Syllabus for B.Tech. programme in Metallurgical & Materials Engg.

L= Lecture hour/ week; T= Tutorial hour/ week; S= Sessional or practical hour/ week
C= Subject credit point; H= Subject contact hour/ week.

FIRST SEMESTER

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) and end assessment (EA))					
Basic concepts of function, limit, differentiation and integration.		CT+EA					
Course Outcomes	• CO1: Fundamentals of Differential Calculus • CO2: Fundamentals of Integral Calculus • CO3: Fundamentals of Vector Calculus • CO4: Basic Concepts 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: 10 th edition, Wiley India Edition. 2. Daniel A. Murray, Differential and Integral Calculus, Fb & c Limited, 2018. 3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2013. **Reference Books:** 1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011. 2. Thomas and Finny: Calculus and Analytic Geometry, 11 th Edition, Addison Wesley.

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	**PHYSICS**	**PCR**	**2**	**1**	**0**	**3**	**3**
Pre-requisites:		Course Assessment methods: (Continuous (CT), MID term and End Term Assessment (EA))					
NIL		CT+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. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 2. Fundamental of Optics, Jankins and White, McGraw-Hill 3. Optics, A. K. Ghatak, Tata McGraw-Hill 4. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 5. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

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	
CYC 01	Engineering Chemistry	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					

Course Outcomes	• 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.
Topics Covered	**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) 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

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) and end assessment (EA))					
		CT+EA					
Course Outcomes	• CO1: Improves the knowledge of mechanics and ability to draw free body diagrams. • CO2: Imparts knowledge on application of mechanics for special problems like truss and frame analysis. • CO3: Builds up ability to calculate centroid and moments of inertia for						

	various shapes and its application thereof. • CO4: Enhances the idea on dynamics with different engineering applications using momentum and energy principles. • CO5: Introduces with Virtual Work Principle and its simple application. • CO6: Prepares the prerequisites for studying the subject Strength of Materials / Solid Mechanics.
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

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) and end assessment (EA))					
		CT+EA					

Course Outcomes	• Understand the importance of environment and ecosystem. • Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system. • Understand the scientific basis of local and as well as global issues. • 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. Venugoplan Rao, Prentice Hall of India. 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. Anji Reddy – BS Publication..

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	• To develop the ability of mental visualization of different objects • To impart knowledge regarding standard conventions on lettering, dimensioning, symbols etc • To introduce with the theory of orthographic projection to solve problems on one/two/three dimensional objects • To prepare for the higher semester departmental drawings • To give exposure 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 Books, 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

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 Test (CT) and/or End Assessment (EA))**					
None		CT					
Course Outcomes	• CO1: Improvement in linguistic proficiency of the learners • CO2: Improvement in communicative ability of the learners						
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. Technical Communication—Raman & Sharma (Oxford UP) 2. Effective Technical Communication—M A Rizvi (McGraw Hill Education)

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 Books, and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Majumdar. 2) Practical Physics – Worsnop and Flint **REFERENCE**: 1) Instruction sheets						

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 engineering 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 weak acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amour of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determination of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, $Fe(acac)_3$, cis-bis(glycinato)copper(II) monohydrate and their characterization by m. p. , FTIR etc. vi. Synthesis and characterization of organic compounds: e.g. Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron present in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatograph x. Determination of saponification value of fat/ vegetable oil
Text Books, and/or reference material	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

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 evaluation (CE) and end assessment (EA))					
NIL		CE+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

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 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** • Introduction of Yoga. • Sitting Posture/Asanas- Padmasana, Vajrasana, Ardha kurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar. • Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra. • Laying Posture/Asanas- Pavana Muktasana, Uttana Padasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani. • Meditation- Yog nidra, Om chant, Pray chant. • Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardha chandrasana, Trikonasana, Utkatasana, Padahastasana. • Pranayama- Deep breathing, Anulom Vilom, Suryabhedi, Chandrabhedi.						

