NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

CURRICULUM

OF

BACHELOR OF TECHNOLOGY IN METALLURGICAL AND MATERIALS ENGINEERING

2017 ONWARD UNDERGRADUATE ADMISSION BATCH

V0:

Resolution of 50th Senate	18-05-2018	Item no: 50.7
Resolution of 51st Senate	04-10-2018	Item no: 51.2
Resolution of UGAC meeting	10-05-2019	
Final approval in 53rd Senate	13-05-2019	Item no: 52.3
Publication date	30-05-2019	

V1:

Incorporation of new elective subjects	27-06-2019

V2:

Rectification of minor errors	UGAC 31-08-2022

Final Approval in 67th Senate dated 20/09/2022 vide Item no: # 67.3

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

Program Name: Bachelor of Technology in Metallurgical and Materials Engineering

DETAILED CURRICULUM

CURRICULUM OF 2021 ONWARD UNDERGRADUATE ADMISSION BATCH FOR METALLURGICAL AND MATERIALS ENGINEERING - B.TECH.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional/ practical hour/ week

C= Subject credit point; H= Subject contact hour/ week.

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31
Semester - II							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

CURRICULUM AND SYLLABUS FOR B.TECH. IN METALLURGICAL AND MATERIALS ENGINEERING

Semester - III							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC331	Mathematics- III	3	1	0	4.0	4
2	MMC301	Metallurgical Thermodynamics and Kinetics	3	1	0	4.0	4
3	MMC302	Introduction of Metallurgy and Materials	3	1	0	4.0	4
4	MMC303	Non - Ferrous Process Metallurgy	3	1	0	4.0	4
5	ESC332	Economic Geology	3	0	0	3.0	3
6	ESS382	Economic Geology Laboratory	0	0	3	1.5	3
7	MMS351	Metallurgical Thermodynamics and Kinetics Laboratory	0	0	3	1.5	3
8	XXS381	Co-curricular Activities - III (Optional)	0	0	0	0.0	0
		TOTAL	**15**	**4**	**6**	**22.0**	**25**
Semester - IV							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MMC401	Transport Phenomena in Metallurgical Processes	3	1	0	4.0	4
2	MMC402	Phase Transformation and Phase Equilibria	3	1	0	4.0	4
3	MMC403	Materials Characterization	3	1	0	4.0	4
4	YYO44*	Open Elective - I	3	0	0	3.0	3
5	CSC433	Data Structures	3	0	0	3.0	3
6	CSS483	Data Structures Laboratory	0	0	3	1.5	3
7	MMS451	Transport Phenomena Laboratory	0	0	3	1.5	3
8	MMS452	Phase Transformation and Phase Equilibria Laboratory	0	0	3	1.5	3
9	XXS481	Co-curricular Activities - IV (Optional)	0	0	0	0.0	0
		TOTAL	**15**	**3**	**9**	**22.5**	**27**
Semester - V							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MMC501	Manufacturing Processes	3	1	0	4.0	4
2	MMC502	Heat Treatment of Materials	3	1	0	4.0	4
3	MMC503	Fundamentals of Plastic Deformation and Strengthening of Materials	3	1	0	4.0	4
4	MMC504	Iron Making	3	1	0	4.0	4
5	YYO54*	Open Elective - 2	3	0	0	3.0	3
6	MMS551	Manufacturing Processes Laboratory - I	0	0	3	1.5	3
7	MMS552	Heat Treatment of Materials Laboratory	0	0	3	1.5	3
8	MMS553	Plastic Deformation and Strengthening of Materials Laboratory	0	0	3	1.5	3
9	XXS581	Co-curricular Activities - V (Optional)	0	0	0	0.0	0
		TOTAL	**15**	**4**	**9**	**23.5**	**28**

Semester - VI							
Sl.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	HSC631	Economics and Management Accountancy	3	0	0	3.0	3
2	MMC601	Steel Making	3	1	0	4.0	4
3	MMC602	Mechanical Working of Materials	3	0	0	3.0	3
4	MME610 --	Depth Elective - 1	3	0	0	3.0	3
5	MME610 --	Depth Elective - 2	3	0	0	3.0	3
6	MMS651	Mineral Beneficiation Laboratory	0	0	3	1.5	3
7	MMS652	Mechanical Working of Materials Laboratory	0	0	3	1.5	3
8	MMS653	Material Characterization Laboratory -I	0	0	3	1.5	3
9	XXS681	Co-curricular Activities - VI (Optional)	0	0	0	0.0	0
		TOTAL	15	1	9	20.5	25
Semester - VII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MSC731	Principles of Management	3	0	0	3.0	3
2	MME710 --	Depth Elective - 3	3	0	0	3.0	3
3	MME710 --	Depth Elective - 4	3	0	0	3.0	3
4	MME710 --	Depth Elective - 5	3	0	0	3.0	3
5	YYO74*	Open Elective - 3	3	0	0	3.0	3
6	MMS751	Manufacturing Processes Laboratory - II	0	0	3	1.5	3
7	MMS752	Material Characterization Laboratory -II	0	0	3	1.5	3
8	MMS753	Ferrous Process Metallurgy Laboratory	0	0	3	1.5	3
9	MMS754	Vocational Training / Summer Internship and Seminar	0	0	2	1.0	2
10	MMS755	Project - I	0	0	3	1.0	3
		TOTAL	15	0	14	21.5	29
Semester - VIII							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MME810 --	Depth Elective - 6	3	0	0	3.0	3
2	YYO84*	Open Elective - 4	3	0	0	3.0	3
3	YYO85*	Open Elective - 5	3	0	0	3.0	3
4	MMS851	Project - II	0	0	15	5.0	15
5	MMS852	Project Seminar	0	0	0	1.0	0
6	MMS853	Viva Voce	0	0	0	1.0	0
		TOTAL	9	0	15	16.0	24

CURRICULUM AND SYLLABUS FOR B.TECH. IN METALLURGICAL AND MATERIALS ENGINEERING

CREDIT UNIT OF THE PROGRAM:

Semester	I + II	III	IV	V	VI	VII	VIII	TOTAL
Credit Unit	45.0	22.0	22.5	23.5	20.5	21.5	16.0	171.0

DEPTH ELECTIVE COURSE BASKETS

THE STUDENTS PRIMARILY WILL OPT FROM THE DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED IN A PARTICULAR SEMESTER BY HIS/ HER OWN DEPARTMENT. HOWEVER, A STUDENT CAN OPT FOR DEPTH ELECTIVE SUBJECT(S) THAT ARE OFFERED BY OTHER DEPARTMENT IN A PARTICULAR SEMESTER, WITH THE PERMISSION/ CONSENT FROM HIS/ HER HEAD OF THE DEPARTMENT AND THE CONCERNED TEACHER OF THAT SUBJECT.

6th Semester

	DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
MME610	Engineering Materials
MME611	Electronic and Thermal Properties of Materials
MME612	Alternative Routes of Iron Making
MME613	Production of Ferroalloys
MME615	Ceramic Technology
MME616	Solidification Phenomena
MME617	Metal Joining Processes

7th Semester

	DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
MME710	Functional Materials
MME711	Fatigue, Creep and Fracture
MME712	Computational Materials Engineering
MME713	Fuel, Furnace and Refractories
MME714	Powder Metallurgy
MME715	Secondary Steel Making
MME716	Composite Materials
MME717	Corrosion Engineering
MME718	Energy and Environment in Metallurgical Industries

8th Semester

	DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
MME810	Nano Science and Technology
MME811	FEM Modelling and Simulation for Materials Design
MME812	Mathematical Modelling and Simulation
MME813	Raw Materials Preparation for Iron and Steel Making

DETAILED SYLLABUS
FIRST SEMESTER

Semester - I							
Sl. No	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	MAC01	Mathematics - I	3	1	0	4.0	4
2	PHC01	Engineering Physics	2	1	0	3.0	3
3	CYC01	Engineering Chemistry	2	1	0	3.0	3
4	XEC01	Engineering Mechanics	2	1	0	3.0	3
5	ESC01	Environmental Science	2	0	0	2.0	2
6	XES51	Engineering Graphics	1	0	3	2.5	4
7	HSS51	Professional Communication Laboratory	1	0	2	2.0	3
8	PHS51	Physics Laboratory	0	0	2	1.0	2
9	CYS51	Chemistry Laboratory	0	0	2	1.0	2
10	WSS51	Workshop Practice	0	0	3	1.5	3
11	XXS51	Co-curricular Activities - I	0	0	2	1.0	2
		TOTAL	13	4	14	24.0	31

Department of Mathematics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MAC 01	MATHEMATICS - I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic concepts of function, limit, differentiation, and integration.		CT+MT+EA					
Course Outcomes	• CO1: To introduce the fundamentals of differential calculus of single and several variables • CO2: To develop the basic concepts of integral calculus including multiple integrals and its application in finding area, volume, centre of mass, centre of gravity etc. • CO3: To introduce the fundamental concepts of vector calculus • CO4: To develop the concept of convergence						
Topics Covered	**Functions of Single Variable:** Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8) **Functions of several variables:** Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10) **Sequences and Series:** Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's						

	ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6) **Integral Calculus:** Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms. (12) **Multiple Integrals:** Double integrals, Evaluation of double integrals, Evaluation of triple integrals, change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10) **Vector Calculus:** Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10th ed., Wiley India Ed. (2010). 2. Daniel A. Murray, Differential, and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2014. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11th Ed., Addison Wesley.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	2	3	2	3	1	1	-	-	1	1	1	2
	CO2	2	3	2	3	-	1	-	-	1	1	2	2
	CO3	2	3	2	3	-	1	1	-	-	2	2	2
	CO4	3	3	2	3	1	1	-	1	-	2	1	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	**Engineering Physics**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal						

	propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. A Text Book of Oscillations and Waves, M. Goswami and S. Sahoo, Scitech Publications 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 2. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 3. Fundamental of Optics, Jankins and White, McGraw-Hill 4. Optics, A. K. Ghatak, Tata McGraw-Hill 5. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 6. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CYC 01</td><td>Engineering Chemistry</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">None</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption, and catalytic processes for engineering applications
• CO2: To learn fundamentals of polymer chemistry and petroleum engineering.
• CO3: Introduced to basic spectroscopic techniques for structure determination and characterization.
• CO4: To study few inorganic and bioinorganic compounds of industrial importance.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">ORGANIC CHEMISTRY
i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb’s catalyst and Wittig reaction. (3)
ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific, and stereo-selective reactions. (3)
iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber, and plastic materials. Conducting polymer. (2)
iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2)
v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3)
INORGANIC CHEMISTRY
i. Coordination Chemistry: Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism, and stereochemistry. (5)
ii. Bioinorganic Chemistry: Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3)
iii. Inorganic Materials: Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2)
iv. Organometallic Chemistry: π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4)
PHYSICAL CHEMISTRY
i. Thermodynamics: 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4)
ii. Chemical Kinetics: 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4)</td></tr>
</table>

	iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation, and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference material	Suggested Text Books: (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu. (iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall Suggested Reference Books: **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introductionand Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYC 01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	-	2	-	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**ENGINEERING MECHANICS**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Acquire knowledge of mechanics and ability to draw free body diagrams. • CO2: Apply knowledge of mechanics for solving special problems like truss and frame analysis. • CO3: Ability to calculate centroid, moments of inertia for various shapes. • CO4: Learn momentum and energy principles. • CO5: Knowledge on virtual Work Principle and its application						
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free						

	body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]
Text Books, and/or reference material	1) S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2) J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3) F P Beer and E R Johnston, Vector Mechanics for Engineers 4) I H Shames, Engineering Mechanics

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC01	**Environmental Science**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	• CO1: Understand the importance of environment and ecosystem. • CO2: Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • CO3: Understand the scientific basis of local and as well as global issues.						

	• CO4: Apply of knowledge to develop sustainable solution.
Topics Covered	**Introduction:** Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2] Human population and the Environment. [1] Social issues and the Environment. [1] **Constituents of our Environment & the Natural Resources:** Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5] Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4] Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5] Biosphere– its components; Ecosystems and Ecology; Biodiversity; Biomes. [5] Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3] **Pollution:** Pollutants and their role in air and water pollution. [2]
Text Books, and/or reference material	1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005 2.Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006. 3.Principles of Environmental Science and Engineering – P. V. Rao, PHI. 4. Environmental Science and Engineering – Meenakshi, Prentice Hall India. 5.Environmental studies – R. Rajagopalan – Oxford Publication - 2005. 6. Text book of Environmental Science & Technology – M. A. Reddy – BS Pub.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES51	**ENGINEERING GRAPHICS**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Ability of mental visualization of different objects • CO2: Theoretical knowledge of orthographic projection to solve problems on one/two/three dimensional objects • CO3: Able to read/interpret industrial drawing and to communicate with relevant people						
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of						

	points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… Engineering Drawing – N D Bhat 3)… Practical Geometry and Engineering Graphics – W Abbott

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	Professional Communication Lab	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners • CO3: Improvement in social connectivity skill						
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2)						

	10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana& Savitha (Cambridge UP) **Reference Books:** 1. English for Engineers -Sudharshana & Savitha (Cambridge UP) 2. Effective Technical Communication-M A Rizvi (McGraw Hill Education) 3. References to relevant NPTEL, MOOC, SWAYAM courses be given by the Instructor

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
HSS51	CO1	1	_	_	1	_	1	_	1	2	3	1	_
	CO2	1	_	_	1	_	2	_	2	2	3	2	_
	CO3	_	_	_	1	_	3	_	3	3	3	2	_

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHS51	**Physics Laboratory**	PCR	**0**	**0**	**2**	**2**	**1**

Pre-requisites	Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))
NIL	CE+EA
Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Mazumdar and B. Ghosh 2) Practical Physics – Worsnop and Flint

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1

Correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**CHEMISTRY LABORATORY**	PCR	0	0	2	2	1

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
None	CT+EA

Course Outcomes	• CO1: To learn basic analytical techniques useful for engg applications. • CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. • CO3: Learn chromatographic separation methods. • CO4: Applications of spectroscopic measurements.
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of we acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amou of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determ. of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, Fe(acac cis-bis(glycinato)copper (II) monohydrate and their characterization by m. p FTIR etc. vi. Synthesis and charact. of organic compounds: e.g.Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron prese in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil
	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu&Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
WSS51	**WORKSHOP PRACTICE**	PCR	**0**	**0**	**3**	**3**	**1.5**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Study and practice on machine tools and their operations • CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding • CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping • CO4: Develop basic electrical engineering knowledge for house wiring practice
Topics Covered	**M/c shop & Carpentry shop -- 3X3= 9hrs.** • Introduction on machining process. • Introduction to machine tools- Lathe, Shaper, Milling and Drill machine. • Introduction to woods- Types, structure, disease and defect of wood. • Introduction to wood working machines and tools. • Making of dovetail joint and bridle joint. **Welding Shop & Sheet metal -- 3X3= 9hrs.** • Introduction to welding.Safety and precautions in welding. • Formation of weld bead by SMAW on mild steel flat. • Formation of weld bead by oxy-fuel welding on mild steel flat. • Introduction to sheet Metal works. • Tools and Machines used in sheet metal works. • Concept of development, marking out of metal sheets. • Cutting and joining of metal sheets. • Safety precautions, General warning needed in the shop floor. **Black smithy & Foundry -- 3X3= 9hrs.** • Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels. • Safety and precautions in blacksmithy. • Making of bars of different cross-sections. • Making of hexagonal headed bolts. • Forge welding. • Introduction to Foundry Technology.

	• Preparation of sand mould using Solid/Split Pattern. **Fitting & Electrical shop -- 3X3= 9hrs.** • Introduction to hand metal cutting tools with specifications, nomenclature and their use. • Marking tools, measuring tools and their use. • Fitting of joints of mild steel flats. • Introduction to electrical hazards and safety precaution. • Wire jointing and soldering. • PVC Conduit Wiring controlled by separate single way switches. • PVC Cashing Capping Wiring for two-way switches. • Conduit wiring for the connection of a Calling Bell with In& Out Indicators. • Batten Wiring and Cleat Wiring. • Tube Light Connection. • Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXS-51	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	CT+EA

Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service
Topics	**YOGA**

Covered	• Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardhakurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- PavanaMuktasana, UttanaPadasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yognidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardhachandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, AnulomVilom, Suryabhedi, Chandrabhedi. • Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch & Block start. • Finishing Techniques. • Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules. • Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance. **BASKETBALL** • Introduction and Players stance and ball handling. • Passing- Two hand chest pass, two hand bounce pass, One hand baseball pass, Side arm pass, Overhead pass, Hook pass. • Receiving- Two hand receiving, one hand receiving, receiving in stationary position, Receiving while jumping and Receiving while running. • Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble. • Rules of Basketball. • Basketball game. **VOLLEYBALL** • Introduction of Volleyball • Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service. • Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set. • Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET**

- Introduction of Cricket
- Batting gripping & Stance, Bowling gripping technique.
- Batting front foot defense& Drive.
- Batting Back foot defense& Drive.
- Batting Square cut.
- Bowling medium pace, Bowling off break.
- Fielding drill, Catching (Short & High).
- Rules & Regulation.

BADMINTON

- Basic introduction about Badminton and Badminton court.
- Racket parts, Racket Grip, Shuttle Grip.
- Basic stance, Basic Footwork, Shadow practice (Full court movement).
- Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm.
- Match practice (Single & Double).
- Rules & Regulation.

TABLE TENNIS

- Introduction of Table Tennis.
- Basic Stance and Grip (Shake hand & Pen hold).
- Service Basic.
- Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash.
- Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash.
- Rules and their interpretations.
- Table Tennis Match (Singles & Doubles).

NCC

- FD-1 General Introduction and words of command.
- FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt.
- FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing.
- FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out.
- FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt.
- FD-7 Turning on the March and Wheeling.
- FD-12 Parade practice.

TAEKWONDO

- Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc.
- Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc.
- Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc.
- Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdalchagi (Butterfly kick), Back kick etc.

