designing and Testing Value Proposition: Design a compelling value proposition: Process, tools and techniques of Value Proposition Design.

Unit IV	**CONCEPT GENERATION**	**9**	**0**	**0**	**9**

Solution Exploration, Concepts Generation and MUP design – Conceptualize the solution concept: explore, iterate and learn; build the right prototype: Assess capability, usability and feasibility. Systematic concept generation; evaluation technology alternatives and the solution concepts.

Unit V	**SYSTEM THINKING & REVERSE ENGINEERING**	**9**	**0**	**0**	**9**

System Thinking, Understanding Systems, Examples and Understandings, Complex Systems, Reverse Engineering Methodology, Identify building blocks/Components – Re-Engineering a complex system.

Total = 45 Periods

Text Books:

1	Steve Blank, (2013), The four steps to epiphany: Successful strategies for products that win, Wiley.
2	Alexander Osterwalder, Yves Pigneur, Gregory Bernarda, Alan Smith, Trish Papadakos, (2014), Value
3	Proposition Design: How to Create Products and Services Customers Want, Wiley
4	Donella H. Meadows, (2015), “Thinking in Systems -A Primer”, Sustainability Institute.
5	Tim Brown,(2012) “Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation”, Harper Business.

Reference Books:	
1	https://www.ideou.com/pages/design-thinking#process
2	https://blog.forgeforward.in/valuation-risk-versus-validation-risk-in-product-innovations-49f253c a8624
3	https://blog.forgeforward.in/product-innovation-rubric-adf5ebdfd356
4	https://blog.forgeforward.in/evaluating-product-innovations-e8178e58b86e
5	https://blog.forgeforward.in/user-guide-for-product-innovation-rubric-857181b253dd 6
6	https://blog.forgeforward.in/startup-failure-is-like-true-lie-7812cdfe9b85

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Define & treat various hypotheses to mitigate the inherent risks in product innovations	L1: Remembering
CO2	Design the solution concept based on the proposed value by exploring various alternate solutions to achieve value-price fit.	L6: Creating
CO3	Develop skills in empathizing, critical thinking, analyzing, storytelling & pitching.	L3: Applying
CO4	Apply system thinking to reverse engineer a product/prototype and understand its internal correlations.	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	3	2	1	1	1	1	1	1	1	2	2	3
CO2	2	2	3	2	2	1	1	1	1	1	1	1	3	3	2
CO3	1	2	2	1	1	3	1	1	3	3	1	1	1	1	1
CO4	2	3	3	3	3	2	2	1	2	2	1	1	3	3	3
AVG	**1.75**	**2.5**	**2.5**	**2.25**	**2**	**1.75**	**1.25**	**1**	**1.75**	**1.75**	**1**	**1**	**2.25**	**2.25**	**2.25**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS12	STARTUP FUNDAMENTALS		Semester			VI
PREREQUISITES		Category		Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	Learn the science of to transforming an innovative idea into high-growth enterprises.
2	To understand the basic concepts of IPR, and develop a patent draft for a potential IP

Unit I	**ENTREPRENEURIAL MINDSET & METHOD**	**9**	**0**	**0**	**9**

Introduction to Innovation-led, tech-powered entrepreneurship - Understand from research the attributes of an expert entrepreneur - Effectuation principles - Dealing with the unknowns - Case studies of startup failures.

Unit II	**IDEA TO ENTERPRISE**	**9**	**0**	**0**	**9**

Design and Planning of Product Concept - Business Model - Business Planning - Building Proof of Product and Value Testing - Target Market and Revenue Planning

Unit III	**MINIMUM VIABLE BUSINESS**	**9**	**0**	**0**	**9**

Framework for Minimum Viable Business - Disruptive Innovation - Theory of Disruption - Competitive advantage - Building proof of viable business model - Demystifying Scalability - Funding Opportunities

Unit IV	**INTELLECTUAL PROPERTY**	**9**	**0**	**0**	**9**

Introduction and the need for Intellectual Property Rights - IPR Genesis and Development - Copyright - Trademark - Trade Secret - Geographical Indicators - Industrial Designs - Types of Patent – Sample Patent Application - IPR in INDIA; Global trends - Patent fees

Unit V	**PRIOR ART SEARCH AND PATENT DRAFTING**	**9**	**0**	**0**	**9**

Prior Art Search - IP Licensing – IP Commercialization - IP Infringement- Case Study on Apple vs Samsung, Case study on basmati rice. The invention as a concept - Keywords formation - Structure of patent - Key attributes in patent drafting - Drafting provisional specifications - Drafting complete specifications - Draft claims - Case studies on patent drafting

Total = 45 Periods

Text Books:

1	Steven Blank and Bob Dorf, (2012), The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company, K&S Ranch
2	Dr Saras Sarasvathy, (2008), Effectuation: Elements of Entrepreneurial Expertise, New Horizons in Entrepreneurship series.
3	Elizabeth Verkey, (2005), Law of Patents, Eastern Book Company
4	Prabuddha Ganguli, (2017), Intellectual Property Rights: Unleashing the Knowledge Economy, McGraw Hill Education; 1st edition

Reference Books:	
1	WIPO Intellectual Property Handbook https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub_489.pdf
2	https://assets.entrepreneur.com/static/20220301113822-Marketing.pdf
3	https://www.deluxe.com/blog/startup-fundamentals-guide/
4	https://www.forbes.com/sites/allbusiness/2018/07/15/35-step-guide-entrepreneurs-starting-a-business/?sh=69a6031e184b

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Develop an entrepreneurial mindset to identify, assess, shape & act on opportunities.	L3: Applying
CO2	Demonstrate the potential of an innovative idea to create economic value, as a startup	L2: Understanding
CO3	Understand the scientific process to explore a viable business model	L2: Understanding
CO4	Demonstrate knowledge on the fundamental concepts of Intellectual Property	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	1	1	2	1	2	2	2	3	3	1	1	2
CO2	2	2	3	1	1	1	1	2	2	1	3	2	2	2	2
CO3	1	2	2	2	1	1	1	1	1	1	3	2	1	1	1
CO4	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1
AVG	**1.25**	**1.75**	**2**	**1.25**	**1**	**1.25**	**1**	**2**	**1.5**	**1.25**	**2.5**	**2**	**1.25**	**1.25**	**1.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS13	COMPUTATIONAL HARDWARE	Semester	VI
PREREQUISITES	Category	PE	Credit 3

	L	T	P	TH
Hours/Week	3	0	0	3

Course Learning Objectives

1	To learn basic concepts of Embedded Systems by familiarizing the functionalities of embedded platforms with development boards.
2	To understand the core concepts of GPIO Pins, Functionality of peripherals, Selection of I/O devices , Usage of Internal functions, and Communication protocols.
3	To familiarize the current technologies and protocols used in the Internet of Things (IoT) and to learn the Cloud services.

Unit I	**BASICS OF EMBEDDED SYSTEM**	**9**	**0**	**0**	**9**

Embedded Platform: Architecture and working - Factors for Microcontroller/Microprocessor selection. Arduino - Boards and schematics – Tool chain - Setup and Configuration - Input/Output Configurations and Access - Libraries - Digital I/O - ADC - Analog I/O - Timers, Interrupts - Pulse Width Modulation - Display: 7-segment , LCD , OLED.

Unit II	**BASICS OF RASPBERRY PI**	**9**	**0**	**0**	**9**

Raspberry Pi: Raspberry pi Board - Processor - Setup and Configuration - Installing Python IDLE using Command Terminal - General Purpose I/O Pins - Protocol Pins - GPIO Access - Pulse Width Modulation - Network Libraries - Web services - Twitter APIs - Twitter Bot - Interfacing pi with camera modules.

Unit III	**SENSORS AND ACTUATORS**	**9**	**0**	**0**	**9**

Interfacing of Sensors and Actuators - Sensors: Introduction, Characteristics: Analog - Potentiometer, Temperature Sensor, Soil Moisture Sensor, LDR - Digital - PIR Sensor, Smoke Sensor, Infrared - Sensor, Ultra- Sonic Sensor. Actuators - Introduction, Characteristics and working with relay, DC motors, Servo motor, Stepper motor and its drivers.

Unit IV	**COMMUNICATION PROTOCOLS**	**9**	**0**	**0**	**9**

Protocols - Wired: RS232 Standard - UART, SPI, I2C - Comparative study of wired protocols - Implementation of wired Serial Communication protocols Wireless: Standards - Bluetooth, RF - Comparative study of wireless protocols - Implementation of wireless Serial Communication protocols.

Unit V	**INTERNET OF THINGS**	**9**	**0**	**0**	**9**

Definition and Architecture of IoT, Building blocks of IoT, Programming with IoT protocols - MQTT, CoAP - Connecting embedded target board to Web, Basics networking in IoT: creating a web page - Creating a server on target board - Controlling I/O peripherals from the webpage, Embedded Application Development, Creating communication between different nodes - Cloud platforms for IoT, Cloud data logging and monitoring, Interfacing with web services.

Total = 45 Periods

Text Books:

1	Raj Kamal, " Embedded Systems - SoC, IoT, AI and Real-Time Systems", 4th Edition, McGraw Hill, 2020.
2	Mohit Arora, "Embedded System Design", 1st Edition, Learning Bytes Publishing, 2016.
3	Elecia White, "Making Embedded Systems", 1st Edition, Shroff/ O' Reilly, 2012.
4	Jack Ganssle, " The Firmware Handbook", 1st Edition, Newnes, 2004.

Reference Books:	
1	https://juniorfall.files.wordpress.com/2011/11/arduino-cookbook.pdf
2	https://drive.google.com/file/d/13s0m3lHPEFP2f2aCuVNRWeBZNKXWKTW5/view?ts=6231cab 3
3	https://ptolemy.berkeley.edu/books/leeseshia/releases/LeeSeshia_DigitalV2_2.pdf 4.
4	https://www.riverpublishers.com/pdf/ebook/RP9788793519046.pdf

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand and implement the functions & Capabilities of embedded platforms for easy prototyping.	L2: Understanding
CO2	Identify the type of sensors and actuators for required applications.	L3: Applying
CO3	Develop communication between devices using different protocols.	L3: Applying
CO4	Develop IoT based systems with wireless network connections and accessing devices over cloud.	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	0	0	0	0	0	0	0	3	2	2
CO2	3	3	2	2	2	0	0	0	0	0	0	0	3	2	2
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
AVG	**3**	**2.25**	**2.75**	**2**	**2.75**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2.5**	**2.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS14	CODING FOR INNOVATORS		Semester			VI
PREREQUISITES		Category		Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To learn and express creativity using coding skills.
2	To gain knowledge of Python programming with hands-on experience.
3	To demonstrate a problem solving using OOPs concepts.
4	To learn basics of Linux by familiarizing the concepts of management and file structure.
5	To practise full stack development using cloud platform.

Unit I	PROGRAMMING PARADIGMS	9	0	0	9

Need for programming - Outside box thinking to solve problems - Need for algorithms and data structures - Flowcharts & Algorithms - Memory Allocation - Conditions and loops - Creating effective functions - Case studies - Visual Programming - Types of programming languages & paradigms - Getting started with development - Build & test an algorithm - best practices

Unit II	BASIC OF PROGRAMMING	9	0	0	9

Introduction to Python: statements, variables, functions, operators, modules, conditional statements, loop statements, Lists: list operations, traversing a list, slicing a list - Text Handling: Strings, string functions, conversion functions, Dictionaries - File Operations: File open, close, read, copy, word frequency, creating word histograms from text file.

Unit III	OOPS 5	9	0	0	9

OOPS- Why OOPS- verticals- implementation in python - Classes and Objects, Methods, Constructors and Destructors, Inheritance, Polymorphism, Abstraction, Encapsulation.

Unit IV	SOFTWARE DEVELOPMENT TO DELIVERY	9	0	0	9

Software Engineering - Life Cycle (Tools), Agile Methodologies - Framework - Why Frameworks - Software Testing(Tool Based) - Data Structures - Database Management System - A case study to experiment from Development to Deployment(D2D) - Source code management and version control - GitHub - GitHub Actions - GitBash - Continuous Integration - Platform as service - Heroku - Build Packs AWS- Anaconda

Unit V	OPERATING SYSTEMS	9	0	0	9

Introduction to Linux - Process Management - Process Scheduling - Memory Management - Storage Management - System calls - File System Structure - Multithreading - Multicore Programming - Deadlock Handling - Disk Structure - Disk Management - Dockers - Kubernetes

Total = 45 Periods

Text Books:

1	Zed A. Shaw, “Learn Python 3 the Hard Way”, 3rd edition, Addison-Wesley Professional, 2013.
2	Silberschatz Abraham, “Operating System Concepts”, 9th edition, John Wiley & Sons Inc (Sea) Pte Ltd, 2016.
3	Paul Barry, "Head-First Python", 2nd edition, O'Reilly Media, Inc, 2016.
4	Anton Spraul, “Think Like a Programmer”, 1st edition, No Starch Press, 2012.

E-References :	
1	https://www.geeksforgeeks.org/python-programming-language/
2	https://www.guru99.com/python-tutorials.html
3	https://www.tutorialspoint.com/python/python_tutorial.pdf

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Level
CO1	Understand the aspects of programming protocols	L2: Understanding
CO2	Develop optimized code for real-world problems	L3: Applying
CO3	Build full-stack development to deployment	L3: Applying
CO4	Demonstrate problem solving and continuous development	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	0	0	0	0	0	0	0	2	1	1
CO2	3	3	3	2	3	0	0	0	0	0	0	0	3	2	2
CO3	3	2	3	1	3	0	0	0	0	0	0	0	3	2	2
CO4	2	3	2	1	2	0	0	0	0	0	0	3	2	1	1
AVG	**2.5**	**2.5**	**2.5**	**1.25**	**2.75**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2.5**	**1.5**	**1.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS15	INDUSTRIAL DESIGN AND RAPID PROTOTYPING TECHNIQUES		Semester			VI
PREREQUISITES		Category	OE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	Learn to design a UI/UX design and develop an android application.
2	Provide working CAD model for prototype development.
3	Knowledge in hardware, 3D Printers and Laser cutters.
4	Acquire basic knowledge in designing electrical circuits and fabrication of electronic devices.

Unit I	UI / UX	9	0	0	9

Fundamental concepts in UI & UX - Tools - Fundamentals of design principles - Psychology and Human Factors for User Interface Design - Layout and composition for Web, Mobile and Devices - Typography - Information architecture - Colour theory - Design process flow, wireframes, best practices in the industry -User engagement ethics - Design alternatives

Unit II	APP DEVELOPMENT	9	0	0	9

SDLC - Introduction to App Development - Types of Apps - web Development - understanding Stack - Frontend - backend - Working with Databases - Introduction to API - Introduction to Cloud services - Cloud environment Setup- Reading and writing data to cloud - Embedding ML models to Apps - Deploying application.

Unit III	INDUSTRIAL DESIGN	9	0	0	9

Introduction to Industrial Design - Points, lines, and planes - Sketching and concept generation - Sketch to CAD - Introduction to CAD tools - Types of 3D modeling - Basic 3D Modeling Tools - Part creation - Assembly - Product design and rendering basics - Dimensioning & Tolerancing

Unit IV	MECHANICAL RAPID PROTOTYPING	9	0	0	9

Need for prototyping - Domains in prototyping - Difference between actual manufacturing and prototyping - Rapid prototyping methods - Tools used in different domains - **Mechanical Prototyping:** 3DPrinting and classification - Laser Cutting and engraving - RD Works - Additive manufacturing

Unit V	ELECTRICAL RAPID PROTOTYPING	9	0	0	9

Electronic Prototyping: Basics of electronic circuit design - lumped circuits - Electronic Prototyping - Working with simulation tool - simple PCB design with EDA

Total = 45 Periods

Text Books:

1	Peter Fiell, Charlotte Fiell, Industrial Design A-Z, TASCHEN America Llc(2003)
2	Samar Malik, Autodesk Fusion 360 - The Master Guide.
3	Steve Krug, Don't Make Me Think, Revisited: A Common Sense Approach to Web Usability, Pearson,3rd edition (2014)

E - References:	
1	https://www.adobe.com/products/xd/learn/get-started.html
2	https://developer.android.com/guide
3	https://help.autodesk.com/view/fusion360/ENU/courses/
4	https://help.prusa3d.com/en/category/prusaslicer_204

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Create quick UI/UX prototypes for customer needs	L6: Creating
CO2	Develop web application to test product traction / product feature	L3: Applying
CO3	Develop 3D models for prototyping various product ideas	L3: Applying
CO4	Built prototypes using Tools and Techniques in a quick iterative methodology	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	3	0	0	0	1	1	0	0	2	1	1
CO2	3	3	3	2	3	0	0	0	1	1	0	0	3	2	2
CO3	3	2	3	2	3	0	0	0	1	1	0	0	3	2	2
CO4	3	2	3	2	3	0	0	0	1	1	0	0	3	2	2
AVG	**2.75**	**2.25**	**3**	**2**	**3**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**2.75**	**1.75**	**1.75**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS16	INDUSTRIAL AUTOMATION DATA LIFE CYCLE MANAGEMENT	Semester			VI
PREREQUISITES	**Category**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Learning Objectives

1	Acquire conceptual knowledge in Industrial Controllers by scaling of on-board devices and embedded board interfacing with various I/O peripherals.
2	Learn PLC by working on internal features and also interfacing with Sensors and actuators along HMI concept using SCADA and standard communication protocols.
3	To work with FPGA boards and RT controllers for reprogrammable embedded applications using LabVIEW
4	Understand the concepts and design electronics circuits

Unit I	**INDUSTRIAL CONTROLLERS - I**	**9**	**0**	**0**	**9**

Industrial Controllers - Introduction to RIO Controllers - Platform - Connection and Configuring controllers - Accessing onboard devices - Module SOM - Interfacing with Input and Output devices - Interfacing protocol based Analog and Digital sensors - Acquiring and Data Logging from sensors - Interfacing Actuators: Relay, DC Motor, Servo Motor - Creating standalone applications.

Unit II	**INDUSTRIAL CONTROLLERS - II**	**9**	**0**	**0**	**9**

Industrial Controllers - II - PLC - Introduction - Mode of Operation - IEC 61131 Programming languages for PLC - Programming & sequence control - Instruction set - Scan Time - Timers - Counters - Interfacing with Input/Output devices - Interfacing with Sensors - Interfacing with Actuators - Interfacing with Human Machine Interface - Commissioning and operational safety of PLC – SCADA.

Unit III	**INDUSTRIAL COMMUNICATION PROTOCOLS**	**9**	**0**	**0**	**9**

Serial Communication Protocols - I2C, SPI - Serial Field bus protocols CAN, PROFIBUS - Ethernet, HTTP, TCP/UDI, WiF, Cloud data logging. Multi-sensor communication, Data parsing between Embedded platforms. Comparative study of Industrial communication protocols - Implementation of Industrial Communication protocols.

Unit IV	**FPGA AND RT CONTROLLER PROGRAMMING**	**9**	**0**	**0**	**9**

Introduction to FPGA - Architecture - Operations in FPGA programming - FPGA Programming in LabVIEW and implementation in myRIO - Introduction to RT controllers - Architecture - Programming RT Controllers - Creating standalone applications.

Unit V	**INDUSTRIAL CIRCUIT BOARD DESIGN**	**9**	**0**	**0**	**9**

Designing basics circuits and to simulate in environment setup - Component selection - Creating libraries - Schematic design - Design rules, supply & communication track rules - Component and footprint editor - Understanding component package types - Test point creation for measurement - PCB Layout, placement rules - Footprint, 3D models, BoMs - Generating GERBER and output documentation.

Total = 45 Periods

Text Books:	
1	Ed Doering, NI myRIO Project Essential Guide, National Instruments, 2016.
2	Willian Bolton, Programmable Logic Controllers, 6th edition, Newnes Publications, 2015
3	Richard Zurawski, Industrial Communication Technology Handbook, Second edition, CRC Press, 2014
4	Simon Monk, Make Your Own PCBs with EAGLE, McGraw Hill Education, 2014.
References Books:	
1	Jeffrey Travis, Jim Kring, LabVIEW for Everyone: Graphical Programming Made Easy and Fun, 3rd edition, Prentice Hall
2	Mikell P. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, Fourth edition, Pearson Education, 2016
3	Michael J. Hamill, Industrial Communications and Control Protocols, PDH centre, 2016
4	Ema Design Automation, The Hitchhiker's Guide to PCB Design, First edition, Blurb Publishers, December 2021

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the usage of controllers in an industrial environment	L2: Understanding
CO2	Build Real-Time systems for Industrial embedded monitoring and controlling deterministic applications	L3: Applying
CO3	Communicate between devices at different levels using industrial protocols	L3: Applying
CO4	Understand the process involved in PCB design using EDA tools and fabricate it	L2: Understanding

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	0	0	0	0	0	0	0	3	2	2
CO2	3	3	3	2	3	0	0	0	0	0	0	0	3	3	3
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	2	3	2	3	0	0	0	0	0	0	0	3	3	2
AVG	3	2.25	2.75	1.75	3	0	0	0	0	0	0	0	3	2.75	2.5

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

18MEPS17	ROBOTICS/ML&MLOps		Semester			VI
PREREQUISITES		Category	EE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	Learn the fundamentals of ROS
2	Understand the requirements and choose the right sensors and actuators for the application development
3	Create Bot in the virtual environment and simulate it to know the functionalities of the system developed
4	Learn the basics of Robotics Vision System
5	Integrate ROS and Computer Vision to build systems for various use cases

Unit I	INTRODUCTION TO ROBOT KINEMATICS	9	0	0	9

Introduction to Robotics - Transformations - Forward Kinematics - Kinematics equations - Link transformations - Inverse Kinematics - Kinematic analysis - Numerical Inverse Kinematic Solutions - Analytical Inverse Kinematic Solutions

Unit II	SELECTION OF SENSORS AND ACTUATORS	9	0	0	9

Introduction - Sensors & Actuators - Types - Selection criteria - Design considerations: Motor sizing - Selection of motors based on torque and speed characteristics - Hardware Interface & Assembly

Unit III	INTRODUCTION TO ROBOT OPERATING SYSTEM	9	0	0	9

Introduction to ROS framework and prerequisites - Understanding communications in ROS - ROS Ecosystem - Introduction to ROS programming - ROS nodes, topics, messages - ROS services - ROS Tools and Utilities - URDF , Rviz - Simulation - Gazebo - ROS Motion

Unit IV	INTRODUCTION TO ROBOTICS VISION SYSTEM	9	0	0	9

Image basics - Image Processing - Histograms - Gray scale, Color, Equalization - Smoothing and blurring/filtering - Averaging, Gaussian, Median, Bilateral - Thresholding - Simple, Adaptive, Otsu - Gradients and Edge detection - Laplacian, Sobel, Canny - Contours - Camera calibration

Unit V	INTEGRATION OF ROS AND COMPUTER VISION	9	0	0	9

Introduction - Installation - CV Bridge - Image publisher node - Image subscriber node - Nodes building and launching - Building real world applications

Total = 45 Periods

Text Books:

1	Introduction to Robotics: Mechanics and Control by John J Craig, Pearson Publishers.
2	Robot Operating System (ROS) for Absolute Beginners by Lentin Joseph, A press; Publishers (2018).
3	Learning OpenCV by Gary Bradski, Adrian Kaehler, O'Reilly Media, Inc.

Reference Books:	
1	https://www.intechopen.com/chapters/379
2	https://www.plantengineering.com/articles/eight-selection-criteria-for-actuation-components/
3	https://www.controleng.com/articles/tips-on-sensor-selection/
4	https://www.toptal.com/robotics/introduction-to-robot-operating-system
5	https://www.thomasnet.com/articles/automation-electronics/machine-vision-systems/
6	https://automaticaddison.com/working-with-ros-and-opencv-in-ros-noetic/

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand kinematics considerations of robot	L2: Understanding
CO2	Selection of sensors and actuators according to application	L3: Applying
CO3	Utilize the ROS environment to simulate and communicate between robot	L3: Applying
CO4	Develop algorithms to extract features and data from image	L3: Applying
CO5	Utilize the open CV for robotic applications	L3: Applying

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1	2	0	0	0	0	0	0	0	3	3	2
CO2	3	3	2	1	2	0	0	0	0	0	0	0	3	3	3
CO3	3	2	3	2	3	0	0	0	0	0	0	0	3	3	3
CO4	3	3	3	2	3	0	0	0	0	0	0	0	3	3	2
AVG	**3**	**2.5**	**2.75**	**1.5**	**2.5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**3**	**2.5**

0: No correlation, 1: Low correlation, 2: Medium correlation, 3: High correlation

HONOURS DEGREE

VERTICAL 1: WELDING

18MTH101	Advanced Metal Joining Processes		Semester			
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To understand the various special/ advanced welding processes.
2	To gain knowledge on the principle of operation, advantages, limitations and applications of various special/ advanced welding processes.

Unit I	ELECTRON BEAM AND LASER BEAM WELDING	9	0	0	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.

Unit II	ELECTRO SLAG WELDING AND RESISTANCE WELDING	9	0	0	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.

Unit III	SOLID STATE WELDING PROCESSES	9	0	0	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.

Unit IV	FRICTION AND FRICTION STIR WELDING	9	0	0	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.

Unit V	OTHER JOINING PROCESSES, CUTTING AND SURFACING	9	0	0	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 Periods

Reference Books:

1	AWS Welding Handbook. 9thedition. 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, 10thEdition. ASM1995.
4	Howard B.Cary, "Modern Welding Technology", Prentice Hall, 6thEd.,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.

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.

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**

18MTH102	METALLURGY OF WELDING	Semester	

PREREQUISITES	Category	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To gain understanding of heat flow and temperature distribution on weld components based on weld geometry
2	To understand the solidification structure and growth morphology on weld joins in relation to the welding parameters
3	Study phase transformations in weld joints with aid of CCT, Schaffler and Delong diagrams and welding of alloy steels, carbon steels and stainless steels.

Unit I	HEAT FLOW IN ARC WELDING	9	0	0	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.

Unit II	WELDABILITY AND WELDABILITY TESTING	9	0	0	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.

Unit III	WELDABILITY OF CARBON STEELS AND LOW ALLOYSTEELS	9	0	0	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.

Unit IV	WELDABILITY OF STAINLESS STEEL	9	0	0	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

Unit V	WELDABILITY OF OTHER ALLOYS AND DISSIMILAR WELDING	9	0	0	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 Periods

Reference 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

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..

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**

18MTH103	WELDING EQUIPMENTS AND CONSUMABLES	Semester			
PREREQUISITES		Category	PE	Credit	3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning 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	0	9

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	0	9

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	0	9

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	0	9

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	0	9

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 =45 Periods

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

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.

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**	

18MTH104	WELDING CODES AND STANDARDS		Semester			
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	Overview and Introductory treatment of codes and standards in the reference–No numerical problems, written document procedures and qualification
2	To acquire knowledge on various welding codes and standards related to various engineering applications.

Unit I	**STRUCTURAL WELDING CODES**	**9**	**0**	**0**	**9**

Design requirements, allowable stress values, workmanship and inspection, introduction to welding codes and standards

Unit II	**PETROLEUM PIPING FABRICATION**	**9**	**0**	**0**	**9**

Process and product standards for manufacturing of pipe – welding procedure and welder qualifications, field welding and inspection, API 1104 and API 5L

Unit III	**PRESSURE VESSEL FABRICATION**	**9**	**0**	**0**	**9**

Design requirements fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydro testing.