	• Kriya- Kapalbhati, Trataka. **ATHLETICS** • Introduction of Athletic. • Starting Technique for Track events- Standing start, Crouch start & 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, Over head 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), Abdal chagi (Butterfly kick), Back kick etc. **NSS** • Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • Matribhasha Saptah celebration

SECOND SEMESTER

<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="2">Pre-requisites</td><td colspan="5">Basic concepts of set theory, differential equations and probability.</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, 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, Stochastic simulation, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. E. Kreyszig, Advanced Engineering Mathematics: 9th edition, Wiley India Edition.
2. Gilbert Strang, Linear algebra and its applications (4th Edition), Thomson (2006).
3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Edition.
Reference Books:
1. S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hall of India (2000).
2. C. Grinstead, J. L. Snell, Introduction to Probability, American Mathematical Society</td></tr>
</table>

<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>CSC01</td><td>INTRODUCTION TO COMPUTING</td><td>PCR</td><td>2</td><td>1</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">Basic knowledge of computer. CSC01 assumes no prior knowledge of programming.</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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..</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
</table>

	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

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	
ECC01	**Basic electronics**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: Acquire idea about basic electronic circuit, construction, operation. • CO2: Learn to use these Circuit elements for different applications.. • CO3: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	Semiconductors and its properties. (3) PN Junction formation and construction of Diode. (5) Diode circuits as rectifiers, Diode based waveform shaping circuits. (4) Bipolar Junction Transistor, construction and operation. (4) BJT Biasing circuits, different types. (3) Amplifier, Single stage, CE,CB, CC, operation and uses. (4) Feedback amplifier, advantages & disadvantages, basic closed loop analysis (3) Other Semiconductor Devices : Operation and use of LED, JFET, DIAC, MOSFET(2) Opamp: Characteristics of ideal operational amplifier Pin Configuration of IC 741, Analysis of simple operational amplifier circuits: concept of virtual ground; non-inverting amplifier and inverting amplifier Applications: voltage follower, summer, differentiator, integrator(6) Oscillator: Positive feedback and condition of oscillation R-C phase-shift oscillator, Wien bridge oscillator(3) Boolean Algebra : Boolean algebra, De Morgan's theorem, simplification of Boolean expression, Number system, range extension of numbers, Different codes: Gray code, ASCII code and different BCD codes and their uses(4) Logic Gates : NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates Simplification of logic functions, Realizations of logic expressions using logic gates(4)						
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Integrated Electronics: Millman & Halkias Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronics - Circuits and Systems, Fourth Edition by Owen Bishop						

	3. Electronics Fundamentals: Circuits, Devices & Applications (8e) by Thomas L. Floyd & David M. Buchla. 4. Electronic Principles, by Albert Paul Malvino Dr. and David J. Bates 5. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul Malvino Dr., David J. Bates, et al.

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	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	• CO1: To learn the fundamentals of Electric Circuits and Network theorems. • CO2: To develop an idea on Magnetic circuits, Electromagnetism • CO3: To learn about single phase and polyphase AC circuits. • CO4: Introduction to single phase transformer. • CO5: Introduction to the transient analysis of RLC circuits with DC excitation.						
Topics Covered	Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (3) Network theorems. (4) Magnetic field, Concept of magnetic circuits, Magnetomotive Force, Reluctance, Ampere's circuital law and Biot-Savart law, Determination of B/H curve, Comparison of electric and magnetic circuit, Electromagnetic induction, Faraday's laws of electromagnetic induction, Direction and Magnitude of induced E.M.F. (7) Self and mutual Inductance, Inductances in series and parallel, Energy stored in inductor, Capacitance, Capacitance in series and parallel, Relationship between charge, voltage and current, Energy stored in capacitor (5) Transients with D.C. excitation. (5) 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, Behaviour of A.C. circuits, Resonance in series and parallel R-L-C circuits (7) Single-Phase Transformer , equivalent circuits, open circuit and short circuit tests (6) Polyphase 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)						
Text Books, and/or reference material	Text Books: 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 Education India						

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>BTC01</td><td>LIFE SCIENCE</td><td>PCR</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</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"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To be familiarized with the basic cellular organization of organisms and cellular communications.

CO2: To impart an understanding about the basic structure and functions of the macromolecules and their biosynthesis and catabolism.

CO3: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa

CO4: To introduce molecular biology to understand biological processes in various applications.

CO5: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens.

CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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
Introduction, 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</td></tr>
</table>

	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, including 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, Publisher: BOOKS & ALLIED (P) LTD.-KOLKATA 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 Edition), Shuler and Kargi, Prentice Hall International.