NSS

- Swachha Bharat Mission

	• Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • MatribhashaSaptah celebration

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SECOND SEMESTER

Sl. No	Code	Subject	L	T	S	C	H
1	MAC02	Mathematics - II	3	1	0	4.0	4
2	CSC01	Introduction to Computing	2	1	0	3.0	3
3	ECC01	Basic Electronics	2	1	0	3.0	3
4	EEC01	Electrical Technology	2	1	0	3.0	3
5	BTC01	Life Science	2	0	0	2.0	2
6	XXC01	The Constitution of India and Civic Norms	1	0	0	1.0	1
7	XES52	Graphical Analysis using CAD	0	0	2	1.0	2
8	CSS51	Computing Laboratory	0	0	2	1.0	2
9	ECS51	Basic Electronics Laboratory	0	0	2	1.0	2
10	EES51	Electrical Technology Laboratory	0	0	2	1.0	2
11	XXS52	Co-curricular Activities - II	0	0	2	1.0	2
		TOTAL	12	4	10	21.0	26

<table>
<tr><td colspan="7">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MAC 02</td><td>MATHEMATICS - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic concepts of set theory, differential equations, and probability.</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems.
• CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations.
• CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work.
• CO4: To grasp the basic concepts of probability theory.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Elementary algebraic structures: Group, subgroup, ring, subring, integral domain, and field. (5)
Linear Algebra: Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15)
Ordinary Differential Equations: Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions,</td></tr>
</table>

	Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12) **Fourier series:** Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4) **Laplace and Fourier Transforms:**Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10) **Probability:** Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)
Text Books, and/or reference material	**Text Books:** 1. E. Kreyszig, Advanced Engineering Mathematics: 10thed, Wiley India Ed. (2010). 2. Gilbert Strang, Linear algebra and its applications (4th Ed), Thomson (2006). 3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Ed (2017). **Reference Books:** 1. S. Kumaresan, Linear algebra - A Geometric approach, PHI (2000). 2. C. Grinstead, J. L. Snell, Introduction to Probability, American Math. Society.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC02	CO1	3	3	2	1	2	-	2	-	-	-	1	2
	CO2	3	3	2	2	2	-	2	-	-	1	-	2
	CO3	3	3	2	2	3	1	1	-	1	1	1	2
	CO4	3	2	1	3	2	1	1	1	1	-	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**INTRODUCTION TO COMPUTING**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Basic knowledge of computer.		CT+MT+EA					
Course Outcomes	CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's (operating Systems) and application software's, languages, number system, logic gates. CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators. CO3: Develop conditional and iterative statements to write C programs. CO4: Exercise user defined functions to solve real time problems						

	CO5: Inscribe C programs that use Pointers to access arrays, strings and functions. CO6: Exercise user defined data types including structures and unions to solve problems.
Topics Covered	Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices. [2] Languages: Assembly language, high level language, compiler, and assembler (basic concepts) [1] Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates. [2] Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart. [1] C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements. [2] Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence, and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8] Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels. [5] Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5] Arrays and Pointers: One-dimensional, two-dimensional arrays, pointers and functions, multi-dimensional arrays. [10] Structures Union and File: Structure, union, structures and functions, arrays of structures, file read, file write.[5]
Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>ECC01</td><td>Basic Electronics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">(10+2) level mathematics and physics</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Knowledge of Semiconductor physics and devices.
• CO2: Have an in depth understanding of basic electronic circuit, construction, operation.
• CO3: Ability to make proper designs using these circuit elements for different applications.
• CO4: Learn to analyze the circuits and to find out relation between input and output.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Semiconductors
1.1. Concept of band formation in solids; Fermi-Dirac distribution function, concept of Fermi level, invariance of Fermi level in a system under thermal equilibrium
1.2. Definitions of insulator, conductor and semiconductor using band diagram
1.3. Crystalline structure of semiconductor
1.3.1. Covalent bond
1.3.2. Generation of holes and electrons
1.3.3. Effect of temperature on semiconductor
1.4 Intrinsic semiconductor
1.5 Doping and Extrinsic semiconductor
1.5.1 n-Type semiconductor and band diagram
1.5.2 p-Type semiconductor and band diagram
1.5.3 Mass-action law of semiconductor
1.6. Conductivity of semiconductor (including mathematical expression)
1.7 Carrier transport phenomenon. (03 hrs.)
2. Diodes
2.1. Construction
2.2. Unbiased diode; Depletion layer and Barrier potential; junction capacitance (expression only)
2.3. Principle of operation with forward biasing and reverse biasing
2.4. Characteristics
2.5 Diode’s three models/equivalent circuits.(02 hrs.)
3.Diode Circuits
3.1 Diode rectifier
3.1.1 Half wave rectifier
3.1.2 Full wave rectifier:centre tap and bridge rectifier
3.1.3 Capacitive filter and DC power supply (Numerical problems)
3.2 Special Diodes
3.2.1 Zenerdiode: Avalanche breakdown and Zener breakdown and characteristics.
3.2.2 Zener diode as a voltage regulator
3.2.3 Displaydevices: LED and LCD. (03 hrs.)
4.Bipolar Junction Transistor (BJT)</td></tr>
</table>

	4.1 n-p-n and p-n-p transistor and their constructions 4.2 Principle of operation 4.3 Transistor configuration: common base, common emitter, and common collector 4.4 Transistor characteristics: input and output characteristics of CB and CE configurations 4.5 DC load line: quiescent (Q) point; cut-off, active, and saturation region 4.6 Amplifier: Principle of operation 4.7 Transistor as a switch. (04 hrs.) 5.**Transistor Biasing** 5.1 Need of biasing 5.2 Methods of biasing: base resistor or fixed bias, emitter feedback, voltage divider biasing 5.3 Stability of Q-point (qualitative discussions) 5.4 (Numerical problems). (02 hrs.) 6.**Single Stage Amplifier:** classification of amplifiers (voltage amplifier, current amplifier, power amplifier etc.) Class-A CE Amplifier with coupling and bypass capacitors, Qualitative discussions of magnitude characteristics of frequency response (graph only) (02 hrs.) 7.**Feedback Amplifier** 7.1 Positive and negative feedback 7.2 Deduction of gain with negative feedback, explanation of stability of gain with negative feedback, other effects of negative feedback (no deduction), numerical problems. (03 hrs.) 8.**Other Semiconductor Devices** 8.1 JFET: Construction, principle of operation, characteristics 8.2 MOSFET: Construction, principle of operation, characteristics 8.3 Power Electronic Device-SCR: Brief discussions. (02 hrs.) 9.**Operational Amplifier** 9.1 Characteristics of ideal operational amplifier 9.2 Pin Configuration of IC 741, 9.3 Analysis of simple operational amplifier circuits: concept of virtual ground; noninverting amplifier and inverting amplifier. 9.4 Applications: voltage follower, summer, differentiator, integrator, and comparator (04 hrs) 10.**Oscillator** 10.1 Positive feedback and condition of oscillation 10.2 R-C phase-shift oscillator, Wien bridge oscillator.(02 hrs.) 11.**Boolean Algebra** 11.1 Boolean algebra, De Morgan's theorem, simplification of Boolean expressions 11.2 Number system, range extension of numbers, overflow 11.3 Different codes: gray code, ASCII code and BCD codes and them Applications. (01 hrs.) 12. **Logic Gates** 12.1 NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates 12.2 Simplification of logic functions 12.3 Realizations of logic expressions using logic gates. (01 hrs.) 13. CRO and its applications and other test and measurement instruments. (01

	hrs.)
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates, 7/e. Reference Books: 1. Integrated Electronics by Millman, Halkias and Parikh, 2/e, McGrawHill. 2. ELECTRONICS Fundamentals and Applications by Chattopadhyay and Rakshit,15/e, New Age Publishers. 3. The Art of Electronics by Paul Horowitz, Winfield Hill, 2/e, Cambridge University. 4. Electronics - Circuits and Systems by Owen Bishop, 4/e, Elsevier. 5. Electronics Fundamentals: Circuits, Devices & Applications by Thomas L. Floyd & David M. Buchla, 8/e, Pearson Education.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECC01	CO1	2	3	2	2	-	1	-	-	-	-	-	1
	CO2	3	2	1	2	2	1	-	2	2	-	-	1
	CO3	3	2	2	2	3	-	-	-	2	-	-	1
	CO4	3	3	2	2	-	-	-	-	2	-	-	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC01	ELECTRICAL TECHNOLOGY	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), Mid Term (MT), and end assessment (EA))					
NIL		CT+MT+ EA					
Course Outcomes	Upon successful completion of this course, the student should be able to • CO1: learn the fundamentals of Electric Circuits and Network theorems and analysis of electrical network based on these concepts. • CO2: develop an idea on Magnetic circuits, Electromagnetism and learning the working principles of some fundamental electrical equipment's • CO3: learn about single phase and poly-phase AC circuits and analysis of such circuits based on these concepts. • CO4: introduce the basic concept of single-phase transformer. • CO5: analyze the transient phenomena in electrical circuits with DC excitation.						

Topics Covered	Introduction: Overview of Electrical power generation systems (2) Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (4) Network theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem (4) Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits. Analysis of coupled circuits (self-inductance, mutual inductance, and dot convention)(8) Transients with D.C. excitation for R-L and R-C circuits. (3) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behavior of A.C. circuits, Resonance in series and parallel R-L-C circuits. AC Network: Superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, solution of networks with AC sources. (10) Single-Phase Transformer, equivalent circuits, open circuit and short circuit tests (6) Poly-phase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)
Textbooks/Reference material	Textbooks: 1. Electrical & Electronic Technology by Hughes, Pearson Education India Reference Books: 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Edu India

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	LIFE SCIENCE	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
		CT+MT+EA					
Course Outcomes	CO1: Basic understanding of basic cellular organization of organisms and cellular communications, structure and functions of the macromolecules and their biosynthesis and cata--bolism.						

	CO2: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO3: To introduce molecular biology to understand biological processes in various applications. CO4: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO5: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them
Topics Covered	**1. Cell Biology (4)** a) Introduction to life science: prokaryotes & eukaryotes Definition; Difference b) Introduction to cells - Define cell, different types of cell c) Cellular organelles - All organelles and functions in brief d) Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** a) Biological function of carbohydrate and lipid - Introduction, structure and function b) Biological function of nucleic acids and protein - structure and function c) Catabolic pathways of Macromolecules - Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose- Glycolysis, TCA; overall degradation of proteins and lipids d) Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** a) Types of microorganisms and their general features - Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases b) Microbial cell organization - Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, c) Microbial nutritional requirements and growth - Different Sources of energy; growth curve d) Basic microbial metabolism - Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** a) Basic concept of innate and adaptive immunity - Immunity-innate and adaptive, differences, components of the immune system b) Antigen and antibody interaction - Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody c) Functions of B cell - B cell, antibody production, memory generation and principle of vaccination d) Role of T cell in cell-mediated immunity - Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** a) Prokaryotic Genomes (Genome organization & structure) - Nucleoid, circular or linear b) Eukaryotic Genomes (Genome organization & structure) - Intron, exon,

	packaging, chromatin c) Central Dogma (Replication, Transcription and Translation) d) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) - Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** a) Microbial growth kinetics - Batch, fed-batch and continuous systems, Monod Equation b) Enzyme kinetics, kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki c) Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization d) Thermodynamics of biological system - Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions e) Material and energy balance for biological reactions - Stoichiometry
Text Books, and/or reference material	1. Biotechnology 01 Edition, authored by U. Satyanarayana, BOOKS & ALLIED (P) LTD. 2. Biochemistry by Lehninger. McMillan publishers 3. Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill 4. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 5. Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. 6. Bioprocess Engineering: Basic Concepts (2nd Ed), Shuler and Kargi, PHI.

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-
	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XXC01	The Constitution of India and Civic Norms	PCR	1	0	0	1	1
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					
Course Outcomes	CO1: Elementary understanding of the evolution of historical events that led to the making of the Indian constitution, the philosophical values, basic structure and fundamental concerns enshrined in the Constitution of India.						

	CO2: Aware of the fundamental rights and duties as a citizen of the country. CO3: Enable to know the civic norms to be followed according to the Indian constitution
Topics Covered	**1.** Historical background of the Making of Indian Constitution (1 Hour) **2.** Preamble and the Philosophical Values of the Constitution (1 Hour) **3.** Brief Overview of Salient Features of Indian Constitution (1 Hour) **4.** Parts I & II: Territoriality and Citizenship (1 Hour) **5.** Part III: Fundamental Rights (2 Hours) **6.** Part IV: Directive Principles of State Policy (1 Hour) **7.** Part IVA: Fundamental Duties (1 Hour) **8.** Union Government: President, Prime Minister and Council of Ministers (2 Hours) **9.** Parliament: Council of States and House of the People (1 Hour) **10.** State Government: Governor, Chief Mister and Council of Ministers (1 Hour) **11.** State Legislature: Legislative Assemblies and Legislative Councils (1 Hour) **12.** Indian Judiciary: Supreme Court and High Courts (1 Hour) **13.** Centre-State Relations (1 Hour) **14.** Reservation Policy, Language Policy and Constitution Amendment (1 Hour)
Text Books, and/or reference material	Primary Readings: 1) P. M. Bakshi, *The Constitution of India*, 18th ed. (2022) 2) Durga Das Basu, *Introduction to the Constitution of India*, 25th ed. (2021) 3) J.C. Johari, *Indian Government and Politics*, Vol. II, (2012) Secondary Readings: Granville Austin, *The Indian Constitution: Cornerstone of a Nation* (1966; paperback ed. 1999); Granville Austin, *Working a Democratic Constitution: The Indian Experience* (1999; paperback ed. 2003).

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**GRAPHICAL ANALYSIS USING CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Introduction to graphical solution of mechanics problems • CO2: Knowledge on graphical solution methods for solving equilibrium in coplanar force system • CO3: Introducing Maxwell diagram and solution of plane trusses by graphical method • CO4: Determination of centroid of plane figures by graphical method • CO5: Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**COMPUTING LABORATORY**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To understand the principle of operators, loops, branching statements, function, recursion, arrays, pointer, parameter passing techniques • CO2: To detail out the operations of strings • CO3: To understand structure, union • CO4: Application of C-programming to solve various real time problems						
Topics Covered	**List of Experiments:** 1. Assignments on expression evaluation 2. Assignments on conditional branching, iterations, pattern matching 3. Assignments on function, recursion 4. Assignments on arrays, pointers, parameter passing 5. Assignments on string using array and pointers 6. Assignments on structures, union						
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS 51	**Basic electronics Lab**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire idea about basic electronic components, identification, and behavior. • CO2: To determine IV characteristics of these Circuit elements for different applications. • CO3: Learn to analyze the circuits and observe and relate input and output signals.						
Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits.: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit. 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.						
Text Books, and/or reference material	Text Books: 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul MalvinoDr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul MalvinoDr. and David J. Bates						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="7">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EES51</td><td>ELECTRICAL TECHNOLOGY LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">None</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1: understand the principle of superposition.
• CO2: understand the principle of maximum power transfer
• CO3: understand the characteristics of CFL, incandescent Lamp, carbon lamp.
• CO4: understand the calibration of energy meter.
• CO5: understand open circuit and short circuit test of single-phase transformer.
• CO6: analyze RLC series and parallel circuits
• CO7: understand three phase connections.
• C08: understand determination of B-H curve</td></tr>
<tr><td>Topics Covered</td><td colspan="6">List of Experiments:
1. To verify Superposition and Thevenin’s Theorem.
2. To verify Norton and Maximum power transfer theorem
3. Characteristics of fluorescent and compact fluorescent lamp
4. Calibration on energy meter
5. To perform the open circuit and short circuit test on single phase transformer
6. To study the balanced three phase system for star and delta connected load
7. Characteristics of different types of Incandescent lamps
8. Study of Series and parallel R-L-C circuit
9. Determination of B-H Curve for magnetic material</td></tr>
<tr><td>Textbooks, and/or reference material</td><td colspan="6">Textbooks:
1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma , H U Ezea
2. Laboratory Courses in Electrical Engineering (5th Edition) by S. G. Tarnekar, P. K. Kharbanda, S. B. Bodhke, S. D. Naik, D. J. Dahigaonkar (S. Chand Publications)</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	2	2	2	3
CO2	3	3	3	3	3	1	1	1	2	2	2	3
CO3	3	3	3	3	3	1	1	1	2	2	2	3
CO4	3	3	3	3	3	1	1	1	2	2	2	3
CO5	3	3	3	3	3	1	1	1	2	2	2	3
CO6	3	3	3	3	3	1	1	1	2	2	2	3
CO7	3	3	3	3	3	1	1	1	2	2	2	3

CO8	3	3	3	3	3	1	1	1	2	2	2	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours**				**Credit**
			Lecture (L)	**Tutorial (T)**	**Practical (P)#**	**Total Hours**	
XXS-52	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	**YOGA** • Sitting Posture/Asanas- Gomukhasana, Swastikasana, Siddhasana, Ustrasana, Janusirsasana, ArdhaMatsyendrasana (Half-Spinal Twist Pose), Paschimottanasana, Shashankasana, Bhadrasana. • Mudra- Vayu, Shunya, Prithvi, Varuna, Apana, Hridaya, Bhairav mudra. • Laying Posture/Asanas- Shalabhasana (Locust Posture), Dhanurasana (Bow Posture), ArdhaHalasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, SuptaVajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- ArdhaChakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), ParshwaKonasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadisodha, Shitali, Ujjayi, Bhastrika, Bhramari. • Bandha- Uddiyana Bandha, Mula Bandha, Jalandhara Bandha, Maha Bandha. • Kriya- Kapalabhati, Trataka, Nauli. **ATHLETICS** • Long Jump- Hitch kick, Paddling, Approach run, Take off, Velocity, Techniques, Flight & Landing • Discus throw, Javelin throw and Shot-put- Basic skill & Technique, Grip, Stance, Release & Follow through. • Field events marking. • General Rules of Track & Field Events. **BASKETBALL** • Shooting- Layup shot, Set shot, Hook shot, Jump shot. Free throw. • Rebounding- Defensive rebound, Offensive rebound. • Individual Defensive- Guarding the man without ball and with ball. • Pivoting.						

- Rules of Basketball.
- Basketball game.

VOLLEYBALL

- Spike- Straight spike, Body turn spike, Tip spike, Back attack, Slide spike, Wipe out spike.
- Block- Single block, Double block, Triple block, Group block.
- Field Defense- Dig pass, Double pass, Roll pass.
- Rules and their interpretation.

FOOTBALL

- Dribbling- Square pass, Parallel pass, Forward pass.
- Heading (Standing & Running)- Fore head, Side fore head, Drop heading, Body covering during heading.
- Kicking- Full volley, Half volley, Drop kick, Back volley, Side volley, Chiping (lobe).
- Tackling: Covering the angle, Chessing time sliding chese, Heading time shoulder tackle etc.
- Feinting- Body movement to misbalance the opponent and find space to go with ball.
- Rules of Football.

CRICKET

- Batting straight drive.
- Batting pull shot.
- Batting hook shot.
- Bowling good length, In swing.
- Bowling out swing, Leg break, Goggle.
- Fielding drill.
- Catching (Long & Slip).
- Wicket keeping technique.
- Rules & Regulation.

BADMINTON

- Net play- Tumbling net shot, Net Kill, and Net Lift.
- Smashing.
- Defensive high clear/Lob.
- Half court toss practice, Cross court toss drop practice, Full court Game practice.
- Player Positioning, Placements.
- Rules & Regulation.
- Doubles & Mixed doubles match practice.

TABLE TENNIS

- Stroke: Backhand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin.
- Stroke: Forehand- Topspin against push ball, Topspin against deep ball, Topspin against rally ball, Topspin against topspin.
- Stroke- Backhand lob with rally, Backhand lob with sidespin, Forehand lob with rally, Forehand lob with sidespin.
- Service: Backhand/Forehand- Push service, Deep push service, Rally service.
- Service: Backhand sidespin (Left to right & Right to left).
- Service: Forehand- High toss backspin service, High toss sidespin service, High toss reverse spin service.
- Rules and their interpretations.

- Table Tennis Match (Singles & Doubles).

NCC

- FD-6 Side pace, Pace Forward and to the Rear.
- FD-7 Turning on the March and Wheeling.
- FD-8 Saluting on the March.
- FD-9 Marking time, Forward March and Halt in Quick Time.
- FD-10 Changing step.
- FD-11 Formation of Squad and Squad Drill.
- FD-12 Parade practice.