Unit IV	**WELDING PROCEDURE AND WELDER QUALIFICATION**	**9**	**0**	**0**	**9**

Welding procedure specification, procedure qualification records, performance qualification, variables

Unit V	**MATERIALS AND CONSUMABLES**	**9**	**0**	**0**	**9**

Introduction to materials standards and testing of materials, consumables testing and qualification as per ASME/AWS requirements

Total =45 Periods

Reference Books:

1	AWS D1.1 Structural Welding Code 2
2	ASME Section VIII – Division 1
3	ASME SectionIX
4	ASME Section II Part A andC
5	API6A
6	API 1104

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

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**

18MTH105	AUTOMATION AND ROBOTICS		Semester			
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To compile and work with the automated equipments and its processing are Automation of arc welding processes and other related welding processes.
2	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.

Unit I	AUTOMATION OF ARC WELDING PROCESSES	9	0	0	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.

Unit II	AUTOMATION OF OTHER RELATED PROCESSES	9	0	0	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

Unit III	AUTOMATED WELDING EQUIPMENT, ARC AND WORK MOTION DEVICES	9	0	0	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.

Unit IV	STANDARDIZED ARC WELDING MACHINES, CONTROLS AND SENSORS	9	0	0	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

Unit V	ROBOTIC ARC WELDING	9	0	0	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 Periods

Reference 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.

Course Outcomes: 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.

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**

18MTH106	WELDING APPLICATION TECHNOLOGY	Semester			
PREREQUISITES	Category	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To understand the materials, process, fabrication techniques used in welding of pressure vessels, piping and pipelines, shipyards, railways, chemical plants and structural.
2	To gain knowledge of the materials, processes, fabrication, inspection and stringent quality control procedures used in oil and gas industries and chemical plants.
3	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.

Unit I	WELDING OF STRUCTURALS AND PRESSURE VESSELS	9	0	0	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.

Unit II	WELDING OF STORAGE TANKS AND PIPINGS	9	0	0	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.

Unit III	WELDINGIN CHEMICAL PLANTS, CRYOGENICS & MICRO JOINING TECHNIQUES	9	0	0	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**.**

Unit IV	WELDING OF SHIP STRUCTURE AND RAILWAYS	9	0	0	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

Unit V	WELDING OF AEROSPACE AND AUTOMOBILE	9	0	0	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 Periods

Reference 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.

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.

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**

18MTH107	BRAZING, SOLDERING, SURFACING AND CUTTING	Semester			
PREREQUISITES	Category	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To understand the fundamental concepts, applications, advantage sand limitations of brazing, soldering, surfacing and cutting

Unit I	FUNDAMENTALS OF BRAZING AND SOLDERING	9	0	0	9

Wetting and spreading characteristics, surface tension and contact angle concepts. Filling of horizontal and vertical capillary joints. Capillary dams.

Unit II	FLUXES AND ATMOSPHERES FOR BRAZING AND SOLDERING	9	0	0	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.

Unit III	SOLDERING AND BRAZING PROCESSES	9	0	0	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

Unit IV	SURFACING	9	0	0	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.

Unit V	THERMAL CUTTING PROCESSES	9	0	0	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 Periods

Reference 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.

Course Outcomes: 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.

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**

18MTH108	DESIGN OF WELDMENTS	Semester			
PREREQUISITES	Category	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	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.

Unit I	DESIGN BASICS	9	0	0	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.

Unit II	WELD DESIGN FOR STATIC LOADING	9	0	0	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

Unit III	WELD DESIGN FOR DYNAMIC LOADING	9	0	0	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).

Unit IV	DISTORTION AND RESIDUAL STRESSES	9	0	0	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.

Unit V	FRACTURE MECHANICS	9	0	0	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 Periods

Reference 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.

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.

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**

18MTH109	FAILURE ANALYSIS IN WELDMENTS		Semester			
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	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.

Unit I	INTRODUCTION TO FAILURE ANALYSIS	9	0	0	9

Stages of failure analysis, classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture.

Unit II	WELDMENT SURFACE FAILURES	9	0	0	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.

Unit III	WELDMENT CREEP AND FATIGUE FAILURES	9	0	0	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.

Unit IV	FAILURE OF WELDED PRODUCTS	9	0	0	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.

Unit V	RELIABILITY	9	0	0	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 Periods

Reference 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.

5	Colangelo.V.J. and Heiser.F.A., "Analysis of Metallurgical Failures", John Wiley and Sons Inc. New York, USA,1987.

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.

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**

18MTH110	FINITE ELEMENT ANALYSIS IN WELDING	Semester	

PREREQUISITES	Category	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To provide the basic FEM modeling and to analyze and solve metallurgical problems using those methods.

Unit I	TWO DIMENSIONAL PROBLEMS	9	0	0	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

Unit II	ISOPARAMETRIC ELEMENTS AND ITS APPLICATIONS	9	0	0	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

Unit III	NON-LINEAR PROBLEMS AND ERROR ESTIMATES	9	0	0	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

Unit IV	DYNAMIC PROBLEM	9	0	0	9

Direct Formulation-Free-Transient and Forced Response-Solution Procedures-Subspace Iterative Technique -Houbolt- Wilson- Newmark - Methods –Examples

Unit V	FLUID MECHANICS	9	0	0	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 Periods

Reference 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

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.

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**

VERTICAL 2: MATERIALS AND PROCESSING

18MTH201	ELECTRICAL, MAGNETIC AND OPTICAL MATERIALS		Semester			
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3
Unit I	ELECTRICAL AND DIELECTRIC MATERIALS:		9	0	0	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 – Ferro electricity, piezo and pyro electricity.						
Unit II	MAGNETIC MATERIALS:		9	0	0	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- Nano materials						
Unit III	SEMICONDUCTING AND SUPERCONDUCTING MATERIALS :		9	0	0	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						
Unit IV	PRODUCTION OF ELECTRONIC MATERIALS:		9	0	0	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.						
Unit V	OPTICAL PROPERTIES OF MATERIALS:		9	0	0	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+15) = 60 Periods						

Reference Books:

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 Outcomes: Upon completion of this course, the students 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	Synthesis and processing of semi-conducting materials for engineering applications
CO4	Study the effect of composition, structure and temperature on the properties of the materials.
CO5	Describe the interactions of light with materials and its effects at the interface

COURSE ARTICULATION MATRIX

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

18MTH202	MATERIALS TECHNOLOGY		Semester			
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3
Unit I	CONSTITUTION OF ALLOYS AND PHASE DIAGRAMS		9	0	0	9
Phases, solid solutions, compounds - Concept of phase diagram – phases and micro constituents 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.						
Unit II	HEAT TREATMENT		9	0	0	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.						
Unit III	STEELS		9	0	0	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						
Unit IV	STAINLESS STEELS AND CAST IRONS		9	0	0	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						
Unit V	NON-FERROUS ALLOYS		9	0	0	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+15) = 60 Periods						

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

Reference Books:

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. Lon

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3
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**
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**

18MTH203	POLYMERS AND COMPOSITES		Semester			
PREREQUISITES		Category		Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Unit I	INTRODUCTION TO POLYMERS	9	0	0	9

Classification- thermoset, thermoplastics and elastomers. Structure of polymers-crystalline and amorphous polymers-concept of Glass Transition Temperature (Tg). Polymerization-types and mechanisms with examples Degree of polymerization -molecular weight of polymers- problems. Polymer additives. Example, properties.

Unit II	POLYMER PROPERTIES AND PROCESSING	9	0	0	9

Applications of engineering plastics. Elastomers- types, properties, examples and applications. Processing of polymers: Processing of thermoset and thermoplastic polymers. Applications. Behaviour of polymers: Viscoelasticity- creep and stress relaxation in polymers. Yielding and fracture of polymers. Crazing of polymers.

Unit III	CERAMICS	9	0	0	9

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

Unit IV	FIBER COMPOSITES	9	0	0	9

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	0	9

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 (45+15) = 60 Periods

Text Books:

1. Bhargava., Engineering Materials- Polymers, Ceramics and Composites, Prentice Hall of India Ltd' New Delhi.
2. Van Vlack L K Physical Ceramics for Engineers, Addison Wesley, Massachusetts, 1964.
3. Mathews & Rawlings, Composites: Science and Engineering, ELBS, London, 1994.

Reference Books:

1	Gabor Koves, Materials for structural and Mechanical Functions, Taraporevala & Sons,Bombay, 1980.
2	Broutman L J and Krock R J, Modern Composite Materials, Addison Wesley Pub. Co., Massachusetts, 1986.
3	Jacobs, J A and Kilduff T F, Engineering Materials Technology, Prentice Hall Inc., N.J., 1988.
4	Mallick P K, Fiber Reinforced Composites: materials, manufacturing and design, CRC Press, Taylor & Francis group, London, 2010.
5	Krishnan K Chawla, Composite materials: Science and Engineering, Springer, 1998.

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3
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**
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**

18MTH204	DESIGN AND SELECTION OF MATERIALS		Semester		
PREREQUISITES	Category	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Unit I		9	0	0	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.					
Unit II		**9**	**0**	**0**	**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 III		**9**	**0**	**0**	**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 IV		**9**	**0**	**0**	**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 V		**9**	**0**	**0**	**9**
Selection of materials for automobile, nuclear, power generation, aerospace, petrochemical, electronic and mining industries.					
Total (45+15) = 60 Periods					

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. and Crane,F.A.A., "Selection and Use of Engineering Materials", Butter worths, 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 this course, the students 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	Know the different methods for process selection
CO5	Selection of materials for Specific engineering applications and processes

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSo2**	**PSO3**
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**
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**

18MTH205	HIGH TEMPERATURE MATERIALS	Semester			
PREREQUISITES	Category	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To impart knowledge on requirements for materials for high temperature use and the Behavior of materials at high temperatures.

Unit I	**INTRODUCTION**	**9**	**0**	**0**	**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**	**0**	**0**	**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**	**0**	**0**	**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**	**0**	**0**	**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**	**0**	**0**	**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+15) = 60 Periods

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.

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.

18MTH206	PROCESSING OF NON METALLIC MATERIALS	Semester			
PREREQUISITES	Category	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	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	0	0	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	0	0	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	0	0	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

Unit IV	PROCESSING OF GLASSES	9	0	0	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	0	0	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+15) = 60 Periods

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	2. Manufacturing Processes for Engineering Materials : S. Kalpakjian, 3rd edition Addison - Wesley, 1997
3	3. Plastic Materials and Processing : A. Brent Strong, Prentice Hall, ISBN 0-13-021626-7
4	4. Handbook of Glass Manufacture - F.V. Tooley
5	5. Composite Materials: Engineering and Science: F.L. Mathews and R.D. Rawlings, CRC press, 084930251X

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

CO1	• list the prominent non-metallic materials available for engineering applications.
CO2	• understand the various processing techniques of polymers.
CO3	• understand the various manufacturing techniques of ceramic materials.
CO4	• Indicate the various glass melting and forming techniques.
CO5	• Understand the various manufacturing techniques of PMCs and CMCs.

COURSE ARTICULATION MATRIX

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
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
AVG	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

18MTH207	BIOMATERIALS	Semester	
PREREQUISITES	Category	PE	Credit 3

	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning 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	0	9

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	0	9

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	0	9

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	0	9

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	0	9

Artificial Heart, Prosthetic Cardiac Valves, Artificial lung (oxygenator), Artificial Kidney (Dialyser membrane) , Dental Implants, Orthopaedic Implants and Biomaterials in Ophthalmology.

Total (45+15) = 60 Periods

Text Books:

1	C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford and Gopinath Mani, Introduction to Biomateria 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.

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

18MTH208	ADVANCES IN NUCLEAR MATERIALS		Semester			
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3
Unit I			**9**	**0**	**0**	**9**
Introduction to nuclear energy / reactors – comparison of different modes of energy generation – ecological and environmental aspects						
Unit II			**9**	**0**	**0**	**9**
Nuclear reactions – concept of half-life, nuclear minerals – related exploration and processing						
Unit III			**9**	**0**	**0**	**9**
Material requirements – structural materials, rare earth materials coolants, shielding materials and fuel rods – fabrication requirements						
Unit IV			**9**	**0**	**0**	**9**
Nuclear irradiation effects on structural materials – safe guards, safety and health protection						
Unit V			**9**	**0**	**0**	**9**
Strategic issues – current status and major needs, overview of nuclear scenario in India, nuclear scenario at international level.						
Total (45+15) = 60 Periods						

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:

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

CO1	Learn different types of materials used to produce nuclear energy
CO2	Understand properties of nuclear materials and applications
CO3	Learn and understand the safety precautions of nuclear radiation and protection.

18MTH209	AUTOMOTIVE AND AEROSPACE MATERIALS		Semester			
PREREQUISITES		Category	PE	Credit		3
		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To know the details of electrodes for various materials used for different welding processes

Unit I	**MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS**	**9**	**0**	**0**	**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**	**0**	**0**	**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**	**0**	**0**	**9**

Aluminum and its alloys: Types and identification. Properties - Castings - Heat treatment processes - Surface treatments. Magnesium and its alloys: Cast and Wrought alloys - Ai rcraft 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**	**0**	**0**	**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**	**0**	**0**	**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+15) = 60 Periods

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	ASM Handbook. "Materials Selection and Design", Vol. 20- ASM Metals Park Ohio.USA, 1997.
7	Cantor," Automotive Engineering: Lightweight, Functional, and Novel Materials", Taylor & Francis Group, London, 2006

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.

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSo2	PSO3
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**
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**

18MTH210	PROCESSING OF NON FERROUS METAL ORES	Semester	

	Category	PE	Credit	3
	Hours/Week	L	T	P	TH
		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

GOVERNMENT COLLEGE OF ENGINEERING, SALEM

REGULATION 2018 A - VERTICALS FOR MINOR DEGREE

VERTICAL - I	VERTICAL - II	VERTICAL - III	VERTICAL - IV	VERTICAL - V	VERTICAL - VI
Civil Engineering	**Computer Science and Engineering**	**Electronics and Communication Engineering**	**Electrical and Electronics Engineering**	**Mechanical Engineering**	**Metallurgical Engineering**
18CEM01 Construction Materials	18CSM01 Programming in C++	18ECM01 Electron Devices	18EEM01 – Network Analysis and Synthesis	18MEM01 Engineering Thermodynamics	18MTM01 Advanced Physical Metallurgy
18CEM02 Building Construction & Equipment	18CSM02 Advanced Data Structures and Algorithms	18ECM02 Digital Electronics	18EEM02 – Signals and Systems	18MEM02 Fluid Mechanics and Machinery	18MTM02 Metallurgical Thermodynamics and kinetics
18CEM03 Concrete Technology	18CSM03 Computer Organization and Design	18ECM03 Electronic Circuits (EC-I & EC-II, LIC)	18EEM03 – Linear and Digital Electronics Circuits	18MEM03 Manufacturing Processes	18MTM03 Mechanical Behaviour of Materials
18CEM04 Environmental Engineering	18CSM04 Advanced Operating Systems	18ECM04 Signal Processing	18EEM04 – Microprocessor and Microcontrollers	18MEM04 Materials Engineering	18MTM04 Rate Processing in Metallurgy
18CEM05 Basics of Transportation Engineering	18CSM05 Data Communication and Computer Networks	18ECM05 Microprocessors and Microcontrollers	18EEM05 – Control Systems	18MEM05 Kinematics of Machinery	18MTM05 Corrosion and Surface Engineering
18CEM06 Repair and Rehabilitation Structures	18CSM06 Programming Essentials in Python	18ECM06 Analog and Digital Communication	18EEM06 – Measurement and Instrumentation	18MEM06 Hydraulics and Pneumatics	18MTM06 Characterization of Materials
18CEM07 Green Building Technology	18CSM07 Advanced Database System Concepts	18ECM07 Communication Networks (CN)	18EEM07 – Electrical Machines	18MEM07 Design of Machine Elements	18MTM07 Automotive, Aerospace and Defense Materials
-----	18CSM08 Virtualization and Cloud Computing	18ECM08 Fundamentals of IoT	18EEM08 – Electric Drives and Control	18MEM08 Heat and Mass Transfer	-----
-----	-----	18ECM09 Wireless Sensors and Networking (WSN)	18EEM09 – Electric Vehicle and Control	18MEM09 Metrology and Quality Control	-----
-----	-----	18ECM10 Basics of Embedded Systems	18EEM10 –Electric Energy Conservation and Auditing	18MEM10 Dynamics of Machinery	-----

LIST OF MINOR DEGREE - VERTICALS

S.No.	Course Code	Course	Cat	Hours/Week			Credits	Maximum Marks		
				L	T	P		CA	FE	Total
CIVIL ENGINEERING										
1	18CEM01	Construction Materials	OE	3	0	0	3	40	60	100
2	18CEM02	Building Construction & Equipment's	OE	3	0	0	3	40	60	100
3	18CEM03	Concrete Technology	OE	3	0	0	3	40	60	100
4	18CEM04	Environmental Engineering	OE	3	0	0	3	40	60	100
5	18CEM05	Basics of Transportation Engineering	OE	3	0	0	3	40	60	100
6	18CEM06	Repair and Rehabilitation of Structures	OE	3	0	0	3	40	60	100
7	18CEM07	Green Building Technology	OE	3	0	0	3	40	60	100
COMPUTER SCIENCE AND ENGINEERING										
1	18CSM01	Programming in C++	OE	3	0	0	3	40	60	100
2	18CSM02	Advanced Data Structures and Algorithms	OE	3	0	0	3	40	60	100
3	18CSM03	Computer Organization and Design	OE	3	0	0	3	40	60	100
4	18CSM04	Advanced Operating Systems	OE	3	0	0	3	40	60	100
5	18CSM05	Data Communication and Computer Networks	OE	3	0	0	3	40	60	100
6	18CSM06	Programming Essentials in Python	OE	3	0	0	3	40	60	100
7	18CSM07	Advanced Database System Concepts	OE	3	0	0	3	40	60	100
8	18CSM08	Virtualization and Cloud Computing	OE	3	0	0	3	40	60	100
ELECTRONICS AND COMMUNICATION ENGINEERING										
1	18ECM01	Electron Devices	OE	3	0	0	3	40	60	100
2	18ECM02	Digital Electronics	OE	3	0	0	3	40	60	100
3	18ECM03	Electronic Circuits	OE	3	0	0	3	40	60	100
4	18ECM04	Signal Processing	OE	3	0	0	3	40	60	100
5	18ECM05	Microprocessors and Microcontrollers	OE	3	0	0	3	40	60	100

6	18ECM06	Analog and Digital Communication	OE	3	0	0	3	40	60	100
7	18ECM07	Communication Networks	OE	3	0	0	3	40	60	100
8	18ECM08	Fundamentals of IoT	OE	3	0	0	3	40	60	100
9	18ECM09	Wireless sensors and networking	OE	3	0	0	3	40	60	100
10	18ECM10	Basics of Embedded systems	OE	3	0	0	3	40	60	100
ELECTRICAL AND ELECTRONICS ENGINEERING										
1	18EEM01	Linear and Digital Electronics Circuits	OE	3	0	0	3	40	60	100
2	18EEM02	Microprocessors and Microcontrollers	OE	3	0	0	3	40	60	100
3	18EEM03	Control Systems	OE	3	0	0	3	40	60	100
4	18EEM04	Measurements and Instrumentation	OE	3	0	0	3	40	60	100
5	18EEM05	Electrical Machines	OE	3	0	0	3	40	60	100
6	18EEM06	Electric Drives and Control	OE	3	0	0	3	40	60	100
7	18EEM07	Electric Vehicles and Control	OE	3	0	0	3	40	60	100
8	18EEM08	Electrical Energy Conservation and Auditing	OE	3	0	0	3	40	60	100
9	18EEM09	SMPS and UPS	OE	3	0	0	3	40	60	100
10	18EEM10	Utilization of Electrical Energy	OE	3	0	0	3	40	60	100
MECHANICAL ENGINEERING										
1	18MEM01	Engineering Thermodynamics	OE	3	0	0	3	40	60	100
2	18MEM02	Fluid Mechanics and Machinery	OE	3	0	0	3	40	60	100
3	18MEM03	Manufacturing Processes	OE	3	0	0	3	40	60	100
4	18MEM04	Materials Engineering	OE	3	0	0	3	40	60	100
5	18MEM05	Kinematics of Machinery	OE	3	0	0	3	40	60	100
6	18MEM06	Hydraulics and Pneumatics	OE	3	0	0	3	40	60	100
7	18MEM07	Design of Machine Elements	OE	3	0	0	3	40	60	100
8	18MEM08	Heat and Mass Transfer	OE	3	0	0	3	40	60	100
9	18MEM09	Metrology and Quality Control	OE	3	0	0	3	40	60	100

10.	18MEM10	Dynamics of Machinery	OE	3	0	0	3	40	60	100
METALLURGICAL ENGINEEING										
1	18MTM101	Advanced Physical Metallurgy	OE	3	0	0	3	40	60	100
2	18MTM102	Thermodynamics and Kinetics in Metallurgy	OE	3	0	0	3	40	60	100
3	18MTM103	Mechanical Behaviour of Materials	OE	3	0	0	3	40	60	100
4	18MTM104	Rate Processes in Metallurgy	OE	3	0	0	3	40	60	100
5	18MTM105	Corrosion and Surface Engineering	OE	3	0	0	3	40	60	100
6	18MTM106	Materials Characterization	OE	3	0	0	3	40	60	100
7	18MTM107	Automotive, Aerospace and Defence Materials	OE	3	0	0	3	40	60	100

B.E. – CIVIL ENGINEERING - MINOR DEGREE

18CEM01	CONSTRUCTION MATERIALS		Semester			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To study the characteristics and Properties of Stones and Brick
2	To impart knowledge on Cement, Aggregate and Mortar
3	To understand the behaviour of concrete and seasoning timber
4	To study the Parts and types of flooring and roofing
5	To study carpentry, arches, lintels and finishing works.

Unit I	**STONES, BRICKS**	**9**	**0**	**0**	**9**

Building Stone –classification of rocks-characteristics of good building stone – deterioration and preservation of stone work – tests on stones - Bricks- manufacture of clay bricks -classification - tests on bricks- bricks for special use- refractory bricks.

Unit II	**CEMENT, AGGREGATES, MORTAR**	**9**	**0**	**0**	**9**

Cement- composition- manufacturing process-wet and dry processes. Aggregates –coarse and fine aggregates- characteristics and function. Mortar- properties- uses- types of mortars- selection of mortars for various Civil Engineering construction.

Unit III	**CONCRETE, TIMBER AND OTHER MATERIALS**	**9**	**0**	**0**	**9**

Concrete- ingredients - principles of hardened concrete- Special concrete- types.
Timber- characteristics- seasoning-preservation- Panels of laminates. Glass- properties- uses. Steel- Uses - market forms.

Aluminum and other metallic materials for construction.

Paints, Varnishes and Distempers-types-properties.

Unit IV	**FLOORING AND ROOFING**	**9**	**0**	**0**	**9**

Components of floor- selection of flooring materials- suitability of floors for various applications. damp proof course, causes of dampness- effect of dampness - requirements of good stairs - classification of stairs -Roofs - types of roofs- requirements - pitched roof - lean to roof-gable roof-hip roof-flat roof-RCC roof.

Unit V	**CARPENTARY, ARCHES, LINTELS AND FINISHING WORKS**	**9**	**0**	**0**	**9**

Location of doors and windows - size of doors - types of doors - fixture and fastenings for doors and windows - arches - classification - stability of an arch - lintels - classification of lintels - steel lintel. scaffolding - component parts - shoring - methods of plastering - defects in plastering - pointing - objectives- methods of pointing

Total= 45 Periods

Text Books:	
1	B.C. Punmia, Building Construction, Laxmi Publications; Eleventh edition -2021
2	S.C.Rangwala, Building Construction,CharotarPublishing House Pvt. Ltd, 34th Edition - 2022
3	P. Purushothama Raj., Building Construction Materials and Techniques, Pearson Education India, First Edition - 2017
Reference Books:	
1	Shetty M.S., Concrete Technology (Theory and Practice), S.Chand& Company Ltd.,2021.
2	Rangwala S.C., Engineering Materials (Material Science) revised and enlarged by Rangwala K.S. and Rangwala P.S., Charotar Publishing House, 2010.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify and characterize and properties of Stone and brick	Remember
CO2	Understand the manufacturing process of cement and functions of mortar	Understand
CO3	Identify the age of timber and preservation methods of timber	Remember
CO4	Differentiate the types of roofing and flooring	Understand
CO5	Understand the miscellaneous works such as carpentry, lintels, Arch, etc.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO2	**-**	**2**	**-**	**-**	**-**	**2**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO3	**1**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO4	**1**	**-**	**2**	**-**	**2**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO5	**1**	**-**	**-**	**-**	**3**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Avg	**1**	**2**	**2**	**-**	**2**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**

18CEM02	BUILDING CONSTRUCTION & EQUIPMENT		Semester			
PREREQUISITES		**Category**	**OE**	**Credit**		**3**
NIL		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	Able to gain basic knowledge in construction methods.
2	Able to gain basic knowledge in equipment.
3	Able to gain basic knowledge in machineries.
4	Able to gain basic knowledge in fire safety principles.
5	Able to gain basic knowledge in green technology.

Unit I	**CLASSIFICATION OF BUILDINGS, FOUNDATIONS AND TYPES OF MASONRY**	**9**	**0**	**0**	**9**

Component parts of a building -Their functions. Classification of buildings according to National building code.
Site investigation for foundation as per N.B.C, Types of foundation and prevention of dampness at basement level,Classification of stone masonry

Unit II	**DOORS, WINDOWS, LINTELS, SCAFFOLDING AND STAIRCASES**	**9**	**0**	**0**	**9**

Doors and windows – parts of door and window – Types of Door and windows–Ventilators – fixed, swinging type and louvered. Lintels – Functions, Scaffolding – Purpose and types –Location of stairs.Types of stairs

Unit III	**ROOFS, FLOORINGS, PROTECTIVE AND DECORATIVE FINISHES**	**9**	**0**	**0**	**9**

Roof Beams and Roof Slabs – Types of Roofing Systems – Methods of Termite Proofing – Methods of Damp proofing.
Types of floors- Plastering (Interior and Exterior) – Pointing for Walls and Floors using Grouts – White Washing, Color Washing with different Color Shades available in the Markets – Painting – Types of Painting for Interior and Exterior application.

Unit IV	**CONSTRUCTION EQUIPMENTS**	**9**	**0**	**0**	**9**

Selection of equipment for earthwork excavation, drilling, blasting, tunnelling, erection and dewatering and pumping, concreting, material handling and erection of structures

Unit V	**GREEN BUILDING TECHNOLOGY**	**9**	**0**	**0**	**9**

Introduction to green technology – types and importance; zero waste and r concept, green materials – green concrete (purpose and limitations), green buildings, green engineering.