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	• Introduction to graphical solution of mechanics problems • Graphical solution of problems related to resultant/equilibrium in coplanar force system (Imparting knowledge on polar diagram, funicular polygon) • Introducing Maxwell diagram and solution of plane trusses by graphical method • Determination of centroid of plane figures by graphical method • 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 Books, and/or reference material	1)… Engineering Drawing and Graphics – K Venugopal 2)… AutoCAD — George Omura 3)… Practical Geometry and Engineering Graphics – W Abbott						

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. • CO2: To understand the principle of loops, branching statements • CO3: To understand the working principle of function, recursion						

	• CO5: To understand arrays , pointer, parameter passing techniques • CO6: To detail out the operations of strings • CO7: To understand structure, union • CO7: 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

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: To study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: To 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 Malvino Dr., David J. Bates, et al. Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul Malvino Dr. and David J. Bates

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	
EES51	**ELECTRICAL TECHNOLOGY 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 superposition. • CO2: To understand the principle of maximum power transfer • CO3: To understand the characteristics of CFL, incandescent Lamp, carbon lamp. • CO4: To understand the calibration of energy meter. • CO5: To understand open circuit and short circuit test of single phase transformer. • CO6: To analyse RLC series and parallel circuits • CO7: To understand three phase connections						
Topics Covered	**List of Experiments:** 1.To verify Superposition and Thevenin 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						
Text Books, and/or reference material	Text Books: 1. Suggested Text Books: 1. Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru (Author), J M Chuma (Author), H U Ezea (Author)						

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, Ardha Matsyendrasana (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), Ardha Halasana (Half Plough Pose), Sarvangasana (Shoulder Stand), Halasana (Plough Pose), Matsyasana, Supta Vajrasana, Chakrasana (Wheel Posture), Naukasana (Boat Posture), Shavasana (Relaxing Pose), Makaraasana. • Meditation- 'Om'meditation, Kundalini Or Chakra Meditation, Mantrameditation. • Standing Posture/Asanas- Ardha Chakrsana (Half Wheel Posture), Trikonasana (Triangle Posture), Parshwa Konasana (Side Angle Posture), Padahastasana, Vrikshasana (Tree Pose), Garudasana (Eagle Pose). • Pranayama- Nadi sodha, 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

Third Semester

<table>
<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC301</td><td>Metallurgical Thermodynamics and Kinetics</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">CYC01: Engineering Chemistry</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr M.K. Mondal & Dr S Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn Fundamentals of Materials Thermochemistry
CO2: Ability to solve problems on different Metallurgical systems.
CO3: Learn principles of solution Thermodynamics and its application to Industrial solutions.
CO4: Identify and solve reaction kinetics and mechanism.
CO5: Ability to correlate electrochemistry with thermodynamic Parameters</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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 Funtion (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)</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Introduction to Metallurgical Thermodynamics – David R Gaskell. 2. Metallurgical Thermochemistry – O. Kubaschewski, E LL Evans and C B Alcock 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.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC302</td><td>Introduction to Metallurgy and Materials</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">PHC01: Engineering Physics</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Prof. J. Maity & Dr. S. Bera</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. To learn atomic structure in view of quantum mechanical approach.
II. To correlate atomic structure, periodic table and elemental properties.
III. To understand the correlation between type of bonding and material properties.
IV. To interpret crystal structure in view of translational periodicity and symmetry.
V. To learn the presence of different kinds of defects in crystal so as to relate their effect on material properties.
VI. To understand different types of binary phase diagrams with regard to the extent of solubility of the two components at solid state and liquid state.
VII. To get an overall idea about different kinds of Engineering materials.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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, semiconductors and polymers; Crystal structure – concept of lattice and crystal, Translational periodicity and symmetry, crystal systems, space lattice, representation of atomic position, lattice directions and lattice planes in cubic and hexagonal systems; atomic packing, voids in FCC, BCC and HCP crystals; crystal imperfections– 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)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Materials Science and Engineering: A first course – V. Raghavan, PHI Learning Pvt. Ltd., 2004.
2. Introduction to Metallurgy - 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. Introduction to solids- L.V. Azaroff, Tata McGraw-Hill, 1990.
6. Crystallography applied to solid state physics- A. R. Verma, O. N. Srivastava, Wiley, 1982.</td></tr>
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<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>MMC303</td><td>Non- Ferrous Process Metallurgy</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) and end assessment (EA))</td></tr>
<tr><td colspan="3">CYC-01: Engineering Chemistry</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• Learn fundamentals and unit operations of Mineral beneficiation (MB).
• Identify and solve the problems of industrial applications of MB unit.
• To learn the design & operational aspects of MB unit.
• Ability to analyze industrial processes to meet the mineral beneficiation industry.
• Learn industrial applications of various modern developments in purification of precious metals.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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. H.S. Ray and A. Ghosh, Principles of extractive metallurgy,Wiley Eastern Ltd., New Delhi (1991)