TAEKWONDO

- Poomsae (Forms)- Jang, Yi Jang.
- Self Defense Technique- Self defense from arms, Fist and Punch.
- Sparring (Kyorugi)- One step sparring, Two step sparring, Fight (Free sparring).
- Combination Technique- Combined kick and punch.
- Board Breaking (Kyokpa)- Sheet breaking.
- Interpretation Rules above Technique of Taekwondo.

NSS

- No Smoking Campaign
- Anti- Terrorism Day Celebration
- Any other observation/celebration proposed by Ministry/institute
- Public Speaking
- Discussion on Current Affairs
- Viva voce

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
XXS52	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

CO-PO Mapping and Matrix

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MAC01	CO1	3	3	1	2	-	-	-	-	1	-	-	-
	CO2	3	3	1	2	-	-	-	-	1	-	-	-
	CO3	3	3	1	2	-	-	-	-	1	-	1	1
	CO4	3	-	-	2	-	2	-	-	1	-	-	-
PHC01	CO1	3	2	1	1	1	-	-	1	-	-	-	1
	CO2	3	2	-	2	-	-	-	-	-	-	-	1
	CO3	3	2	2	2	1	1	1	1	1	-	1	1
	CO4	3	2	2	2	1	1	1	-	1	-	1	1
CYC01	CO1	1	2	-	-	-	-	-	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	1	2	1	1	1	-	-	-	-	-	-	-

	CO4	-	1	-	-	2	-	1	-	-	-	-	-
XEC01	CO1	1	-	-	-	-	-	-	-	-	-	-	1
	CO2	1	1	1	1	-	-	-	-	-	-	-	1
	CO3	1	1	-	-	-	-	-	-	-	-	-	1
	CO4	1	2	-	-	-	-	-	-	-	-	-	1
	CO5	-	2	2	2	2	1	-	-	-	1	-	1
ESC01	CO1	3	-	-	-	-	-	2	-	-	-	-	-
	CO2	1	-	-	-	-	-	2	-	-	-	-	-
	CO3	2	-	-	-	-	-	2	-	-	-	-	-
	CO4	1	-	3	-	-	2	1	-	-	-	-	-
XES51	CO1	1	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	1	-	-	-	-	-	-	-	-	-	-
	CO3	1	-	1	-	-	-	-	-	-	-	-	-
HSS51	CO1	-	-	-	-	-	1	-	-	1	3	-	3
	CO2	-	-	-	-	-	2	-	-	2	3	-	3
PHS51	CO1	3	2	1	-	-	-	-	-	2	1	-	1
	CO2	3	2	1	-	-	1	-	-	2	1	-	1
	CO3	3	1	-	-	-	-	-	-	2	1	-	1
	CO4	3	2	-	1	-	1	1	-	2	1	-	1
	CO5	3	2	1	-	1	1	1	-	2	1	-	1
CYS51	CO1	2	1	-	1	-	-	-	-	-	-	-	-
	CO2	-	1	-	1	1	2	-	-	-	-	-	-
	CO3	2	-	-	1	1	-	-	-	-	-	-	-
	CO4	-	1	-	1	1	-	-	-	-	-	-	-
WSS51	CO1	2	-	-	-	-	1	-	-	-	1	-	-
	CO2	1	-	1	-	-	1	-	-	-	1	-	-
	CO3	1	-	2	-	-	1	-	-	-	1	-	-
	CO4	1	-	-	-	-	2	-	-	-	1	-	-
MAC02	CO1	2	3	1	3	-	-	-	-	2	-	-	-
	CO2	2	3	1	2	-	-	-	-	2	-	-	-
	CO3	2	2	2	3	2	-	-	-	3	-	1	1
	CO4	2	3	2	3	2	1	1	-	2	-	-	-
CSC01	CO1	3	1	2	1	-	-	-	-	-	-	-	-
	CO2	-	2	1	2	1	-	-	-	-	-	-	-
	CO3	1	2	-	-	3	-	-	-	-	-	-	-
	CO4	1	3	1	2	3	-	-	-	-	-	-	1
	CO5	2	1	-	-	3	-	-	-	-	-	-	-
	CO6	2	-	3	-	1	-	-	-	-	-	-	-
ECC01	CO1	-	-	-	-	-	-	-	-	-	-	-	-
	CO2	-	-	-	-	-	-	-	-	-	-	-	-
	CO3												
	CO4	-	-	-	-	-	-	-	-	-	-	-	-
EEC01	CO1	3	1	-	-	2	-	-	-	-	1	-	-
	CO2	2	3	2	-	2	-	-	-	-	-	-	-
	CO3	2	3	1	-	-	-	-	-	-	1	-	-
	CO4	3	1	2	-	1	-	-	-	-	-	-	-
	CO5	3	1	2	-	1	-	-	-	-	-	-	-
BTC01	CO1	2	1	1	-	1	-	-	-	-	-	-	-

	CO2	2	1	1	-	1	-	1	-	-	-	-	-
	CO3	2	1	1	-	1	-	-	-	-	-	-	-
	CO4	2	1	1	-	1	-	-	1	-	-	-	1
	CO5	2	1	1	-	1	1	1	-	-	-	-	-
XES52	CO1	2	-	-	-	-	-	-	-	-	-	-	-
	CO2	1	2	-	-	-	-	-	-	-	-	-	-
	CO3	2	1	-	-	-	-	-	-	-	-	-	-
	CO4	2	1	-	-	-	-	-	-	-	-	-	-
	CO5	1	-	-	-	2	-	-	-	-	-	-	-
CSS51	CO1	3	-	1	-	-	-	-	-	-	-	-	-
	CO2	-	2	1	3	-	-	-	-	-	-	-	-
	CO3	-	1	-	2	1	-	-	-	-	-	-	-
	CO4	-	-	3	2	-	-	1	-	-	-	2	-
ECS51	CO1	3	2	1	2	2	1	-	-	2	-	-	-
	CO2	3	2	2	2	3	-	-	-	2	-	-	-
	CO3	3	3	2	2	-	-	-	-	2	-	-	-
EES51	CO1	3	-	2	-	3	-	-	-	1	-	-	-
	CO2	3	-	2	-	3	-	-	-	1	-	-	-
	CO3	2	3	2	2	1	-	2	-	1	-	-	-
	CO4	2	3	1	2	2	-	1	-	1	1	-	-
	CO5	2	3	1	2	2	-	-	-	1	-	-	-
	CO6	2	3	2	2	2	-	-	-	1	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-
XXS51	CO1	-	-	-	-	-	2	-	-	3	-	-	-
	CO2	-	-	-	-	-	-	-	2	-	-	-	-
	CO3	-	-	-	-	-	-	1	-	-	-	-	3
	CO4	-	-	-	-	-	-	-	-	2	2	-	-
	CO5	-	-	-	-	-	3	1	-	-	-	-	-

THIRD SEMESTER

<table>
<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC331</td><td>Mathematics- III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of topics included in MAC01 & MAC02</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
• CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
• CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
• CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Partial Differential Equations (PDE): Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14]
Numerical Methods: Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange’s interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson’s 1/3 rule for numerical integration; Euler’s method and modified Eular's methods for solving first order differential equations. [14]
Complex Analysis: Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy’s integral theorem; Cauchy’s integral formula; Taylor’s theorem, Laurent’s theorem (Statement only); Singular points and residues; Cauchy’s residue theorem. [17]
Optimization:
Mathematical Preliminaries: Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2]
Linear Programming Problem (LPP): Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. An Elementary Course in Partial Differential Equations-T. Amarnath
2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K. Jain.
3. Foundations of Complex Analysis- S. Ponnuswami</td></tr>
</table>

	4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg 5. Advanced Engineering Mathematics- E. Kreyszig **Reference Books:** 1. Complex Analysis-L. V. Ahfors 2. Elements of partial differential equations- I. N. Sneddon 3. Operations Research- H. A. Taha

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC301	Metallurgical Thermodynamics and Kinetics	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CYC01: Engineering Chemistry		CT+MT+EA					
Course Outcomes	CO1: Acquire the knowledge of thermodynamic laws to apply in metallurgical processes and materials. CO2: Identify the feasibility of metallurgical processes and reactions. CO3: Learn to analyze the kinetics of metallurgical processes and design the alloy systems by applying the concepts of thermodynamics.						
Topics Covered	Definitions, behaviour of gasses, vapours and gaseous moisture, materials balances in metallurgical processes. (4) First law of thermodynamics, Heat and work changes in reversible processes, Concept of Heat Capacity, Enthalpy energy balance in metallurgical processes, Reversible adiabatic process. (4) The Carnot cycle, concept of entropy, Entropy changes in reversible, irreversible processes and universe, Clausius inequality, Combined statement of first and second law, Entropy change for irreversible chemical reactions. (6) Helmholtz free energy and the Gibbs free energy, Free-energy equations in differential form, Thermodynamic potentials, The Maxwell relations, Criteria of equilibrium and spontaneity (or irreversibility), The Gibbs-Helmholtz equation, Third law of thermodynamics. (6) Concept of chemical potential, Chemical potential of oxygen, partial molar quantities, Integral molar quantities, Raoult's law and Henry's law, Alternative standard states,Sievert's law, Mixing function, Excess function, Regular solution, concept of interaction parameter. (13)						

	Fugacity, Activity, standard state, equilibrium constant, Van't Hoff reaction isotherm,Le Chatelier's Principle, Free-energy Charts and Ellingham diagrams, Gas-solid reaction, Van't Hoff equation, Sigma Function (Σ), Clausius-Clapeyron Equation, Trouton's Rule. (8) Types of electrochemical cells, Laws of electrolysis, determination of thermodynamics quantities using reversible electrochemical cells, Electrochemical cell based on solid electrolytes. (3) Types of reaction, Order of reaction, Determination of order and rate constant of a reaction. (6)
Text Books, and/or reference material	Suggested Text Books: 1. Introduction to Metallurgical Thermodynamics – David R Gaskell. 2. Metallurgical 2. Textbook of Materials and Metallurgical Thermodynamics –A. Ghosh 3. Thermochemistry – O. Kubaschewski, E LL Evans and C B Alcock Suggested Reference Books: 1. Stoichometry and thermodynamics of Metallurgical processes - Y K Rao. 2. Problems in Metallurgical Thermodynamics and Kinetics – G S Upadhyay and R K Dube. 3. Chemical Kinetics - Keith Laidler.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	1	1	1	1	1
CO2	2	3	1	1	1	1	1	1	1	1	1	1
CO3	1	2	3	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core(PCR) / Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC302	Introduction to Metallurgy and Materials	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
PHC01: Engineering Physics		CT+EA					
Course Outcomes	I. To correlate atomic structure, periodic table, elemental properties, chemical bonding and material properties. II. To interpret crystal structure in view of translational periodicity and symmetry and as well as to introspect different kinds of defects in a crystal. III. To study the binary phase diagrams and a brief introduction to different engineering materials.						
TopicsCovered	Atomic Structure and chemical Bonding: Quantum mechanical approach, Schrödinger wave equation, wave function, Quantum state, Periodic Table, electronic configuration and atomic structure. Bonding in solids, different types						

	of bonds, Bond energy, effect of bonding on material properties. (10) Structure of Solids: The crystalline and the noncrystalline states – Metals and Alloys,Ceramics,semiconductorsandpolymers;Crystalstructure– conceptoflatticeandcrystal,Translationalperiodicityandsymmetry,crystalsystems,spacelattice,representationofatomicposition,latticedirectionsandlatticeplanesincubicandhexagonalsystems;atomicpacking,voidsinFCC,BCCandHCPcrystals;crystalimperfections– point defect, line defect, surface defect and volume defect; equilibrium concentration of point defect. (12) Solidification of metals and alloys including Rapid Solidification Technology (6) Phase diagrams: The phase rule, single component system. Binary phase diagrams with reference to a few important metallic systems. (6) Corrosion and oxidation of materials: The principles of corrosion; Protection against corrosion; Mechanism of oxidation; Oxidation resistant materials. (6) Introduction to Materials (Classification, Selection and Applications): Metals and Alloys, Intermetallics, Polymers, Glasses and Ceramics, Composite Materials, nano-crystalline materials. (10)
Text Books,and/orreferencematerial	Text Books: 1. Materials Science and Engineering: A first course – V. Raghavan, PHI Learning Pvt.Ltd., 2004. 2. IntroductiontoMetallurgy-A.H.Cottrell,Arnold,1968. 3. Structure and Properties of Engineering Materials – R. M. Brick, A. W.Pense and R. B.Gordon. 4. The Structure and properties of Materials (I – IV) – R.M. Rose, L. A. Shepard and J.Wulff. 5. Introductiontosolids-L.V.Azaroff,TataMcGraw-Hill,1990. 6. Crystallographyappliedtosolid statephysics-A. R.Verma,O.N. Srivastava,Wiley,1982.

Department of Earh and Environmental Studeis							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESC332	Economic Geology	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
		CT+EA					
Course Outcomes	● It helps to acquire technical knowledge of basic geological principles and their application in Metallurgical Engineering. ● Enhances knowledge of natural resources and their utilization for Metallurgical purposes. ● It enables to scientifically assess the materials of the earth and helps in solving industrial problems related to materials.						

Topics Covered	Mineralogy: Definition, simple classifications, examples; Studies of crystals - symmetry elements, crystal classes and systems, twinning of crystals; Physical properties of minerals, Optical properties of minerals, Chemical characteristics, Atomic bonding in minerals, Structural classification of silicate minerals, occurrence. [10] Petrology: Igneous rocks - Magma – composition, physical properties; Rock cycle; Formation of Igneous rocks; Form and Structure; Classification; Texture; Phase diagram and crystallisation behaviour, Bowen's Reaction Series; Sedimentary rocks – Origin, classifications and examples, primary structures, textures; Metamorphic rocks – roles of agents of metamorphism, types of metamorphism, grades and degrees of metamorphism, metamorphic textures. [12] Structural Geology: Dip, Strike; Folds, Faults, Joints, Cleavage & Schistosity. [4] Economic Geology: Processes of formation of mineral deposits; Economic mineral deposits with special reference to Indian occurrences – Metallic minerals – Iron, Copper, Manganese, Aluminium, etc.; Non-metallic minerals – Refractory minerals, phosphate minerals. [10]
Text Books, and/or reference material	1) A Textbook of Geology : P. K. Mukherjee, World Press 2) The Principles of Petrology : G. W. Tyrrel; B. I. Publications 3) Dana's Manual of Mineralogy: Dana & ford 4) Economic Mineral Deposits: Jensen M. L & Bateman A. M

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	2	2	1	-	2	3	3	2	3
CO2	2	3	3	2	3	-	2	2	2	3	3	3
CO3	3	3	3	2	2	1	3	1	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC303	Non- Ferrous Process Metallurgy	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
CYC-01: Engineering Chemistry		CT+MT+EA					
Course Outcomes		● CO1: Understand fundamentals and unit operations of Mineral Beneficiation (MB). ● CO2: Understand developments in processing of non-ferrous metals. ● CO3: Identify and solve the problems of industrial applications of MB unit.					
Topics Covered		Sources of nonferrous metals (Sources in land and sea, exploration methods, methods of beneficiation, nonferrous metals wealth in India) (2)					

	Principles of metals extraction, (Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, electro-chemistry) (8) General methods of extraction, (Pyro-metallurgy – calcinations, roasting (predominance area diagram) and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy – electrolysis and electro-refining)(6) General methods of refining, (Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk) (2) Extraction of metals from oxide sources, (Basic approaches and special features of specific extraction processes, extraction of metals such as Mg, Al, Sn) (5) Extraction of metals from sulphide ores, (Pyro-metallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel etc.) (5) Extraction of metals from halides, (Production of halides and refining methods, production of reactive and reactor metals. Methods of extraction of metals such as Ti, Ur) (5) Production of precious metals (Methods applied for gold, silver and Pt.) (3)
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Extraction of nonferrous metals, H.S. Ray, R.Sridhar and K.P. Abraham Affiliated East West Press Pvt Ltd., New Delhi (2007). 2. H.S. Ray and A. Ghosh, Principles of extractive metallurgy,Wiley Eastern Ltd., New Delhi (1991) <u>Suggested Reference Books:</u> 1. W.H. Dennis, Extractive Metallurgy, Philosophical Library,New York (1965) 2. F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York (1969). 3. T. Rosenqvist, Principles of Extractive Metallurgy, McGraw Hill, New York (1983). 4. J.L. Bray, Nonferrous production metallurgy, Wiley, NewYork(1954).