Total= 45 Periods

Text Books:	
1	Building Construction by S.C.Rangawala
2	Construction Technology by Sarkar Oxford University Press
3	Building Material & Construction by S.P. Arora& S. P. Bindra
Reference Books:	
1	Hopkinson And Kay J.D., The Lighting of Building, Faber and Faber, London.
2	Koerner, R.M, Construction & Geotechnical Methods in Foundations Engineering, McGraw Hill, 1984
3	Varna M., Construction Equipment and Its Planning & Applications, Metropolitan Books Co, 1979

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Organize the construction technique to be followed in brick and stone masonry, concreting, flooring, roofing and plastering etc.	Create
CO2	Select safe practices in building construction activities	Evaluate
CO3	Clarify the different types of roofs, floor and productive materials of buildings	understand
CO4	Select the relevant equipment for building construction	Evaluate
CO5	Apply the Principles of green building technology.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	-	-	-	-	**3**	**2**	**2**	**2**	**1**	**1**	-	-	-	-	**1**
CO2	-	-	-	-	**3**	**2**	**2**	**2**	**2**	**2**	-	-	-	-	**1**
CO3	-	-	-	-	**2**	**3**	**2**	**2**	**2**	**1**	-	-	-	-	**1**
CO4	-	-	-	-	**2**	**2**	**3**	**1**	**1**	**2**	-	-	-	-	**1**
CO5	-	-	-	-	**2**	**3**	**2**	**2**	**2**	**2**	-	-	-	-	**1**
Avg	-	-	-	-	**2.4**	**2.4**	**2.2**	**1.8**	**1.6**	**1.6**	-	-	-	-	**1**

3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**

18CEM03	CONCRETE TECHNOLOGY		Semester			
PREREQUISITES		Category	OE	Credit		3
NIL		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To understand the properties of ingredients of concrete.
2	To study the behavior of concrete at its fresh and hardened state.
3	To study about the concrete design mix.
4	To know about the procedures in concrete at different stage.
5	To understand special concrete and their uses.

Unit I	INTRODUCTION	9	0	0	9

Concrete materials, Cement: Field and laboratory tests on cement, Types of cement and their uses, different tests for aggregates. Methods for manufacturing of cement- Wet and dry process. Hydration of cement, Bogue's compound.

Unit II	ADMIXTURES	9	0	0	9

Accelerating admixtures, Retarding admixtures, water reducing admixtures, Air entraining admixtures, coloring agent, Plasticizers. Batching, Mixing, Transportation, placing of concrete, curing of Concrete

Unit III	MIX DESIGN	9	0	0	9

Factors influencing mix proportion, Mix design by ACI method and I.S. code method, Design of high strength concrete.

Unit IV	BEHAVIOUR OF CONCRETE	9	0	0	9

Strength of concrete, Shrinkage and temperature effects, creep of concrete, permeability of concrete, durability of concrete, Corrosion, Causes and effects, remedial measures, Thermal properties of concrete, Micro cracking of concrete.

Unit V	SPECIAL CONCRETE	9	0	0	9

Light-weight concrete, Fibre reinforced concrete, Polymer modified concrete, Ferro cement, Mass concrete, Ready-mix concrete, Self-compacting concrete, Quality control, Sampling and testing, Acceptance criteria.

Total= 45 Periods

Text Books:

1	Neville A.M Properties of Concrete, Pearson publication, 2012.
2	Shetty M.S Concrete technology, S.Chand and Company Ltd, New Delhi 2022.
3	Santha Kumar A.R Concrete Technology, Oxford university Press, NewDelhi, 2022.
4	Mehta K.P Concrete Technology, Chand & Co, NewDelhi, 2006.
5	Robert RatayForensic Structural Engineering Handbook, McGraw Hill LLC, 2009

Reference Books:	
1	Indian Standard Recommended Guide lines for Concrete Mix Design, IS:10262 – 2019, Bureau of Indian Standards, NewDelhi.
2	Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete IS:383-1970 R2011, Bureau of Indian Standards, NewDelhi.
3	Gambhir.M.L,Concrete Technology, Volume I & II, Tata McGraw-HillBookCompany,Third print, 2003
4	Krishna Raju N. Design of Concrete Mixes, CBS publishers. NewDelhi, 2002.
5	Stephen E. Petty,Forensic Engineering: Damage Assessments for Residential and Commercial Structures,CRCpress,Taylor& Francis,2013.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	To identify suitable materials to be used in the cement concrete by conducting various tests as per BIS code.	Evaluate
CO2	To know about the specific applications and uses of admixtures.	Understand
CO3	Design the concrete mix using ACI and BIS code methods.	Create
CO4	Determine the properties of fresh and hardened of concrete.	Evaluate
CO5	Design special concretes and to Ensure quality control while testing/ sampling and acceptance criteria for pre and post construction work.	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	-	-	-	-	3	-	1	1	1	2	1	1	1	-	1
CO2	-	-	-	-	3	-	3	-	1	1	-	-	2	-	1
CO3	-	-	-	-	3	-	3	-	-	1	-	-	1	-	1
CO4	-	-	-	-	3	2	1	-	-	-	-	-	-	-	1
CO5	-	-	-	-	3	3	3	1	1	3	1		3	-	1
Avg	-	-	-	-	3	2.5	2.2	1	1	1.75	1	1	1.75	-	1
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM04	ENVIRONMENTAL ENGINEERING		Semester			
PREREQUISITES		Category	OE	Credit		3
NIL		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To evaluate the sources of water and analyse its characteristics and processes in water treatment, express the analysis of distribution network
2	To design sewer system, basic design of the biological treatment processes, gain knowledge on sludge treatment and its disposal
3	To predict the sources, effects, dispersion of air pollutants air quality management and its control measures
4	To identify the characteristics and sources of municipal solid wastes, its collection methods, off-site processing of municipal solid wastes and its recovery, disposal methods
5	To assess the sources, effects and control measures of noise pollution

Unit I	WATER TREATMENT	9	0	0	9

Water Quality and its Treatment: Basics of water quality standards – Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment.

Unit II	WASTEWATER TREATMENT	9	0	0	9

Sewerage system design, quantity and quality of domestic wastewater, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications.

Unit III	AIR POLLUTION	9	0	0	9

Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality standards, Air quality Index and limits.

Unit IV	SOLID WASTE MANAGEMENT	9	0	0	9

Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).

Unit V	NOISE POLLUTION	9	0	0	9

Noise pollution: Sources; Health effects; Standards; Measurement and control methods

Total= 45 Periods

Text Books:

1	Garg, S.K. Water supply Engineering, Khanna Publishers, New Delhi, 2010.
2	Garg, S.K. Sewage water disposal and Air pollution, Khanna Publishers, New Delhi, 2010.
3	George Tchobanoglous et.al., Integrated Solid Waste Management, McGraw-Hill, Publishers, 1993.
4	Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Delhi, 1996.

Reference Books:	
1	Manual on Water Supply and Treatment, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
2	Peavy S.W., Rowe D.R. and Tchobanoglous G. Environmental Engineering, McGraw Hill, NewDelhi, 1985.
3	Metcalf and Eddy,M.C., Wastewater Engineering – Treatment &Reuse,TataMcGraw-Hill Publications, New Delhi,2003.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Identify the sources of water supply, analyze the characteristics of water with its standards and various unit operations and processes in water treatment, express the analysis of distribution network	Remember
CO2	Expertise design sewer system, basic design of the biological treatment processes, gain knowledge on sludge treatment and disposal and justify the methods for disposal of sewage	Analyze
CO3	Predict the sources, effects, dispersion of air pollutants air quality management and its control measures	Apply
CO4	Aware about the characteristics, types and sources of municipal solid wastes, Learn the collection methods, Know about off-site processing of municipal solid wastes and its recovery, disposal methods	Remember
CO5	Understand the sources, effects and control methods of noise pollution	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	2	1	3	2	1	1	2	1	1	3	-	2
CO2	2	1	3	1	1	3	1	-	1	2	2	1	3	-	2
CO3	2	1	3	1	1	3	1	-	1	2	2	1	3	-	2
CO4	2	1	3	1	1	3	1	-	-	2	2	1	3	-	2
CO5	2	-	3	-	-	3	-	-	-	2	1	1	3	-	2
Avg	2	1	3	1.3	1	3	1.3	1	1	2	1.6	1	3	-	2

3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**

18CEM05	BASICS OF TRANSPORTATION ENGINEERING		Semester			
PREREQUISITES		Category	OE	Credit		3
NIL		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	The objective of the course is to educate the students on various components of highway engineering.
2	To educate the geometric design concepts of highway engineering
3	To develop skills on construction and maintenance of highway.
4	Ability to plan various civil engineering aspects of railways and educate various components of railways
5	The course enables the students to develop skill on evaluation and maintenance of railway track.

Unit I	CROSS SECTIONAL ELEMENTS OF HIGHWAYS	9	0	0	9

Classification of Highways - Classification and Cross Section of Urban and Rural Roads (IRC), Highway Cross Sectional Elements- Right of Way, Carriage Way, Camber, Kerbs, Shoulders and Footpaths (IRC Standards), Sight Distances - Stopping Sight Distance (SSD), Overtaking Sight Distance (OSD), Sight Distance at Intersections, Intermediate Sight Distance and Illumination Sight Distance - Cross Sections of Different Class of Roads -

Unit II	GEOMETRIC DESIGN OF HIGHWAYS	9	0	0	9

Horizontal Alignments – Superelevation, Widening of Pavements on Horizontal Curves, Vertical Alignments - Rolling. Limiting, Exceptional and Minimum Gradients, Summit and Valley Curves -Geometric Design of Hill Roads (IRC Standards Only)

Unit III	CONSTRUCTION AND MAINTENANCE OF HIGHWAY	9	0	0	9

Construction of Flexible and Rigid Pavements – Defects in Flexible and Rigid Pavements -Highway Drainage – Evaluation and Maintenance of Pavements.

Unit IV	RAILWAY PLANNING AND DESIGN	9	0	0	9

Permanent Way, its Components and Functions of Each Component: Rails - Types of Rails, Rail Fastenings, Concept of Gauges, Coning of Wheels, Creeps Sleepers - Functions, Materials, Density. Ballasts - Functions, Materials, Ballast less Tracks Geometric Design of Railway Tracks Gradients and Grade Compensation, Super-Elevation, Widening of Gauges in Curves, Transition Curves, Horizontal and Vertical Curves.

Unit V	RAILWAY TRACK CONSTRUCTION MAINTENANCE AND OPERATION	9	0	0	9

Points and Crossings – Turnouts, Track circuiting, Signaling, Interlocking, Lay Outs of Railway Stations and Yards, Rolling Stock, Tractive Power, Track Resistance, Level Crossings.

Total= 45 Periods

Text Books:

1	Khanna K., Justo C.E.G., Highway Engineering Revised 10th Edition Khanna Publishers, Roorkee, 2014
2	Kadiyalil. R, Engineering Traffic and Transport Planning, Khanna Publishers, New Delhi, 2019.
3	Chandola S.P. Transportation Engineering-2019

Reference Books:	
1	Sharma S.K., Principles Practice and Design of Highway Engineering, S. Chand & Co Ltd. New Delhi, 2006
2	Guidelines Of Ministry of Road Transport and Highways, Government of India.
3	Agarwal M.M., Indian Railway Track, 14th Edition, Prabha and Co., New Delhi, 2002.
4	Saxena S.C. Highway & Traffic Engineering, 2014.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Classify roads as per Indian Road Congress and describe the principles of highway alignment	Understand
CO2	Determine the highway geometric elements	Analyse
CO3	Differentiate between types of pavements, their construction and design principles	Analyse
CO4	Explain the functions of components of Railways	Understand
CO5	Carry out the various methods for track alignment & procedure for construction of railway & maintenance of track	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	-	-	-	-	**2**	**2**	**3**	**1**	**2**	-	-	-	**1**	-	-
CO2	**2**	**3**	**2**	**2**	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	**2**	**2**	**3**	**1**	**3**	-	-	-	**1**	-	-
CO4	-	-	-	-	**2**	**2**	**3**	**1**	**2**	-	-	-	-	-	-
CO5	-	-	-	-	**2**	**2**	**3**	**1**	**2**	-	-	-	**1**	-	-
Avg	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**1**	**2.25**	-	-	-	**1**	-	-
3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**															

18CEM06	REPAIR AND REHABILITATION OF STRUCTURES	Semester	

PREREQUISITES	Category	OE	Credit		3
NIL	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	Study the various types and properties of repair materials
2	Learn various distress and damages to concrete structures
3	Understand the importance of maintenance of structures
4	Assess the damage to structures using various tests
5	Learn various repair techniques of damaged structures, corroded structures

Unit I	MAINTENANCE AND REPAIR STRATEGIES	9	0	0	9

Maintenance, repair and rehabilitation, Facts of Maintenance, importance of Maintenance various aspects of inspection, assessment procedure for evaluating a damaged structure, causes of deterioration.

Unit II	SERVICEABILITY AND DURABILITY OF CONCRETE	9	0	0	9

Quality assurance for concrete construction, concrete properties- strength, permeability, thermal properties and cracking- effects due to climate, temperature, chemical, corrosion- Design and construction errors-effects of cover thickness and cracking.

Unit III	MATERIALS AND TECHNIQUES FOR REPAIR	9	0	0	9

Special concretes and mortar, concrete chemical, special elements for accelerated strength gain, expansive cement, polymer concrete, Sulphur infiltrated concrete, ferro cement, fibre reinforced concrete, rust eliminators and polymers coating for rebars during repair, foamed concrete, mortar and dry pack, vacuum concrete, gunite and shotcrete, epoxy injection, mortar repair for cracks, shoring and underpinning. Methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings and cathodic protection.

Unit IV	REPAIRS, REHABILITATION AND RETROFITTING OF STRUCTURES	9	0	0	9

Strengthening of Structural elements, deflection, cracking, chemical disruption, weathering corrosion, wear, fire, leakage and marine exposure.

Unit V	DEMOLITION TECHNIQUES	9	0	0	9

Demolition methods by machines, explosives, Advanced techniques-Demolition sequences, dismantling techniques, safety precautions in dismantling and demolition, Engineered demolition techniques for dilapidated structures- case studies

Total= 45 Periods

Text Books:

1	Shetty, M.S, Concrete Technology- Theory and Practice, S. Chand and company, New Delhi,2019
2	Repair and protection of concrete structures by Noel P. Mailvaganam, CRC Press,1991.
3	CPWD: Handbook on Repair & Rehabilitation of R.C.C. Buildings, CPWD, Govt. of India, 2002, updated reprint 2011

Reference Books:	
1	Santhakumar A.R, Training Course notes on Damage Assessment and Repair in Low-cost housing, "RHDC.NBO" Anna University, July 1992.
2	Raikar R.N.,Learning from failures- deficiencies in design, construction and services – R&D Centre (SDCPL), Raikar bhavan, Bombay,1987
3	Palaniyappan, N., Estate management, Anna Institute of Management, Chennai,1992.
4	Lakshmipathy, M. etal., Lecture notes of workshop on Repairs and Rehabilitation of structures, 29-30th October 1999.
5	https://nptel.ac.in/courses/114106035/38

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Demonstrate the condition of structures	Understand
CO2	Inspect and evaluate the damaged structure	Analyze
CO3	Implement the repairing techniques of a structure	Analyze
CO4	Identify and Use different materials for repairing works	Apply
CO5	Demonstrate the dismantling and demolishing structures	Apply

COURSE ARTICULATION MATRIX

COs/ POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO2	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO3	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO4	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO5	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
Avg	**1**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**

3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**

18CEM07	GREEN BUILDING TECHNOLOGY		Semester			
PREREQUISITES		Category	OE	Credit		3
NIL		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To Know various aspects of green buildings
2	To Learn the principles of planning and orientation of buildings.
3	To Relate the construction of green building with prevailing energy conservation policy and regulations.
4	To Know and identify different green building construction materials.
5	To Learn different rating systems and their criteria

Unit I	INTRODUCTION TO GREEN BUILDING	9	0	0	9

Introduction, Necessity, Definition & concept of Green Building, Issues and strategies of Green Building, Principles and Benefits of Green Building, Components/ features of Green Building, Energy Efficiency, Water efficiency, Material Efficiency, Indoor Air Quality.

Unit II	SITE SELECTION AND PLANNING	9	0	0	9

Site selection, Site selection strategies, Landscaping, building form, orientation, building envelope and fenestration, material and construction techniques, roofs, walls, fenestration and shaded finishes, Environmental design (ED) strategies for building construction, Rainwater harvesting methods for roof & non-roof, reducing landscape water demand by proper irrigation systems, recycle and reuse systems, Waste Management.

Unit III	ENERGY AND ENERGY CONSERVATION	9	0	0	9

Introduction, Environmental impact of building constructions, present scenario, Need of energy conservation, Concepts of embodied energy,

operational energy and life cycle energy, Methods to reduce operational energy, Energy efficient building, zero ozone depleting potential (ODP) materials, wind and solar energy harvesting, energy metering and monitoring, concept of net zero buildings.

Unit IV	BUILDING MATERIALS	9	0	0	9

Green building materials and products- Bamboo, Rice husk ash concrete, plastic bricks, Bagasse particle board, Insulated concrete forms. use of materials with recycled content such as blended cements, pozzolana cements, flyash bricks, vitrified tiles, materials from agro and industrial waste, reuse of waste material-Plastic, rubber, Newspaper wood, Nontoxic paint, green roofing.

Unit V	RATING SYSTEM	9	0	0	9

Introduction to Leadership in Energy and Environmental Design (LEED) criteria, Indian Green Building council (IGBC) Green rating, Green Rating for Integrated Habitat Assessment. (GRIHA) criteria, National Productivity council (NPC) Ministry of New and Renewable Energy (MNRE) Bureau of Energy efficiency (BEE) -BER (Building Energy Rating) – Certificates.

Total= 45 Periods

Text Books:

1	Kibert, C.J., Sustainable construction: Green Building design and Delivery, John Wiley Hobouken, NewJersey, 3rd Edition, 2012.
2	Chauhan, D S Sreevasthava, S K., Non-conventional Energy Resources, New Age International Publishers, NewDelhi, 4th Edition, 2021

Reference Books:	
1	O.P. Gupta, Energy Technology, Khanna Publishing House, NewDelhi
2	Jagadeesh, K S, Reddy Venkatta Rama &Nanjunda Rao, K S., Alternative Building Materials and Technologies, New Age International Publishers,Delhi.
3	Sam Kubba., Handbook of Green Building Design and Construction, Butterworth- Heinemann.
4	Means R S, Green Building - Project Planning and Cost Estimating, John Wiley &Sons
5	Sharma K V, Venkataseshaiah P., Energy Management and Conservation, IK International.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Understand the concepts of Green Building	Understand
CO2	Discuss the Planning of Green Building.	Understand
CO3	Explain the concept of Energy and Energy Conservation.	Understand
CO4	Select appropriate green building material and technique.	Understand
CO5	Summarize the Green Building Functions in various organizations.	Understand

COURSE ARTICULATION MATRIX

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	1	-	2	3	-	-	-	2	1	2	-	-
CO2	1	1	1	2	1	-	-	-	-	-	-	-	2	-	-
CO3	-	1	3	-	2	-	-	-	-	-	-	-	2	-	-
CO4	-	1	2	-	3	-	-	-	-	-	2	-	2	-	-
CO5	1	1	2	3	2	-	-	-	-	-	2	-	2	-	-
Avg	1	1	2	2	2	2	3	-	-	-	2	1	2	-	-

3/2/1 – indicates strength of **correlation (3- High, 2- Medium, 1- Low)**

B.E. – COMPUTER SCIENCE ENGINEERING - MINOR DEGREE

18CSM01	PROGRAMMING IN C++				
PREREQUISITES	**Category**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Learning Objectives

1	To understand and develop the object oriented programming concepts.
2	To familiarize and design the template functions and classes
3	To disseminate and apply exception handling mechanisms.
4	To learn and exploit stream classes.

Unit I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Procedure oriented programming paradigm - Object oriented programming paradigm - Basic concepts of object oriented programming, benefits of OOP, application of OOP - C++ fundamentals –structure of C++ program, tokens, data types - Operators and expressions - Control structures - Functions.

Unit II	**INHERITANCE AND VIRTUAL FUNCTIONS**	**9**	**0**	**0**	**9**

Classes and objects - friend functions- constructors and destructors- Operator overloading – binary and unary operator overloading using member function and friend function - Type conversions.

Unit III	**INHERITANCE AND VIRTUAL FUNCTIONS**	**9**	**0**	**0**	**9**

Inheritance – defining derived classes, types, virtual base classes, abstract classes, constructor in derived classes - Pointers-pointers to objects, this pointer, pointer to derived classes - Virtual functions.

Unit IV	**TEMPLATES AND EXCEPTION HANDLING**	**9**	**0**	**0**	**9**

Generic Classes – class template, class templates with multiple parameters - Generic Functions - function templates, function templates with multiple parameters, member function templates - Exception handling – basics, exception handling mechanism, rethrowing an exception – Exception handling options – understanding terminate() and unexpected() – the uncaught_exception() function – bad_exception().

Unit V	**CONSOLE I/O AND FILE HANDLING**	**9**	**0**	**0**	**9**

C++ Stream Classes – unformatted I/O operations, formatted console I/O operations, manipulators - Files-classes for file operation, opening and closing a file, detecting end of file, files modes, sequential file operations, random file operations.

Total (45 L) =45 Periods

Text Books:

1	E. Balagurusamy “Object –Oriented Programming with C++” Sixth Edition Tata McGraw-Hill

Reference Books:

1	Herbert Schildt, "The Complete Reference C++", Fifth Edition, Tata McGraw Hill
2	Bjarne Stroustrup, “The C++ programming language”, Fourth Edition Addison Wesley
3	K.R.Venugopal, Rajkumar Buyya, T.Ravishankar , Mastering in C++, Second Edition, Tata McGraw Hill

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Build the object oriented programming concepts.	Apply
CO2	Familiarize and build the template functions and classes	Understand
CO3	Disseminate and apply exception handling mechanisms.	Apply
CO4	Depict and exploit steam classes.	Understand

18CSM02	ADVANCED DATA STRUCTURES AND ALGORITHMS				
PREREQUISITES		**Category**	**OE**	**Credit**	**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the concepts of ADTs
2	To Learn linear data structures – lists, stacks, and queues
3	To have knowledge about non-linear data structures like trees and graphs
4	To understand concepts about searching and sorting and hashing techniques

Unit I	**LINEAR DATA STRUCTURES – LIST**	**9**	**0**	**0**	**9**

Abstract Data Types (ADTs) – List ADT - Array based Implementation - Linked List Implementation – Singly Linked Lists - Circularly Linked Lists - Doubly-Linked Lists - Applications of Lists – Polynomial Manipulation – All operations (Insertion, Deletion, Merge, Traversal).

Unit II	**LINEAR DATA STRUCTURES –STACKS AND QUEUES**	**9**	**0**	**0**	**9**

Stack ADT - Operations - Applications of Stacks - Evaluating Arithmetic Expression - Conversion of infix to postfix Expression - Queue ADT - Operations - Circular Queue - DeQueue - Applications of Queue

Unit III	**NON LINEAR DATA STRUCTURES – TREES**	**9**	**0**	**0**	**9**

Tree ADT – Tree traversals – Binary Tree ADT – Expression Trees – Applications of Trees – Binary Search Tree ADT – Threaded Binary Trees- AVL Trees – B-Tree – Heaps - Operations of Heaps - Priority Queues - Binary Heap - Max Heap - Min Heap - Applications of Heap.

Unit IV	**NON LINEAR DATA STRUCTURES – GRAPHS**	**9**	**0**	**0**	**9**

Definition – Representation of Graphs –Types of Graphs - Graph Traversals - Breadth First Search - Depth First Search - Application of Graph Structures: Shortest Path Problem: Dijkstra's Algorithm - Minimum Spanning Trees: Prim's Algorithm - Kruskal's Algorithms

Unit V	**SEARCHING, SORTING AND HASHING TECHNIQUES**	**9**	**0**	**0**	**9**

Searching: Linear Search - Binary Search - Sorting Algorithms - Insertion Sort - Selection Sort - Shell Sort - Bubble Sort - Quick Sort - Merge Sort - Radix Sort - Hashing: Hash Functions – Separate Chaining – Open Addressing – Rehashing – Extendible Hashing.

Total (45 L) =45 Periods

Text Books:

1	Mark Allen Weiss, " Data Structures and Algorithm Analysis in C ", 4/E Pearson Education, 2013.

Reference Books:

1	Seymour Lipschutz, "Data Structures With C ",(Schaum`s Outline Series) Published by Tata McGraw-Hill Education Pvt. Ltd., 2015
2	Ellis Horowitz, Sartaj Sahni, Dinesh Mehta, "Fundamentals of Data Structures In C", Second Edition, Silicon Press, 2008.
3	Richard F.Gilberg & Behrouz A.Forouzan, "Data Structures: A Pseudo code Approach With C", Second Edition, Cengage Learning Publishers,2005.
4	Classic Data Structures", Second Edition by Debasis Samanta, PHI Learning, 2009.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Implement various abstract data types to solve real time problems by using Linear Data Structures	Apply
CO2	Apply the different Non-Linear Data Structures to solve problems	Apply
CO3	Analyze and implement graph data structures to solve various computing problems.	Analyze
CO4	Critically analyze the various sorting and searching algorithms	Analyze

18CSM03	COMPUTER ORGANIZATION AND DESIGN				
PREREQUISITES		**Category**	**OE**	**Credit**	**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To understand the basic structure and operations of digital computer
2	To learn the working of different arithmetic operations
3	To understand the different types of control and the concept of pipelining
4	To study the hierarchical memory system including cache memory and virtual memory
5	To understand the different ways of communication with I/O devices and standard I/O interfaces

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Functional units ,Basic Operational Concepts, Bus Structure ,Memory Locations and Addresses, MemoryOperations, Instruction and Instruction Sequencing, Addressing modes.

UNIT II	**ARITHMETIC UNIT**	**9**	**0**	**0**	**9**

Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, BoothAlgorithm, Fast Multiplication, Integer Division, Floating point number operations.

UNIT III	**PROCESSOR UNIT AND PIPELINING**	**9**	**0**	**0**	**9**

Fundamental Concepts, Execution of Instruction, Multi Bus Organization, Hardwired control, Micro programmed control, Basic Concepts of pipelining, Data Hazards, Instruction Hazards ,Data path & Control Considerations.

UNIT IV	**MEMORY SYSTEMS**	**9**	**0**	**0**	**9**

Basic Concepts, Semiconductor RAM, ROM, Cache memory, Improving Cache Performance, Virtual memory,Memory Management requirements, Secondary Storage Device.

UNIT V	**INPUT AND OUTPUT ORGANIZATION**	**9**	**0**	**0**	**9**

Accessing I/O devices, Programmed I/O, Interrupts, Direct Memory Access, Interface circuits, Standard I/O Interfaces (PCI, SCSI, USB).

Total (45 L) =45 Periods

Text Books:

1	Carl Hamacher V.,Zvonko G.Vranesic, Safwat G. Zaky, " Computer organization ", Tata McGraw Hill,5th Edition, 200

Reference Books:

1	Patterson and Hennessey, “Computer Organization and Design ". The Hardware/Software interface,Harcourt Asia Morgan Kaufmann, 3rd Edition, 2007
2	Hayes, “Computer Architecture and Organization ", 3rd edition,Tata McGraw Hill, 2006
3	Heuring V.P., Jordan H.F., " Computer System Design and Architecture ", 6th edition ,Addison Wesley,2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the working principles of computer componets	Understand
CO2	Design the arithmetic and processing units	Create
CO3	Analyze the various computer components	Analyze

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18CSM04	ADVANCED OPERATING SYSTEMS	Semester			
PREREQUISITES	Category	OE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To understand the structure and functions of Operating systems
2	To understand the process concepts and scheduling algorithms
3	To understand the concept of process synchronization and deadlocks
4	To learn various memory management schemes
5	To illustrate various file systems and disk management strategies

UNIT I	INTRODUCTION AND OPERATING SYSTEM STRUCTURES	9	0	0	9

Main frame Systems, Desktop Systems, Multiprocessor Systems, Distributed Systems, Clustered Systems, Real Time systems, Hand held Systems; Operating Systems Structures - System Components, Operating System Services, System calls, System Programs, System Design and Implementation.

UNIT II	PROCESS MANAGEMENT	9	0	0	9

Processes-Process Concepts, Process Scheduling, Operation on Processes, Co-Operating Processes, InterProcess Communication; Threads- Multithreading Models, Threading Issues; CPU Scheduling-Basic Concepts, Scheduling Criteria, Scheduling Algorithms.

UNIT III	PROCESS SYNCHRONIZATION AND DEADLOCKS	9	0	0	9

Process Synchronization- The Critical Section Problem, Synchronization Hardware, Semaphores, Classical Problem of Synchronization, Monitors; Deadlocks- Deadlock Characterization, Methods for handling Deadlocks, Deadlock Prevention, Deadlock Avoidance ,Deadlock Detection, Recovery from Deadlock.

UNIT IV	MEMORY MANAGEMENT AND VIRTUAL MEMORY	9	0	0	9

Memory Management- Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with paging; Virtual Memory - Demand paging, Page Replacement, Thrashing.

UNIT V	FILE SYSTEM AND MASS-STORAGE STRUCTURE	9	0	0	9

File System Interface - File Concepts, Access methods, Directory Structure, File Sharing, File Protection; File System Implementation- File System Structure and Implementation, Directory Implementation, Allocation Methods, Free Space Management; Mass-Storage Structure - Disk Structure, Disk scheduling, Disk Management, RAID Structure; Case study: Linux system.

Total (45 L) =45 Periods

Text Books:

1	Abraham Silberschatz, P.B.Galvin, G.Gagne ―Operating System Concepts 6th edition, John Wiley & Sons, 2003.

Reference Books:

1	Andrew S. Tanenbaum, ―Modern Operating Systems, PHI , 2nd edition, 2001
2	D.M.Dhamdhere, "Systems Programming and Operating Systems ", 2nd edition, Tata McGraw Hill Company, 1999.
3	Maurice J. Bach, ―The Design of the Unix Operating System, 1st edition, PHI, 2004.

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Identify the components and their functionalities in the operating system	Apply
CO2	Apply various CPU scheduling algorithms to solve problems	Apply
CO3	Analyze the needs and applications of process synchronization and deadlocks	Analyze
CO4	Apply the concepts of memory management including virtual memory and page replacement to the issues that occur in real time applications	Apply
CO5	Solve issues related to file system implementation and disk management	Apply

18CSM05	DATA COMMUNICATION AND COMPUTER NETWORKS	Semester			
PREREQUISITES	Category	OE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To study the concepts of data communications and functions of different ISO/OSI reference architecture
2	To understand the error detection and correction methods and also the types of LAN
3	To study the concepts of subnetting and routing mechanisms
4	To understand the different types of protocols and congestion control
5	To study the application protocols and network security

UNIT I	DATA COMMUNICATIONS AND PHYSICAL LAYER	9	0	0	9

Data Communication; Networks- Physical Structures (Types of Connections, Physical Topology),Categories of Networks, Interconnection of Networks: Internetwork; Protocols and Standards; Network Models-The OSI Model, Layers in the OSI Model, Addressing; Transmission media-Guided Media, Unguided Media.

UNIT II	DATA LINK LAYER	9	0	0	9

Introduction-Types of errors, Redundancy, Detection versus Correction, Modular Arithmetic; Block Coding-Error Detection and Correction (VRC,LRC,CRC, Checksum, Hamming Code);Data link Control- Flow Control (Stop- and-Wait, Sliding Window),Error Control (Automatic Repeat Request, Stop-and-wait ARQ, Sliding Window ARQ), HDLC; Local Area Networks-Ethernet, Token Bus, Token Ring, FDDI.

UNIT III	NETWORK LAYER	9	0	0	9

Network Layer services-Packet Switching-Network Layer Performance-IPv4 addresses-IPv6 addressing- Subnetting-Bridges-Gateways- Routers-Routing Algorithm-Distance Vector Routing, Link State Routing.

UNIT IV	TRANSPORT LAYER	9	0	0	9

Duties of the Transport layer-User Datagram Protocol-Transmission Control Protocol- Congestion Control and Quality of Service-Congestion, Congestion Control, Quality of Service, Techniques to improve QoS, Integrated Services.

UNIT V	PRESENTATION LAYER AND APPLICATION LAYER	9	0	0	9

Domain Name System - Domain Name Space, DNS in the Internet; Electronic Mail-FTP- HTTP- World Wide Web.

Total (45 L) =45 Periods

Text Books:

1	Behrouz A.Ferouzan, "Data Communications and Networking", 4th Edition, Tata McGraw-Hill, 2007.

Reference Books:

1	Andrew S. Tanenbaum, "Computer networks "PHI, 4th edition 2008
2	William Stallings," Data and computer communications", 10th edition,PHI, 2012
3	Douglas E. comer," Internetworking with TCP/IP-Volume-I", 6th edition,PHI, 2008

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Classify the fundamentals of data communications and functions of layered architecture	Understand
CO2	Apply the error detection and correction methods and also identify the different network technologies	Apply
CO3	Analyze the requirements for a given organizational structure and select the most appropriate networking architecture and routing technologies	Analyze
CO4	Illustrate the transport layer principles and reliable data transfer using protocols	Apply
CO5	Analyze the application layer protocols and also the use of network security	Analyze

18CSM06	PROGRAMMING ESSENTIALS IN PYTHON	Semester			
PREREQUISITES	Category	OE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To learn Python data structures, conditional and control structures and files
2	To study Python Modules, packages, Functions and Exceptions.
3	To describe Object oriented programming features and Regular Expressions.
4	To learn about Web programming, GUI Programming and Database programming

UNIT I	INTRODUCTION	9	0	0	9

Python: Features - The Basics-Python Objects-Numbers-Sequences-Mapping and set types- Conditionals and loops-if statement-else statement-elif-Conditional Expressions-while statement-for statement-break-continue.

UNIT II	FUNCTIONS, MODULES AND PACKAGES	9	0	0	9

Functions-Calling functions-Creating functions-Passing Functions-Formal Arguments-Variable length arguments-variable scope-Recursion, Modules-Packages.

UNIT III	FILES AND EXCEPTIONS	9	0	0	9

Files and Input/ Output –Errors and Exceptions-Introduction-Detecting and handling Exceptions-Context Management-Raising Exceptions-Assertions-Standard Exceptions.

UNIT IV	OBJECT ORIENTED PROGRAMMING AND REGULAR EXPRESSIONS	9	0	0	9

Object Oriented Programming Introduction-Classes-class Attributes-Instances-Instances attributes-Building and Method Invocation-Static methods and class Methods-Inheritance-Operator overloading - Regular Expressions-Network Programming – Multithreaded Programming

UNIT V	ADVANCED TOPICS	9	0	0	9

GUI Programming- Web Programming-Database Programming

Total (45 L) =45 Periods

Text Books:

1	Wesley J.Chun-"Core Python Programming" –Prentice Hall, Second Edition, 2006.

Reference Books:

1	Swaroop C N, " A Byte of Python ", ebshelf Inc., 1st Edition, 2013
2	"A Practical Introduction to python programming", Brian Heinold,Mount St.Mary's University,2012
3	Learning to Program with Python," Richard L. Halterman"., Southern Adventist University

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Level
CO1	Develop programs using control structures and files.	Create
CO2	Create own Python Modules, packages, functions and Exceptions.	Create
CO3	Illustrate Object oriented Programming features and Regular Expressions.	Apply
CO4	Create own Web programs, GUI and database programs.	Create

22CSM07	ADVANCED DATABASE SYSTEM CONCEPTS	Semester			
PREREQUISITES	Category	OE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To understand the fundamentals of data models ,SQL queries and relational databases
2	To make a study of database design using ER Diagram and normalize
3	To impart knowledge in transaction processing.
4	To make the students to understand the file operations and indexing
5	To familiarize the students with advanced databases

UNIT I	RELATIONAL DATABASES	9	0	0	9

Purpose of Database System – Views of data – Data Models – Database System Architecture – Introduction to relational databases – Relational Model – Keys – Relational Algebra – SQL fundamentals – Advanced SQL features – Embedded SQL– Dynamic SQL.

UNIT II	DATABASE DESIGN	9	0	0	9

Entity-Relationship model – E-R Diagrams – Enhanced-ER Model – ER-to-Relational Mapping – Functional Dependencies – Non-loss Decomposition – First, Second, Third Normal Forms, Dependency Preservation – Boyce/Codd Normal Form – Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form.

UNIT III	TRANSACTION	9	0	0	9

Transaction Concepts – ACID Properties – Schedules – Serializability – Concurrency Control – Need for Concurrency – Locking Protocols – Two Phase Locking – Deadlock – Transaction Recovery – Save Points – Isolation Levels – SQL Facilities for Concurrency and Recovery.

UNIT IV	IMPLEMENTATION TECHNIQUES	9	0	0	9

RAID – File Organization – Organization of Records in Files – Indexing and Hashing –Ordered Indices – B+ tree Index Files – B tree Index Files – Static Hashing – Dynamic Hashing – Query Processing Overview – Algorithms for SELECT and JOIN operations – Query optimization using Heuristics and Cost Estimation.

UNIT V	ADVANCED TOPICS	9	0	0	9

Distributed Databases: Architecture, Data Storage, Transaction Processing – Object-based Databases: Object Database Concepts, Object-Relational features, ODMG Object Model, ODL, OQL – XML Databases: XML Hierarchical Model, DTD, XML Schema, XQuery – Data Warehousing and Data Mining - information Retrieval: IR Concepts, Retrieval Models, Queries in IR systems.

Total (45 L) =45 Periods

Text Books:

1	Abraham Silberschatz, Henry F.Korth and S.Sundarshan “Database System Concepts”, Sixth Edition,Tata McGraw Hi 2011.

Reference Books:

1	Ramez Elamassri and Shankant B-Navathe, “Fundamentals of Database Systems”, Sixth Edition,Pearson Education, 2011.
2	C.J. Date, “An Introduction to Database Systems”, Eighth Edition, Pearson Education Delhi, 2008.
3	Raghu Ramakrishnan, ―Database Management Systems, Fourth Edition, McGraw-Hill CollegePublications, 2015.
4	G.K.Gupta,”Database Management Systems”, Tata McGraw Hill, 2011.

E-References:

1.	Lecture Series on Database Management System by Dr.S.Srinath, IIIT Bangalore, nptl

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Understand the basic concepts of the database and data models.	Understand
CO2	Design a database using ER diagrams and map ER into Relations and normalize the relations.	Create
CO3	Develop a simple database for applications	Create

18CSM08	VIRTUALIZATION AND CLOUD COMPUTING	Semester	

PREREQUISITES	Category	OE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning Objectives

1	To introduce the broad perceptive of Parallel Computing, Distributed Computing and Cloud Computing.
2	To understand the concept of Virtualization
3	To identify the approaches of SLA and programming model in Cloud
4	To understand the Cloud Platforms in Industry and Software Environments.
5	To learn to design the trusted Cloud Computing system

UNIT I	INTRODUCTION	9	0	0	9

Principles of Parallel and Distributed Computing – Elements of Parallel and Distributed Computing, Technologies for Distributed Computing; Vision of Cloud, Defining a Cloud, characteristics and benefits; Cloud Computing Architecture- Cloud Reference Model, Types of Clouds, Open Challenges.

UNIT II	VIRTUALIZATION	9	0	0	9

Introduction, Characteristics of Virtualized environments, Virtualization techniques-Machine Reference Model, Hardware-Level Virtualization, Programming Language-Level Virtualization, Application-Level Virtualization ,Other types of Virtualization, Virtualization and Cloud computing, Pros and cons of Virtualization, Technology examples-Xen: Para virtualization, VMware: Full Virtualization.

UNIT III	SLA MANAGEMENT IN CLOUD COMPUTING AND PROGRAMMING MODEL	9	0	0	9

Traditional Approaches to SLA Management, Types of SLA, Life Cycle of SLA, SLA Management in Cloud; Data Intensive Computing - Technologies for Data Intensive Computing, MapReduce Programming Model.

UNIT IV	CLOUD INDUSTRIAL PLATFORMS AND SOFTWARE ENVIRONMENTS	9	0	0	9

Cloud Platforms in Industry - Amazon Web Service, Google App Engine; Cloud Software Environments –Eucalyptus, OpenNebula; Aneka Cloud Application Platform-Aneka Framework Overview, Anatomy of Aneka Container.

UNIT V	CLOUD SECURITY AND APPLICATIONS	9	0	0	9

An Introduction to the Idea of Data Security, The Current State of Data Security in the Cloud, Cloud Computing and Data Security Risk, Cloud Computing and Identity; The Cloud, Digital Identity, and Data Security, Content Level Security, Pros and Cons; Cloud Scientific Applications.

Total (45L) = 45 Periods

Text Books:

1	Rajkumar Buyya, Christian Vecchiola, S.Tamarai Selvi, 'Mastering Cloud Computing-Foundations and Applications Programming", TMGH,2013.(Unit- I,II & IV)
2	RajKumar Buyya, James Broberg, Andrezei M.Goscinski, "Cloud Computing: Principles and paradigms",2011(Unit-III & V)

Reference Books:

1	Kai Hwang.GeoffreyC.Fox.JackJ.Dongarra, " Distributed and Cloud Computing ,From Parallel Processing to The Internet of Things", 2012 Elsevier
2	Barrie Sosinsky, "Cloud Computing Bible", Wiley Publisher, 2011

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Level**
CO1	Explain the main concepts and architecture of Parallel computing, Distributed Computing and Cloud Computing.	Understand
CO2	Analyze the concept of Virtualization	Analyze
CO3	Identify the approaches of SLA and programming model in Cloud	Apply
CO4	Analyze the Cloud Platforms in Industry and Software Environments.	Analyze
CO5	Identify the security issues in scientific and real time applications.	Apply

B.E. – ELECTRONICS AND COMMUNICATION ENGINEERING - MINOR DEGREE

18ECM01	ELECTRON DEVICES				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1. To introduce components such as diodes, BJTs and FETs, their characteristics and applications
2. To understand, analyse and design of simple diode and transistor circuits.
3. To know the switching characteristics of components and the concept of rectifiers and power supplies

Unit I	**EXTRINSIC SEMICONDUCTOR AND PN JUCTIONS**	**9**	**0**	**0**	**9**

N and P type semiconductor and their energy band structures- Law of electrical neutrality-calculation of location of Fermi level and free electron and hole densities in extrinsic semiconductors-Mobility, drift current and conductivity-diffusion current-continuity equation- Hall effect and its applications. Band structure of PN junction – current component in a PN junction- derivation of diode equation-temperature dependence of diode characteristics and equivalent models.

Unit II	**SWITCHING CHARACTERISTICS OF PN JUNTION AND SPECIAL DIODES**	**9**	**0**	**0**	**9**

Calculation of transition and diffusion capacitance- varactor diode-charge control description of diode-switching characteristics of diode- mechanism of avalanche and Zener breakdown-temperature dependence of breakdown voltages-backward diode-tunneling effect in thin barriers - tunnel diode-photo diode-light emitting diodes.

Unit III	**BIPOLAR JUNCTION TRANSISTORS**	**9**	**0**	**0**	**9**

Construction of PNP and NPN transistors- BJT current components-emitter to collector and base to collector current gains-base width modulation CB, CE and CC characteristics- breakdown characteristics- Ebers-Moll model - transistor switching times- Photo translator.

Unit IV	**FIELD EFFECT TRANSISTORS**	**9**	**0**	**0**	**9**

Construction and characteristics of JFET-relation between pinch off voltage and drain current derivation. MOSFETS - enhancement and depletion types. CMOS circuits. MOS capacitance, BICMOS, SOI CMOS.

Unit V	**RECTIFIERS AND POWER SUPPLIES**	**9**	**0**	**0**	**9**

Half-wave, full-wave and bridge rectifiers with resistive load. Analysis for Vdc and ripple voltage with C, CL, L-C and C-L-C filters. Voltage multipliers Zener diode regulator. Electronically regulated d.c power supplies. Line regulation, output resistance and temperature coefficient.

Total (45L)= 45 Periods

Text Books:

1. JaconMillman& Christos C. Halkias, " Electronic Devices and Circuits" Tata McGraw-Hill, 1991.

2.	Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory 8th edition.", PHI, 2002
Reference Books:	
1.	Donald A. Neaman. " Semiconductor Physics and Devices" 3rd Ed., Tata McGraw-Hill 2002
2.	S. Salivahanan, N. Suresh kumar and A. Vallavaraj, Electronic Devices and Circuits, TMH, 1998.
3.	Ben, G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, Pearson Education 2000
4.	Floyd, "Electronic Devices", Sixth edition, Pearson Education, 2003.
E-References:	
1.	https://archive.nptel.ac.in/courses/108/108/108108122/
2.	https://www.youtube.com/watch?v=qqQ8wO-lNmI
3.	https://slideplayer.com/slide/12438044/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Interpret various applications of diode.	Applying
CO2	Classify various configurations and biasing technique of BJT	Applying
CO3	Apply the knowledge of using special devices for various applications	Understanding
CO4	Discuss operation, biasing and applications of JFET.	Analysing
CO5	Design power supplies and rectifiers	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	-	-	-	-	-	-	-	1	-	-
CO2	2	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO3	2	2	1	-	-	-	-	-	-	-	-	-	3	-	-
CO4	2	2	1	-	-	-	-	-	-	-	-	-	2	2	1
CO5	2	2	1	-	-	-	-	-	-	-	-	-	3	2	2
Avg	2	2	1	-	-	-	-	-	-	-	-	-	2.2	2	1.5
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM02	DIGITAL ELECTRONICS				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives

1	To introduce basic postulates of boolean algebra and show the correlation between expressions
2	To Introduce the methods for Simplifying Boolean expressions
3	To Outline the formal procedures for the analysis and design of combinational circuits and sequential circuits
4	To introduce the Concept of Memories and programmable logic devices
5	To illustrate the concept of synchronous and Asynchronous sequential circuits

Unit I	**NUMBER SYSTEMS AND LOGIC GATES**	**9**	**0**	**0**	**9**

Number Systems - signed Binary numbers - Binary Arithmetic - Binary codes -conversion from one code to another - Boolean Algebra and Minimization Techniques - Canonical forms – Conversion between canonical forms – Simplifications of Boolean expressions using Karnaugh map - LOGIC GATES - Implementations of Logic Functions using gates.

Unit II	**COMBINATIONAL CIRCUITS**	**9**	**0**	**0**	**9**

Design procedure – Adders/Subtractor – Serial adder/ Subtractor - Parallel adder/ Subtractor- BCD adder- Multiplexer/ Demultiplexer - encoder / decoder – code converters.

Unit III	**SEQUENTIAL CIRCUITS**	**9**	**0**	**0**	**9**

Design Procedure - Flip flops: SR, JK, T, D and JKMS – Triggering of Flip-flop - Realization of flip flops – Moore and Mealy – Counters: Asynchronous / Ripple counters – Synchronous counters – Modulo n counter. Register: shift registers- Universal shift register.

Unit IV	**ASYNCHRONOUS SEQUENTIAL CIRCUITS**	**9**	**0**	**0**	**9**

Design of fundamental mode circuits – primitive state / flow table – Minimization of primitive state table –state assignment. Problems in Asynchronous Circuits: Cycles – Races – Hazards. Design of Hazard Free Circuits: Static, Dynamic Hazards elimination

Unit V	**PLD AND MEMORY DEVICES**	**9**	**0**	**0**	**9**

Classification of memories –RAM organization –ROM organization. Programmable Logic Devices: Programmable Logic Array (PLA) - Programmable Array Logic (PAL). Implementation of combinational logic using MUX, ROM, PAL and PLA.

Total (45 L) = 45 Periods

Text Books:

1	M. Morris Mano, Digital Design, 4.ed.,Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2008
2	R.P.Jain, Modern Digital Electronics, 4th edition, TMH, 2010.

Reference Books:

1	S. Salivahanan and S. Arivazhagan, Digital Circuits and Design, 2nd ed., Vikas Publishing House Pvt. Ltd, New Delhi, 2004
2	Charles H.Roth. “Fundamentals of Logic Design”, Thomson Publication Company, 2003.
3	Donald P.Leach and Albert Paul Malvino, Digital Principles and Applications, 5 ed., Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
4	John F.Wakerly, Digital Design: Principles and practices, PHI, 2006

E-Reference:

1	http://nptel.ac.in/noc/individual_course.php?id=noc15-ec01

2	https://nptel.ac.in/courses/117105080/6
3	https://nptel.ac.in/courses/117105080/12

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom's Taxonomy Mapped
CO1	Minimize Boolean expressions and implement using logic gates	Applying
CO2	Design and analyse combinational logic circuits.	Analysing
CO3	Design and analyse synchronous and asynchronous sequential logic circuits	Analysing
CO4	Understand the concepts of memories and PLDs	Understanding
CO5	Implement circuits using memory and PLDs.	Applying

COURSE ARTICULATION MATRIX

COs/POs	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	3	2	3	2	-	-	-	-	2	1	-
CO2	3	3	2	2	3	3	2	1	1	-	-	-	3	2	-
CO3	2	2	3	3	2	1	2	1	1	-	-	-	2	2	-
CO4	2	1	2	1	2	2	3	1	-	-	-	-	2	1	-
CO5	2	1	2	1	3	2	1	2	-	-	-	-	3	2	-
Avg	2.4	1.8	2.2	1.8	2.6	2	2.2	1.4	1	-	-	-	2.4	1.6	-

3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)

18ECM03	ELECTRONIC CIRCUITS				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
Electron Devices	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives

1	To perform analysis on Small signal amplifiers and large signal amplifiers.
2	To give a comprehensive exposure to all types of discrete amplifiers and oscillators.
3	To understand the various linear and non-linear applications of op-amp

Unit I	**MIDBAND ANALYSIS OF SMALL SIGNAL AMPLIFIERS**	**9**	**0**	**0**	**9**

BJT – Need for biasing - Fixed bias circuit - Load line and quiescent point. Different types of biasing circuits. Use of Self bias circuit as a constant current circuit. CE, CB and CC amplifiers. Method of drawing small-signal equivalent circuit. Mid-band analysis of various types of single stage amplifiers to obtain gain - input impedance and output impedance. Miller's theorem. Darlington connection using similar and Complementary transistors. Methods of increasing input impedance using Darlington connection and bootstrapping. CS, CG and CD (FET) amplifiers. Multistage amplifiers-Basic emitter coupled differential amplifier circuit. Differential gain - CMRR. Use of constant current circuit to improve CMRR.

Unit II	**LARGE SIGNAL AMPLIFIERS**	**9**	**0**	**0**	**9**

Low frequency & High frequency analysis of amplifiers -Hybrid – pi equivalent circuit of BJTs.-High frequency equivalent circuit of FETs. Gain-bandwidth product of FETs. General expression for frequency response of multistage amplifiers. Calculation of overall upper and lower cut off frequencies of multistage amplifiers. Amplifier rise time and sag time and their relation to cut off frequencies. Classification of amplifiers (Class A, B, AB, C&D), Efficiency of class A, RC coupled and transformer-coupled power amplifiers. Class B complementary-symmetry, push-pull power amplifiers. Calculation of power output, efficiency and power dissipation. Crossover distortion and methods of eliminating it. Calculation of actual power handling capacity of transistors with and without heat sink. Heat sink design.

Unit III	**OSCILLATORS**	**9**	**0**	**0**	**9**

Feedback Amplifier: Block diagram - Gain with feedback - Barkhausen Criterion - Mechanism for start of oscillation and stabilization of amplitude - Analysis of Oscillator using Cascade connection of RC and LC filters - RC phase shift Oscillator - Wien bridge Oscillator and Twin-T Oscillators - Analysis of LC Oscillators: Colpitts – Hartley – Clapp - Miller and Pierce oscillators - Frequency range of RC Oscillators - Electrical equivalent circuit of Crystal.

Unit IV	**TUNED AMPLIFIERS AND MULTIVIBRATORS**	**9**	**0**	**0**	**9**

Analysis of single tuned and synchronously tuned amplifiers - Class C tuned amplifiers and their applications - Efficiency of Class C tuned Amplifier- Collector coupled and Emitter coupled Astable Multi vibrator – Mono stable Multi vibrator – Bistable Multi vibrator - Triggering methods – Mono stable and Astable Blocking Oscillators using Emitter and base timing.

Unit V	**OPERATIONAL AMPLIFIERS AND ITS APPLICATIONS**	**9**	**0**	**0**	**9**

Basic structure and principle of operation - Calculation of differential gain - Common Mode gain, CMRR - OP-AMP design - DC and AC characteristics of OP-AMP. Applications: Inverting and non-inverting amplifiers - Integrator and Differentiator - Summing amplifier - Precision rectifier - Schmitt trigger and its applications - Active filters: Low pass, high pass, band pass and band stop filters - Sine wave oscillators – Comparator – Multi vibrator.

Total (45 L) = 45 Periods

Text Books:

1	B.Visvesvara Rao, K.Raja Rajeswari, P.Chalam Raju Pantulu, K.Bhaskara Rama Murthy, "Electronic Circuits-II", Pearson Education,2012
2	D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Pvt. Ltd., 2011.

Reference Books:

1	Millman J. and Taub H., "Pulse Digital and Switching waveform", 3rd Edition, McGraw-Hill International , 2011.

2	Sedera& Smith, “Micro Electronic Circuits”, 4 th Edition, Oxford University Press, Chennai.
3	Michael Jacob, ‘Applications and Design with Analog Integrated Circuits’, Prentice Hall of India, 1996.
4	K.R.Botkar, ‘Integrated Circuits’, 10th edition, Khanna Publishers, 2010.
e-Reference:	
1	http://nptel.ac.in/courses/117105080/40
2	http://nptel.ac.in/courses/117108038/1
3	https://freevideolectures.com/course/2915/linear-integrated-circuits

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	To analyze small signal amplifiers and Large signal Amplifiers.	Applying
CO2	Analyze the frequency response characteristics of amplifiers	Applying
CO3	Develop insight of on oscillator design.	Applying
CO4	Construct and analyse tuned amplifiers and multivibrators.	Applying
CO5	Develop competence in linear and nonlinear Op amp circuit analysis.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	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
CO1	2	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO2	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO3	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO4	3	2	1	2	-	-	-	-	-	-	-	-	1	2	1
CO5	1	2	1	2	-	-	-	-	-	-	-	-	1	2	1
Avg	2.4	2	1	2	-	-	-	-	-	-	-	-	1	2	1
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM04	SIGNAL PROCESSING				
PREREQUISITES		**CATEGORY**	**OE**	**Credit**	**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand and perform Fourier and Laplace analysis on signals and systems respectively.
2.	To analyse the Discrete Fourier Transform, Fast Fourier Transform algorithms.
3.	To design and realize IIR, FIR filters.

Unit I	**INTRODUCTION TO SIGNALS AND SYSTEMS**	**9**	**0**	**0**	**9**

Classification of Signals: Even and Odd Signal - Energy and power signals - Continuous time (CT) and Discrete time (DT) signals - Continuous and Discrete amplitude signal -. System properties and representation: linearity - Tme-invariance – Causality – Stability - Realizability. - Linear Time-Invariant (LTI) systems: Impulse response and step response – Convolution – Correlation - System representation through differential equations and difference equations.