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	1	1	1	1	1	1	3
CO2	3	3	2	2	1	1	2	1	1	1	1	3
CO3	3	3	3	3	2	1	2	1	3	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Earth and Environmental Studies							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
ESS382	Economic Geology	PCR	0	0	3	3	1.5

	Laboratory						
Pre-requisites		Course Assessment methods (Continuous (CT) assessment)					
		CT					
Course Outcomes	● Students will develop concept of Symmetry of crystals of minerals used for metallurgical purposes. ● The students will learn to study the properties of minerals including ores under polarizing microscope which will contribute to the beneficiation process. ● Students will learn to solve geological problems associated with occurrence of new materials to be used for metallurgical purposes.						
Topics Covered	Experiment 1: To study the symmetry elements of crystals (Part 1). [3] Experiment 2: To study the symmetry elements of crystals (Part 2). [3] Experiment 3: To study the physical properties of minerals in hand specimens. [3] Experiment 4: Identification of minerals in hand specimens on the basis of physical properties. [3] Experiment 5: To study optical properties of minerals under Polarising Microscopes (Part 1). [3] Experiment 6: To study optical properties of minerals under Polarising Microscopes (Part 2). [3] Experiment 7: Determination of apparent dips in given directions from true dip. [3] Experiment 8: Determination of true dip from given apparent dips. [3] Experiment 9: Study of a geological map. [3]						

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS351	Metallurgical Thermodynamics and Kinetics Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) assessment)					
NIL		CT					
Course Outcomes	CO1: Learn to estimate the thermodynamic parameters from experiments CO2: Identify the rate law of a reaction and determine the rate constant CO3: Determine the value of activation energy for a reaction in a temperature range.						
Topics Covered	Experiment 1: Non-Isothermal Decomposition of pure Calcium Carbonate (3) Experiment 2: Non-Isothermal Decomposition of pure Magnesium Carbonate (3) Experiment 3: Oxidation kinetics of copper at elevated temperature (12) Experiment 4: Oxidation kinetics of mild steel at elevated temperature (12) Experiment 5: Determination of partial molar volume (3) Experiment 6: Determination of the stability of the oxide using Ellingham diagram. (3) Experiment 7: Study the reducibility of iron ore to evaluate(dr/dt) 40% (3)						
Text Books, and/or reference	Suggested Text Books: 4. Introduction to Metallurgical Thermodynamics – David R Gaskell. 2. Metallurgical 5. Textbook of Materials and Metallurgical Thermodynamics −A. Ghosh 6. Thermochemistry – O. Kubaschewski, E LL Evans and C B Alcock						

material	Suggested Reference Books: 4. Stoichometry and thermodynamics of Metallurgical processes - Y K Rao. 5. Problems in Metallurgical Thermodynamics and Kinetics – G S Upadhyay and R K Dube. 6. Chemical Kinetics - Keith Laidler.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	1	1	1	1	1	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FOURTH SEMESTER

<table>
<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC401</td><td>Transport Phenomena in Metallurgical Processes</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="2">XEC-01: Engineering Mechanics</td><td colspan="6">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understand the fundamentals of fluid flow and momentum transfer.
CO2: Understand different modes of heat transfer and mass transfer.
CO3: Ability to solve metallurgical industry oriented problems involving heat, mass, and momentum transfer.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction, Conservation, fluid statics. (3)
Fluid flow: Newton's law of viscosity, Non-newtonian fluids. (5)
continuity equation, Navier-Stokes equations, Laminar flow. (6)
Turbulence and experimental correlations, the concept of friction factor. (3)
Flow through porous media, fluidized bed, Ergun equation. EX: centrifugal casting, bottom gating system. (6)
Modes of heat transfer, Industrial examples, Fundamental law and Subsidiary law (3)
Concept of thermal resistance and overall heat transfer coefficient, Differential equation of heat conduction. (3)
Conduction-convection system, Moving fins, Application in estimating heat losses from furnaces, Two dimensional steady state heat conduction. (3)
Lumped heat capacity analysis, Time constant and response time of temperature measuring instruments, Heisler's charts, application in heat treatment and solidification. (4)
Concept of the boundary layer, correlation for external flow and internal flow, continuous casting cooling system, heat losses from hot surfaces. (3)
View factor between surfaces, radiation heat transfer in furnace enclosures, reactors in used in materials processing, radiation shields Case studies involving multimode heat transfer in materials processing. (5)
Fick's Laws of diffusion, advection due to diffusion, case of evaporation of liquid through a column, Analogy between mass and heat transfer, mass transfer coefficient, application in gas-solid reactions such as oxidation, reduction etc. (7)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
7. Rate Phenomena In process metallurgy – J. Szekely and N.J. Themelis
8. Transport Phenomena in Metallurgy – G.H. Geiger and D.R.Poirier
<u>Suggested Reference Books:</u>
7. Heat Transfer– J.P. Holman
8. Heat and Mass Transfer – F. P. Incropera and D. P. DeWitt
9. Transport Phenomena – R. B. Bird, W. E. Stewart and E. N. Lightfoot</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	1	1	1	1	1	1
CO3	3	3	3	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="7">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core(PCR) / Electives(PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC402</td><td>Phase Transformation and Phase Equilibria</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC302:Introduction to Metallurgy and Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">I. To understand and interpret Free energy-composition diagram and origin of phase diagrams.
II. A detailed understanding on diffusion in solid and solid state phase transformations in steel.
III. To understand the fundamentals of solidification in order to apply it in Foundry industry.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Introduction: Basic concepts about Stability of Phases and equilibrium; Types of PhaseTransformations,Orderoftransformations. (5 hours)
Phase Equilibria: Thermodynamics of phase changes, phase diagrams and equilibria inrelationtoFreeenergy-compositiondiagrams.Interpretationofphasediagrams,determination and calculations. Solid-liquid Miscibility gap; invariant reaction. Principlesofternaryphasediagram,Examplesofafewmetallicandceramicphasediagrams.(6 hours)
Diffusion:Phenomenologicalequationofdiffusion,Chemicalpotentialgradient,Fick’sfirst law of diffusion, diffusion coefficient (diffusivity), representation of diffusion flux interms of chemical potential gradient; Nernst-Einstein Equation, Diffusion in ideal solutionand in solutions with positive and negative deviation; Uphill diffusion, determination ofdiffusion coefficient (diffusivity) for ideal binary solid solution in terms of jump frequencyand jump distance, atomic mechanism of diffusion,Expression of diffusion coefficient(diffusivity) for self diffusion in pure metal or diffusion in substitutional solid solutionthrough vacancy mechanism and in interstitial solid solution; Steady state diffusion andtransientdiffusion;Fick’ssecondlawofdiffusion;determinationofselfdiffusioncoefficient by radioactive method; solution of Fick’s second law: analysis of carburizinganddecarburizingprocesses;solutionofFick’ssecondlawforvariablediffusivity:Boltzmann-Matano analysis, Matano interface, determination of diffusivity as</td></tr>
</table>

	a function ofconcentration;Diffusioninsubstitutionalsolidsolution:Kirkendalleffect,Darken'sanalysis. (10hours) Liquid-SolidPhaseTransformation:PrinciplesofSolidificationinmetalsandalloys:thermodynamicsinvolved,eutecticandperitecticSolidification,Homogeneousandheterogeneous nucleation,Mechanismsofgrowth.RapidSolidificationProcessing.(8 hours) Solid State Phase Transformations: Nucleation and growth Kinetics, homogeneous andheterogeneoustransformation,Precipitation:Coherency,agehardening,particleCoarsening.Ostwaldripening,Order-disordertransformation,spinodaldecomposition,massive transformations. (8hours) Solid State Phase Transformations in steel: Reconstructive and displacive transformations;Pearlitic transformation: mechanism and kinetics: Johnson-Mehl equation, morphology ofpearlite; Bainitic transformation: mechanism and kinetics; morphology of upper bainite andlowerbainite;Martensitictransformation:Mechanism-diffusionlessdisplacivenature; morphologyofhigh carbonand lowcarbon martensite. (8hours)
Text Books, and/or reference material	Text Books: 1.Phasetransformationsinmetalsandalloys-D.A.PotterandK.E.Easterling,CRCPress, 1992. 2.TransformationsinMetals, P.G.Shewmon, Mc-GrawHill, 1969. 3. Introductionto PhysicalMetallurgy– S. N. Avner, TataMcGrawHill, 1997. 4.Physical Metallurgy–PeterHaasen,CambridgeUniversityPress, 1996. 5.PhysicalMetallurgyPrinciples,R.E.Reed-HillandR.Abbaschian,3rded,PWS-Kent Publishing,1992. 6.PhysicalMetallurgyforEngineers–A. G.Guy,Addison-WesleyPub.Co.,1962. 7.ModernPhysicalMetallurgy,R.E.Smallman,Butterworths,1963.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC403	Materials Characterization	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT)					

	and end assessment (EA))
MMC-302: Introduction to Metallurgy and Materials	CT+MT+EA
Course Outcomes	I. Learn fundamentals of X-ray diffraction, electron microscopy and other characterization techniques. II. Identify the crystal structure and index the diffraction patterns of different phases to meet contemporary needs (including tutorials). III. Learn different applications and developments in characterization techniques.
Topics Covered	**X-ray basics:** Production of X-ray; The continuous and characteristic spectrum; Absorption; Filters. 4h **Elementary Crystallography:** Overview the basics of crystallography; real and reciprocal lattice. 2h **X-ray diffraction:** Bragg's Law; Ewald sphere construction; Diffraction methods– Laue method, rotating crystal methods, powder methods; Diffractometers; diffraction under non ideal condition; 6h **Intensity of diffracted beams:** Structure factor calculations and other factors; Extinction rules; 4h **Application of X-ray diffraction:** Crystal structure determination; Precise lattice parameter measurements; Phase diagram determination, Chemical analysis by diffraction, residual stress determination, particle size determination. 10h **Electron microscopy:** elements of transmission electron microscopy; Sample preparation techniques for TEM, Image contrast in TEM: Identification of crystal defects and precipitates. Diffraction pattern analysis. 12h Advanced Materials Characterization: Thermal characterization of materials; Precipitation kinetics, Characterization through atomic force microscope. 6h
Text Books, and/or reference material	Text Books: 1. "Elements of X-Ray Diffraction", by B.D. Cullity, Addision Wesley Publishing Co., Massachusetts, 1968. 2. "X-ray diffraction-a practical approach", by C. Suryanarayana and M. Grant Norton, Springer, 1998. 3. "X-ray Diffraction: Its Theory and Applications", by S. K. Chatterjee, Prentice-Hall of India Pvt. Limited,2004. *4. "Electron Microscopy in the Study of Materials"*, by *P.J. Grundy and G.A. Jones*, Arnold, London, 1976. 5. "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol set)", by David B. **Williams** and C. Barry **Carter**, 2nd ed., Springer, 2009. 6. "Electron Microscopy and Analysis", by Peter J. Goodhew, John Humphreys and Richard Beanland, Third Edition, CRC Press, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	1		1	2	3		3	1	1	1	1	3

Correlation levels 1, 2 or 3 as defined below:

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<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSC433</td><td>Data Structures</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">Introduction to computing which covers the following preliminary concepts:
(a) Number Systems, different parts of a computer system, flowchart, Algorithm,
(b) Time and Space Complexities of algorithm, high level programming
(c) Language-C, etc.</td><td colspan="5">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">1. Student will be able to choose appropriate data structure as applied to specified problem definition.
2. Student will be able to handle operations like searching, insertion, deletion, traversing mechanism etc. on various data structures.
3. Students will be able to implement the concepts learned in various domains like DBMS, compiler construction etc.
4. Students will be able to decide the applicability of the concepts of stacks, queues, linked list etc. in different types of applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">● Introduction: Algorithms versus Programming, Definition of Data Structures, Characteristics of algorithms, Abstract data types, Asymptotic notations, Computation of time complexity, Static and dynamic memory allocations. [6]
● Arrays: Single and multi-dimensional arrays, Row and column major representation of matrices, sparse matrices [4]
● Linked Lists: Linked list as ADT, Singly, doubly, and circular linked lists. Different operations on singly and doubly linked lists: insertion, deletion, searching and modification of a node. Array representation of linked lists. Applications: Operations on polynomials. [6]
● Stacks: Stack as an ADT, Stack representations with array and linked lists, Operations on stacks: push AND pop, Applications of stacks: subroutine call, recursive function call, conversion of infix to postfix expressions, evaluation of postfix expression using stack, checking validity of a parenthesized expression. [5]
● Queues: Queue as an ADT, Queue representations with array and linked lists, Queue operations: addqueue and dequeue, circular queue and its operations, concept of priority queues. [5]
● Trees: Basic terminology, Binary tree and its implementation, Tree traversal techniques, threaded binary tree, Binary search tree and its operations. [6]
● Searching: Sequential search, binary search.</td></tr>
</table>

	[2] ● Sorting: Definition of sorting, internal and external sorts, Insertion Sort, Bubble Sort, Selection sort, Quick Sort, Merge Sort, Heap sort. [8]
Text Books, and/or reference material	Text Books: ● Data Structures: A Pseudo code Approach with C, Richard F. Gilberg & Behrouz A. Forouzan, second edition, CENGAGE Learning. ● Data Structures using C, Reema Thareja, Oxford University press. ● Data Structure using C & C++, Angenstein & Tanenbaum, PHI. ● An introduction to Data Structure, Trembly & Sorensen, MCHILL. ● Data Structure & Algorithms, Aho, Hopcroft & Ullman, AddnWesley.

Department of Computer Science and Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS483	Data Structures Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))					
Knowledge of programming		CE+EA					
Course Outcomes	CO1: Student will be able to implement basic applications using data structures as applied to specified problem definition. CO2: Student will be able to handle operations like searching, insertion, deletion, traversing mechanism etc. on various data structures. CO3: Students will be able to implement the concepts learned in various domains. CO4: Students will be able to decide the applicability of the concepts of stacks, queues, linked list etc. in different types of applications.						
Topics Covered	● Arrays: Implementation of insertion, deletion, merging and sparse matrix using arrays. ● Linked lists: (a) Implementation of insertion, deletion, searching and merge with singly and doubly connected linked lists. (b) Implementation of polynomial addition using linked list. ● Stacks: (a) Implementation of PUSH and POP operations using array and linked lists. (b) Implementation of conversion of infix to postfix expressions, evaluation of postfix expression using stack and checking validity of a parenthesized expression. ● Queues: (a) Implementation of Enqueue and Dequeue operations using array and linked lists. (b) Implementation of circular queue. ● Trees: (a) Implementation of tree traversal techniques. (b) Implementation of insertion, deletion and searching a node on a binary search tree. ● Searching: Implementation of sequential and binary search. ● Sorting: Implementation of Insertion Sort, Bubble Sort, Selection sort, Quick Sort, Merge Sort and Heap sort.						
Text Books, and/or reference	Text Books: ● Data Structures: A Pseudo code Approach with C, Richard F. Gilberg & Behrouz A. Forouzan, second edition, CENGAGE Learning.						

material	• Data Structures using C, Reema Thareja, Oxford University press. • Data Structure using C & C++, Angenstein & Tanenbaum, PHI. • An introduction to Data Structure, Trembly & Sorensen, MCHILL. • Data Structure & Algorithms, Aho, Hopcroft & Ullman, AddnWesley.

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS451	Transport Phenomena Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) assessment)					
NIL		CT					
Course Outcomes	CO1: Identify the nature of Flow. CO2: Determine the value of the different constants in a fluid flow and heat transfer. CO3: Evaluate the thermal conductivity and diffusivity for a particular system.						
Topics Covered	Experiment 1: Measurement of Reynold's Number Experiment 2: Measurement of friction factor during fluid flow in a pipe Experiment 3: Measurement of total energy across various points in a fluid flow system Experiment 4: Measurement of coefficient discharge through a venturimeter. Experiment 5: Measurement of coefficient discharge through an orificemeter. Experiment 6: Measurement of pressure drop through a packed bed Experiment 7: Measurement of coefficient of Pitot Tube and point velocity at different points across the flow Experiment 8: Determination of Stefan – Boltzman Constant Experiment 9: Measurement of thermal Conductivity of Metal Rod Experiment 10: Study the molecular diffusion of vapors in air						
Text Books, and/or reference material	Suggested Text Books: 1. Fundamentals of Momentum, Heat, and Mass Transfer by Welty, Wicks, Wilson, and Rorrer 2. Transport Phenomena − R. Byron Bird, Warren E. Stewart, Edwin N. Suggested Reference Books: 1. An Introduction to Transport Phenomena in Materials Engineering − D. R. Gaskell, 2. A Textbook on Heat Transfer −S. P. Sukhatme						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	2	3	3	1	1	1	1	1	1	1	1

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMS452</td><td>Phase Transformation and Phase Equilibria Lab</td><td>PCR</td><td>0</td><td>0</td><td>6</td><td>6</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">I. To introspect phase equilibria and phase transformation in steels of varying carbon content through investigation of microstructure in correlation to iron-carbon diagram.
II. To investigate microstructures of different cast irons in correlation to associated phase equilibria and phase transformation.
III. To understandtheapplication ofleverrule andphaserule.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">(i) Experiment1:Investigationsofthe microstructuresof pure metals(Fe,Cu,Zn,Al)
(ii)Investigationofthemicrostructuresofcarbonsteelscontaining~0.2%C,~0.4%C, ~0.6%C,~0.8%C,~1.0%C,incorrelationwithphaseequilibriainFe-Csystem(Iron–Carbonphasediagram).
Experiment2(PartI):Microstructureof0.2wt.%C steel (4hours)
Experiment3(PartII):Microstructure of 0.4wt.%Csteel (4hours)
Experiment4 (PartIII): Microstructure of0.6wt.% Csteel (4hours)
Experiment5(PartIV):Microstructure of0.8wt.% Csteel (4hours)
Experiment6 (PartV):Microstructureof1.0 wt.% Csteel (4hours)
(iii) With regard to Fe-C-Si phase equilibria, investigation of the microstructure of differenttypes of cast irons, viz. White Cast iron, Grey Cast iron, Spheroidal (Nodular) graphite castironandMalleablecast iron.
Experiment8 (PartI): MicrostructureofWhite Castiron (4hours)
Experiment9(PartII):Microstructure ofGreyCastiron (4 hours)Experiment10(PartIII):MicrostructureofSpheroidal(Nodular)graphitecastiron (4hours)
Experiment11(PartIV):Microstructure ofMalleable castiron (4hours)
(iv) Experiment 12: Study of the precipitation hardening process in Duralumin (Al-4.5%Cualloy) (3 hours)
(v) Experiment 13: ApplicationofLeverRule. (3 hours)
(vi)Experiment14:ApplicationofPhaseRuletodifferenttypesofbinaryphasediagrams.(3 hours)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Textbook:
1. Phasetransformationsinmetalsandalloys-D.A. Potter andK.E. Easterling,CRCPress, 1992.2. Introductionto PhysicalMetallurgy– S. N. Avner,Tata McGrawHill, 1997.
3.PhysicalMetallurgyPrinciples, R.E.Reed-HillandR.Abbaschian,3rded,PWS-Kent Publishing,1992.
4.ModernPhysicalMetallurgy,R.E.Smallman,Butterworths,1963.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XEO441	Brain to Mind Creation	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
BTC01: Life Science		CT+MT+EA					
Course Outcomes	● CO1: Understanding Cognitive Science and the Processes ● CO2: Understanding the Physics and Electrochemical Reactions in Brain. ● CO3 : Understanding the Behavioral Pattern of a Human Being						
Topics Covered	Brain to Mind-- and how do we know it---(essentially single neuron to multiple). (4) Brain and gross specialization --- areas , right-left , association ,connectivity and our tools to learn including EEG (6) Being Conscious -- Dynamics --- how do we learn about it from EEG (8) Cognition, Memory, Emotion -- Normal and Pathology . (6) Sleep and neural network (4) Brain and Future-- with interactive session (2)						
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1) Biological basis of Behavior- Prof. Braj Bhushan 2) A Beautiful Mind - Dr. Alok Bajpai 3) Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience, 2nd Edition by Bernard J. Baars (Author), <u>Suggested Reference Books:</u> Principles of Neural Science, Fifth Edition by Eric R. Kandel and James H. Schwartz						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

FIFTH SEMESTER

<table>
<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC501</td><td>Manufacturing Processes</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC-301: Metallurgical Thermodynamics and Kinetics</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● To understand different Manufacturing Processes
● Ability to design casting techniques and the basics of Welding Metallurgy
● To have ability to have a practical concept of manufacturing objects.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to casting as a shaping technique; Characteristic and effects of sand, binders and additives; Different types of Moulding and Machine moulding; Special casting techniques (12)
Design of Gating and Risering of casting; Solidification (5)
Melting furnace- cupola, rotary furnace, induction furnace; Defects in casting and their remedy; Metallurgy of cast iron, Aluminium and copper based alloy. (12)

Joining: Physics of welding, Process of different welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints. (14)

Historical perspective of Powder Metallurgy; Reasons for using Powder Metallurgy; The Future of Powder Metallurgy; Powder Fabrication: Different powder fabrication techniques; Powder Characterization: Experimental methods for measuring particle size, shape, distribution, surface area; Significance of true, apparent and tap densities of powders; Flow rate of powders and its significance; compressibility and green strength; Powder Handling: Powder Packing; Mixing and Blending; Mixing with Binders and Lubricants; Powder Lubrication; Compaction: Phenomenology of Powder Compaction; Conventional Compaction; Fundamentals of Compaction; Influence of Material and Powder Characteristics; Sintering: Sintering fundamentals; Full Density Processing. (14)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. O. P. Khanna: Foundry technology, 17th Edition, DhanpatRai Publications, 2011.
2. Rajender Singh: Introduction to Basic Manufacturing Processes & Workshop Technology, New Age International (P) Limited, Publishers, 2006.
3. R. A. Flinn: Fundamentals of Metal Casting, Addison-Wesley; Underlining edition,
4. Powder Metallurgy – AUpadhyaya and G S Upadhyaya.
5. Powder metallurgy: principles and applications- Fritz V. Lenel
Reference Books:
1. P. L. Jain: Principles of Foundry Technology, 5th Edition, Tata Mcgraw Hill Education Private, 2009.</td></tr>
</table>

2. M. C. Flemings: Solidification processing, McGraw-Hill, 1974.
3. Metals Handbook, Casting, vol. 15, 10th Edition, ASM International, Materials Park, Ohio, USA, 1998.