Unit II	**ANALYSIS OF SIGNAL AND SYSTEMS**	**9**	**0**	**0**	**9**

Introduction to Fourier Transform, Fourier Series, Relating the Laplace Transform to Fourier Transform, Frequency response of continuous time systems. Introduction to z- Transform.

Unit III	**DISCRETE FOURIER TRANSFORM**	**9**	**0**	**0**	**9**

Introduction to DFT – Properties of DFT - Circular convolution - FFT algorithms – Radix-2 FFT algorithms – Decimation in Time and Decimation in Frequency algorithms.

Unit IV	**INFINITE IMPULSE RESPONSE FILTER DESIGN**	**9**	**0**	**0**	**9**

Characteristics of Analog Butterworth filter - Chebyshev filter - Low pass filter, High pass filter, Band pass filter and Band stop filter - Transformation of analog filters in to equivalent digital filters using bilinear transformation method - Realization structure for IIR filters-Direct form - Cascade form - Parallel form.

Unit V	**FINITE IMPULSE RESPONSE FILTER DESIGN**	**9**	**0**	**0**	**9**

Linear phase response of FIR filter - FIR design using window method: Rectangular, Hamming, Hanning and Blackmann Windows - Park-McClellan's method - Realization structures for FIR filters - Linear phase structures and Direct form structure - Comparison of FIR and IIR filters.

Total (45L)= 45 Periods

Text Books:

1.	A.Anand Kumar, “Signals and Systems” , 3rd Edition, PHI, 2013.
2.	John G Proakis and Manolakis, “Digital Signal Processing Principles, Algorithms and Applications”, 4th Edition, Pearson Education, 2009.

Reference Books:	
1.	Alan V Oppenheim, Alan S Willsky and S Hamid Nawab, “Signals and Systems”, 2nd edition, PHI Learning Private Limited, New Delhi, 2010.
2.	B.P. Lathi, "Principles of Signal Processing and Linear Systems", Oxford University Press, 2009.
3.	Emmanuel C. Ifeacher, Barry W. Jervis, “Digital Signal Processing: A Practical Approach”, 2nd Edition, Pearson Education, 2004.
4.	S.K. Mitra, “Digital Signal Processing, A Computer Based approach”, 4th Edition, McGraw-Hill, 2010.
E-References:	
1.	http://nptel.ac.in/courses/117104074/
2.	https://www.coursera.org/learn/dsp
3.	https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	Analyse and understands different types of signals.	Analysing
CO2	Represent continuous signals and systems in time and frequency domain using different transforms.	Analysing
CO3	Analyse the need for Discrete Fourier Transform, Fast Fourier Transform algorithms in digital signals & systems.	Analysing
CO4	Design and realize IIR filters.	Applying
CO5	Design and realize FIR filters.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	-	-	-	-	-	-	-	2	2	2
CO2	3	2	2	3	3	2	-	-	-	-	-	-	2	2	2
CO3	3	2	2	2	1	-	1	-	-	-	-	-	1	1	1
CO4	3	2	2	2	1	-	1	-	-	-	-	-	1	1	1
CO5	1	1	1	1	1	-	-	-	-	-	-	-	2	2	1
Avg	2.6	1.8	2	2.2	1.8	2	1						1.6	1.6	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM05	MICROPROCESSORS AND MICROCONTROLLERS				
PREREQUISITES		**CATEGORY**	**OE**	**Credit**	**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To familiarise with 8086 and 8051 architectures.
2.	To interface 8086 microprocessor and 8051 microcontrollers with peripherals by programming.
3.	To gain basic knowledge of PIC microcontrollers.

Unit I	**8086 MICROPROCESSOR ARCHITECTURE**	9	0	9
Overview of Microcomputer systems-8086 Architecture – Pin Assignments – Internal Architecture – Addressing modes-Instruction Formats- Directives and Operators-Assembly process.				
Unit II	**PROGRAMMING AND INTERFACING OF 8086**	9	0	9
Fundamental I/O considerations- Programmed I/O- Interrupt I/O- Basic 8086 Configurations- Minimum Mode-Maximum Mode-System Bus timing- I/O Interfaces-Peripheral Interfacing using 8255 PPI - 8279 Keyboard/Display controller - 8251 USART.				
Unit III	**8051 ARCHITECTURE**	9	0	9
8051 architecture - Registers in 8051 - Pin description - 8051 parallel I/O ports - memory organization - Instruction set — Addressing modes				
Unit IV	**PROGRAMMING AND INTERFACING OF 8051**	9	0	9
Assembly language programming.8051Timers - Serial Port Programming - Interrupts Programming - LCD and Keyboard Interfacing - ADC, DAC and Sensor Interfacing - Motor Control.				
Unit V	**PIC MICROCONTROLLERS**	9	0	9
Main characteristics of PIC microcontrollers – PIC microcontroller families-Memory-Program Memory – RAM Data Memory - Instruction set and timers in PIC				
Total (L+T) = 45 periods				

Text Books:	
1.	Yu-Cheng Liu, Glenn A. Gibson," Microcomputer Systems, The 8086/8088 Family", Pearson, 2e, 2019.
2.	Muhammad Ali Mazidi, Janice GillispieMazidi, RolinD.McKinlay, "The 8051 Microcontroller and Embedded Systems using Assembly and C", 2e, 2022.
Reference Books:	
1.	Mohamed Ali Mazidi, Janice GillispieMazidi, RolinMcKinlay, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", 2nd Edition, Pearson education, 2011.
2.	Martin Bates,"PIC Microcontrollers-An Introduction to Microelectronics", 3e, Elsevier, 2011.
3.	Mathur Sunil,"Microprocessor 8086: Architecture, Programming and Interfacing" PHI Learning Pvt. Ltd. 2011.
4.	Salvador PinillosGimenez," 8051 Microcontrollers Fundamental Concepts, Hardware, Software and Applications in Electronics", Springer 2019.
E-References:	
1.	Ashraf Almadhoun,"A Detailed Look Into PIC Microcontroller and Its Architecture", Amazon 2020.
2.	https://nptel.ac.in/courses/108105102
3.	http://www.satishkashyap.com/2012/02/video-lectures-on-microprocessors-and.html

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Describe and analyse the architecture of 8086 microprocessor and 8051 architectures.	Remembering
CO2	Develop assembly language programs and Interface peripherals with 8086.	Applying
CO3	Develop assembly language programs and Interface peripherals with 8051.	Applying
CO4	Determine application specific circuit for real-time applications.	Understanding
CO5	Associate appropriate PIC microcontroller for a given application.	Understanding

COURSE ARTICULATION MATRIX

COs/POs	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	PSO3
CO1	2	2	-	-	-	-	-	-	-	-	2	-	1	-	-
CO2	2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO3	2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO4	2	2	2	2	-	-	-	-	-	-	-	-	2	2	2
CO5	2	2	-	2	-	-	-	-	-	-	-	-	2	2	-
Avg	2	2	2	2	-	-	-	-	-	-	2	-	1.8	2	2

18ECM06	ANALOG AND DIGITAL COMMUNICATION				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	Understand analog and digital communication techniques.
2.	Learn data and pulse communication techniques.
3.	Be familiarized with source and Error control coding.

Unit I	**INFORMATION THEORY**	**9**	**0**	**0**	**9**

Uncertainty, information and entropy – Source coding theorem – Shannon Fano coding – Huffman coding – Discrete memoryless channels – Mutual information – Channel capacity – Channel coding theorem.

Unit II	**ANALOG COMMUNICATION**	**9**	**0**	**0**	**9**

Noise: Source of Noise – External Noise- Internal Noise- Noise Calculation. Introduction to Communication Systems: Modulation – Types – Need for Modulation. Theory of Amplitude Modulation – Evolution and Description of SSB Techniques – Theory of Frequency and Phase Modulation – Comparison of various Analog Communication System (AM – FM – PM).

Unit III	**DIGITAL COMMUNICATION**	**9**	**0**	**0**	**9**

Amplitude Shift Keying (ASK) – Frequency Shift Keying (FSK) Minimum Shift Keying (MSK) –Phase Shift Keying (PSK) – BPSK – QPSK – 8 PSK – 16 PSK – Quadrature Amplitude Modulation (QAM) – 8 QAM – 16 QAM – Bandwidth Efficiency– Comparison of various Digital Communication System (ASK – FSK – PSK – QAM).

Unit IV	**PULSE COMMUNICATION AND MULTIPLE ACCESS TECHNIQUES**	**9**	**0**	**0**	**9**

Pulse Communication: Pulse Amplitude Modulation (PAM) – Pulse Time Modulation (PTM) – Pulse code Modulation (PCM) – Comparison of various Pulse Communication System (PAM – PTM – PCM). Multiple access techniques: FDMA, CDMA, TDMA, SDMA.

Unit V	**ERROR CONTROL CODING**	**9**	**0**	**0**	**9**

Linear block codes - Cyclic codes - Convolution codes – Maximum likelihood decoding of convolutional codes – Sequential decoding of convolutional codes – Trellis codes – Applications.

Total (45L)= 45 Periods

Text Books:

1.	Simon Haykin, "Communication Systems", 4th Edition, John Wiley & Sons, 2014.
2.	J.G.Proakis, M.Salehi, ―Fundamentals of Communication Systems‖, Pearson Education 2014.

Reference Books:

1.	B.P.Lathi, ―Modern Digital and Analog Communication Systems‖, 4th Edition, Oxford University Press, 2013.
2.	D.Roody, J.Coolen, ―Electronic Communications, 4th edition PHI 2015.
3.	B.Sklar, ―Digital Communications Fundamentals and Applications‖, 5th Edition Pearson Education 2017
4.	H P Hsu, Schaum Outline Series - ―Analog and Digital Communications‖ TMH, 5th edition 2006

E-References:

1.	https://onlinecourses.nptel.ac.in/noc21_ee74/preview
2.	https://nptel.ac.in/courses/117101051
3.	https://www.digimat.in/nptel/courses/video/117105143/L51.html

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO	:	Apply the concepts of Random Process to the design of Communication	Applying
CO	:	Apply analog and digital communication techniques.	Applying
CO	:	Understand the use of data and pulse communication techniques.	Understanding
CO	:	Analyze Source and Error control coding.	Analysing
CO	:	Design AM communication systems and Angle modulated communication	Applying

COURSE ARTICULATION MATRIX															
COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO1 2	PSO 1	PSO 2	PSO 3
CO1	2	3	2	1	1	-	-	-	-	-	-	-	3	-	-
CO2	3	2	2	1	1	-	-	-	-	-	-	-	3	2	1
CO3	2	2	2	3	1	-	-	-	-	-	-	-	3	2	-
CO4	1	1	2	1	2	-	-	-	-	-	-	-	2	3	-
CO5	1	1	2	2	2	-	-	-	-	-	-	-	2	3	1
Avg	1.8	1.8	2	1.6	1.4	-	-	-	-	-	-	-	2.6	2.5	1
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM07	COMMUNICATION NETWORKS				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	Understand the division of network functionalities into layers.
2.	Be familiar with the components required to build different types of networks
3.	Be exposed to the required functionality at each layer
4.	Learn the flow control and congestion control algorithms

Unit I	**FUNDAMENTALS & LINK LAYER**	9	0	0	9

Overview of Data Communications- Networks – Building Network and its types– Overview of Internet - Protocol Layering - OSI Mode – Physical Layer – Overview of Data and Signals - introduction to Data Link Layer - Link layer Addressing- Error Detection and Correction

Unit II	**MEDIA ACCESS & INTERNETWORKING**	9	0	0	9

Overview of Data link Control and Media access control - Ethernet (802.3) - Wireless LANs – Available Protocols – Bluetooth – Bluetooth Low Energy – WiFi – 6LowPAN–Zigbee - Network layer services – Packet Switching – IPV4 Address – Network layer protocols (IP, ICMP, Mobile IP)

Unit III	**ROUTING**	9	0	0	9

Routing - Unicast Routing – Algorithms – Protocols – Multicast Routing and its basics – Overview of Intradomain and interdomain protocols – Overview of IPv6 Addressing – Transition from IPv4 to IPv6

Unit IV	**TRANSPORT LAYER**	9	0	0	9

Introduction to Transport layer –Protocols- User Datagram Protocols (UDP) and Transmiision Control Protocols (TCP) –Services – Features – TCP Connection – State Transition Diagram – Flow, Error and Congestion Control - Congestion avoidance (DECbit, RED) – QoS – Application requirements

Unit V	**APPLICATION LAYER**	9	0	0	9

Application Layer Paradigms – Client Server Programming – World Wide Web and HTTP - DNS- Electronic Mail (SMTP, POP3, IMAP, MIME) – Introduction to Peer to Peer Networks – Need forCryptography and Network Security – Firewalls.

Total (45L)= 45 Periods

Text Books:

1. Behrouz A Forouzan, Data Communications and Networking, 4th Edition, 2020

2.	James F. Kurose, Keith W. Ross, Computer Networking - A Top-Down Approach Featuring the Internet, Seventh Edition, Pearson Education, 2016.
Reference Books:	
1.	Nader. F. Mir," Computer and Communication Networks", Pearson Prentice Hall Publishers, 2nd Edition, 2014.
2.	Alberto Leon-Garcia, IndraWidjajaCommunication Networks 2nd Edition McGraw-Hill Education, 2003
3.	Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, "Computer Networks: An Open Source Approach", McGraw Hill Publisher, 2011.
4.	Larry L. Peterson, Bruce S. Davie, "Computer Networks: A Systems Approach", Fifth Edition, Morgan Kaufmann Publishers, 2011.
E-References:	
1.	https://onlinecourses.nptel.ac.in/noc22_ee61/preview
2.	https://www.ee.iitb.ac.in/~sarva/courses/EE706/2012/EE706LecNotes.pdf
3.	http://www.cs.kent.edu/~farrell/net01/lectures/

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the basic concept in modern data communication and different level of layers in the protocol	Understanding
CO2	Analyse the functions and services of data link layer	Analysing
CO3	Categorize the functions and services of network layer	Understanding
CO4	Examine the basic functions of transport layer and congestion in networks	Understanding
CO5	Analyse the concepts of various network applications and data security	Analysing

COURSE ARTICULATION MATRIX															
COs/POs	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	2	1	1	-	1	-	-	-	-	-	-	-	2	-	1
CO2	2	1	2	-	1	-	-	-	-	-	-	-	2	1	1
CO3	2	1	1	-	-	-	-	-	-	-	-	-	3	1	2
CO4	3	2	1	-	2	-	-	-	-	-	-	-	2	-	2
CO5	2	1	1	-	1	-	-	-	-	-	-	-	1	1	1
Avg	2.2	1.2	1.2	-	1.25	-	-	-	-	-	-	-	2	1	1.4
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM08	INTERNET OF THINGS				
PREREQUISITES	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives

1	To understand Smart Objects and IoT Architectures
2	To learn about various IOT-related protocols
3	To build simple IoT Systems using Arduino and Raspberry Pi
4	To understand data analytics and cloud in the context of IoT
5	To develop IoT infrastructure for popular applications

Unit I	**FUNDAMENTALS OF IOT**	**9**	**0**	**0**	**9**

Evolution of Internet of Things - Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects

Unit II	**IoT PROTOCOLS**	**9**	**0**	**0**	**9**

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT

Unit III	**DESIGN AND DEVELOPMENT**	**9**	**0**	**0**	**9**

Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.

Unit IV	**DATA ANALYTICS AND SUPPORTING SERVICES**	**9**	**0**	**0**	**9**

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS for IoT – System Management with NETCONF-YANG

Unit V	**CASE STUDIES/INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**

Cisco IoT system - IBM Watson IoT platform – Manufacturing - Converged Plantwide Ethernet Model (CPwE) – Power Utility Industry – Grid Blocks Reference Model - Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control

Total (45 L) = 45 Periods

Text Books:

1	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, ―IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017
2	ArshdeepBahga, Vijay Madisetti, ―Internet of Things – A hands-on approach‖, Universities Press, 2015

Reference Books:

1	Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols, Wiley, 2012 (for Unit 2).

2	Jan Ho¨ ller, VlasiosTsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
3	Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things‖, Springer, 2011.
4	Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.

E-References:

1	https://online.stanford.edu/courses/xee100-introduction-internet-things
2	https://www.udemy.com/topic/internet-of-things/
3	https://www.netacad.com/courses/iot

Course Outcomes: Upon completion of this course, the students will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the concept of IoT.	Understanding
CO2	Analyze various protocols for IoT.	Applying
CO3	Design a PoC of an IoT system using Rasperry Pi/Arduino	Applying
CO4	Apply data analytics and use cloud offerings related to IoT.	Applying
CO5	Analyze applications of IoT in real time scenario	Analysing

COURSE ARTICULATION MATRIX															
COs/POs	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
CO1	2	1	2	1	1	-	-	-	-	-	1	-	2	2	2
CO2	2	1	2	1	1	-	-	-	-	-	1	-	2	2	2
CO3	2	2	3	2	1	-	-	-	-	-	2	-	2	2	2
CO4	2	2	2	1	1	-	-	-	-	-	1	-	2	2	2
CO5	2	2	3	2	1	-	-	-	-	-	2	-	2	2	2
Avg	2	1.6	2.4	1.4	1	-	-	-	-	-	1.4	-	2	2	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM09	WIRELESS SENSORS AND NETWORKING				
PREREQUISITE:	**CATEGORY**	**OE**	**Credit**		**3**
	Hours/Week	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	Learn fundamental of Ad hoc network and architecture
2.	Understand the MAC and routing protocols.
3.	Have an in-depth knowledge on QoS, security and sensor network platforms

Unit I	**ROUTING PROTOCOLS**	9	0	0	9

Elements of Ad hoc Wireless Networks, Issues in Ad hoc wireless networks, Example commercial applications of Ad hoc networking, Ad hoc wireless Internet, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Table Driven Routing Protocols – Destination Sequenced Distance Vector (DSDV), On–Demand Routing protocols –Ad hoc On–Demand Distance Vector Routing (AODV).

Unit II	**ARCHITECTURES OF WSN**	9	0	0	9

WSN application examples, Types of applications, Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, Single-Node Architecture: Hardware Components, Energy Consumption of Sensor Nodes, Operating systems and execution environments

Network Architecture: Sensor Network Scenarios, Optimization goals and figures of merit, Design principles of WSN, Service interfaces of WSNs, gateway concepts.

Unit III	**MAC PROTOCOLS AND ROUTING PROTOCOLS**	9	0	0	9

Image compression: Predictive techniques – PCM – DPCM - DM - Transform coding - Introduction to JPEG - JPEG-2000 - JBIG standards - Study of EZW. Video compression: Video signal representation – ITU-T Recommendation H.261 – Model based coding – The MPEG-1 Video Standard - The MPEG-2 Video Standard: H.262 - ITU-T Recommendation H.263.

Unit IV	**QUALITY OF SERVICE AND ADVANCED APPLICATION SUPPORT**	9	0	0	9

Quality of Service: Coverage and deployment, Reliable data transport, Single packet delivery, Block delivery, Congestion control and rate control - Advanced application support: Advanced in-network processing, Security and Application-specific support.

Unit V	**SENSOR NETWORK PLATFORMS AND TOOLS**	9	0	0	9

Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms – TinyOS, nesC, CONTIKIOS, Node-level Simulators – NS2 and its extension to sensor networks, COOJA, TOSSIM, Programming beyond individual nodes – State centric programming.

Total (45L) = 45 Periods

Text Books:	
1.	C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education – 2008
2.	Holger Karl and Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2007.
Reference Books:	
1.	Feng Zhao and LeonidesGuibas, "Wireless sensor networks ", Elsevier publication - 2004.
2.	Charles E. Perkins, ―Ad Hoc Networking‖, Addison Wesley, 2000.
3.	William Stallings, "Wireless Communications and Networks ", Pearson Education – 2004
4.	I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, "Wireless sensor networks: a survey", Computer Networks, Elsevier, 2002, 394 - 422.
E-References:	
1.	https://nptel.ac.in/courses/106105183
2.	https://nptel.ac.in/courses/106105183
3.	https://archive.nptel.ac.in/courses/106/105/106105160/

Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Know the basics of Ad hoc networks and Wireless Sensor Networks	Understanding
CO2	Have a knowledge on architecture of Wireless Sensor Networks	Applying
CO3	Apply the knowledge to identify MAC and routing protocols	Applying
CO4	Understand the transport layer and security issues possible in Ad hoc and sensor networks	Understanding
CO5	Be familiar with the OS used in Wireless Sensor Networks and build basic modules	Remembering

COURSE ARTICULATION MATRIX															
COs/POs	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
CO1	3	3	1	3	3	3	2	-	-	-	3	3	3	-	2
CO2	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
CO3	3	3	3	3	3	3	2	-	-	-	3	3	3	-	2
CO4	3	3	2	3	3	3	2	-	-	-	2	3	3	-	2
CO5	3	3	2	3	3	3	2	-	-	-	3	3	3	-	2
Avg	3	3	2	3	3	3	2	-	-	-	2.8	3	3	-	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

18ECM10	BASICS OF EMBEDDED SYSTEMS					
PREREQUISITES		**CATEGORY**	**OE**	**Credit**		**3**
Microprocessors and Mmicrocontrollers		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives	
1	To impart knowledge on embedded system architecture and embedded development Strategies
2	To understand the bus Communication in processors and peripheral interfacing
3	To understand basics of Real Time Operating System

UNIT I	**BASICS OF EMBEDDED SYSTEMS**	9	0	0	9

Introduction - Fundamental Components of Embedded Systems - Challenges for Embedded Systems - Examples - Programming Languages - Recent Trends in Embedded Systems - Architecture of Embedded Systems - Embedded Design Life Cycle - Selection Process - Hardware Software Partitioning - Development Environment.

UNIT II	**MEMORY MANAGEMENT AND INTERRUPTS**	9	0	0	9

Memory Access Procedure - Types of Memory - Memory Management Methods - DMA – Memory Interfacing - Polling Vs Interrupts - Types of Interrupts - Interrupt Latency - Interrupt Priority – Programmable Interrupt Controllers - Interrupt Service Routines

UNIT III	**COMMUNICATION INTERFACES**	9	0	0	9

Interfacing Buses - Serial Interfaces - RS232/UART - RS422/RS485 - I2C Interface - SPI Interface - USB – CAN - IRDA - Ethernet - IEEE 802.11 – Bluetooth

UNIT IV	**REAL TIME OPERATING SYSTEMS**	9	0	0	9

Real-Time Concepts - Task Management - Task Scheduling - Classification of Scheduling Algorithms - Clock Driven Scheduling - Event Driven Scheduling - Resource Sharing - Priority Inheritance Protocol - Priority Ceiling Protocol - Inter Task Communication - Mutex - Semaphores - Message Queues - Timers - Commercial RTOS.

UNIT V	**VALIDATION AND DEBUGGING**	9	0	0	9

Host and Target Machines - Validation Types and Methods - Host Testing - Host-Based Testing Setup - Target Testing - Remote Debuggers and Debug Kernels - ROM Emulator - Logical Analyzer – Background Debug Mode - InCircuit Emulator CASE STUDY: RFID Systems - GPS Navigation System – Development of Protocol Converter.

Total (45 L) = 45 Periods

Text Books:	
1	Sriram V Iyer and Pankaj Gupta, ―Embedded Real-time Systems Programming‖, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.
2	Arnold S Berger, ―Embedded Systems Design - An Introduction to Processes, Tools and Techniques, Elsevier, New Delhi, 2011.
Reference Books:	
1	Prasad K V K K, ―Embedded/Real-Time Systems: Concepts, Design and Programming – The Ultimate Reference, Himal Impressions, New Delhi, 2003
2	Heath, "Embedded Systems Design‖", Newnes an Imprint of Elsevier, Massachusetts, 2003.
3	Tammy Noergaard, "Embedded Systems Architecture‖, Newnes an Imprint of Elsevier, Massachusetts, 2006.
4	Raj Kamal, 'Embedded System-Architecture, Programming, Design', McGraw Hill, 2013
E-References:	
1	https://lecturenotes.in/subject/225/embedded-system-es
2	https://nptel.ac.in/courses/108102045/19

3	https://www.coursera.org/learn/introduction-embedded-systems.

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Course Outcomes: Upon completion of this course, the students will be able to		**Bloom's Taxonomy Mapped**
CO1	Outline the concepts of embedded systems	Understanding
CO2	Understand the concept of memory management system and interrupts.	Understanding
CO3	Know the importance of interfaces.	Understanding
CO4	Understand real time operating system concepts.	Understanding
CO5	To realize the applications of validation and debugging.	Applying

COURSE ARTICULATION MATRIX															
COs/POs	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
CO1	3	3	1	3	-	-	-	-	-	-	3	3	3	-	2
CO2	3	3	2	3	-	-	-	-	-	-	3	3	3	-	2
CO3	3	3	3	3	-	-	-	-	-	-	3	3	3	-	2
CO4	3	3	2	3	-	-	-	-	-	-	2	3	3	-	2
CO5	3	3	2	3	-	-	-	-	-	-	3	3	3	-	2
Avg	3	3	2	3	-	-	-	-	-	-	2.8	3	3	-	2
3/2/1 - indicates strength of correlation (3-High,2- Medium,1- Low)															

B.E. - ELECTRICAL AND ELECTRONICS ENGINEERING - MINOR DEGREE

18EEM01	LINEAR AND DIGITAL ELECTRONICS CIRCUITS		SEMESTER			
PREREQUISITES		CATEGORY	PE	Credit		3
Electron Devices and Circuits		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1. To impart knowledge on the characteristics& applications of Operation Amplifier, functional diagram and applications of linear ICs.
2. To simplify the switching functions
3. To design the combinational logic circuits and sequential logic circuits

Unit I	OPERATIONAL AMPLIFIERS	9	0	0	9

Operational amplifiers - Equivalent circuit, voltage transfer curve - Open loop Op-amp configurations –Voltage series, Voltage shunt feedback amplifiers configurations, closed loop differential amplifiers for single and differential outputs.

Output offset voltage, minimizing output offset voltage due to input bias current and input offset current, factors affecting off set parameters, CMRR - Open loop and closed loop frequency response of op-amps, circuit stability, slew rate and its effects in applications.

Unit II	APPLICATION OF OPERATIONAL AMPLIFIER AND LINEAR ICS	9	0	0	9

DC & AC amplifiers- Summing, Scaling and Averaging amplifiers-Instrumentation amplifier- Voltage to Current converter for floating and grounded loads - Current to voltage converter - Integrator, Differentiator. Voltage comparators - Zero Crossing Detector - Schmitt trigger with voltage limiter- Precision Rectifier Circuits-Peak Detector-Sample and Hold circuit, Active Filters - Frequency response characteristics of major active filters, first and higher order low pass and high pass filters, all pass filters.

Functional block diagram and Applications of Linear ICs: IC 555 Timer -IC 566 Voltage controlled oscillator- IC 565 Phase-locked loops - IC LM317 voltage regulators.

Unit III	COMBINATIONAL LOGIC CIRCUITS	9	0	0	9

Representation of logic functions: SOP and POS forms - Simplification of switching functions: K-maps method and QuineMcCluskey (Tabulation) method.

Design:Adders -Subtractors– 2 bit Magnitude Comparator-Multiplexer- Demultiplexer- Encoder - Priority Encoder - Decoder – Code Converters. Implementation of combinational logic circuits using multiplexers and Decoder.