MMC 501 Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	2	1	2	3	1	1	3	1
CO2	1	1	2	1	3	2	2	3	2	2	2	1
CO3	1	2	1	1	3	2	2	3	1	1	2	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC 502	Heat Treatment of Materials	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Phase Transformation and Phase Equilibria (MMC 402)		CT+MT+EA					
Course Outcomes		● CO1: To learn the theory of heat treatment including the kinetic principles of solid state transformations. ● CO2: To understanding of the role of heat treatment on the development of microstructure and properties of metallic materials. ● CO3: The course will highlight a number of commercially-significant applications where heat treatment are important.					
Topics Covered		Objectives and Principles of heat treatment. [1 hour] Iron-Carbon Phase Equilibrium Diagram; Austenitisation, Transformation of austenite to pearlite, bainite and martensite; Characteristics of transformation products. [6 hours] T-T-T-and C-C-T diagrams; Factors affecting T-T-T curves. [6 hours] Heat treatment processes: Different types of annealing, spheroidizing, normalsing, hardening, tempering, patenting, austempering, martempering, Sub-zero treatment. [8 hours] Thermo mechanical treatment of Steels; Ausforming, Isoforming, Cryoforming, Heat removal mechanism, Hardenability of steels– Significance of hardenability, Determination of hardenability, Jominy End quench test, Factors influencing hardenability. [6 hours] Heat Treatment Defects, Residual stresses developed upon heat treatment [2 hours] Age Hardening: Basic requirements and steps, [1 hour] Heat treatment of non-ferrous metal and alloys -Aluminium alloys, Copper alloys, Magnesium alloys, Titanium alloys.					

	[6 hours] Practical considerations in heat treatment: Accessories, Cooling media, Types of furnace and Furnace atmosphere. [1 hour] Surface heat treatment – Carburizing of steels, Cyniding and Carbonitriding, Nitriding, Flame hardening, Induction hardening, Laser hardening etc. [6 hours]
Text Books, and/or reference material	**Suggested Text Books:** An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill Book Company. ASM Metals Hand Book – Vol. IX, ASM International Materials Society. Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, Charlie R. Brooks, ASM international, 1996. **Suggested Reference Books:** Principles of Heat Treatment – R. C. Sharma, New Age International (P) Ltd. Heat Treatment of Metals – V. Singh (Standard Publication Distributors) New Delhi

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1							2	3	3
CO2	3	3	3							2	3	3
CO3	3	3	3							3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC503	Fundamentals of Plastic Deformation & Strengthening of Materials	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1: To understand the fundamental concepts of plastic deformation of materials CO2: To know about various lattice defects and the roles played by these defects in plastic deformation and strengthening of materials CO3: To correlate the fundamentals ideas of deformation and strengthening with the observations in materials testing and mechanical processing						

Topics Covered	**Introduction and various types of plastic deformation:** Concept of stresses and strains, engineering stress and strain, true stress and strain, different types of loading for bulk deformation, slow strain rate deformation, evaluation of mechanical properties of materials by tensile and compression testing, stress-strain response of different materials - elastic region, yield point, plastic deformation, necking and fracture, effects of strain rate and temperature on stress-strain response of materials, superplastic behavior, evaluation of shear stress - shear strain curve from torsion testing, deformation and fracture of materials under impact loading, ductile to brittle transition, elementary concept of fatigue deformation and fracture, elementary concept of creep deformation and fracture, localized deformation at surface and indentation hardness, different methods of hardness measurement. [26 h] **Mechanisms of plastic deformation and strengthening:** Plastic deformation by slip, slip system, slip line, slip band, critical resolved shear stress (CRSS) of a material, theoretical shear strength, defects/imperfections in crystals, classification of defects, thermodynamics of defects, geometry of dislocations, Burgers vector, Burgers circuit, various types of dislocations, dislocation glide, Peierls stress, partial dislocations and stacking faults, cross slip, dislocation climb, intersection of dislocations, jogs and kinks in dislocation, force on a dislocation, line tension of a dislocation, dislocation generation - Frank-Read and grain boundary sources, stress and strain field around dislocations, strain energy of a dislocation, dislocation interactions, forces between dislocations, polygonization, dislocation movement and strain rate, deformation behavior of single crystals - flow curve and strain hardening/work hardening mechanisms of single crystals, deformation behavior of polycrystalline aggregates, plastic deformation by twinning, interaction between dislocations and interstitial atoms - yield point phenomena and strain ageing, dislocation phenomena involved in fatigue and fracture, Hall-Petch and other hardening mechanisms of polycrystalline aggregates, grain size effect, Hall-Petch breakdown, strengthening due to fine particles, fiber strengthening, solid solution strengthening, strengthening due to point defects, plastic deformation of two-phase aggregates, cold-worked structure of polycrystalline materials, annealing of cold-worked polycrystalline materials, Bauschinger effect, preferred orientation.[30 h]
Text Books, and/or reference material	● Mechanical Metallurgy, SI Metric Edition, *George E. Dieter,* McGraw-Hill (UK) Limited, 1988 ● Mechanical Behavior of Materials, *William F. Hosford,* Cambridge University Press, New York, 2005 ● Mechanical Behavior of Materials, Second Edition, *Marc A. Meyers and Krishan K. Chawla,* Cambridge University Press, New York, 2009 ● Mechanical Behavior of Materials, 2nd Ed., *Thomas H. Courtney,* Waveland Press, Inc., Illinois, 2005 ● The Plastic Deformation of Metals, *R.W.K. Honeycombe,* Edward Arnold, 1968 ● Dislocations and Plastic Flow in Crystals, *A.H. Cottrell,* Clarendon Press, 1965

CO-PO Mapping

POs COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	3	3	3	2	2	2			1			
2	3	2	3	3	3	1			1			
3	3	2	3	2	3	1			1			2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC504</td><td>Iron Making</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MMC-301: Metallurgical Thermodynamics and Kinetics</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">● CO1: Understand fundamentals of physico-chemical principles of blast furnace iron making.
● CO2: Understand the design & operational aspects of blast furnace technology.
● CO3: Understand the development in alternative iron making processes.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">History of Iron Making Pig Iron production in India. (2)
Raw Materials – Valuation and preparation of raw materials (6)
Methods of Agglomeration: sintering, pelletizing. (6)
Testing of raw materials. (2)
Design and construction of the blast furnace. (2)
Theory and practice of pig iron making – charge distribution, burden calculation. mass balance (4)
Physico-chemical aspects of blast furnace reactions, Blast furnace slags. Operating line (6)
Developments in blast furnace practice. Blast furnace irregularities. (4)
Blast furnace accessories: blowers, stoves, gas cleaning plants. (4)
Alternative methods of Iron making. (4)
Manufacture of ferro alloys. (2)
Environmental considerations in iron making. (1)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. A Text Book on Modern Iron Making - R. H. Tupkary (new edition)
2. Principles of Iron Making - A. K. Biswas.
3. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008
<u>Suggested Reference Books:</u>
1. Manufacture of Iron & Steel. Vol. I.- G. B. Bashforth.</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	1	1	1	1	1	1	1	2
CO2	3	3	2	3	1	1	2	1	3	3	1	2
CO3	3	3	3	3	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS551	Manufacturing Processes Lab - I	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	● To understand the basic of metal Casting and the techniques of welding. ● To understand casting and welding defects and methods of elimination. ● To understand the microstructures of three different zones of a welded portion.						
Topics Covered	Experiment-1: Determination of various properties of sand -clay -water mixture Experiment-2 : Design and preparation of green sand mould with various gating system Experiment-3 : Melting and Casting of Aluminum in green sand mould Experiment-4 : Welding of Butt -Joint by MMAW Experiment-5 : Determination of various defects by NDT of weld Joint Experiment-6 : Observation of Microstructure of welded joint Experiment-7 : Welding of Butt -Joint by TIG Experiment -8 : Comparison weld by 2 different Routes.						
Text Books, and/or reference material	Text Books: 1. O. P. Khanna: Foundry technology, 17th Edition, Dhanpat Rai Publications,2011 2. P. L. Jain: Principles of Foundry Technology, 5th Edition, Tata Mcgraw Hill Education Private, 2009.						

MMS 551 Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	2	1	2	3	1	1	3	1
CO2	1	1	2	1	3	2	3	3	2	2	2	2
CO3	1	2	1	1	3	2	2	3	1	3	3	1

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS 552	Heat treatment of Materials	PCR	0	0	3	3	2

	Laboratory						

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
Phase Transformation and Phase Equilibria (MMC 402)	CT+MT+EA
Course Outcomes	CO1: To learn fundamental of change in microstructure, hardness and mechanical properties with different cooling rate, cooling medium and temperature CO2: To understand the change in surface structure and property with chemical treatment CO3: To get an overall idea on a microstructure and assessment of hardness and mechanical property of steel under various industrial cooling condition.
Topics Covered	Acquaintance with Furnaces and their Operation [3 hours] Annealing, normalizing, hardening, and tempering treatments of plain carbon steels [12 hours] Influence of underheating and overheating on microstructure and properties [3 hours] Jominy End Quench Test [3 hours] Determination of critical diameter of Steel by trial hardening method. [6 hours] Pack Carburizing of steels, Post-carburizing heat treatment, Measurement of case depth. [6 hours
Text Books, and/or reference material	Suggested Text Books: 1. Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, Charlie R. Brooks, ASM international, 1996. 2. ASM Metals Hand Book – Vol. IX, ASM International Materials Society. Suggested Reference Books: 1. Principles of Heat Treatment – R. C. Sharma, New Age International (P) Ltd. 2. Heat Treatment of Metals – V. Singh (Standard Publication Distributors) New Delhi

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1								3	3
CO2	3	3	1	1							3	3
CO3	3	3	1	2							3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS553	Plastic Deformation & Strengthening of Materials Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		EA					
Course Outcomes	CO1: To know about the method of tension, compression, torsion, impact, hardness testing CO2: To analyze the results of different mechanical testing and interpret the mechanical behaviour of the materials CO3: To correlate structure with the mechanical properties under different conditions of deformation						
Topics Covered	1) Tensile and compression testing of ductile (metallic) materials and evaluation of strength and ductility properties [6 h] 2) Evaluation of shear stress - shear strain plot of ductile metals and alloys from torsion testing and determination of useful mechanical properties [6] 3) Studying localized deformation at surface of metallic materials by various hardness testing methods [3] 4) Studying materials behavior under impact loading by Charpy V-notch testing [3] 5) Studying the effects of cold working and annealing on the hardness and microstructure of ductile metals and alloys [18]						
Text Books, and/or reference material	● Mechanical Metallurgy, SI Metric Edition, *George E. Dieter,* McGraw-Hill Book Company (UK) Limited, 1988 ● Mechanical Behavior of Materials, *William F. Hosford,* Cambridge University Press, New York, 2005 ● Mechanical Behavior of Materials, Second Edition, *Marc A. Meyers and Krishan K. Chawla,* Cambridge University Press, New York, 2009						

Mapping of CO (Course outcome) and PO (Programme Outcome)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MMS553	CO1	3	3	2	2	2	2	1	1	1	-	1	1
	CO2	3	3	1	1	2	3	1	1	1	-	-	-
	CO3	3	2	1	3	3	2	1	1	1	1	-	2

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SIXTH SEMESTER

Department of Humanities and Social Sciences							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSC631	Economics and Management Accountancy	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
NIL		CT+MT+EA					

Course Outcomes

- Learners will be able to review basic economic principles.
- Learners will be introduced to the basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works.
- Learners will gain a good knowledge of financial accounting, enabling them prepare, analyse and interpret financial statements for taking informed decisions.

Topics Covered

PART 1: Economics

Group A: Microeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Economics: Basic Concepts	2	0	0	2	2
Unit 2:	Theory of Consumer Behaviour	3	0	0	3	3
Unit 3:	Theory of Production, Cost and Firms	3	0	0	3	3
Unit 4:	Analyses of Market Structures: Perfect Competition	3	0	0	3	3
Unit 5:	Monopoly Market	2	0	0	2	2
Unit 6:	General Equilibrium & Welfare Economics	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

Group B: Macroeconomics

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	Introduction to Macroeconomic Theory	2	0	0	2	2
Unit 2:	National Income Accounting	3	0	0	3	3
Unit 3:	Determination of Equilibrium Level of Income	4	0	0	4	4
Unit 4:	Money, Interest and Income	2	0	0	2	2
Unit 5:	Inflation and Unemployment	2	0	0	2	2
Unit 6:	Output, Price and Employment	2	0	0	2	2
	TOTAL	**15**	**0**	**0**	**15**	**15**

PART 2: Management Accountancy

Sl. No.	Name	L	T	P	Cr	H
Unit 1:	**Introduction to Accounting**: Accounting Environment of Business; Objectives of Accounting; Accounting Equations for Financial Statements. Books of Accounting: Journal, Ledger, Cash book.	3	0	0	3	3

	Unit 2:	**Financial Statement Preparation and Analysis:** Preparation of Trial Balance, Trading, Profit & Loss account and Balance Sheet. Case study discussion.	5	0	0	5	5
	Unit 3:	**Financial Ratio Analysis:** Common Size Statements; Computation of Financial Ratios; Interpretation and analysis of Financial Ratios with the help of case studies.	4	0	0	4	4
	TOTAL		**12**	**0**	**0**	**12**	**12**

Text Books, and/or reference material	**PART 1: Economics** **Group A: Microeconomics** 1. Koutsoyiannis: Modern Microeconomics 2. Maddala and Miller: Microeconomics 3. AnindyaSen: Microeconomics: Theory and Applications 4. Pindyck&Rubenfeld: Microeconomics **Group B: Microeconomics** 1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed) 2. N. G. Mankiw: Macroeconomics, Worth Publishers 3. Dornbush and Fisher: Macroeconomic Theory 4. Soumyen Sikder: Principles of Macroeconomics **PART 2: Management Accountancy** 1. Gupta, R. L. and Radhaswamy, M: Financial Accounting; S. Chand & Sons 2. Ashoke Banerjee: Financial Accounting; Excel Books 3. Maheshwari: Introduction to Accounting; Vikas Publishing 4. Shukla, MC, Grewal TS and Gupta, SC: Advanced Accounts; S. Chand & Co.

CO-PO MAPPING of Economics and Management Accountancy (HSC631)

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

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC601	Steel Making	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))
MMC-301: Metallurgical Thermodynamics and Kinetics	CT+MT+EA
Course Outcomes	● CO1: Understand fundamentals of physicochemical principles of steel making ● CO2: Understand the design & operational aspects of steel making

	technology. ● CO3 :Understand the design & operational aspects of Continuous Casting
Topics Covered	Historical Perspective, An Overview of Modern Steel making. (2) Steelmaking Fundamentals - Chemical Reactions Equilibria, Steel Making Slag (6) LD Steelmaking process - Design aspects of Converter and Lance ; LD Shop Layout, Charge Calculations ;Raw Materials ; Blowing Curve and theories of LD Steelmaking. (6) Bottom Blown Steelmaking - Distinctive Features and combined blow (4) Steelmaking in Electric Arc Furnaces (EAF) - Construction of an Arc Furnace ; Operation ; Developments in EAF steelmaking Technology. Alloy Steelmaking and stainless steel making 6) Refractory in steelmaking - Requirements and various types of refractory Material (2) Secondary Steelmaking: Types of Deoxidation and Deoxidation Kinetics and Products. Vacuum Degassing - Principles - Degassing Techniques (4) Ladle Metallurgy : V.A.D ; V.O.D ; R H (4) Ingot Casting and its Defects (2) Continuous Casting - Process description - Continuous Casting Products (5) Near net shape Casting (1)
Text Books, and/or reference material	Suggested Text Books: 1. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008. 2. Steel Making - By R.H. Tupkary 3. Steel Making - By A Chakroborty. Suggested Reference Books: 1. Turkdogan, E.T., A Text Book of Steelmaking, Academic Press, London, 1997. 2. Ghosh, A., Secondary Steelmaking, CRC Press, Boca Raton, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	3	1	1	3
CO2	3	3	3	3	1	1	1	1	2	1	1	3
CO3	3	3	3	3	2	1	1	1	3	1	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMC602	Mechanical Working of Materials	PCR	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MMC503: Fundamentals of Plastic Deformation & Strengthening of Materials	CT+EA

Course Outcomes	CO1: To understand the mechanics of metal forming processes CO2: To know about tools and techniques of different metal forming processes CO3: To understand the parameters which are needed to be controlled for increasing quality and productivity of different metal forming operations
Topics Covered	**1) Introduction:** Overview, objectives of mechanical working or plastic deformation of materials, classification of plastic deformation processes, mechanics of mechanical working of materials, influence of friction and lubrication in mechanical working processes, workability. [6h] **2) Theory of Elasticity:** Description of stress and strain at a point within a loaded body, stress tensor, principal stresses under 3D state of stress, concept of Mohr's circle construction and its implications under 3D state of stress, hydrostatic and deviator components of stress, elastic stress - strain relations, strain energy. [10h] **3) Theory of Plasticity:** Yielding criteria for ductile metals, yield locus, yield surface, plastic stress - strain relations, plane strain condition of plastic deformation, stress analysis under plane strain condition of plastic deformation using slip line - field theory. [10h] **4) Rolling:** Classification of rolling processes, forces and geometrical relationships in rolling, angle of bite, neutral point, theories of cold rolling and hot rolling, calculation of rolling load, torque and horse power, maximum allowable back tension in cold rolling, variables controlling rolling process, common defects in rolled products and their remedies. [8h] **5) Forging:** Classification of forging processes, open-die forging, closed-die forging, stress distribution in open-die forging, calculation of forging load, common forging defects. [6h] **6) Extrusion:** Classification of extrusion processes, analysis of extrusion process, hot extrusion, cold extrusion, deformation, lubrication and defects in extrusion processes, hydrostatic extrusion, extrusion for producing tubes. [5h] **7) Drawing:** Different types of drawing processes, analysis of wire drawing and tube drawing, limit of drawability, residual stresses in drawn products. [3h] **8) Sheet - Metal Forming:** Various sheet-metal forming processes, stretch forming, deep drawing, limiting draw ratio, forming limit criteria, defects in sheet-formed products. **[8h]**
Text Books, and/or reference material	● Mechanical Metallurgy, SI Metric Edition, *George E. Dieter,* McGraw-Hill Book Company, London, 1988 ● Principles of Industrial Metal Working Processes, *G.W. Rowe,* CBS Publishers & Distributors, New Delhi, 2005 ● Metal Forming: Mechanics and Metallurgy, 3rd Edition, *William F. Hosford and Robert M. Caddell,* Cambridge University Press, New York, 2007 ● The Rolling of Strip, Sheet and Plate, 2nd Edition, *E.C. Larke,* Chapman and Hall, Ltd., London, 1963

	● The Extrusion of Metals, 2nd Edition, *C.E. Pearson and R.N. Parkins,* John Wiley & Sons, Inc., New York, 1960 ● Wire Technology, 1st Edition, *Roger Wright,* Butterworth-Heinemann, 2010 ● Metal Forming: Processes and Analysis, *B. Avitzur,* McGraw-Hill Book Company, New York, 1968 ● Mechanical Working of Metals: Theory and Practice, *J.N. Harris,* Pergamon Press, 1983 ● Principles of Metal Working, *Surender Kumar,* Oxford & IBH Publishing Company, 1985 ● An Introduction to Plasticity, *G.C. Spencer,* Chapman & Hall, London, 1968

CO-PO Mapping

POs COs	1	2	3	4	5	6	7	8	9	10	11	12
1	3	3	1	3	3		1		2	1		1
2	3	2	3	3	3	1	1		3	2		2
3	2	3	1	3	2	2	1		3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME 610	Engineering Materials	PCL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Introduction to Metallurgy and Materials (MMC 302)		CT+MT+EA					
Course Outcomes	● CO1: To learn the basic fundamental of internal structure and properties of different metals ● CO2: To understand the microstructure-property relationship for various engineering applications in different conditions ● CO3: To learn technology aspect on application of engineering materials						
Topics Covered	Introduction to Various Classes of Engineering Materials: Factors affecting selection of Engineering Materials-Service requirements, fabrication requirements and economic requirements. [2 hours] Study of the industrially important of steels, their mechanical and thermal treatment and uses: Plain carbon steels. Conventional low carbon steels. [5 hours] Mild Steel, Dual Phase Steels and High Strength Low alloys (HSLA) Steels. [4 hours] Effect of Alloying Elements in Steel. [2 hours] Alloy Steels: Manganese Steels, Hadfield manganese Steel, [2 hours]						

	Heat Resistant and Stainless Steels. [8 hours] Tool and Die Steels, High speed tool steel (HSTS), Maraging Steels. [4 hours] Study of Nonferrous Alloys, their mechanical and thermal treatment: Brasses, Bronzes, Bearing Metals, Light alloys based on Aluminium and Magneium, Titanium Base alloys [10 hours] Alloy cast irons, Special purpose materials, such as, Cryogenic and High temperature Materials, Materials for Aerospace, Nuclear Reactors etc. [4 hours] Electrical and Magnetic Materials. [2 hours]
Text Books, and/or reference material	Suggested Text Books: 1. An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill Book Company. 2. Structure and properties of materials – J Wulff and other. Vols. I–IV. Wiley Eastern pub Ltd. New Delhi 3. Metallurgy for Engineers – E C Rollason 4. Physical Metallurgy – Vijendra Singh. 5. Engineering Materials : H. J. Sharp Haywood, London (1961) 6. Engineering Materials : M. F. Ashby and D. R. N. jones, Pergamon press Oxford (1980). Suggested Reference Books: 7. Materials Science and Engineering by Raghavan - PHI 8. Physical Metallurgy of Engineering Materials, N. R. petty, Allen Unwin (1968) 9. Light Alloys: Metallurgy of the light Metals, I.J. Polmser-Edwaraed annord. 10. The Super alloys by C. T. Sims and W. C. Hegel –Wily-Interscience.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3								2	2
CO2	3	3	2								2	3
CO3	3	3	3								3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME611	Electronic and Thermal Properties of Materials	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC302: Introduction to		CT+EA					

Metallurgy and Materials	
Course Outcomes	CO1: To get fundamental understanding about the quantum mechanics theory related with the electronic structure of solid state materials CO2: To know about fundamentals of electron transport and electrical conductivity of conducting, semiconducting and insulating materials CO3: To know about fundamentals of conductive heat transfer and thermal conductivity of solid materials
Topics Covered	1. **Introduction:** Overview; wave - particle duality. [4 h] 2. **Fundamentals of Electron Theory:** Schrodinger equation; solution of Schrodinger equation; energy bands in crystals; Brillouin zones; free electron bands; band structure of metals and semiconductors; electrons in crystals; Fermi energy; Fermi distribution function; density of states. [18 h] 3. **Electrical Properties of Materials:** Electrical conduction - classical electron theory, quantum mechanical consideration; superconductivity; thermoelectric phenomena; galvano-electric phenomena; semiconductor - intrinsic and extrinsic; band structure; Hall effect; semiconductor devices; electrical properties of polymers, ceramics, dielectrics, and amorphous materials. [18 h] 4. **Thermal Properties of Materials:** Heat capacity; thermal conductivity; classical and quantum mechanical consideration for heat capacity and thermal conductivity; phonon spectrum; thermal expansion. [6 h]
Text Books, and/or reference material	• Electronic Properties of Materials, *Rolf E.* ***Hummel,*** Springer-Verlag, New York, 2011 • Electronic Properties of Engineering Materials, *James D. Livingston,* John Wiley & Sons, 1999 • Electronic, Magnetic, and Thermal Properties of Solid Materials, *Klaus Schroder,* Marcel Dekker Inc, 1978 • Thermophysical Properties of Materials, *Göran Grimvall, Elsevier, B.V., 1999*

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	-	-	-	1	1	-	3
CO2	3	3	3	2	1	-	-	-	1	1	-	3
CO3	3	3	3	2	1	-	-	-	1	1	-	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME612	Alternative Routes of Iron Making	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					

MMC-504: Iron Making, MMC-301:Thermodynamics & Kineticsof Engineering Materials	CT+EA
Course Outcomes	● CO1: Apply the thermodynamic knowledge to understand the fundamentals of direct reduction and smelting reduction of iron oxides ● CO2: Acquire the knowledge of reaction mechanism and the process technology of alternative routes of iron making ● CO3: Learn to analyze raw materials requirements for different processes
Topics Covered	Concept of alternative routes to Iron & Steel Making (3) Advent of the alternative methods of production (2) Consideration of local resources and other conditions with particular emphasis on Indianconditions (5) Classification of various DR processes (3) Raw materials and relevant considerations for various DR and SR processes (4) Techno-economic and environmental evaluation of DR and SR processes (4) Physico-chemical principles of reduction and smelting (8) Technology of production through solid reductant and gaseous reductants (7) Technological developments at various places worldwide (4)
Text Books, and/or reference material	Suggested Text Books: 1. B. F. Ironmaking Principles -A.K Biswas 2. Direct Reduced Iron – Stephansion & Smailer 3. Modern Iron Making – R. H. Tupkery 4. Physical Chemistry of Iron & Steel manufacture – C. Bodsworth. Suggested Reference Books: 1.Beyond the Blast Furnace – Amit Chatterjee, CRC Press, USA. 2.Production of Liquid Iron Using Coal-Proc. of the Workshop, RRL, Bhubaneshwar,1964.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	3	1	1	1	1	1
CO3	3	1	1	1	1	1	3	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME613	Production of Ferroalloys	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC-301: Thermodynamics &		CT+EA					

Kinetics of Engineering Materials	
Course Outcomes	● CO1: Apply thermodynamic knowledge to understand the fundamentals of Ferro alloys production and their use ● CO2: Acquire the knowledge of reaction mechanism and the process technology of production of different ferro alloys ● CO3: Learn to analyze the different design aspects of submerged arc furnace
Topics Covered	Background for ferroalloy development and it's need for steel industry. [5] Trend of growth, as commensurate with steel growth. [5] Popular categories and reactions/mechanisms involved. [6] Processing Technologies for Ferrochrome/Ferromanganese/Ferrosilicon, etc. [6] Furnace details in terms of design/operation. [6] Processing of raw materials /reduction/melting/refining/casting, etc. [6] Case studies. [6]
Text Books, and/or reference material	Suggested Text Books: 1. The Complete Book on Ferroalloys by B.P Bhardwaj, NIIR PROJECT CONSULTANCY SERVICES Publisher, 2014. 2. Production of ferroalloys: electrometallury, V. P. Elı u ˉtin, State Scientific and Technical Pub. House for Literature on Ferrous and Nonferrous Metallurgy, 1957. Suggested Reference Books: 1. Production of ferroalloys, by M. Riss, Y. Khodorovsky, Mir Publishers, 1967. 2. Production of ferroalloys: electrometallurgy, by V.P. Elyutin, Israel Program for Scientific Translation, 1961.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	2	1	1	1	1	1
CO3	3	1	3	1	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME615	Ceramic Technology	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC302		CT+EA					
Course Outcomes	CO1: Describes generic classification of ceramics and their specific engineering applications. Emphasis is put on such engineering ceramics, which are traditionally and commercially important as well as new advanced ceramics. CO3: Learn various techno-economic aspects of ceramics						

	CO4: Learn structure-property relationships, and solve problems of fabrication of high performance ceramic parts
Topics Covered	**Introduction**: Knowledge of different ceramic materials [4 hours] **Structures of ceramics:** Atomic structure, crystal structures, oxide structure, silicate structure, other structures and polymorphism. [6 hours] **Structural imperfections:** Frankel defects, schottky defects, nonstoichiometry etc [4 hours] **Microstructure of ceramics:** Microstructure of different ceramic materials: Oxides, Carbides, Nitrides, Silicides, Borides, etc. Glass and Glass-ceramics [6 hours] **Properties of ceramics:** Physical, Mechanical, Electrical, Thermal and Magnetic properties of ceramics [6 hours] **Applications and processing of ceramics:** Glasses and glass ceramics, refractoties, and abrasives [6 hours] **Advanced and nanostructured ceramics:** Structure, properies and applications [4 hours] **Bioceramics:** Fundamentals of bioceramics and their applications [6 hours]
Text Books, and/or reference material	Text Books: 1. Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery: Physical Ceramics: Principles for Ceramic Science and Engineering, , John Wiley and Sons., 1996. Reference Books: 2. D.W. Richerson: Modern Ceramic Engineering, , CRC Press, Third Edition, 2005.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	3	2	1	1	1	1	3	1	1
CO2	3	3	1	3	1	2	3	1	1	1	1	1
CO3	3	3	1	3	2	1	3	1	3	1	3	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME616	Solidification Phenomena	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC501: Manufacturing Processes		CT+MT+EA					
Course Outcomes		● CO1: Understand solidification theories to industrial processes ● CO2: Predict microstructures as a function of process parameters. ● CO3: Understand solidification of alloys in different industrial conditions					
Topics Covered		Properties of metals and alloys before and during solidification. Surface phenomena. (2) Basic terms: surface energy, surface tension, Wetting angle. Wetting speed.					

	Classification and influence of wetting. (4) Rapid solidification processes (RSP). Classification of high cooling rates. Conventional and unconventional effects. (2) Under cooling and recalescence. Amorphous state. Glaze-ability. (1) Processing of alloys in the semi-solid state. Rheology. Newton's law of viscosity. Newtonian and non-Newtonian materials. (3) Distribution of non-Newtonian materials, physical models of materials and their rheograms. The apparent viscosity. Thixotropy.. Submersible rotational viscometry. (3) High-speed mixing. The intensity of the flow and its significance for the primary crystallization. The materials in the semi-solid state - SSM (Semi-Solid Metals). (2) Theories of solid solution morphology spheroidization. Types of alloys suitable for SSM. Case studies of selected castings. (4) Pressure solidification processes (PSP). Effect of pressure on the primary crystallization, change the thermo-physical properties, cooling rate and the force induced solidification flow. Alloys used in PSP. (3) Practical use of the rheological behavior of the alloys in the solidification processes and its importance. Case studies of selected castings. (4)
Text Books, and/or reference material	<u>Suggested Text Books:</u> 1. Principles of Solidification by Laurens Kagerman 2. Modelling the Flow and Solidification of Metals by T. A Smith 3. Physical Metallurgy- Principles and Practise by A Raghavan <u>Suggested Reference Books:</u> Kirkwood, D.H. – Suéry, M. – Kapranos, P. – Atkinson, H.V. – Young,K.P. Semi-solid processing of Alloys. Springer.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME617	Metal Joining Processes	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MMC501: Manufacturing Processes	CT + EA

Course Outcomes	CO1: Indicate which types of joining processes are suited for production. CO2: Determine various gas, arc, solid state, thermo chemical welding processes with their process parameters. CO3: Identify the various Weld Joints & Metallurgy
Topics Covered	Principles and theory, mechanism and key variables of different joining processes. (5) Soldering, brazing and welding processes types of tooling and equipment and consumables in welding. (6) Microstructures of fusion and HAZ: Carbon and alloy steels, corrosion resistance materials: stainless steels, aluminium alloys. Welding stresses. Heat flow in welding, chemical reactions in welding. Pre and post treatments advantages and disadvantages. (8) Weld joint consideration testing and inspection of weld joints. (6) Welding standard and specification. (5) Weldability field of application of the welding w.r.to gas welding, submerged arc welding, gas-tungsten arc welding, shielded metal arc welding, Plasma arc welding, flux core arc welding, electron beam welding, electro-slag welding, spot welding, laser welding, diffusion welding. (10)
Text Books, and/or reference material	Text Books: 1. Fabrication, Welding & Metal Joining Processes: A Textbook for Technicians and Craftsmen, C.R. Flood, Butterworths, 1981. 2. An introduction to Welding - R S Parmar 3. Principles of welding technology – L M Gourd, Edward Arnold / ELBS, London, 1980. Reference Books: 1. Welding for Engineers – H. Udin, E. R. Funk and J Wulff, John Wiley, New York. 2. Welding Engineering, B. E. Rossi, McGraw Hill New York 3. Welding Metallurgy, Sindo Kou, A John Wiley and Sons Incorporation Publication.

MME 617 Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	2	1	2	1	3	2	1	1	1
CO2	2	1	1	2	1	1	1	3	1	2	2	1
CO3	1	1	2	2	2	3	1	3	1	2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS651	Mineral Beneficiation Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC303: Non- Ferrous Process Metallurgy		CT					
Course Outcomes	● CO1: Correlate crushing of a material with different crushers ● CO2: Separation of fines from different fraction and measuring efficiency ● CO3 : Separation of sulphide ores by froth floatation unit						
Topics Covered	Experiment -1: Crushing of material in Jaw crusher followed by Roll Crusher Experiment-2 : Crushing the product of Roll Crusher in ball Mill Experiment-3 : Sieve shaking of the fines generated from Ball Mill Experiment-4 : Separation of Micro fines in a Cyclone Separator Experiment-5 : Froth Floatation Experiment-6 : Jigging Experiment-7 : Magnetic separation of metallic fines Experiment-8 : Separation of Material in a double-decker screen.						
Text Books, and/or reference material	Suggested Text Books: 1. Extraction of nonferrous metals, H.S. Ray, R.Sridhar and K.P. Abraham Affiliated East West Press Pvt Ltd., New Delhi (2007). 2. W.H. Dennis, Extractive Metallurgy, Philosophical Library, New York (1965) Suggested Reference Books: 1. F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	1	1	1	1	1	1	1	2
CO2	3	3	2	3	1	1	1	1	1	1	1	2
CO3	3	3	2	3	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering						
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours			Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS652	Mechanical Working of Materials Lab	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

Nil	EA
Course Outcomes	CO1: To know about the methods of rolling, forging under different conditions CO2: To learn the parameters needed to be controlled in rolling, forging processes CO3: To assess and understand the factors affecting the quality of the products
Topics Covered	1. Hot rolling to produce round bars (merchant product) from square stock using grooved rolls and evaluating changes in microstructure and hardness 2. Cold rolling to produce sheet from plate using plain barreled rolls and evaluating changes in microstructure and hardness. Estimation of angle of contact, no-slip angle, forward slip, interfacial frictional coefficient, rolling load, rolling torque and horse power based on the process data 3. Open-die forging operation by hydraulic press and analysis of process data. Evaluation of hardness and microstructural changes of the forged product 4. Closed-die forging operation by hydraulic press and analysis of process data. Evaluation of hardness and microstructural changes of the forged product 5. Hot forging and cold forging of a given ductile (metallic) material and evaluation of hardness and microstructural variations 6. To study the effect of friction and lubrication in open-die cold forging operation
Text and/or reference material	● Mechanical Metallurgy, SI Metric Edition, *George E. Dieter,* McGraw-Hill Book Company (UK) Limited, 1988 ● The Rolling of Strip, Sheet and Plate, 2nd Edition, *E.C. Larke,* Chapman and Hall, Ltd., 1963

CO-PO Mapping

POs / COs	1	2	3	4	5	6	7	8	9	10	11	12
1	3	2	1	2	3		1		2	1	1	1
2	3	3	3	3	2	1	1		3	2	1	2
3	2	3	1	2	2	2	1	1	3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS653	Materials Characterization Lab-I	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC-403: Materials Characterization		CT+EA					
Course Outcomes	I. Learn fundamentals and operational aspects of X-ray diffraction, electron microscopy and other characterization techniques. II. In-hand identification of the crystal structure and indexing of diffraction patterns of different phases to meet contemporary needs. III. Data analysis and report writing of various experiments.						