Unit IV	SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS	9	0	0	9

Flip-flops: SR, D, JK and T- Conversion of flip-flops; Classification of sequential circuits: Moore and Mealy models - Analysis and design of synchronous sequential circuits - Design of synchronous counters- Universal shift register.

Unit V	ASYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS	9	0	0	9

Fundamental mode and pulse mode circuits , Analysis procedure of asynchronous circuits with /without using of SR latches-primitive state / flow table – Reduction of state and flow table - state assignment –Design Procedure of asynchronous circuits with /without using of SR latches-Problems in asynchronous sequential circuits: cycles -Races –Hazards.

Total (45L+0T) = 45 Periods

Text Books:

1. Ramakant A Gayakward, “Op-Amps and Linear Integrated Circuits”, Fourth Edition, Pearson Education, 2003.
2. Donald.E.Neaman, “Electronic Circuit, Analysis and Design”, Tata McGraw Hill Publishing Company Limited, Second Edition, 2002.
3. D.Roy Chowdhury and Shail B. Jain, “Linear Integrated Circuits”, Fourth Edition, New Age International (P) Ltd Publishers, 2014.
4. M. Morris Mano, “Digital Design” , Third Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2010 .
5. S. Salivahanan and S. Arivazhagan, “Digital Circuits and Design”, Third Edition, Vikas Publishing House Pvt. Ltd, New Delhi, 201

Reference Books:

1.	Jacob Millman, Christos C.Halkias, "Integrated Electronics - Analog and Digital circuits system", Tata McGraw Hill 2003.
2.	R.P.Jain, "Modern Digital Electronics", Third Edition, Tata McGraw–Hill Publishing company limited, New Delhi, 2011.
3.	Thomas L. Floyd, "Digital Fundamentals", Pearson Education, Inc, New Delhi, 2015
4.	Donald P.Leach and Albert Paul Malvino, "Digital Principles and Applications", Fifth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2012.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the Op-amp characteristics	L2: Understanding
CO2	:	Understand the applications of Op-amp and other linear ICs.	L2: Understanding
CO3	:	Apply K-map and Tadulation methods to simplify the switching functions	L3: Applying
CO4	:	Design and implement of combinational logic circuits	L6: Creating
CO5	:	Analyse and design of synchronous & asynchronous sequential logic circuits	L4: Analyzing

COURSE ARTICULATION MATRIX

CO/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2	1											2		
CO2	3	2	1	1									3		
CO3	3	2		2	2								3	3	
CO4	3	2	3	1	2							2	3	3	1
CO5	3	2	3	1	2							2	3	3	1
Avg.	**2.8**	**1.8**	**2.3**	**1.25**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**2.8**	**3**	**1**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM02	MICROPROCESSOR AND MICROCONTROLLER		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
C Programming		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To study the architecture of μP8085 and μC 8051.
2.	To study the Interrupt structure of 8085 and 8051.
3.	To do simple applications development with programming 8085 and 8051.

UNIT I	**8085 8 BIT MICROPROCESSOR**	**9**	**0**	**0**	**9**

Fundamentals of microprocessors – Architecture of 8085 – Groups of Instructions - Addressing modes – Basic timing diagram – Organization and addressing of Memory and I/O systems –Interrupt structure – Stack and sub-routines - Simple 8085 based system design and programming.

UNIT II	**8051 8 BIT MICROCONTROLLER**	**9**	**0**	**0**	**9**

Fundamentals of microcontrollers – Architecture of 8051 – Groups of Instructions - Addressing modes – Organization of Memory systems – I/O Ports – Timers/Counters – Serial Port - Interrupt structure – Simple programming concepts using Assemblers and Compliers.

UNIT III	**INTERFACING WITH 8051 MICROCONTROLLER**	**9**	**0**	**0**	**9**

Need and requirements of interfacing – Interfacing – LED, 7 segment and LCD Displays – Tactile switches, Matrix keyboard – Parallel ADC – DAC – Interfacing of Current, Voltage, RTD and Hall Sensors.

UNIT IV	**EXTERNAL COMMUNICATION INTERFACE**	**9**	**0**	**0**	**9**

Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

UNIT V	**APPLICATIONS OF MICROCONTROLLERS**	**9**	**0**	**0**	**9**

Simple programming exercises- key board and display interface –Control of servo motor stepper motor control- Application to automation systems.

Total (45L+0T)= 45 Periods

Text Books:

1.	R.S. Gaonkar, 'Microprocessor Architecture Programming and Application', with 8085, Wiley Eastern Ltd., New Delhi, 2013.
2.	K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004.
3.	Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely 'The 8051 Micro Controller and Embedded Systems', PHI Pearson Education, 5th Indian reprint, 2003.

Reference Books:

1.	R. Kamal, "Embedded System", McGraw Hill Education, 2009.
2.	D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991.

E-References;

1.	www.onlinecourses.nptel.ac.in/noc18_ee41
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand basics of microprocessor and microcontroller	L2: Understanding
CO2	:	Understand the architecture of Microprocessor and Microcontroller	L1: Remembering
CO3	:	Apply the digital concepts to measure and control simple electrical systems	L3: Applying
CO4	:	Design and interface communications between digital systems	L2: Understanding
CO5	:	Design a microcontroller based electrical control system.	L5: Evaluating

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	1	1								1	1	1	
CO2	2	1	1	1								1	1	1	
CO3	2	3	2	3	2							1	1	1	2
CO4	2	3	3	3	2							2	2	2	2
CO5	2	3	3	3	2							2	2	2	2
Avg.	**2**	**2.2**	**2**	**2.2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1.4**	**1.4**	**1.4**	**2**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM03	CONTROL SYSTEMS		SEMESTER			
PREREQUISTIES		CATEGORY	PE	Credit		3
Electrical Machines and Electric circuit analysis		Hours/Week	L	T	P	TH
			1	1	0	3

Course Objectives:

1.	To understand the methods of representation of physical systems and getting their transfer function models.
2.	To provide adequate knowledge in the time response of systems and steady state error analysis.
3.	To give basic knowledge in obtaining the open loop and closed loop frequency response of systems.
4.	To understand the concept of stability of control system and methods of stability analysis.
5.	To study the designing compensators for a feedback control system.

UNIT I	MODELLING OF LINEAR TIME INVARIANT SYSTEMS	6	9	0	9

Basic elements in control systems – Open and closed loop systems – Feedback control system characteristics - Mathematical model and Electrical analogy of mechanical systems – Transfer function Representation– Synchro – AC and DC servo-motors – Block diagram reduction techniques – Signal flow graphs.

UNIT II	TIME RESPONSE ANALYSIS	6	3	0	9

Standard test signals – Time response of first order and second order systems –time domain specifications - Steady-state errors and error constants – Type and order of control systems – Effect of adding poles and zeros to transfer functions – Response with P, PI, PD and PID controllers.

UNIT III	FREQUENCY RESPONSE ANALYSIS	6	3	0	9

Correlation between time and frequency response: Second order systems – Frequency domain specifications - Polar plots – Bode plots – Computation of Gain Margin and Phase Margin — Constant M and N-circles – Nichols chart.

UNIT IV	STABILITY OF CONTROL SYSTEM	6	3	0	9

BIBO stability – Necessary conditions for stability – Routh-Hurwitz stability criterion – Root locus concepts – Rules for the construction of Root loci – Nyquist stability criterion – Assessment of relative stability using Nyquist criterion.

UNIT V	COMPENSATOR AND CONTROLLER DESIGN	6	3	0	9

Need for compensation – Types of compensators – Electric network realization and frequency characteristics of basic compensators: Lag, lead and lag-lead compensators – Design of compensators using root locus and Bode plot techniques- PID controller: Design using reaction curve and Ziegler - Nichols technique.

Total (30L+15T) = 45 Periods

Text Books:

1.	A. Anand Kumar, "Control Systems", PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2017.
2.	I.J. Nagrath, and M. Gopal, "Control Systems Engineering", New Age International Publishers, Delhi, 7th Edition, 2021.

Reference Books:

1.	K. Ogata, "Modern Control Engineering", Pearson Education, New Delhi, 5th Edition, 2021.
2.	M. Gopal, "Control Systems: Principles and Design", TMH, New Delhi, 4th Edition, 2018.

E-Reference

1.	https://nptel.ac.in/courses/107106081
2.	https://nptel.ac.in/courses/108106098

Course Outcomes: Upon completion of this course, the students will be able to:			Bloom's Taxonomy Mapped
CO1	:	Develop the transfer function models of any electrical and electro-mechanical systems.	L2: Understanding
CO2	:	Obtain the time responses of the systems and construct root locus plot.	L3: Applying
CO3	:	Analyze the frequency response of the system	L3: Applying
CO4	:	Analyze the absolute / relative stability of a control system.	L4: Analyzing
CO5	:	Design the compensators and PID controller of a feedback control system.	L3: Applying

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	2	2	2							1	3	2	1
CO2	3	3	3	2	2							1	3	2	1
CO3	3	3	3	2	2							1	3	2	1
CO4	3	3	3	2	2							1	3	2	1
CO5	3	3	3	2	2							1	3	2	1
Avg	**3**	**3**	**2.8**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM04	MEASUREMENTS AND INSTRUMENTATION		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
Electric Circuit Analysis		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To educate the fundamental concepts and characteristics of measurement System
2.	To introduce the fundamentals of electrical and electronic instruments for measurement of Electrical and Non-electrical quantities
3.	To familiarize Oscilloscope and the bridge circuits for electrical parameters measurement

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**
Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement. Measurement of voltage and current - permanent magnet moving coil and moving iron type meters					
UNIT II	**MEASUREMENT OF POWER , ENERGY AND FREQUENCY**	**9**	**0**	**0**	**9**
Measurement of power - single and three phase- electrodynamometer type watt meters – Construction, operation – torque equation for deflection – errors. Measurement of energy-Single phase induction type energy meters, Instrument transformers – Current and Potential transformers, Power factor meters- Single phase electrodynamometer type power factor meter, frequency meter-Electrical resonance type frequency meter					
UNIT III	**DC AND AC BRIDGES**	**9**	**0**	**0**	**9**
Balance equations - Wheatstone bridge – Kelvin double Bridge –Maxwell's inductance capacitance bridge – Hay's bridge – Anderson's bridge – Schering bridge and De Sauty's bridge					
UNIT IV	**POTENTIOMETERS, OSCILLOSCOPES AND DIGITAL INSTRUMENTS**	**9**	**0**	**0**	**9**
DC Potentiometer- Crompton's Potentiometer, AC potentiometer– Drysdale polar potentiometer- Gall Tinsley co-ordinate type potentiometer, Cathode Ray Oscilloscope and Digital storage Oscilloscope-Construction, operation and Applications, Digital multi-meters, Digital voltmeters.					
UNIT V	**MEASUREMENT OF NON-ELECTRICAL QUANTITIES**	**9**	**0**	**0**	**9**
Classification of transducers –Position transducers, Piezo-electric transducers and Hall effect transducers. Measurement of pressure, temperature and displacement– Introduction to Smart Sensors					
					Total (45L+0T)= 45 Periods

Text Books:

1.	A.K. Sawhney, 'A Course in Electrical & Electronics Measurement & Instrumentation', Dhanpat Rai and Co, 2015
2.	E.O. Doebelin, 'Measurements Systems- Application and Design', Tata McGraw Hill publishing company, 2015.

Reference Books:

1.	D.V.S. Moorthy, 'Transducers and Instrumentation', Prentice Hall of India Pvt. Ltd, 2010.
2.	H.S. Kalsi, 'Electronic Instrumentation', Tata McGraw Hill, 2015.
3.	Martin Reissland, ' Electrical Measurements', New Age International(P) Ltd., Delhi, 2011.

E-Reference:

1	https://archive.nptel.ac.in/courses/108/105/108105153/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of measurement system in electrical engineering.	L1: Remembering
CO2	:	Describe the working principle of different measuring instruments	L2: Understanding
CO3	:	Choose appropriate instrument for measuring the electrical parameters	L3: Applying
CO4	:	Employ the digital instruments in real time measurements.	L3: Applying
CO5	:	Select an appropriate transducer for measurement of non-electrical quantities	L4: Analysing

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	2	2	3				1		2		2	2	1	1
CO2	1	3			3					2		1	2	1	
CO3	1	1		2	1	1	2		1				1	2	1
CO4	1	1		1	1		2	2	1		2	2	1	3	1
CO5	2	2	3	1	2	2	1			1	3		1	2	
Avg	**1.4**	**1.8**	**2.5**	**1.75**	**1.75**	**1.5**	**1.67**	**1.5**	**1**	**1.67**	**2.5**	**1.67**	**1.4**	**1.8**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM05	ELECTRICAL MACHINES	SEMESTER			
PREREQUISTIES	CATEGORY	PE	Credit		3
	Hours/Week	L	T	P	TH
		3	0	0	3

Course Objectives:

1.	To impart knowledge on construction, working and performance of DC generators and motors.
2.	To deliberate the construction, working and performance of single phase and three phase transformers.
3.	To impart knowledge on construction, working and performance of synchronous generators and motors.
4.	To impart knowledge on construction, principle of operation and performance of single and three-phase induction motors.

UNIT I	DC GENERATORS	9	0	0	9

Principle of operation, constructional details, types - EMF equation, armature reaction, demagnetizing and cross magnetizing Ampere turns, compensating winding, commutation, methods of improving commutation, interpoles, Open circuit and load characteristics of different types of DC Generators. Parallel operation of DC Generators, applications of DC Generators.

UNIT II	DC MOTORS	9	0	0	9

Principle of operation, significance of back emf, torque equation and power developed by armature, load characteristics of shunt, series and compound type motors, starting methods, speed control methods - losses and efficiency calculation, condition for maximum efficiency. Testing of DC Machines: Brake test, Swinburne's test, Hopkinson's test, Retardation test, Separation of core losses - applications of DC motors**.**

UNIT III	TRANSFORMER	9	0	0	9

Single phase transformer: Construction and principle of operation, working of practical transformer - equivalent circuit, voltage regulation, losses and efficiency- testing : polarity test, open circuit and short circuit tests, back-to back test, all day efficiency, parallel operation, applications.

Autotransformer: Construction and working, saving of copper - applications, **Three phase transformer**: construction, types of connections and their comparative features.

UNIT IV	SYNCHRONOUS GENERATOR AND MOTOR	9	0	0	9

Synchronous Generator: Constructional and working details – Types of rotors – EMF equation – Phasor diagrams of non-salient pole synchronous generator connected to infinite bus - Synchronizing and parallel operation – Synchronizing torque - Voltage regulation – EMF, MMF and ZPF method – steady state power angle characteristics – Two reaction theory – slip test.

Synchronous Motor: Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power Developed -Hunting – natural frequency of oscillations – damper windings- synchronous condenser.

UNIT V	THREE PHASE AND SINGLE PHASE INDUCTION MOTOR	9	0	0	9

Three phase induction motor: Constructional details – Types of rotors –- Principle of operation – Equivalent circuit – Torque-Slip characteristics - Condition for maximum torque – Losses and efficiency – load test - No load and blocked rotor tests - Circle diagram – Separation of losses – Starters: DOL, Autotransformer and Star delta starters – Speed control methods: Voltage control, Frequency control and pole changing – V/f control – Slip power recovery Scheme.

Single phase induction motor: Constructional details – Double field revolving theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors – split phase, Capacitor-start, capacitor start and capacitor run Induction motor.

Total (45L+0T)= 45 Periods

Text Books:

1.	I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 5th Edition, 2017.
2.	P. S. Bimbhra, "Electric Machinery", Khanna Publishers, 2nd Edition, 2021.
3.	B.L.Theraja and A.K.Theraja," A text book of Electrical Technology - Volume-II", S.Chand & Company Ltd., New Delhi, 23rd Edition, 2009.

Reference Books:

1.	B.R.Gupta, 'Fundamental of Electric Machines' New age International Publishers,3rd Edition, Reprint 2015.

2.	Murugesh Kumar, 'Electric Machines', Vikas Publishing House Pvt. Ltd, First edition, 2010.
3.	A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, 'Electric Machinery', Mc Graw Hill publishing Company Ltd, 6th Education, 2017.
4.	Stephen J. Chapman, 'Electric Machinery Fundamentals'4th edition, McGraw Hill Education Pvt. Ltd, 4th Edition 2017.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Explain the construction and working principle of DC machines, and Interpret various characteristics of DC machines.	L2: Understanding
CO2	:	Compute various performance parameters of the machine, by conducting suitable tests.	L5: Evaluating
CO3	:	Describe the working principle of transformer, auto transformer, three phase transformer connection, and determine the efficiency and regulation.	L3: Applying
CO4	:	Understand the construction and working principle of Synchronous Machines.	L3: Applying
CO5	:	Understand the construction and working principle, speed control of three phase and single phase induction motor.	L5: Evaluating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	1	1	1			1				1	3	2	1
CO2	3	3	1	1	1			1				1	3	2	1
CO3	3	3	1	1	1			1				1	3	2	1
CO4	3	3	1	1	1			1				1	3	2	1
CO5	3	3	1	1	1			1				1	3	2	1
Avg.	**3**	**3**	**1**	**1**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**3**	**2**	**1**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM06	ELECTRICAL DRIVES AND CONTROL		SEMESTER			
PREREQUISTIES		**CATEGORY**	**PE**	**Credit**		**3**
DC Machines and Transformers, Synchronous and Induction Machines, and Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To know about the operation analyse of chopper fed DC drive, both qualitatively and quantitatively.
2.	To understand the operation and performance of AC motor drives.

UNIT I	**DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES**	**9**	**0**	**0**	**9**

Review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed. Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper.

UNIT II	**MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE**	**9**	**0**	**0**	**9**

Review of Four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, current controller specification and design, speed controller specification and design.

UNIT III	**INDUCTION MOTOR CHARACTERISTICS**	**9**	**0**	**0**	**9**

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency. Review of three-phase voltage source inverter, generation of three-phase PWM signals, constant V/f control of induction motor

UNIT IV	**CONTROL OF SLIP RING INDUCTION MOTOR**	**9**	**0**	**0**	**9**

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery. .

UNIT V	**CONTROL OF SRM AND BLDC MOTOR DRIVES.**	**9**	**0**	**0**	**9**

SRM construction - Principle of operation - SRM drive design factors-Torque controlled SRM- Block diagram of Instantaneous Torque control using current controllers and flux controllers. Construction and Principle of operation of BLDC Machine - Sensing and logic switching scheme,-Sinusoidal and trapezoidal type of Brushless dc motors – Block diagram of current controlledd Brushless dc motor drive

Total (45L+0T)= 45 Periods

Text Books:

1.	G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2.	R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall,2010
3.	Bose B K, "Modern Power Electronics and AC Drives", Pearson Education New Delhi, 2010.

Reference Books:

1.	G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2012.
2.	W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.

E-Reference

1	https://www.iith.ac.in/~ketan/drives.htmL

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Understand the characteristics of dc motors and induction motors.	L2: Understanding
CO2	:	Summarize the operation of chopper fed DC drives.	L4: Analyzing
CO3	:	Understand the principles of speed-control of dc motors and induction motors.	L2: Understanding
CO4	:	Identify suitable power electronic converters used for dc motor and induction motor speed control.	L3: Applying

CO5	:	Analyze the SRM and BLDC motor drive control	L4: Analyzing

COURSE ARTICULATION MATRIX

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	1	3			1	1					1	3	2	
CO2	3	3	1	3		1	1					1	3	2	
CO3	3	3	3	3	1	1	1					1	3	2	
CO4	1	3	3	2	1	1	1					1	3	2	
CO5	3	3	3	3	1	1	1					1	3	2	
Avg.	**2.6**	**2.6**	**2.6**	**2.75**	**1**	**1**	**1**	-	-	-	-	**1**	**3**	**2**	-

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18EEM07	ELECTRIC VEHICLES AND CONTROL		SEMESTER			
PREREQUISTIES		CATEGORY	PE	Credit		3
Electrical drives and control		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To provide knowledge on electric vehicle architecture and its configurations
2.	To impart knowledge on vehicle control, use of energy storage systems and energy management in Electric Vehicle

UNIT I	**ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Configurations of Electric Vehicles (EV), Performance of Electric Vehicles, Tractive Effort in Normal Driving and Energy Consumption, Hybrid Electric Vehicles (HEV): Classification, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains

UNIT II	**PLUG-IN HYBRID ELECTRICVEHICLES (PHEV) AND FUEL CELL ELECTRIC VEHICLES**	**9**	**0**	**0**	**9**

Functions and Benefits of PHEV, Components of PHEVs, Operating Principles of Plug-in Hybrid Vehicle, Control Strategy of PHEV, Fuel Cell: Operation and Types, Fuel Cell Electric Vehicle: Configuration and Control Strategy

UNIT III	**ELECTRIC PROPULSION SYSTEMS**	**9**	**0**	**0**	**9**

Typical electric propulsion system, Classification of electric motor drives for EV and HEV, Multiquadrant Control of Chopper-Fed DC Motor Drives, Vector Control of Induction Motor drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives for Electric Vehicles

UNIT IV	**ENERGY STORAGE SYSTEM**	**9**	**0**	**0**	**9**

Status of Battery Systems for Automotive Applications, Battery Technologies: Nickel–Metal Hydride (Ni–MH) Battery, Lithium–Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors: Features, operation and performance, Ultrahigh-Speed Flywheels, Hybridization of Energy Storages

UNIT V	**ENERGY MANAGEMENT SYSTEM**	**9**	**0**	**0**	**9**

Energy Management System(EMS) in Electric Vehicle, Rule-based control strategy: Deterministic rule-based control, Fuzzy logic-based control, and Neural network-based control. Optimization based control strategy: Dynamic Programming, Metaheuristic optimization methods and Model predictive control, Semi-active type Hybrid Energy Storage System-based EMS, Fully-active type Hybrid Energy Storage System-based EMS

Total (45L+0T)= 45 Periods

Text Books:

1.	Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, Taylor & Francis Group, Second Edition ,2011.
2.	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, AliEmadi,, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles" CRC Press, 2016

Reference Books:

1.	Ali Emadi, Mehrdad Ehsani, John M.Miller ,"Vehicular Electric Power Systems", Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010

E-Reference:

1	https://archive.nptel.ac.in/courses/108/106/108106170/

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Recall the fundamentals of electric vehicle and its mechanics	L1: Remembering
CO2	:	Explain the architecture of different forms of hybrid electric vehicles.	L2: Understanding
CO3	:	Illustrate the four-quadrant operation of DC drive, induction motor drive and SRM drive for Electric Vehicles.	L4: Analyzing
CO4	:	Select an appropriate energy storage system for Electric vehicle	L4: Analyzing
CO5	:	Use the suitable energy management control strategy for hybrid electric vehicle	L3: Applying

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1		1	3	1		1					1	1	2	1
CO2	1	2	3	1			2					2	1	2	
CO3	1	1			2		3						1	1	1
CO4	3	1	2	1	2		1					2	1	2	1
CO5	1	2	1	2	1							1	1	2	1
Avg	**1.4**	**1.5**	**1.75**	**1.75**	**1.5**	**-**	**1.75**	**-**	**-**	**-**	**-**	**1.5**	**1**	**1.8**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM08	ELECTRICAL ENERGY CONSERVATION AND AUDITING		SEMESTER			
PREREQUISITES		CATEGORY	PE	Credit		3
Power Generation, Transmission and Distribution System		Hours/Week	L	T	P	TH
			3	0	0	3

Course Objectives:

1.	To get knowledge about basics of energy and energy scenario of India.
2.	To familiarise the energy conservation methods.
3.	To acquire knowledge on energy auditing, energy efficiency and modern energy efficient devices.

UNIT I	ENERGY SCENARIO	9	0	0	9

Commercial and non-commercial energy -Primary energy resources - Commercial energy production - Final energy consumption - Energy needs of growing economy - Long term energy scenario - Energy pricing - Energy sector reforms - Energy and environment - Energy security - Energy conservation and its importance - Restructuring of the energy supply sector - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

UNIT II	BASICS OF ENERGY	9	0	0	9

Electricity tariff - Load management and maximum demand control - Thermal Basics-fuels - Thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

UNIT III	ENERGY MANAGEMENT AND AUDIT	9	0	0	9

Definition - Energy audit – Need and types of energy audit. Energy management (audit) approach understanding energy costs - Bench marking - Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements, fuel and energy substitution - Energy audit instruments. Material and energy balance: Facility as an energy system - Methods for preparing process flow, material and energy balance diagrams.

UNIT IV	ENERGY EFFICIENCY	9	0	0	9

Electrical system: Electricity billing - Electrical load management and maximum demand control -Power factor improvement and its benefit - Selection and location of capacitors - Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types - Losses in induction motors - Motor efficiency - Factors affecting motor performance - Rewinding and motor replacement issues - Energy saving opportunities with energy efficient motors.

UNIT V	ENERGY EFFICIENT TECHNOLOGIES	9	0	0	9

Maximum demand controllers - Automatic power factor controllers - Energy efficient motors –Soft starters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.

Total (45 L+ 0 T) = 45 Periods

Text Books:

1.	Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2015.
2,	Tripathy, S. C, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.
3.	Hossam A Gabbar, “Energy Conservation in Infrastructure Systems”, Wiley-IEEE Press, New Jersey, 2018

Reference Books:

1.	General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, New Delhi, 2015.
2,	Energy Efficiency in Electrical Utilities, Bureau of Energy Efficiency, New Delhi, 2015.

Course Outcomes: Upon completion of this course, the students will be able to:		Bloom’s Taxonomy Mapped
CO1	Identify the present energy scenario and future energy strategy.	L1: Understanding
CO2	Recognize the various forms of energy.	L1: Understanding
CO3	Interpret energy management methods and energy auditing.	L3: Applying
CO4	Familiar in energy efficiency of electrical systems.	L4: Analysing
CO5	Familiar with the advanced energy efficient technologies.	L4: Analysing

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	1	2	3	2	2		3					1	2	2	1
CO2	1	2	2	2	2		3					1	2	2	1
CO3	2	2	2	3	2		3					1	1	3	1
CO4	2	3	2	2	3		3					1	3	3	1
CO5	2	2	3	1	2		3					1	3	2	1
Avg	**1.6**	**2.2**	**2.4**	**2**	**2.2**	**-**	**3**	**-**	**-**	**-**	**-**	**1**	**2.2**	**2.4**	**1**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM09	SMPS AND UPS		SEMESTER			
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Power Electronics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart knowledge about modern power electronic converters and their applications in power utility.
2.	To impart knowledge about Resonant converters and UPS.

UNIT I	**DC-DC CONVERTERS**	**9**	**0**	**0**	**9**

Introduction to SMPS – Non-isolated DC-DC converters: Cuk, SEPIC topologies, Z-source converter – Zeta converter - Analysis and state space modeling –- Concept of volt-second and charge balance – High gain input-parallel output-series DC-DC converter.

UNIT II	**SWITCHED MODE POWER CONVERTERS**	**9**	**0**	**0**	**9**

Isolated DC-DC converters: Analysis and state space modelling of fly back, Forward, Push pull, Luo, Half bridge and full bridge converters- control circuits and PWM techniques – Bidirectional DC-DC converters.

UNIT III	**RESONANT CONVERTERS**	**9**	**0**	**0**	**9**

Introduction- classification- basic concepts- Resonant switch- Load Resonant converters- ZVS , Clamped voltage topologies- DC link inverters with Zero Voltage Switching- Series and parallel Resonant inverters- Voltage control.

UNIT IV	**DC-AC CONVERTERS**	**9**	**0**	**0**	**9**

Introduction – Multilevel concept – Types of multilevel inverters – Diode-clamped MLI – Flying capacitors MLI – Cascaded MLI – Cascaded MLI – Applications – Switching device currents – DC link capacitor voltage balancing – Features of MLI – Comparisons of MLI.

UNIT V	**POWER CONDITIONERS, UPS, AND FILTERS**	**9**	**0**	**0**	**9**

Introduction- Power line disturbances- Power conditioners –UPS: offline UPS, Online UPS, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for power electronic applications – Selection of capacitors.

Total (45L+0T)= 45 Periods

Text Books:

1.	Simon Ang, Alejandro Oliva," Power-Switching Converters", Third Edition, CRC Press, 2010.
2.	M.H. Rashid – Power Electronics handbook, Elsevier Publication, 2001.

Reference Books:

1.	Ned Mohan, Tore.M.Undeland, William.P.Robbins, "Power Electronics Converters, Applications and Design", 3rd Edition, John Wiley and Sons, 2006.
2.	M.H. Rashid, "Power Electronics circuits, devices and applications", 3rd Edition, PHI, New Delhi, 2007.

E-References:

1.	NPTEL Course: Power Electronics, IIT-B.
2.	www.cdeep.iitb.ac.in. (Electrical Engineering)

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Analyze the state space model for DC – DC converters.	L4: Analyzing
CO2	:	Acquire knowledge on switched mode power converters.	L2: Understanding
CO3	:	Outline the PWM techniques for DC-AC converters.	L1: Remembering
CO4	:	Discuss about modern power electronic converters and its applications in electric power utility.	L2: Understanding
CO5	:	Identify the filters and UPS.	L2: Understanding

COURSE ARTICULATION MATRIX															
COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	2	1	2	2			1					2	2	2	1
CO2	1	1	3	2			1					2	3	3	2
CO3	2	2	2	3			1					1	2	2	1
CO4	2	1	1	2			1					2	2	3	2
CO5	1	1	2	1			1					1	2	2	1
Avg.	**1.6**	**1.2**	**2**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1.6**	**2.2**	**2.4**	**1.4**
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															

18EEM10	UTILIZATION OF ELECTRICAL ENERGY	SEMESTER			
PREREQUISITES	**CATEGORY**	**PE**	**Credit**		**3**
Electrical Machines, Power System, and Power Electronics	**Hours/Week**	**L**	**T**	**P**	**TH**
		3	**0**	**0**	**3**

Course Objectives:

1.	To understand the economics of power generation, tariff and energy conservation methods.
2.	To impart knowledge on principle and design of illumination systems.
3.	To analyze the performance and different methods of electric heating and electric welding.
4.	To impart knowledge on electric traction systems and their performance.
5.	To understand electric drives for various industrial applications.

UNIT I	**INTRODUCTION**	**9**	**0**	**0**	**9**

Economics of generation – definitions – load duration curve – number and size of generator units – Cost of electrical energy – tariff — availability based Tariff- (ABT) – Battery Energy storage system (BESS)- Frequency based energy measurement - need for electrical energy conservation – methods.- Introduction to energy audit

UNIT II	**ILLUMINATION**	**9**	**0**	**0**	**9**

Introduction-nature of radiation – definition – laws of illumination – luminous efficacy-photometry – lighting calculations – design of illumination systems for residential, commercial, street lighting and sports ground– types of lamps –incandescent lamp- mercury vapour –fluorescent lamp-energy efficiency lamps – types of lighting schemes – requirements of good lighting

UNIT III	**HEATING AND WELDING**	**9**	**0**	**0**	**9**

Introduction- classification of methods of heating – requirements of a good heating material – design of heating element – temperature control of resistance furnace – electric arc furnace –induction heating – dielectric heating – electric welding – resistance welding – electric arc welding-electrical properties of arc-applications of electric arc welding.

UNIT IV	**ELECTRIC TRACTION**	**9**	**0**	**0**	**9**

Introduction – requirements of an ideal traction system – supply systems – train movement -mechanism of train movement – traction motors and control –speed control of three phase induction motor- multiple unit control – braking – recent trends in electric traction.

UNIT V	**DRIVES AND THEIR INDUSTRIAL APPLICATIONS**	**9**	**0**	**0**	**9**

Electric drive –advantages of electric drive-individual drive and group drive –factors affecting selection of motor – types of loads – steady state –transient characteristics –size of motor– load equalization – industrial applications – modern methods of speed control of D.C drives-dynamic braking using thyristors-regenerative braking using thyristors.

Total (45L+0T)= 45 Periods

Text Books:

1.	C.L. Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Pvt.Ltd, 2003.
2.	Eric Openshaw Taylor, “Utilisation of Electric Energy”, English Universities Press Limited, 1937
3.	J.B. Gupta, “Utilization of Electric Power and Electric Traction”, S.K.Kataria and Sons, 2002.

Reference Books:

1.	G.C.Garg, S.K.Gridhar&S.M.Dhir, “A Course in Utilization of Electrical Energy”, Khanna Publishers, Delhi, 2003.
2.	H. Partab, “Art and Science of Utilization of Electrical Energy”, Dhanpat Rai and Co, New Delhi, 2004.

E-References:

1.	www.onlinecourses.nptel.ac.in
2.	www.class-central.com
3.	www.mooc-list.com

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Understand the economics of power generation, tariff and energy conservation methods.	L2: Understanding
CO2	:	Interpret the concept behind illumination and design a suitable illumination system for a specific application.	L3: Applying
CO3	:	Design and choose an appropriate heating method for specific application and gain knowledge about electric welding system.	L4: Analyzing
CO4	:	Explain the concepts and recent trends of traction system.	L4: Analyzing
CO5	:	Discuss the concepts of electric drives and their characteristics.	L2: Understanding

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	1	1	1	1	2	1	2	2	1	1	1	2	2	3
CO2	2	3	2	3	1	1	2	1	1			1	3	3	2
CO3	3	3	1	3	1	1	2	1					2	2	3
CO4	1	2	2	3	3	1	2	1					2	3	2
CO5	3	1	1	2	1	1	2	1		1		1	2	2	3
CO6	1	3	3	3	3	1	2	2				1	3	3	2
Avg	**2.17**	**2.17**	**1.67**	**2.5**	**1.67**	**1.17**	**1.83**	**1.33**	**1.5**	**1**	**1**	**1**	**2.33**	**2.5**	**2.5**

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

B.E. – MECHANICAL ENGINEERING - MINOR DEGREE

18MEM01	ENGINEERING THERMODYNAMICS *(Use of standard thermodynamic tables, Mollier diagram are permitted)*					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart the knowledge on concepts of zeroth and first law of thermodynamics.
2.	To make the learners to understand the third law of thermodynamics and analyze the various work and heat interactions in closed and open systems.
3.	To teach properties of pure substance.
4.	To impart knowledge on the concepts of steam power cycle.
5.	To derive thermodynamic relations for ideal and real gases.

UNIT I	**BASIC CONCEPT AND FIRST LAW**	**9**	**0**	**0**	**9**

Role of Thermodynamics in Engineering and Science - Applications of Thermodynamics. Basic concepts - concept of continuum, macroscopic approach, thermodynamic systems, Property, state, path and processes, quasi-static process, Thermodynamic equilibrium, Displacement work, P-V diagram. Zeroth law of thermodynamics – concept of temperature and heat. First law of thermodynamics – application to closed and open systems, steady flow processes with reference to various thermal equipment.

UNIT II	**SECOND LAW AND ENTROPY**	**9**	**0**	**0**	**9**

Heat engine – Refrigerator – Heat Pump, Second law of thermodynamics – Kelvin's and Clausius statements- Equivalence of these statements their corollaries. Reversibility and irreversibility. Carnot cycle, reversed Carnot cycle. Clausius inequality, Concept of entropy, principle of increase of entropy, T-s diagram, T-ds equations, Entropy.

UNIT III	**PROPERTIES OF PURE SUBSTANCES**	**9**	**0**	**0**	**9**

Steam - formation and its thermodynamic properties - p-v, p-T, T-v, T-s, h-s diagrams. PVT surface. Determination of dryness fraction. Calculation of work done and heat transfer in non-flow and flow processes using Steam Table and Mollier Chart.

UNIT IV	**STEAM POWER CYCLE**	**9**	**0**	**0**	**9**

Basic Rankine cycle, T-s & h-s diagrams - Performance Improvement - Reheat cycle, regenerative cycle and their combination cycles.

UNIT V	**IDEAL AND REAL GASES AND THERMO DYNAMIC RELATIONS**	**9**	**0**	**0**	**9**

Properties of ideal and real gases, equation of state of ideal and real gases, Avogadro's law, Vander Waal's equation of states, Principle of corresponding states, reduced properties and compressibility chart. Exact differentials, Maxwell relations, Specific heat equations, Tds, relations, Clausius Clapeyron equations and Joule Thomson Coefficient.

Total (45L)= 45 Periods

Text Books:

1.	Nag. P.K, "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 2017.
2.	Sonntag, R.E., Borgnakke, C., and Van Wylen, G.J., Fundamentals of Thermodynamics, 6th ed., John Wiley, 2003.
3.	Arora C.P, "Thermodynamics", Tata McGraw Hill, New Delhi, 2003.
4.	Venwylen and Sontag, "Classical Thermodynamics", Wiley Eastern, 1987.

Reference Books:	
1.	Cengel, “Thermodynamics- An Engineering Approach”, 3rd Edition, Tata McGraw Hill, 2015.
2.	Merala C, Pother, Craig W and Somerton, “Thermodynamics for Engineers”, Schaum Outline Series, Tata McGrawHill, New Delhi, 2004.

COURSE OUTCOMES: Upon completion of this course, the students will be able to:		**Bloom Taxonomy Mapped**
CO1	Understand the concepts of zeroth, first and second law of thermodynamics.	Remember
CO2	Analyze the various work and heat interactions for different types of processes for closed and open systems	Evaluate
CO3	Evaluate the different properties of pure substances using steam tables and Mollier chart	Evaluate
CO4	Analyze the performance of steam power cycle.	Analyze
CO5	Derive thermodynamic relations for ideal and real gases.	Analyze

COURSE ARTICULATION MATRIX															
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	2			1					1	3	1	1
CO2	3	3	2	2			1					1	3	1	1
CO3	3	3	3	2		1	1					1	3	1	1
CO4	2	3	2	2		1	1					1	3	1	1
CO5	3	3	2	2		1						1	3	1	1
Avg	**2.8**	**3**	**2.2**	**2**		**1**	**1**					**1**	**3**	**1**	**1**
3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)															

18MEM02	FLUID MECHANICS AND MACHINERY					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1.Engineering Physics 2.Engineering Chemistry 3.Engineering Mathematics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic concepts and properties of fluids.
2.	To analyze the kinematic and dynamic concepts of fluid flow.
3.	To understand the various incompressible fluid flow through pipes and between parallel plates.
4.	To apply the principles of fluid mechanics to design and operation of hydraulic turbines.
5.	To apply the principles of fluid mechanics to design and operation of hydraulic pumps.

UNIT I	**INTRODUCTION AND FLUID STATICS**	**9**	**0**	**0**	**9**

Basic concepts and units of measurement of physical quantities- Classification of fluids - Properties of fluids – density, relative density, vapour pressure, surface tension, Capillarity and viscosity. Fluid statics- hydrostatic pressure, buoyancy and Archimedes' principle.

UNIT II	**FLUID KINEMATICS AND DYNAMICS**	**9**	**0**	**0**	**9**

Classification of fluid flow - system and control volume - Lagrangian and Eulerian description for fluid flow - flow patterns-streamline, pathline, streakline and timeline. Velocity potential function and Stream function - continuity equation and its applications. Fluid dynamics - Bernoulli's equation and its applications. Dimensional analysis – Buckingham's theorem, dimensional homogeneity, similarity-laws and models.

UNIT III	**FLOW THROUGH PIPES AND PLATES**	**9**	**0**	**0**	**9**

Incompressible fluid flow-Laminar flow- Hagen-Poiseuille equation, shear stress, pressure gradient relationship - flow through pipes and flow between parallel plates. Turbulent flow – flow through pipes, friction factors in turbulent flow - total energy line, hydraulic gradient line, flow through pipes in series and parallel- Moody's friction factor chart. Power transmission-Boundary layer flows - Boundary layer thickness, momentum thickness, energy thickness-boundary layer separation.

UNIT IV	**HYDRAULIC TURBINES**	**9**	**0**	**0**	**9**

Hydraulic turbines classification-impulse and reaction turbines-Working Principle, work done-efficiency and performance curves for Pelton, Francis and Kaplan turbines (Only descriptive) - Comparison between impulse and reaction turbine-specific speed degree of reaction -draft tubes.

UNIT V	**HYDRAULIC PUMPS**	**9**	**0**	**0**	**9**

Classification of hydraulic pumps- Centrifugal pumps - working principle, specific speed, performance curves and priming(Only descriptive) - Reciprocating pumps - classification, working principle, indicator diagram, air vessels and performance curves. Cavitation in pumps (Only descriptive) - Working principles of gear and vane pumps.

Total (45L)= 45 Periods

Text Books:

1.	Bansal, R.K., "A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Ed", Laxmi Publication Pvt Ltd, 2010.
2.	Rajput, R.K., "A Textbook of Fluid Mechanics and Hydraulic Mechanics", S.Chand and Company Ltd, 2011.
3.	Subramanya. K., "Fluid Mechanics and Hydraulic Machines", Tata McGraw Hill Publishing Company Ltd, 2011.

Reference Books:	
1.	White, “Fluid Mechanics, 8 Ed”, McGraw Hill India, 2017.
2.	Munson, Young and Okiishi, “Fundamentals of Fluid Mechanics 8 th Edition”, Wiley, 2016.
3.	Yunuscengel, John. M.cimbala, “Fluid Mechanics Fundamentals and Applications”, McGraw Hill, 2017.
4.	Som, S.K, Biswas.G and SumanChakraborty, “Introduction to Fluid Mechanics and Fluid Machines”, Tata McGraw Hill India, 2011.
5.	Dr.P.N.Modi, Dr.S.M.Seth, “Hydraulics and Fluid Mechanics including Hydraulic Machines”, Standard book house, 2018.
E-References:	
1.	NPTEL courses: http://nptel.iitm.ac.in/courses.php - web and video sources on fluid mechanics.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Understand the basic concepts and properties of fluids.	Remember
CO2	Analyze the kinematic and dynamic concepts of fluid flow.	Analyze
CO3	Understand the various incompressible fluid flow through pipes and between parallel plates.	Understand
CO4	Apply the principles of fluid mechanics to design and operation of hydraulic turbines.	Apply
CO5	Apply the principles of fluid mechanics to design and operation of hydraulic pumps.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	1	1				2				1		2	2	1
CO2	3	3	1		2								2	2	1
CO3	2	3	2	2	1								2	2	1
CO4	3	3	3	2	1	2	1						2	2	1
CO5	3	3	3	2	1	2	1						2	2	1
Avg	**2.8**	**2.6**	**2**	**2**	**1.25**	**2**	**1.3**				**1**		**2**	**2**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM03	MANUFACTURING PROCESSES					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Basic science, Engineering mathematics, Engineering Physics 2. Engineering Materials		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To make the students familiarize with various manufacturing processes and fabrication techniques of metals and design of casting.
2.	To develop design concepts of various manufacturing processes.
3.	Gain knowledge to select appropriate manufacturing processes for various parts.
4.	To develop an entrepreneur skill among the students.
5.	To evaluate and select plastic deformation processes for various parts.

UNIT I	**CASTING**	**9**	**0**	**0**	**9**

Concepts of Manufacturing Process -Sand casting -Patterns – Design of Pattern, mould and cores- gating and risering design, solidification time calculation - Moulding machines - Core making. Special moulding processes – CO2 moulding; shell moulding, investment moulding, pressure die casting, centrifugal casting, casting defects.

UNIT II	**WELDING**	**9**	**0**	**0**	**9**

Classification of welding processes. Principles of Oxy-acetylene gas welding. Metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, Soldering and Brazing, Adhesive Bonding.

UNIT III	**METAL FORMING**	**10**	**0**	**0**	**10**

Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, load estimation of bulk deformation processes, Hot working and cold working of metals, Forging processes – open, closed and impression die forging – forging operations. Rolling of metals– Types of Rolling mill – Flat strip rolling – shape rolling operations – Defects in rolled parts. Principle of rod and wire drawing – Tube drawing – Principles of Extrusion – Types.

UNIT IV	**SHAPING OF PLASTICS**	**8**	**0**	**0**	**8**

Types of plastics - Characteristics of the forming and shaping processes – Moulding of Thermoplastics – Working principles and typical applications of - Injection moulding – Plunger and screw machines – Blow moulding – Rotational moulding – Film blowing – Extrusion - Typical industrial applications – Thermoforming – Processing of Thermosets – Working principles and typical applications - Compression moulding – Transfer moulding.

UNIT V	**SHEET METAL FORMING AND POWDER METALLURGY**	**9**	**0**	**0**	**9**

Formability of Sheet Metal, load estimation of sheet metal processes - Shearing, Deep drawing, Bending operations- types of presses used, Super Plastic forming; Introduction to Powder Metallurgy– Principal steps involved – sintering and compacting techniques, Advantages, limitations and applications of powder metallurgy.

Total (45L) = 45 Periods

Text Books:

1.	HajraChoudhury, "Elements of Workshop Technology", Vol. I and II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2005.
2.	NagendraParashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007.

Reference Books:

1.	Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", 4/e, Pearson Education, Inc. 2007.
2.	Jain. R.K., and S.C. Gupta, "Production Technology", 16th Edition, Khanna Publishers, 2001.
3.	"H.M.T. "Production Technology – Handbook", Tata McGraw-Hill, 2000.
4.	Roy. A. Linberg, "Process and Materials of Manufacture", PHI, 2000.
5.	Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems.
E-References:	
1.	https://fdocuments.in/document/production-technology-55844cac00bfc.html?page=40

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Describe the operational features of various casting processes, design gate and riser and discover various defects in casting.	Understand
CO2	Explain various metal joining processes and compare them.	Understand
CO3	Summarize several types of metal forming processes and select suitable method for different applications.	Analyze
CO4	Analyze various manufacturing methods for plastics and their needs in industry.	Analyze
CO5	Describe various sheet metal forming processes, load estimation calculation and principles of powder metallurgy	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	2	1						1			1	2	1
CO2	2	1	2	1		1			1	1			1	2	1
CO3	1	1	1	1						1			1	1	1
CO4	1	1	1		1					1			1	1	1
CO5		1							1	1			1		1
Avg	**1.5**	**1**	**1.5**	**1**	**1**	**1**			**1**	**1**			**1**	**1.5**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM04	MATERIALS ENGINEERING					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Engineering Physics 2. Engineering Chemistry		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To impart concept on reactions, treatment, microstructure and mechanical behavior of engineering materials at different temperature.
2.	To learn basic principles in metallurgy and materials engineering.
3.	To identity and select suitable engineering materials based on their applications.

UNIT I	**PHASE DIAGRAMS**	**9**	**0**	**0**	**9**

Crystal structures, Phases, solid solution types, compounds, Hume- Rothery rules; Gibb's phase rule; Binary isomorphous alloy systems – Eutectic, Eutectoid, Peritectic systems. Lever rule, Equilibrium and non-equilibrium cooling, Fe-C Equilibrium diagram - effects of alloying elements – Ferrite and Austenite Stabilizers, TTT and CCT diagrams.

UNIT II	**HEAT TREATMENT**	**9**	**0**	**0**	**9**

Definition – Full annealing, stress relief, recrystallisation and spheroidizing –normalizing, hardening and Tempering of steel. Isothermal transformation diagrams – cooling curves superimposed on I.T. diagram CCR - Hardenability, Jominy end quench test – Austempering, martempering – case hardening, carburising, nitriding, cyaniding, carbo-nitriding – Flame and Induction hardening. Heat treatment of non-ferrous alloys - precipitation hardening. Heat treatment of HSS tools, gears, springs and gauges.

UNIT III	**FERROUS AND NON FERROUS METALS**	**9**	**0**	**0**	**9**

Plain carbon steels – Tool steels - maraging steels – HSLA steels .Stainless steels- ferritic and Austenitic, martensitic, duplex and precipitation hardened stainless steels. Types of Cast Irons- Gray cast iron, white cast iron, malleable cast iron, S.G.Iron. Copper alloys – Brass, Bronze and Cupronickel, Aluminium alloys, Bearing alloys.

UNIT IV	**MECHANICAL PROPERTIES AND TESTING**	**9**	**0**	**0**	**9**

Mechanical properties of engineering materials - Mechanisms of plastic deformation, slip and twinning – Creep, Fatigue and Fracture - Types of fracture – Testing of materials - tension, compression and shear loads - fatigue and creep tests – hardness and its effects – testing for hardness (Brinell, Vickers and Rockwell) - Impact test - Izod and Charpy.

UNIT V	**NON DESTRUCTIVE TESTING AND SURFACE ENGINEERING**	**9**	**0**	**0**	**9**

Non Destructive Testing: Basic principles - Testing method - Radiographic testing, Ultrasonic testing, Magnetic Particle Inspection and Liquid Penetrant Inspections. Introduction to surface engineering - Definition, diffusion techniques, deposition methods, high and low energy beam methods, surface engineering charts, elastic contact mechanics.

Total (45L) = 45 Periods

Text Books:

1.	Kenneth G. Budinski and Michael K. Buinski, "Engineering Materials", Prentice Hall of India Ltd, 2002.
2.	Raghavan, V, "Materials Science and Engineering", Prentice Hall of India (P) Ltd., 1999.
3.	Aswani.K.G, "A Text Book of Material Science", S.Chand and Co. Ltd., New Delhi, 2001.
4.	Khanna O.P., "A Text Book of Materials Science and Metallurgy", DhanpatRai Sons, 2004.

Reference Books:

1.	William. D.Callsber, "Material Science and Engineering", John Wiley and Sons, 1997.
2.	Sydney.H.Avner, "Introduction to Physical Metallurgy" Mc Graw Hill Book Company, 1994.

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom's Taxonomy Mapped**
CO1	Understand the formation of materials and their classification based on atomic structure.	Understand
CO2	Understand the principles of various heat treatment processes in fabrication industry.	Understand
CO3	Describe properties, applications and types of various ferrous and non-ferrous metals used in fabrication industry	Understand
CO4	Describe various types of failure and select methods for destructive testing	Understand
CO5	Select methods for non destructive testing	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	1	1	2	2	1	1	1						2	3	1
CO2	1		2	1	1	2	1						2	3	1
CO3		1	1	1	1		1						3	2	1
CO4		2	2	1	1	1	1						2	3	1
CO5		2	2	2	1		1						2	2	1
Avg	**1**	**1.5**	**1.8**	**1.4**	**1.0**	**1.3**	**1**						**2.2**	**2.6**	**1.0**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM05	KINEMATICS OF MACHINERY					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Engineering graphics. 2.Engineering Mechanics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To understand the basic components and layout of linkages in the assembly of a system/ machine.
2.	To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
3.	To understand basics of cam profile and its displacement.
4.	To understand the basic concepts of toothed gearing and kinematics of gear trains.
5.	Illustrate the effects of friction drives in transmission system.

UNIT I	**BASICS OF MECHANISMS**	**9**	**0**	**0**	**9**

Classification of mechanisms- Basic kinematic concepts and definitions- Degree of freedom, mobility- Grashof's law, Kinematic inversions of four bar chain and slider-crank chains Limit positions- Mechanical advantage - Transmission angle- Description of some common mechanisms- Quick return mechanism, straight-line generators.

UNIT II	**KINEMATIC ANALYSIS**	**9**	**0**	**0**	**9**

Displacement, velocity and acceleration analysis of simple mechanisms, graphical velocity analysis using instantaneous centres - kinematic analysis of simple mechanisms- slider-crank mechanism dynamics Coincident points- Coriolis component of acceleration introduction to linkage synthesis three Position graphical synthesis for motion and path generation.

UNIT III	**KINEMATICS OF CAM**	**9**	**0**	**0**	**9**

Classification of cams and followers- Terminology and definitions- Displacement diagrams- Uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- specified contour cams circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical method for cam profile design.

UNIT IV	**GEARS AND GEAR TRAINS**	**9**	**0**	**0**	**9**

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference / undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

UNIT V	**FRICTION IN MACHINE ELEMENTS**	**9**	**0**	**0**	**9**

Surface contacts- sliding and rolling friction- friction drives- friction in screw threads – bearings and lubrication- friction Clutches- belt and rope drives.

Total (45L) = 45 Periods

Text Books:

1.	Rattan S.S, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1998.
2.	Ghosh, A and Mallick, A.K, "Theory of Mechanisms and Machines", East-West Pvt. Ltd., New Delhi, 1988.

Reference Books:

1.	Thomas Bevan, "Theory of Machines", CBS Publishers and Distributors, 1984.
2.	Rao J.S and Dukkipati R.V, "Mechanism and Machine Theory", Wiley-Eastern Ltd., New Delhi, 1992.

3.	Erdman AG and Sandor G N, “Mechanism Design, Analysis and Synthesis”, Vol.I, PHI Inc., 1997.
4.	Ambekar A.G, “Mechanism and Machine Theory” Prentice Hall of India, New Delhi, 2007.
5.	John Hannah and Stephens R C, “Mechanisms of Machines”, Viva Low Price Student Edition, New Delhi, 1999.
E-References:	
1.	https://archive.nptel.ac.in/courses/112/104/112104121/
2.	https://nptel.ac.in/courses/112106270
3.	http://velhightech.com/Documents/ME8492 Kinematics of Machinery.pdf

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Demonstrate and understand the concepts of various mechanisms and pairs.	Apply
CO2	Analyze the velocity and acceleration of simple mechanisms.	Analyze
CO3	Construct the cam profile for various motion.	Create
CO4	Solve problems on gears and gear trains.	Evaluate
CO5	Evaluate the friction in transmission system	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1									3	1	
CO2	3	2	2	1									3	1	
CO3	3	2	2	1									3	1	
CO4	3	2	2	1									3	1	
CO5	3	2	2	1									3	1	
Avg	**3**	**2**	**2**	**1**									**3**	**1**	

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM06	HYDRAULICS AND PNEUMATICS					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
		Hours/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	To enable the students understand the basics of hydraulics and pneumatics
2.	Applying the working principles of hydraulic actuators and control components.
3.	Designing and develop hydraulic circuits and systems.
4.	Applying the working principles of pneumatic power system and its components.
5.	Solving problems and troubles in fluid power systems.

UNIT I	**FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS**	**9**	**0**	**0**	**9**

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque - Problems, Sources of Hydraulic power; Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of pumps – Fixed and Variable displacement pumps – Problems.

UNIT II	**HYDRAULIC ACTUATORS AND CONTROL COMPONENTS**	**9**	**0**	**0**	**9**

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary actuators - Hydraulic motors - Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Accessories; Reservoirs, Pressure Switches – Filters – types and selection - Applications – Fluid Power ANSI Symbols – Problems.

UNIT III	**HYDRAULIC CIRCUITS AND SYSTEMS**	**9**	**0**	**0**	**9**

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double - Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail - Safe, Speed Control, Deceleration circuits, Sizing of hydraulic systems, Hydrostatic transmission, Electro hydraulic circuits – Servo and Proportional valves – Applications - Mechanical, hydraulic servo systems.