Topics Covered	**List of Experiments** 1.Indexing the X-ray diffraction (XRD) pattern of different phases. (a). Indexing the XRD pattern of BCC structure. (b) Indexing the XRD pattern of FCC structure. (c) Indexing the XRD pattern of HCP structure. (d) Indexing the XRD pattern containing a mixture of BCC and FCC phase. 2.Precise lattice parameter determination. 3.X-ray diffraction of powders to show the effect of powder size on peak broadening. 4.Microstructural and Fractographic study by SEM. 5.Indexing of SADP 6.Precipitation kinetics study of age hardenable Al alloy 7.Characterization through atomic force microscope
Text Books, and/or reference material	Text Books: 1. "Elements of X-Ray Diffraction", by B.D. Cullity, Addision Wesley Publishing Co., Massachusetts, 1968. 2. "X-ray diffraction-a practical approach", by C. Suryanarayana and M. Grant Norton, Springer, 1998. 3. "X-ray Diffraction: Its Theory and Applications", by **S. K. Chatterjee**, PHI. Limited,2004. *4. "Electron Microscopy in the Study of Materials"*, by *P.J. Grundy and G.A. Jones*, Arnold, London, 1976. 5. "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol set)", by David B. **Williams** and C. Barry **Carter**, 2nd ed., Springer, 2009. 6. "Electron Microscopy and Analysis", by Peter J. Goodhew, John Humphreys and Richard Beanland, Third Edition, CRC Press, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	2	3	1	2	2		1	2	3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SEVENTH SEMESTER

<table>
<tr><td colspan="8">DEPARTMENT OF MANAGEMENT STUDIES</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MSC-731</td><td>PRINCIPLES OF MANAGEMENT</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites- NIL</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1:To make budding engineers aware of various management functions required for any organization
• CO2:To impart knowledge on various tools and techniques applied by the executives of an organization
• CO3:To make potential engineers aware of managerial function so that it would help for their professional career
• CO4:To impart knowledge on organizational activities operational and strategic both in nature
• C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science and Quantitative Techniques and decision science</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT I: Management Functions and Business Environment: Business environment-macro, Business environment -micro; Porter’s five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization (8)
UNIT II: Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7)
UNIT III: Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8)
UNIT IV: Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8)
UNIT V: Finance and Accounting: Basics of Financial management of an organization, Preparation of Financial accounting, Analysis of Financial statements, CVP Analysis, An overview of financial market with special reference to India .(12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House.
2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India
3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education
4. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India
5. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey</td></tr>
</table>

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core(PCR) / Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME710	Functional Materials	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC-302:Introductionto MetallurgyandMaterials		CT+MT+EA					
Developer		Dr.S. Bera					
CourseOutcomes	CO1: Learn thefundamentals ofdifferent kinds of functional materials CO2: Types and applications of differentfunctional materials CO3: Tutorials, problemsand solutionsetc.						
TopicsCovered	Fundamentals of atomic structure- chemical bonding-crystal structure-property correlation;classificationofdifferentfunctionalmaterials. [6 hours] Opto-electronic Materials: Optical properties of semiconductors, absorption and emissionprocesses,Electronic materials suchasGaAsandGaN. [6hours] Sensor Materials: Metal oxide based sensors, Principles of operation, Solid electrolytesensors,Oxygensensors,OpticalSensors,ThermalSensorsandMagneticSensors,Thermistorsand relatedsensors. [6 hours] Shape memory and Superelastic alloys: shape memory effect, thermodynamic aspects andmicromechanism of martensitic transformation, Stress induced martensitic transformationandsuperelasticity,Ni-TiandNi-Albasedalloysandtheirapplications. [8 hours] Biomaterials:Conceptandassessmentofbiocompatibility,materialsforbiomedicalapplications:Ti-alloys,stainlesssteeletc. [8 hours] Nanomaterials,Smartmaterials,Metalfoams,Nanofluids,Carbonnanotubes,MetalHydride,Hybrid nanocomposites,Nanoporous materials,Nanocoatings. [8 hours]						
Text Books, and/or reference material	Text Books: 1.MaterialsScienceandEngineeringAnIntroduction–WilliamD.Callister,Jr.,John Wiley&Sons,Inc., 2007 2.Materials;Engineering,Science,ProcessingandDesign–MichaelAshby,Hugh Shercliffand DavidCebon 3.IntroductiontoMagnetic Materials–B. D.Cullity and C.D. Graham						

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	3		2	2	1	2	2	

CO2	3	1	1	2	3		2	2	2	3	2	
CO3	3	3	3	2	3	2	3	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME711	Fatigue, Creep and Fracture	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC-302: Introduction to Metallurgy and Materials		CT+MT+EA					
Course Outcomes	I. Learn fundamental and detailed understanding of fatigue, creep and fracture (including fracture mechanics). II. Solve problems on fracture, fatigue life, creep and different design problems to meet contemporary needs (including tutorials). III. Learn different applications and developments in fatigue, creep and fracture.						
Topics Covered	**Fatigue:** Types of stress cycles, S-N diagram and endurance limit, Various failure relations, viz., Goodman, Soderberg, Gerber parabola; Fatigue crack nucleation and propagation; application of fracture mechanics for fatigue cracking cyclic stress strain curve; low cycle fatigue; effect of stress concentration on fatigue; size effect; surface effects; effect of metallurgical variables on fatigue; Increased fatigue life due to surface protection cumulative fatigue damage rule; concept reverse plastic zone; corrosion fatigue; fretting; high temperature fatigue. 14h **Creep:** Materials problem at high temperature; time dependant mechanical behavior; Creep curves, Stress rupture test; Creep mechanisms; Deformation mechanism map; Super plasticity; Creep resistant alloys; Presentation of engineering creep data; Prediction of long time properties; Creep-fatigue interaction. 7 h **Fracture:** Examples of fracture in real components; Different design philosophies; atomic view of fracture; stress concentration effects of flaws; 2 h **Linear elastic plastic fracture mechanics (LEFM):** Griffith's theory of brittle fracture; The energy release rate; R-curve; Different modes of loading; Stress analysis of cracks, crack tip plasticity; concepts of plane stress and plane strain. 10 h **Elastic plastic fracture mechanics:** CTOD, J integral, HRR singularity; 4 h Types of fracture in metals; microstructural aspects of fracture; Different toughening mechanisms; 2h **Fracture toughness testing of metals:** K_{1C}, CTOD and J_{1C}. 3h						
Text Books, and/or reference material	Text Books: 1. "Elements of X-Ray Diffraction", by B.D. Cullity, Addision Wesley Publishing Co., Massachusetts, 1968. 2. "X-ray diffraction-a practical approach", by C. Suryanarayana and M. Grant Norton, Springer, 1998.						

	3. "X-ray Diffraction: Its Theory and Applications", by **S. K. Chatterjee**, Prentice-Hall of India Pvt. Limited,2004. *4. "Electron Microscopy in the Study of Materials"*, by *P.J. Grundy and G.A. Jones*, Arnold, London, 1976. 5. "Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol set)", by David B. **Williams** and C. Barry **Carter**, 2nd ed., Springer, 2009. 6. "Electron Microscopy and Analysis", by **Peter J. Goodhew**, **John Humphreys** and **Richard Beanland**, Third Edition, CRC Press, 2000.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	1		1	2	2		2	1	1	1	1	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME712	Computational Materials Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					
Course Outcomes	CO1: To understand the different methodologies of materials modelling and simulation CO2: To explore materials structure, properties, and behaviour under externally imposed variables CO3: To design materials for different applications						
Topics Covered	**1. Introduction:** Overview of different modeling approaches; aims and scopes; concept of multiscale modeling and simulation; significance of materials modeling and simulation. [2 h] **2. DFT Modeling:** Quantum Mechanics principles; Schrodinger's wave equation; waves and wave functions; solution of Schrodinger's wave equation; electron density; Hohenberg-Kohn theorems; Kohn-Sham approach; Kohn-Sham equations; exchange-correlation functionals; local density approximation; generalized gradient approximation; solution of Kohn-Sham equations; treating solids with pseudopotential approach; Bloch's theorem; plane wave expansions. [12 h] **3. Atomistic Modeling:** Classical Newtonian mechanics; overview of molecular dynamics (MD) simulation and its field of applicability; statistical mechanics principles; N-body problem; ensembles and ergodicity; interatomic potentials; initialization and thermal equilibration; boundary conditions; force calculation; potential energy cut-off and truncation schemes; integration algorithms with their relative merits and demerits; thermostatting; barostatting; evaluation of different physical, mechanical, structural,						

	thermodynamic, and transport properties of materials using MD simulation technique; illustration of equilibrium MD and non-equilibrium MD techniques; MD exercises with LAMMPS; overview of probability theory based Monte Carlo (MC) simulation and its field of applicability; Metropolis algorithm; Kawasaki dynamics; kinetic Monte Carlo method; simulation of phase evolution and phase transformation using Monte Carlo method. [16 h] **4. Stochastic Simulation:** Overview; Brownian dynamics; modeling diffusion of a particle in a fluid medium. [4 h] **5. Continuum Modeling:** Overview; types; outline of continuum modeling using FEM technique; illustration of solving structural mechanics and heat transfer problems using FEM simulation. [5 h] **6. Multiscale Approaches:** Overview and examples; bridging the scale gaps between different simulation levels; simultaneous integration of models; sequential integration of models (hierarchical approach); illustration of coupled MD-MC model, coupled MD-FEM model, coupled MD-stochastic model. [5 h]
Text Books, and/or reference material	• Understanding Molecular Simulation*: D. Frenkel and B. Smit*, Academic Press, 2002 • The Art of Molecular Dynamics Simulation: *D.C. Rapaport*, Cambridge University Press, 2004 • Statistical mechanics: *Donald A. Mcquarrie*, Harper Row, 1976 • Handbook of Materials Modeling: Ed.: *Sydney Yip*, Springer, 2005 • Monte Carlo Methods in Statistical Physics, *M.E.J. Newman and G.T. Barkema,* Clarendon Press, 1999 • Density functional theory of atoms and molecules, *R. G. Parr and W. Yang,* Oxford University Press, 1989 • Electronic Structure of Materials, *A. P. Sutton,* Clarendon Press, 1994 • An Introduction to the Finite Element Method, *J.N. Reddy,* Mc-Graw Hill, 2006 • Materials Modelling using Density Functional Theory: Properties and Predictions,*F. Giustino,* Oxford University Press, 2014

CO-PO Mapping

POs / COs	1	2	3	4	5	6	7	8	9	10	11	12
1	✔	✔	✔	✔	✔				✔			✔
2	✔	✔	✔	✔	✔	✔	✔		✔			✔
3	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME713	Fuel, Furnace and Refractories	PER	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC-301: Thermodynamics		CT+MT+EA					

& Kinetics of Engineering Materials	
Course Outcomes	● CO1: Understanding the Conventional and Non- Conventional energy sources ● CO2: Understanding the property of Fuel and Refractories. ● CO3 : Understanding the design of furnace with respect to usage of fuel and Refractories
Topics Covered	Definition, Comparative study of solid, liquid and gaseous fuels. Constitution, classification and grading of coal. (4) Testing of fuels like: Grindability, Caking properties, calorific value, Proximate and ultimate analysis, Flash and Fire point, viscosity. (6) Non-conventional Energy Resources like Nuclear fuel, Solar, Wind, Geo-thermal, Bio-mass, Hydrogen (2) Carbonization of coal: Coke making and by-products. (2) Producer gas, Water gas, Natural gas, LPG, Industrial Gases, Gobar Gas. Storage of fuels. (2) Combustion of fuels and problems (2) Definition and Classification of Furnaces, Batch furnaces, Continuous furnaces. (2) Construction and working of furnaces Pit furnace, Rotary furnace, Muffle furnace etc. (4) Evolution of heat and flame temperature. Available heat. Natural, forced, induced and balanced draft. Chimney height, (2) Heat losses in furnaces and minimization. Waste heat recovery. (2) Nature and Type and Properties of Refractories, Manufacture of Common Refractories (4) Furnace Design: Lay out of Refractories in a furnace. (2)
Text Books, and/or reference material	Suggested Text Books: 1. Elements of Fuels, Furnaces and Refractories, O. P. Gupta, Khanna publication. 2. Fuels, Furnaces and Refractories, J. D. Gilchrist 3. Fuels, Furnaces, Refractories and Pyrometry,-A.V.K. Suryanarayana, B. S. Publication Suggested Reference Books: Industrial Furnaces - Vol. I & II, W. Trinks and M. H. Mawhiney, Wiley

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	1	1	1	1	1	1	1	1
CO2	3	3	3	3	1	1	1	1	1	1	1	1
CO3	3	3	3	3	2	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:
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<table>
<tr><td colspan="8">Department of Metallurgical & Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME714</td><td>Powder Metallurgy</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC302</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learn science and technological aspects of the Powder Metallurgy Techniques.
CO2: The contemporary need can be met by the ability to analyze the industrial processes.
CO3: Solve problems of near net shape fabrication of powder metallurgy parts and explore powder-processing-property relationship</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Historical perspective of Powder Metallurgy; The Future of Powder Metallurgy. [4 hours]
Fabrication of Powders: Basics methods, Mechanical fabrication techniques; Electrolytic fabrication techniques, Chemical fabrication techniques, Atomization techniques. Production of Ferrous powders [8 hours]
Powder Characterization: Experimental methods for measuring particle size, shape, distribution, surface area; Significance of true, apparent and tap densities of powders;Flow rate; compressibility and green strength; Characteristics of common ferrous powders [6 hours]
Mixing and Blending: Dry Mixing, wet mixing; Powder Lubrication [4 hours]
Compaction: Injection Molding; Fundamentals of Compaction; Influence of Material and Powder Characteristics on compaction. [6 hours]
Sintering Behavior: Sintering fundamentals; Sintering Theory; Mixed Powder Sintering; Liquid Phase Sintering; Sintering Atmosphere, Sintering Furnaces; Full Density Processing. [8 hours]
Finishing Operations: Machining; Heat Treatments; Surface Treatments [4 hours]
Applications: Competitive Processes; Examples of Powder Metallurgy Applications and Properties. [4 hours]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
1. Powder Metallurgy – A Upadhyaya and G S Upadhyaya.
2. Powder Metallurgy Science – R. M. German, 2nd Edition, MPIF, 1994
REFERENCE BOOKS:
1. Powder metallurgy: principles and applications, Fritz V. Lenel, Metal Powder Industries Federation, 1980
2. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	1	1	1		3	1	1
CO2	3	3	1	1	1	2	3		1	1	1	1
CO3	3	3	2	1	2	1	2	1	3	1	2	3

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME715</td><td>Secondary Steel Making</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT), mid-term (MT), and end assessment (EA))</td></tr>
<tr><td colspan="3">Metallurgical Thermodynamics and Kinetics, Transport Phenomena in Metallurgical Process</td><td colspan="5">CT+MT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learn fundamentals of physico-chemical principles of Secondary steel making.
CO2: Apply laws of thermodynamics and kinetics for producing clean steel.
CO3: Design process route for economical production of steel.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">A brief review of fluid flow, thermodynamics and primary steel making processes, composition of the crude steel, need for secondary refining, the objective of secondary steel making, physico-chemical principles of Secondary steel making, Slag basicity and capacities, secondary steel making equipment and processes, preheating and recycling of ladles. (8)
Furnace tapping operations; Phenomena during furnace tapping; carry over slag and slag detection devices; slag making in ladles and de-oxidation: common de-oxidisers and requirement of de-oxidisers; addition methodology; melting and dissolution of deoxidisers; de-oxidation thermodynamics and kinetics; simple vs. complex de-oxidation; De-oxidation products; Elementary de-oxidation calculations. (5)
Inert Gas Stirring in Ladles (objectives, Devices, gas flow regimes, stirring energy and stirring intensity); Temperature and Composition Control in Ladles (arcing, alloying addition, and aluminium wire feeding). (3)
Degassing and Decarburization in liquid steel: Introduction, Principles and thermodynamics of reactions in vacuum degassing, equipment's and degassing Methods and their relative merits and demerits; slag eye area and re-oxidation, fluid flow and mixing in vacuum degassing, rates of vacuum degassing and decarburization, decarburization for Ultra-low carbon (ULC), stainless steel making. (8)
Desulfurization in secondary steelmaking: Introduction, thermodynamics aspects, desulfurization with only top slag, injection metallurgy for Desulfurization. (3)</td></tr>
</table>

	Clean steel, Types of inclusions, Morphology, Properties of inclusions, Inclusion assessment, sources of inclusions, control of inclusions, Inclusion modification, Calcium Treatment (cored wire injection. objectives and devices reactions, calcium recovery and inclusion morphology and composition). (6) Teeming speed, Gas absorption during tapping and teeming form surrounding, Temperature changes of molten steel during secondary Steel making, phosphorus control in secondary steel making, Nitrogen control in steel making, application of Magnetohydrodynamics, Modeling of secondary steelmaking processes. (6)
Text Books, and/or reference material	Suggested Text Books: 9. Principles and Practices in Iron and Steelmaking – A. Ghosh, and A. Chatterjee. 10. Secondary Steelmaking – A. Ghosh Suggested Reference Books: 10. Making, Shaping and Treating of Steel (Steelmaking and Refining), 10th Edition, 1985, AISE, Pittsburgh

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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CO1	3	3	1	1	1	1	1	1	1	1	1	1
CO2	3	3	1	1	1	1	1	1	1	1	1	1
CO3	3	2	3	3	1	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

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Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core(PCR) / Electives(PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME716	Composite Materials	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC-302: Introduction toMetallurgyand Materials		CT+EA					
CourseOutcomes	Learn the fundamentals of compositematerials,classification, properties and applications Metalmatric composites(MMCs) Solidand liquidstate synthesisofMMCs, joining of MMCs						

TopicsCovered	Course assessment methods: Mid semester examination and End semester examinationIntroduction:Classificationofcompositesonthebasisofmatrix,ex-situorin-situsynthesis,typeofreinforcementetc.;Metalmatrixcomposite,polymermatrixcomposites,ceramicmatrix compositeand carbon-carboncomposite; applicationofdifferentcompositematerials. (8 hours) Differentroutesofcompositesynthesis:castingroute,powdermetallurgyrouteandother routes. (4hours) PowdermetallurgyprocessedComposite:highenergymilling,Mechanicalalloying:Fundamentals and parameters; Compaction and Sintering: material dependent routes andprocess parameters; Recent trends- Spark plasma sintering, Equal channel angular pressingetc.;process parameter-structure-propertycorrelation. (12hours) Cast metal matrix composites: different synthesis routes: dispersion process (stir casting,compocasting and screw extrusion)-contact angle, wettability and particle-matrix bonding;Liquid metal impregnation/infiltration (pressure infiltration, squeeze casting and Lanxideprocess)- principle of molten metal infiltration-capillary flow ofmolten metal; Sprayprocess(Ospreyprocessandrapidsolidificationprocess);In-situproductionofdispersoids-XD process; evolved microstructure: structural defects in cast metal matrixcomposites-porosity,particlesegregation(macrosegregationandmicrosegregation),interfacialreactionand particledegradation;structure-propertycorrelation. (12 hours) Joiningofmetalmatrixcomposites,limitationsofconventionalfusionwelding,Applicationoftransientliquidphase(TLP)diffusionbonding,basicmechanismanddifferentstagesofTLPbondingprocessformonolithicandcompositesystem,processparametersofTLPbonding,joint efficiency. (4hours)
Text Books, and/or reference material	Text Books: 1. MetalMatrix Composites-Chawla and Chawla, Springer, 2006. 2.'Joiningofaluminiumbasedmetalmatrixcomposites'-JoydeepMaity,in'Engineered MetalMatrix Composites: Forming Methods, Material Properties and Industrial Applications',Editor:LucaMagagnin,2012,NOVASciencePublishers,Inc.,NewYork, USA,pp 329-354. 3.MaterialsScienceandEngineering:AnIntroduction-WilliamD.Callister,Jr.,John Wiley&Sons,Inc., 2007. 4.FundamentalsofMetal-MatrixComposites-AndreasMortensenandAlanNeedleman, Butterworth-Heinemann,1993. 5.AnIntroductiontoCompositeMaterials–DerekHull,CambridgeUniversityPress, 1981. 6.CompositeMaterials–DeborahD.L.Chung,Springer, 2009. 7.Metal-Matrixcomposite–P.K.Rohatgi,DefenceScienceJournal,Vol43,No4, October1993,pp 323-349. 8.Y. B.Liu, S. C.Lim, L. Lu,M. O. Lai,Recentdevelopment inthefabricationof metal matrix-particulatecomposites usingpowder metallurgy techniques,Journalof MateralsScience29(1994)1999-2007.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

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

Correlation levels 1, 2 or 3 as defined below:

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Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME717	Corrosion Engineering	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
CYC-01: Engineering Chemistry		CT+EA					
Course Outcomes	CO1: To learn Fundamentals of Corrosion Engineering CO2: Techniques to acquaint with Actual Corrosion Testing CO3: To understand the Principles, Mechanism and Prevention of High Temperature Corrosion						
Topics Covered	Introduction: Definition of corrosion, Cost of Corrosion, corrosion damage, environments, and classification of corrosion. (1) Corrosion Principles: Electrochemical reactions, thermodynamics of corrosion, cell potential, emf and galvanic series, representation of cell / cell diagram, electrode kinetics, exchange current density, polarization - activation, concentration and combined, Pourbaix diagram, Evans diagram, Passivation. (11) Forms of Corrosion: Uniform attack; galvanic or two-metal corrosion; crevice corrosion; pitting corrosion; intergranular corrosion – sensitization and weld decay; Selective leaching - dezincification; erosion corrosion; Stress corrosion cracking (SCC) and hydrogen damage. Case studies of corrosion in industry e.g. steel, chemical, fertilizer and food etc. (11) Corrosion Prevention: Materials selection, alteration of environments, design, inhibitors, cathodic and anodic protection, coatings – electroplating. (5) Corrosion Testing: Purpose, standard expression of corrosion rate, polarization technique – Tafel extrapolation, linear polarization method, AC impedance method, evaluation of pitting damage, Huey and stretcher test for stainless steel, slow strain rate test (SSRT). Corrosion failure analysis. (5) High Temperature Corrosion: Introduction, oxidation, Pilling – Bedworth (PB) ratio, electrochemical and morphological aspects, oxidation kinetics, internal oxidation, corrosion in mixed environments, salt deposited hot corrosion, case studies for high temperature corrosion. (2)						

Text Books, and/or reference material	Text Books: 1. Corrosion Engineering – Mars G. Fontana, McGraw- Hill Publication, 1987. 2. The Fundamentals of corrosion – J. C. Scully Reference books: 1. An Introduction of Metallic Corrosion – R. Evans, Eward Arnold (Publishers) Ltd, London. 2. Introduction of High Temperature Corrosion – N. Birks and G. H. Meier

MME 717 Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	1	2	2	1	3	2	2	2	1
CO2	1	1	3	2	2	2	1	2	2	2	2	1
CO3	1	1	3	1	1	2	2	2	3	2	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME-718	Energy and environment in metallurgical industries	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC-301:Metallurgical Thermodynamics and Kinetics		CT+EA					
Course Outcomes	CO1: To give concept of effective utilization of energy in metallurgical processes. CO2: To provide knowledge regarding various pollutants and their methods of control in metallurgical industries. CO3: To learn the methods of minimization of energy requirements and prevention of energy loss CO4: To learn about the application of recycling methods of wastes materials generated in metallurgical industries						
Topics Covered	**UNIT I:** Energy: (14 hrs) Energy resources: non-renewable and renewable, Indian energy resources. Use of energy in metal production, process fuel equivalent. Conservation of energy in metallurgical industries with examples of aluminium, iron & steel making. Hydrogen energy: characteristics, production, storage and utilization in metal industries. **Biomass:** types of biomass, wood char as reductant in iron making.						