UNIT IV	**PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS**	**9**	**0**	**0**	**9**

Properties of air – Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – classification - single cylinder and multi cylinder circuits - Cascade method – Integration of fringe circuits, Electro Pneumatic System – Elements – Ladder diagram – timer circuits problems, Introduction to fluidics and pneumatic logic circuits.

UNIT V	**DESIGN OF FLUID POWER CIRCUITS AND TROUBLESHOOTING**	**9**	**0**	**0**	**9**

Servo systems, Hydro mechanical servo systems, electro hydraulic servo systems and proportional Valves, Introduction to electro hydraulic pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits, failure and troubleshooting. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. – Low cost Automation – Hydraulic and Pneumatic power packs. Case studies: A simple sequence, synchronize circuits using hydraulic and pneumatics components.

Total (45L) = 45 Periods

Text Books:

1.	Manjumdar S.R, "Oil Hydraulics", Tata McGraw-Hill, December 2002.

2.	Anthony Esposito, “Fluid Power with Applications”, Pearson Education 2013.
Reference Books:	
1.	Andrew Parr, “Hydraulic and Pneumatics”, Jaico Publications House, 2005.
2.	Bolton W. “Pneumatic and hydraulic system”, Butterworth-Heinemann 1997
3.	Majumdar S.R., “Pneumatic systems – Principles and maintenance”, Tata McGraw Hill, 2010
4.	Shanmugasundaram.K, “Hydraulic and Pneumatic controls”, Chand & Co, 2006
5.	Srinivasan.R. “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 2008.
E-References:	
1.	http://www.fluidpowerjournal.com
2.	http://14.139.160.15/courses/112102011/2
3.	https://www.nfpa.com/home.htm

COURSE OUTCOMES: **Upon completion of the course, the students will be able to:**		**Bloom’s Taxonomy Mapped**
CO1	Select the components as per the application	Evaluate
CO2	Apply the working principles of hydraulic actuators and control components.	Apply
CO3	Design and develop hydraulic circuits and systems.	Create
CO4	Apply the working principles of pneumatic power system and its components.	Apply
CO5	Solve problems and troubles in fluid power systems.	Evaluate

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1										1	1	1
CO2		2	2	1									1	1	1
CO3	1	2	3			1							1	2	1
CO4	1	1	3	2	2								2	1	1
CO5	1	1	2										1	1	1
Avg	**1.25**	**1.4**	**2.2**	**1.5**	**2**	**1**							**1.2**	**1.2**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM07	DESIGN OF MACHINE ELEMENTS					
PRE-REQUISITE:		**CATEGORY**	**PE**	**Credit**		**3**
1. Student should study engineering mechanics. 2. Student should study kinematic of machinery.		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Objectives:

1.	Understanding of background in mechanics of materials and design of machine components.
2.	An understanding of the origins, nature and applicability of empirical design principles, based on safety considerations
3.	An understanding the design of shafts and couplings.
4.	Familiarize the design of energy storing elements and engine components.
5.	An appreciation of the relationships between component level design and overall machine system design and performance

UNIT I	**STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS**	**9**	**0**	**0**	**9**

Introduction to the design process – Product development cycle- factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers– Direct, Bending and Torsional stress – Impact and shock loading – Calculation of principle stresses for various load combinations, eccentric loading – Factor of safety -theories of failure – stress concentration – design for variable loading – Soderberg, Goodman and Gerber relations .

UNIT II	**DESIGN OF SHAFTS AND COUPLINGS**	**9**	**0**	**0**	**9**

Design of solid and hollow shafts based on strength, rigidity and critical speed – Design of keys and key ways - Design of rigid and flexible couplings.

UNIT III	**DESIGN OF THREADED FASTENERS, RIVETED AND WELDED JOINTS**	**9**	**0**	**0**	**9**

Threaded fasteners - Design of bolted joints including eccentric loading – Design of riveted and welded joints for pressure vessels and structures- theory of bonded joints.

UNIT IV	**DESIGN OF ENERGY STORING ELEMENTS AND ENGINE COMPONENTS**	**9**	**0**	**0**	**9**

Various types of springs, optimization of helical springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines- Connecting rods and crank shafts.

UNIT V	**DESIGN OF BEARINGS**	**9**	**0**	**0**	**9**

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number - Selection of Rolling Contact bearings.

Total (45L) = 45 Periods

Text Books:

1.	Bhandari V.B, “Design of Machine Elements”, Tata McGraw Hill Book Co, 2020
2.	Md.Jalaludeen.S, “A text book of Machine Design”, Anuradha Publications, 2006

Reference Books:

1.	Shigley, J.E. and Mischke, C.R., Mechanical Engineering Design, Fifth Edition, McGraw-Hill International; 1989.
2.	Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan, 1992.

3.	Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley, 1994.
4.	PSG Tech, "Design Data Handbook", M/s.DPV Printers, Coimbatore, 2009
E-References:	
1.	https://nptel.ac.in/courses/112105124
2.	Design of Machine Elements - V. B. Bhandari - Google Books
3.	A Textbook of Machine Design by R.S.Khurmi And J.K.Gupta [tortuka] 1490186411865.pdf | DocDroid

COURSE OUTCOMES: On completion of the course the student will be able to		**Bloom's Taxonomy Mapped**
CO1	Understand the influence of steady and variable stresses in machine component design.	Understand
CO2	Apply the concepts of design to shafts, keys and couplings.	Apply
CO3	Familiarize the design of temporary and permanent joints.	Understand
CO4	Design the various energy storing elements and engine components.	Analyse
CO5	Familiarize the design of various types of bearings.	Understand

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	2		1	1				1		3	2	1
CO2	2	2	1	2		1	1				1		3	2	1
CO3	2	2	1	2		1	1				1		3	2	1
CO4	2	2	1	2		1	1				1		3	2	1
CO5	2	2	1	2		1	1				1		3	2	1
Avg	**2.0**	**2.0**	**1.0**	**2.0**		**1.0**	**1.0**				**1.0**		**3.0**	**2.0**	**1.0**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM08	HEAT AND MASS TRANSFER					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
1.The laws and basic concepts of thermodynamics 2. The concept of energy transfers and their conversion principles		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES

1.	Understanding the science behind conduction heat transfer and its applications.
2.	Differentiating the concepts of forced and natural convection heat transfer.
3.	Describing the laws and concepts of radiation heat transfer.
4.	Understanding phase change processes and analyzing heat exchangers.
5.	Studying the concept of mass transfer process and its modes.

UNIT-I	**CONDUCTION HEAT TRANSFER**	**9**	**0**	**0**	**9**

General Differential equation – Cartesian(derivation of General Differential Equation), Cylindrical (derivation of General Differential Equation) and Spherical Coordinates – One DimensionalSteady State Heat-Concepts of electrical analogy, Conduction — plane and Composite Systems – Conduction with Internal HeatGeneration., Critical thickness of insulation.

Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infiniteand Infinite Solids –Use of Heisler's charts.

UNIT-II	**CONVECTION HEAT TRANSFER**	**9**	**0**	**0**	**9**

Conservation equations, boundary layer concept – Forced convection: external flow – flow over plates, cylinders, spheres and bank of tubes. Internal flow – entrance effects.

Free convection –flow over vertical plate, horizontal plate, inclined plate, cylinders and spheres.

UNIT-III	**BOILING, CONDENSATION AND HEAT EXCHANGERS**	**9**	**0**	**0**	**9**

Regimes of Pool boiling and Flow boiling, Nusselt's theory of condensation- correlations in boiling and condensation. Heat Exchanger types - Overall Heat Transfer Co-efficient – Fouling Factors. LMTD and NTU methods.

UNIT-IV	**RADIATION HEAT TRANSFER**	**9**	**0**	**0**	**9**

Radiation laws - Black Body and Gray body Radiation - Shape Factor - Electrical Analogy -Radiation Shields.

UNIT-V	**MASS TRANSFER**	**9**	**0**	**0**	**9**

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state Molecular Diffusion - Equimolal counter diffusion. Basic Convective Mass Transfer Problems.

Total(45L) = 45 Periods

TEXT BOOKS:

1	R.C. Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, 2017
2	Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 7th Edition, 2014.

REFERENCE BOOKS:

1	Yunus A. Cengel, "Heat Transfer A Practical Approach" – Tata McGraw Hill, 5 th Edition - 2013
2	Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2017
3	Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 2012
4	Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., 1994.

COURSE OUTCOMES: On completion of the course the student will be able to:		**Bloom's Taxonomy Mapped**
CO1	Analyze the mechanism of heat conduction under steady and transient conditions.	Apply
CO2	Develop solutions to problems involving convective heat transfer.	Create
CO3	Design a heat exchanger for any specific application.	Understand
CO4	Adopt the concept of radiation heat transfer in real time systems.	Understand
CO5	Develop solutions to problems involving combined heat and mass transfer.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	2		1						3	3	1
CO2	3	3	3	3	2		1						3	3	1
CO3	3	3	3	3	2		1						3	3	1
CO4	3	3	3	3	2		1						3	2	1
CO5	2	2	2	2	1		1						3	1	
Avg	**2.8**	**2.8**	**2.8**	**2.8**	**1.8**		**1**						**3**	**2.4**	**1**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEM09	METROLOGY AND QUALITY CONTROL					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
		Horus/Week	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES

1.	Explaining the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty
2.	Applying the applications of linear and angular measuring instruments
3.	Interpretation of various tolerance symbols.
4.	Applying the SQC methods in manufacturing.
5.	Applying the advances in measurements for quality control.

UNIT-I	**BASICS OF MEASUREMENT SYSTEM AND DEVICES**	**9**	**0**	**0**	**9**

Definition of metrology, accuracy, precision and sensitivity, Abbe‘s principle. Three stages of generalized measurement system - mechanical loading – static characteristics of instruments – factors considered in selection of instruments - commonly used terms, error analysis and classification - sources of error. Measurement uncertainty.

UNIT-II	**CALIBRATION OF INSTRUMENTS AND QUALITY STANDARDS**	**9**	**0**	**0**	**9**

Calibration of measuring instruments - principles of calibration, Calibration of Instruments - Vernier caliper, Micrometer, feeler gauges, dial indicator, surface plates, slip gauges, care of gauge blocks. General cares and rules in measurement, ISO 9000 quality standards. Comparators- mechanical, electrical, optical and pneumatic.

UNIT-III	**GEOMETRICAL MEASUREMENT AND MACHINE ELEMENTS**	**9**	**0**	**0**	**9**

Angular measurement - optical protractors, sine bar, roundness measurement, limit gauge, design of plug gauge, Taylor‘s principle, three basic types of limit gauges, Tomlinson surface meter, computer controlled CMM. ISO metric thread, measurement of major, minor and effective diameters. Gear terminology; spur gear measurement, checking of composite errors, base pitch measurement. Principle of interferometry, laser interferometer, Machine vision, Fundamental of GD&T. Inspection of straightness, flatness, roundness deviations.

UNIT-IV	**STATISTICAL QUALITY CONTROL**	**9**	**0**	**0**	**9**

Surface finish – terminology and measurements – Optical measuring instruments –Acceptance test for machines. Statistical Quality Control - Control charts - Sampling plans.

UNIT-V	**SIX SIGMA**	**9**	**0**	**0**	**9**

Six sigma: Define measure, analyse, improve and control phases. Analyze phase tools: CommonTools: Histogram, Box Plot, Control chart, Scatter chart, Cause and effect diagram, Pareto analysis, interrelations diagram. Special Tools: Regression Analysis, Hypothesis Testing, ANOVA Multi variate analysis.

Total(45L) = 45 Periods

TEXT BOOKS:

1	Gupta.I.C, ―A text book of Engineering Metrology, Dhanpat Rai publications, New Delhi, 2018
2	Beckwith.T.G, Roy D. Marangoni, John H. Lienhard, - Mechanical Measurements‖, Prentice Hall, 2006

REFERENCE BOOKS:

1	Jain.R.K, ―Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.
2	Holmen.J.P, ―Experimental Methods for Engineers‖, Tata McGraw Hill Publications Co Limited, 2017.

3	Grant, E.L., Statistical Quality Control, Mc Graw-Hill, 2004. 3. Doeblin E.O., Measurement Systems, Mc Graw-Hill, 2004.
4	Alan S Morris, ―Measurement and Instrumentation Principles, Butterworth, 2006.
5	De Feo J A and Barnard W W, ―Six Sigma: Break trough and BeyondG, Tata McGraw-Hill, New Delhi, 2005.
E-REFERENCES:	
1	https://nitsri.ac.in/Department/Mechanical%20Engineering/MEC_405_Book_2,_for_Unit_2B.pdf
2	https://www.nist.gov/system/files/documents/srm/NIST-SRM-RM-Articlefinal.pdf
3	https://www.researchgate.net/publication/319587859_Computer-Aided_Metrology-CAM

COURSE OUTCOMES: On completion of the course the student will be able to:		**Bloom's Taxonomy Mapped**
CO1	Explain the importance of measurements in engineering and the factors affecting measurements and to compute measurement uncertainty.	Understand
CO2	Apply the working principle and the applications of linear and angular measuring instruments.	Apply
CO3	Interpret of various tolerance symbols.	Apply
CO4	Apply the SQC methods in manufacturing.	Apply
CO5	Apply the advances in measurements for quality control in manufacturing industries.	Apply

COURSE ARTICULATION MATRIX

COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1							2	1	2				2	1	
CO2							3	1	2				1	2	
CO3							2	1					2	1	
CO4				3			2		1				1	2	
CO5				2				3	1				2	1	
Avg				**2.5**			**2.25**	**1.5**	**1.5**				**1.6**	**1.4**	

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

18MEMI10	DYNAMICS OF MACHINERY					
PREREQUISITES		**CATEGORY**	**PE**	**Credit**		**3**
Engineering Mechanics, Kinematics of Machinery, Strength of Materials		**Hours\Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

1.	To impart students with the knowledge about motion, masses and forces in machines and the Principle of Virtual Work.
2.	To facilitate the students, to understand the concept of balancing of rotating and reciprocating masses.
3.	To teach concepts of free vibration analyses of one and two degree-of-freedom rigid body systems
4.	To teach concepts of forced vibrations analyses of rigid body systems and to give awareness to students on the phenomenon of vibration and its effects.
5.	To learn about the concept of various types of governors.

UNIT I	**FORCE ANALYSIS**	**9**	**0**	**0**	**9**

Static Force Analysis, Free Body Diagrams, Conditions of Two, Three and Four Force Members. Inertia Forces and D'Alembert's Principle – Inertia Force Analysis in Reciprocating Engines – Crank Shaft Torque. Flywheels – Turning Moment Diagrams and Fluctuation of Energy of reciprocating engine mechanisms, Coefficient of Fluctuation of Energy and Speed, Weight of Flywheel Required.

UNIT II	**BALANCING**	**9**	**0**	**0**	**9**

Static and dynamic balancing - Balancing of rotating masses - Balancing a single cylinder Engine - Balancing Multi-cylinder Engines - Partial balancing in locomotive Engines - Balancing linkages - balancing machines

UNIT III	**FREE VIBRATION**	**9**	**0**	**0**	**9**

Basic Features of Vibratory Systems – Types – Single Degree of Freedom System – Transverse Vibration of Beams – Natural Frequency by Energy Method, Dunkerly's Method - Critical Speed - Damped Free Vibration of Single Degree Freedom System -Types of Damping – Free Vibration with Viscous Damping, Critically Damped System, Under Damped System. Torsional Systems: Natural Frequency of Two and Three Rotor Systems.

UNIT IV	**FORCED VIBRATION**	**9**	**0**	**0**	**9**

Response to Periodic Force – Harmonic Force – Force caused by Unbalance – Support Motion - Logarithmic Decrement-Magnification Factor – Vibration Isolation and Transmissibility.

UNIT V	**GOVERNORS**	**9**	**0**	**0**	**9**

Governors - Types - Centrifugal governors - Gravity controlled and spring controlled centrifugal governors – Characteristics - Effect of friction - Controlling Force - other governor mechanisms.

Total (45L) = 45 Periods

TEXT BOOKS:

1.	Design of Machinery, Fourth Edition, by R.L. Norton, McGraw Hill, 2007
2.	Mechanical Vibration, V.P.Singh, Dhanpatrai, Delhi

REFERENCE BOOKS:

1.	Ballaney, P.L., "Theory of Machines and Mechanisms", Khanna Publishers, New Delhi, 2002.
2.	Shigley, J.E. and Uicker, J.J., "Theory of Machines and Mechanisms", TMH ND, 1998.
3.	Amithabha Ghosh, and Ashok Kumar Malik., "Theory of Mechanisms and Machines", 2nd Ed., Affiliated East and West Press Limited, 1998.
4.	Prof.Nakara, IIT-Delhi Reference Books

E-REFERENCES:	
1.	www.university.youth4work.com/IIT_Kharagpur_Indian-Institute-of-Technology/study/1653-dynamics-of-Machinery-ebook
2.	http://nptel.ac.in/courses/112104114/

COURSE OUTCOMES: On completion of the course the student will be able to		Bloom's Taxonomy Mapped
CO1	Apply basic principles of mechanisms in mechanical system.	Apply
CO2	Familiarize the static and dynamic analysis of simple mechanisms.	Understand
CO3	Analyze the mechanical systems subjected to free vibration.	Analyze
CO4	Analyze mechanical systems subjected to forced vibration.	Analyze
CO5	Analyze the various types of governors and its speed control mechanism.	Analyze

COURSE ARTICULATION MATRIX

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	3	1					1		3	2	1	2
CO2	2	2	3	2	1					1		3	2	1	2
CO3	2	2	3	2						1		3	2	1	2
CO4	2	2	3	2	1					1		3	2	1	2
CO5	1	2	3	2						1		3	2	1	1
Avg	**1.8**	**2.0**	**3.0**	**2.2**	**1**					**1.0**		**3.0**	**2.0**	**1.0**	**1.8**

3/2/1 – indicates strength of correlation (3 – High, 2- Medium, 1- Low)

MINOR DEGREE: METALLURGICAL ENGINEEING

18MTM01	ADVANCED PHYSICAL METALLURGY		Semester			
PREREQUISITES		Category	OE	Credit		3
Engineering physics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1. To impart knowledge on the crystal structure, diffusion, phase diagrams for various engineering materials.

Unit I	CRYSTAL STRUCTURES	9	0	0	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 II	CRYSTALLINE IMPERFECTIONS	9	0	0	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 III	ATOMIC DIFFUSION IN SOLIDS AND SOLIDIFICATION OF METAL	9	0	0	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 IV	PHASE DIAGRAMS	9	0	0	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 V	IRON-CARBON PHASE DIAGRAM	9	0	0	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 (45+0) = 45 Hours

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, 199.
4	William F.Smith, "Foundations of Materials Science and Engineering", Second Edition, McGraw-Hill Inc, New York, 1993.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the basic crystal structure, orientation and their influence on macroscopic properties.	L2: Understanding
CO2	:	Discuss the role of imperfections in strengthening the materials.	L2: Understanding
CO3	:	Diagonise the diffusion mechanism in solidification of materials under different conditions.	L4:Analysing
CO4	:	Apply the concept of phase diagrams in equilibrium transformation of materials phases.	L3:Applying
CO5	:	Construct the Fe-Fe_3C phase diagram and discuss various properties of steel and cast iron.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1		1	1								1		1	
CO2	1	1				1	1						1			1
CO3	1	1	1	1		1							1	1		
CO4	1	1		1	1								1			
CO5	1	1		1									1			1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM02	THERMODYNAMICS AND KINETICS IN METALLURGY	Semester			
PREREQUISITES	Category	OE	Credit		3
Engineering physics and Engineering chemistry	Hours/Week	L	T	P	TH
		3	0	0	3

Course Learning 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	FUNDAMENTAL CONCEPT AND INTERNAL ENERGY	9	0	0	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 II	ENTROPY AND AUXILARY FUNCTIONS	9	0	0	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 III	THERMODYNAMIC POTENTIALS AND PHASE EQUILIBRIA	9	0	0	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 IV	THERMODYNAMICS OF SOLUTIONS	9	0	0	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 V	THERMODYNAMICS OF REACTIONS AND KINETICS	9	0	0	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 (45+0) = 45 Hours

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

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the fundamental concepts of thermodynamics and internal energy	L2: Understanding
CO2	:	State the thermodynamics entropy and auxilary functions.	L2: Understanding
CO3	:	Identify the basic laws, chemical potential and phase equilibria.	L4:Analysing
CO4	:	Describe the thermodynamics of the solution and various important equations.	L2: Understanding
CO5	:	Apply to solve problems related to electrochemical processes and kinetics.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1		1	1								1	1		
CO2	1	1	1										1		1	
CO3	1	1		1	1								1			
CO4	1			1	1								1		1	1
CO5	1	1				1	1						1		1	
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM03	MECHANICAL BEHAVIOUR OF MATERIALS		Semester			
PREREQUISITES			**OE**	**Credit**		**3**
Engineering physics		**Hours/Week**	**L**	**T**	**P**	**TH**
			3	**0**	**0**	**3**

Course Learning Objectives

1	To know the fundamental concepts of deformation behaviour for structural engineering applications.

Unit I	**DISLOCATIONS AND PLASTIC DEFORMATION**	**9**	**0**	**0**	**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 II	**STRENGTHENING MECHANISMS**	**9**	**0**	**0**	**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 III	**FRACTURE AND FRACTURE MECHANICS**	**9**	**0**	**0**	**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 IV	**FATIGUE BEHAVIOUR AND TESTS**	**9**	**0**	**0**	**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 V	**CREEP BEHAVIOUR AND TESTS**	**9**	**0**	**0**	**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 (45+0) = 45 Hours

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

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom’s Taxonomy Mapped**
CO1	:	Discuss the mechanical behaviour of materials.	L2: Understanding
CO2	:	Discuss the strengthening mechanisms of materials.	L2: Understanding
CO3	:	List the various types of fractures and their mechanisms, fracture mechanics and various theories describing fracture mechanics.	L2: Understanding
CO4	:	Discuss the fatigue behaviour and the mechanism of fatigue, SN curve and fatigue testing machines.	L2: Understanding
CO5	:	Describe the creep behaviour and mechanism, factors affecting creep and creep testing machines.	L2: Understanding

COURSE ARTICULATION MATRIX

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	1		1	1								1	1		
CO2	1	1		1	1								1	1		
CO3	1	1	1		1										1	1
CO4	1	1				1	1								1	1
CO5	1	1		1	1								1	1		
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

18MTM04	RATE PROCESSES IN METALLURGY		Semester			
PREREQUISITES			OE	Credit		3
Engineering physics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

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

Unit I	INTRODUCTION	9	0	0	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	0	0	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	0	0	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	0	0	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	0	0	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+0) = 45 Hours

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

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the thermodynamic aspects of phase changes.	L2: Understanding
CO2	:	Discuss the fundamentals of solid –fluid reactions.	L2: Understanding
CO3	:	Explain the eutectic and peritectic solidifications and rapid solidification processes.	L2: Understanding
CO4	:	Describe the fundamentals of solidification.	L1: Remembering
CO5	:	Apply the solid state phase transformations in steel.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1			1
CO2	1	1			1	1									1	1
CO3	1	1		1	1								1	1		
CO4	1	1		1	1									1		1
CO5	1		1			1	1								1	1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM05	CORROSION AND SURFACE ENGINEERING		Semester			
PREREQUISITES			OE	Credit		3
Engineering chemistry		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1 To understand the corrosion and surface engineering, with its application in engineering field.

Unit I	**MECHANISMS AND TYPES OF CORROSION**	**9**	**0**	**0**	**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

Unit II	**TESTING AND PREVENTION OF CORROSION**	**9**	**0**	**0**	**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.

Unit III	**CORROSION OF INDUSTRIAL COMPONENTS**	**9**	**0**	**0**	**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.

Unit IV	**SURFACE ENGINEERING FOR WEAR AND CORROSION RESISTANCE**	**9**	**0**	**0**	**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.

Unit V	**THIN LAYER ENGINEERING PROCESSES**	**9**	**0**	**0**	**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 (45+0) = 45 Hours

Reference 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.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Name the different types of corrosion and their mechanism.	L2: Understanding
CO2	:	Estimate corrosion resistance by different tests.	L4:Analysing
CO3	:	Explain the corrosion behavior of different metals in different industries.	L2: Understanding
CO4	:	Classify the different forms of processing techniques of surface engineering materials.	L1: Remembering
CO5	:	Select the type of deposition and spraying technique.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1		1		1							1	1		
CO3	1	1	1	1			1								1	1
CO4	1	1		1	1										1	1
CO5	1	1		1	1								1	1		
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)

18MTM06	MATERIALS CHARACTERIZATION		Semester			
PREREQUISITES			OE	Credit		3
Engineering physics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To acquire knowledge on various characterizations, chemical and thermal analysis of metallurgical components using its analysis tools.

Unit I	**OPTICAL MICROSCOPY**	**9**	**0**	**0**	**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.

Unit II	**X-RAY DIFFRACTION**	**9**	**0**	**0**	**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.

Unit III	**ELECTRON MICROSCOPY**	**9**	**0**	**0**	**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.

Unit IV	**SPECTROSCOPIC TECHNIQUES**	**9**	**0**	**0**	**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.

Unit V	**THERMAL ANALYSIS AND ADVANCED CHARACTERIZATION TECHNIQUES**	**9**	**0**	**0**	**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+0) = 45 Hours

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

Reference Books:	
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.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Discuss the principles of metallurgical microscope, optical properties and various illumination techniques.	L2: Understanding
CO2	:	Analyze the various diffraction methods, X-ray diffractometer and determination of crystal parameter.	L4:Analysing
CO3	:	Discuss the principles of TEM, SEM, EPMA.	L2: Understanding
CO4	:	Explain various spectroscopic techniques,	L2: Understanding
CO5	:	Discuss the chemical and thermal analysis using advanced methods.	L2: Understanding

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	`1		1	1								1		1	
CO2	1	1	1	1		1							1			1
CO3	1		1			1	1					1	1			1
CO4	1	1		1	1							1	1			1
CO5	1	1		1	1								1		1	
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0					1.0	1.0		1.0	1.0
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)																

18MTM07	AUTOMOTIVE, AEROSPACE AND DEFENCE MATERIALS		Semester			
PREREQUISITES			OE	Credit		3
Engineering physics		Hours/Week	L	T	P	TH
			3	0	0	3

Course Learning Objectives

1	To understand the properties and applications various materials suitable for automobile, aircraft and defnce industries and its components.

Unit I	**MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS**	**9**	**0**	**0**	**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**	**0**	**0**	**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**	**0**	**0**	**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**	**0**	**0**	**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**	**0**	**0**	**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+0) = 45 Hours

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

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	Describe the materials selection criteria for engine and transmission systems.	L2: Understanding
CO2	:	Analyze the different materials used for automotive structures and Different electronic materials for automotive applications.	L4:Analysing
CO3	:	Explain various topics such as elements of aerospace materials and mechanical behaviour of materials,	L2: Understanding
CO4	:	Compare the ceramics and composites of aerospace materials	L4:Analysing
CO5	:	Examine the fuels for nuclear materials.	L3:Applying

COURSE ARTICULATION MATRIX

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	1		1	1								1	1		
CO2	1	1	1			1							1	1		
CO3	1			1	1								1		1	
CO4	1	1	1				1						1			1
CO5	1	1		1	1								1			1
Avg.	1.0	1.0	1.0	1.0	1.0	1.0	1.0						1.0	1.0	1.0	1.0

3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)