	UNIT II:(25 hrs) Environment: Sources and types of pollutants (wastes) from metal / minerals industries. Gaseous emissions: control of SPM, hazardous gases, viz. sulphur dioxide, fluorides, nitrogen oxides. Greenhouse gases: Greenhouse effect, global warming potential, Kyoto protocol, carbon trading. Emission and control from, iron & steelmaking and aluminium smelting. Liquid effluents: treatment of waste water, with examples from metal industries. Solid wastes: types, disposal and utilization of slime, red mud and spent pot lining, iron and steel slags. Impact of pollutants on human health, management of radioactive wastes,e-waste, noise pollution, thermal pollution.
Text Books, and/or reference material	**Text Books:** 1. R.C.Gupta: Energy and Environmental Management in Metallurgical Industries, PHI Learning 2. H.S.Ray. B.P.Singh, S.Bhattcharya, V.N.Misra,. Energy in Mineral and Metallurgical Industries, Allied Publisher 3. C.S.Rao: Environmental Pollution Control Engineering, Wiley Eastern Ltd. 4. J.A.Nathanson: Basic Environmental Technology, prentice-Hall India **Reference Books:** 1. R.C. Gupta(ed.): Proc. Environmental Management in Metallurgical Industries(EMMI-2000),Allied Publishers 2. R.C. Gupta(ed.): Proc. Environmental Management in Metallurgical Industries(EMMI-2010),Allied Publishers 3. Fathi Habashi: Pollution Problems in Mineral and Metallurgical Industries, Metallurgie Extractive Quebec. 4. H.S.Peavy et al.: Environmental Engineering, McGraw Hill

POs vs. COs

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	1	1	2	2	1	1	1	1	1
CO2	3	1	1	1	1	2	3	1	1	1	1	1
CO3	3	3	2	2	2	3	3	1	1	3	3	3
CO4	3	3	3	3	3	3	3	3	2	3	3	3

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS751	Manufacturing Processes Lab - II	PCR	0	0	1	4	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MMC403 and MMC501		CT+EA					
Course Outcomes	CO1: Learn science and technological aspects of the Powder production and characterization						

	CO2: To study the effect of compaction pressure on densification and learn various sintering techniques to produce net shape product CO3: Explore powder-processing-property relationship through laboratory assignment.
Topics Covered	Exp 1: Demonstration of ball milling, compaction unit, dynamic light scattering technique and tube furnace [3 hours] Exp 2: Synthesis of nano powders by Chemical reduction [3 hours] Exp 3: Particle reduction by Ball milling [3 hours] Exp 4: Characterization of nano and milled powders [3 hours] Exp 5: Particle size analysis by different techniques [3 hours] Exp 6: Conventional die compaction of powders [3 hours] Exp 7: Solid state sintering [3 hours] Exp 8: Liquid phase sintering [3 hours] Exp 9: Microstructural characterization and phase analysis of sintered products [3 hours] Exp 10: Hardness measurement of sintered products [3 hours]
Text Books, and/or reference material	TEXT BOOKS: 1. Powder Metallurgy – A Upadhyaya and G S Upadhyaya. 2. Powder Metallurgy Science – R. M. German, 2nd Edition, MPIF, 1994 REFERENCE BOOKS: 1. Powder metallurgy: principles and applications, Fritz V. Lenel, Metal Powder Industries Federation, 1980 2. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	2	3	1	2	2		1	2	3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS752	Materials Characterization Lab - II	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					

MMC-503: Fundamentals of Plastic Deformation and Strengthening of materials	CT+EA
Course Outcomes	I. Learn fundamentals and operational aspects of wear, non-destructive and other testing techniques. II. In-hand interpretation of wear mechanisms and fractographs of different materials to meet contemporary needs. III. Data analysis and report writing of various experiments.
Topics Covered	**List of Experiments:** 1. Materials Characterization Using Non Destructive Testing (NDT) Methods: (a) Magnetic particle testing (b) Dye penetrant test. (c) Ultrasonic technique 2. Tribological study and worn surface characterisation of different materials using: (a) Pin-on-disk wear testing machine. (b) High stress abrasive wear testing machine. 3. Effect of strain rate on tensile behaviour and fracture surface of different materials 4 Determination of fracture toughness by indentation technique
Text Books, and/or reference material	Text Books: **1. Mechanical Metallurgy by George Dieter**

Mapping of CO (Course Outcome) and PO (Programme Outcome)

CO ↓	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	1	1	1			1	1	2	1		1
II	3	3	3	3	1	2	1	2	3	2	2	2
III	2	3	1	2	2		1	2	3	3	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MMS753	Ferrous Process Metallurgy Laboratory	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
MMC303: Non- Ferrous Process Metallurgy		CT					

Course Outcomes	● CO1: Understand the method of agglomeration of iron ore fines by sintering and pelletization ● CO2: Study the fluid dynamics in a cold model of B.O.F ● CO3: Evaluate the properties of agglomerates
Topics Covered	Experiment -1: Sintering of iron ore fines in laboratory Sintering Machine Experiment-2: Pelletization of iron ore fines in a disc pelletizer Experiment -3: Measure the properties of sinter produced Experiment-4: Measure the green and indurated properties of pellets Experiment -5: Briquetting of iron ore fines. Experiment-6: Study the effect of velocity and nozzle diameter and no of nozzles on the diameter and depth of Crater formed in a water model of LD Converter
Text Books, and/or reference material	Suggested Text Books: 1. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008. 2. F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York

Mapping of CO (Course Outcome) and PO (Programme Outcome)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	1	1	1	1	1	1	1	2
CO2	3	3	2	3	1	1	1	1	1	1	1	2
CO3	3	3	2	3	1	1	1	1	1	1	1	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

EIGHTH SEMESTER

<table>
<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME810</td><td>Nano Science and Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MMC302: Introduction to Metallurgy and Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To gain fundamental knowledge about the nanomaterials and their properties
CO2: To learn about various techniques of the synthesis and characterization of nanomaterials
CO3: To explore the various applications of nanomaterials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction: Basics of nano-scale, History of nano-technology, Uses of technology (natural and manufactures) in nano-scale, advantages and disadvantages. [6 h]
2. Nano-materails, Different types of nano-materails. Uses of current technology. [4 h]
3. Basics of mechanical, electrical, magnetic and optical properties of materials. Effect of miniaturization (nano-scale) on mechanical, electrical, magnetic and optical properties of materials. [12 h]
4. Synthesis of nano-materials (different synthesis routes: top down and bottom up approach), Characterization of nano-materials by different techniques. [12 h]
5. Application of nanomaterials, effect on daily life, environmental effects. [6 h]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Materials Science and Engineering: An Introduction - William D. Callister, Jr., John Wiley & Sons, Inc., 2007
2. Nanomaterials Nanotechnologies and Design – D.L. Schodek, P. Ferreira, M.F. Ashby, Butterworth-Heinemann, 2009
3. Introduction to Nanotechnology – C.P. Poole, F.J. Owens, Wiley Interscience, 2003</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	1	-	-	-	1	1	-	3
CO2	3	3	3	3	3	2	1	-	1	1	-	3
CO3	2	2	1	2	1	3	3	-	1	1	-	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME811	FEM Modelling and Simulation for Materials Design	PEL	3	0	0	3	3
Pre-requisites			Course Assessment methods (Continuous (CT) and end assessment (EA))				
XEC01: Engineering Mechanics, MMC503: Fundamentals of Plastic Deformation and Strengthening of Materials			CT+EA				
Course Outcomes	CO1: To understand the basics and methodologies for FEM modelling and simulation CO2: To explore materials mechanical behaviour under externally imposed variables CO3: To design materials for different structural applications						
Topics Covered	1. **Introduction:** Overview of different continuum modelling techniques - finite element method (FEM) modelling and simulation - advantages and drawbacks of the method; types and applications of the method. [4 h] 2. **Basics of FEM modeling and simulation:** General steps; different approaches for deriving element properties: direct approach, variational approach, and Galerkin's method; types of elements and interpolation functions and their applicability; condensation and substructuring; continuity requirements; mesh refining; Gauss quadrature; FEM modelling for structural and thermal problems. [32 h] 3. **Applications:** Structural design; stress mapping; heat transfer; temperature mapping; FEM based design of composite materials; study of deformation of materials under different loading conditions. [10 h]						
Text Books, and/or reference material	● The Finite Element Method for Engineers, 4th Edition: *Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith, and Ted G. Byrom,* Wiley, 2001 ● An Introduction to the Finite Element Method, 3rd Edition: *J. N. Reddy,* Mcgraw Hill Series in Mechanical Engineering, 2005						

Department of Metallurgical and Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME812	Mathematical Modelling and Simulation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					

Transport Phenomena in Metallurgical Process	CT+MT+EA
Course Outcomes	CO1: Learn fundamentals of Modelling. CO2: Identify nature of engineering problems and solving by numerical methods CO3: Build physical and mathematical models to describe the complex physical phenomena pertaining to real world.
Topics Covered	Review of Fluid Flow, heat transfer and Mass transfer, Type of Models, Advantages of Mathematical Model, Types of Mathematical model, Method of prediction, Modeling vs. experimentation, nature of coordinates. (3) Classification of partial differential equations, Elliptic, Parabolic, and Hyperbolic Equations, Initial and Boundary Conditions, Initial Value and Boundary Value Problems, Substantial derivative, Concept of grid points, cell and mesh, methods of discretization, Types of cells and mesh, Basic approach in solving a problem. (4) Central, Forward, and Backward difference expressions for a uniform grid, Central difference expression for a nonuniform grid, Numerical errors, Accuracy of solution: optimum step size, grid Independence test. (3) Application heat of conduction and diffusion, one dimensional steady state problem, Method of solution: Gaussian elimination, Tri-diagonal matrix algorithm (TDMA), Gauss-Seidel iterative method, the concept of Relaxation factor, optimization of Relaxation factor, Two-dimensional steady state problem, Block iterative methods, There-dimensional steady state problem, Transient one dimensional problem, Euler method, Crank-Nicolson method, Pure Implicit method, Accuracy of Euler, Crank-Nicolson and Pure Implicit method, stability, Von Neumann stability analysis, Two-dimensional transient, Alternative Direction Implicit method, Problem in cylindrical and spherical geometry, Non-axissymmetric problem, Transient conduction in composite media, Treatment of non-linierities in conduction and diffusion, irregular geometry, Diffusive- convective system with Flow, Met lab codes. (22) Physical modeling: Introduction, dimensional analysis, similarity criteria, modeling of steel making processes. (4) Application related to metallurgical processes (3)
Text Books, and/or reference material	Suggested Text Books: 11. Finite difference Method in heat transfer- M. N. Ozisik 12. Computational Fluid dynamics and heat transfer – P.S. Ghoshdastidar 13. Modeling of Steelmaking Processes – D. Mazumdar and James W. Evans Suggested Reference Books: 11. Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers– R. Pratap. 12. Numerical Methods for Engineers - D. Vaughan Griffiths and I.M. Smith.

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	1	1	1	1	1	1	1
CO2	3	3	2	2	2	1	1	1	1	1	1	1
CO3	3	3	3	3	3	1	1	1	1	1	1	1

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

<table>
<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME-813</td><td>Raw materials preparation for iron and steel making</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC-502: Iron making</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To acquire ideas of preparing raw materials as burden for different iron and steel making methods.
CO2: To learn about the different processing routes for raw materials preparation
CO3: To learn about the application of different testing methods of raw materials in context to iron and steel making</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Need of Raw Material Preparation. [1hr]
Ore Preparation: Important minerals and their characteristics; Ore reserves in India and World; Techno - economic appraisal of ore- breaking, crushing and grinding techniques considering sizing operations. [8hrs]
Agglomeration: Purpose, technological appraisal of various methods with merits and demerits, bonding mechanism. [3hrs]
Sintering: Process, mechanism, factors affecting sinter quality, fluxed sinter, sinter mineralogy, sintering machine design, process control.[5hrs]
Pelletizing: Process, green ball formation and growth, additives and their effect, pellet drying and hardening (cold and hot), pelletizing machine types, design, pellet firing systems. [6hrs]
Briquetting and Nodulizing: Process, additives and hardening methods. Rotary hearth furnace, its operation, future prospective. Techno- economic evaluation of various iron ore feed materials. [4hrs]
Coal preparation: Coal washing purpose and methods, use of coal in iron and steel making [6hrs]
Coke quality: Stamp charging, coke quality affected by process parameters, coke testing, methods for reactivity, strength etc. [4hrs]
Industry status: Agglomeration scenario in India and world, coking coal in India and world, future prospects. [1hr]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text books:
1. O.P. Gupta: Elements of Fuels, Furnaces and Refractories, Khanna Publishers (Delhi).
2. J.D. Gilchrist: Fuels, Furnaces and Refractories, Pergamon.
3. RC Gupta : Theory and laboratory experiments in ferrous metallurgy,PHI, New Delhi
4. R.H. Tupkary: Introduction to Modern Iron Making, Khanna Publishers.
5.A. Ghosh, Amit Chatterjee: Ironmaking and Steelmaking: Theory and Practice, PHI, New Delhi
Reference books:
1. Efficient Use of Fuel, HMSO (London).</td></tr>
</table>

Mapping of CO (Course Outcome) and PO (Programme Outcome)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1	3	1	1	1	1	2	2	1	1	1	1	1
CO2	3	3	2	2	2	3	3	1	1	3	3	3
CO3	3	3	3	3	3	3	3	3	2	3	3	3

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Department of Metallurgical & Materials Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MME814	Experimental Techniquesin Metallurgy	PEL	3	0	0	3	3
Engineering Physics (PH 01)		Course Assessment methods (Continuous (CT), mid-term (MT) and end assessment (EA))					
Engineering Physics		CT+MT+EA					
Course Outcomes	CO1: To understand the principle and theory of different experimental techniques CO2: To understand the mechanisms used to measure the different properties of materials using different techniques. CO3: To learn science and technological aspects of different experimental techniques used for materials						
Topics Covered	OpticalMethods:Fundamentalofimageformation,Differentaberrationinoptical systems, Opticalmicroscopy,characteristic ofmicroscope,differentconditionsof imageformation suchas brightfield,darkfield, obliqueillumination. Special TechniquesinMetallography:Polarizedbeam,Phase Contrast,Differential Interference Microscopy,Fluorescent's microscopy,Principles of above techniques andtheirapplications.QuantitativeMetallurgy andImageanalysis,Applications Developments forQuantitativeImage analysis in Metallurgy. [10 hrs] BasicprincipleofScanningElectronMicroscopy (SEM),TransmissionElectron Microscopy (TEM),secondary electron,backscatteredelectron,Diffractionpattern analysis,energy dispersiveX-ray spectroscopy(EDS),Wavelengthdispersive spectrometeranalysis(WDS),electron backscattereddiffraction(EBSD), electron probe microanalysis(EPMA).FundamentalofAtomic Force microscopy,Basic theory,Imageformationand its applications.[8 hrs.] Techniquesfor chemical analysis:Atomic absorption spectrometer,Emission spectroscopy&directreadingspectrometer, Mass spectrometer. Principle of temperature measurement by suing thermocouple and radiation pyrometers. [4 hrs.] Thermalanalysisofphase transformations: Thermal Analysis techniques: Principle, Working andapplicationofDTA,TGA,DSCandThermo-MechanicalAnalysis, Principles and Applications. [2 hrs.] Principle of magneticcharacterization, characterization of soft magnetand hard							

	magnets.Application. [4 hrs.] NDT:BasicprincipleofDye Penetranttesting,Typesofdyemethodsand application,Developer applicationandInspection,Magneticparticletesting,Basic theory ofmagnetism,Magnetizationmethods,Fieldindicators,Particleapplication, Inspection.Eddy currenttesting,Basicprinciple;Faraday'slaw,Inductance, Ultrasonic testing:Basicsofultrasonicwaves,Pulseandbeamremarks, Radiographictesting,Basics,differentisotopesanddifferenttechniquestoidentify the flaws. [10 hrs.]
Text Books, and/or reference material	Suggested Text Books: 1. ExperimentalTechniquesinPhysicalMetallurgy,V.T.Cherepin&A.K. Malik, I.I.T., Bombay. 2. Thermal Analysis byBernhard WiindrelichAcademic Press. 3. ImageAnalysis &Metallography.(MicrostructuralScienceVol.-17)ASTM 1989. 4. 1.F.Weinberg,Editor,Tools&TechniquesinPhysicalMetallurgy,Vol.I& Vol.II, Marcel Dekker, 1970. Suggested Reference Books:

Mapping of CO (Course Outcome) and PO (Programme Outcome)

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3							2	2	3
CO2	3	3	3							2	2	3
CO3	3	3	2							2	2	2

Correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)