REFERENCE BOOKS:
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).</td></tr>
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<tr><td colspan="8">Department of Earth and Environmental 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>ESC332</td><td>Economic Geology</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</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">• 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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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</td></tr>
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<tr><td colspan="8">Department of Earth and Environmental Studies</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>ESS382</td><td>Economic Geology Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) assessment)</td></tr>
<tr><td colspan="3"></td><td colspan="5">CT</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• 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 mineral beneficiation process.
• Students will learn to solve geological problems associated with occurrence of raw materials to be used for metallurgical purposes.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
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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>MMS351</td><td>Metallurgical Thermodynamics and Kinetics Lab</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">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr M.K. Mondal & Dr S Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To Co-relate Evaluation of thermodynamic parameters from experiments
CO2: To carry out gas solid equilibrium experiments
CO3: To study reducibility of ores and measure data
CO4: Understanding the fundamentals for drawing Ellingham Diagram
CO5: To study different rate kinetics for mild steel and copper</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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%</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Introduction to Metallurgical Thermodynamics – David R Gaskell.
2. Metallurgical Thermochemistry – O. Kubaschewski, E LL Evans and C B Alcock
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..</td></tr>
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Fourth Semester

<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>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="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">XEC-01 : Engineering Mechanics</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr S Pramanik & Dr M.K.Mondal</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learn fundamentals of Fluid flow, heat transfer and mass transfer
CO2: Identify nature of fluid flow and methods of heat transfer & mass transfer
CO3: Design &analyze ideal & non-ideal systems
CO4:Learn industrial applications of Fluid flow, heat transfer and mass transfer
CO5: Solve Fluid flow, heat transfer and mass transfer problems of different difficulty levels through tutorials</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, 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 resistanceand 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 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">Text Books:
1. Rate Phenomena In process metallurgy – J. Szekely and N.J. Themelis
2. Transport Phenomena in Metallurgy – G.H. Geiger and D.R.Poirier
Reference Books:
1. Heat Transfer– J.P. Holman
2. Heat and Mass Transfer – F. P. Incropera and D. P. DeWitt
3. Transport Phenomena – R. B. Bird, W. E. Stewart and E. N. Lightfoot</td></tr>
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<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 colspan="2">Developer</td><td colspan="5">Prof. J. Maity & Dr. S. Bera</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">I. To learn the thermodynamic aspects of phase changes.
II. To understand and interpret Free energy-composition diagram and origin of phase diagrams.
III. To learn atomic mechanism of diffusion.
IV. To analyze diffusion mechanism in different kinds of solid solutions.
V. To derive mathematical expressions of diffusion in order to interpret industrial processes such as carburizing, homogenizing annealing etc.
VI. To understand the fundamentals of solidification in order to apply it in Foundry industry.
VII. To learn solid state phase transformations in steel.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Introduction: Basic concepts about Stability of Phases and equilibrium; Types of Phase Transformations, Order of transformations. (5 hours)

Phase Equilibria: Thermodynamics of phase changes, phase diagrams and equilibria in relation to Free energy-composition diagrams. Interpretation of phase diagrams, determination and calculations. Solid-liquid Miscibility gap; invariant reaction. Principles of ternary phase diagram, Examples of a few metallic and ceramic phase diagrams. (6 hours)

Diffusion: Phenomenological equation of diffusion, Chemical potential gradient, Fick's first law of diffusion, diffusion coefficient (diffusivity), representation of diffusion flux in terms of chemical potential gradient; Nernst-Einstein Equation, Diffusion in ideal solution and in solutions with positive and negative deviation; Uphill diffusion, determination of diffusion coefficient (diffusivity) for ideal binary solid solution in terms of jump frequency and jump distance, atomic mechanism of diffusion, Expression of diffusion coefficient (diffusivity) for self diffusion in pure metal or diffusion in substitutional solid solution through vacancy mechanism and in interstitial solid solution; Steady state diffusion and transient diffusion; Fick's second law of diffusion; determination of self diffusion coefficient by radioactive method; solution of Fick's second law: analysis of carburizing and decarburizing processes; solution of Fick's second law for variable diffusivity: Boltzmann-Matano analysis, Matano interface, determination of diffusivity as a function of concentration; Diffusion in substitutional solid solution: Kirkendall effect, Darken's analysis. (10 hours)

Liquid-Solid Phase Transformation: Principles of Solidification in metals and alloys: thermodynamics involved, eutectic and peritectic Solidification, Homogeneous and heterogeneous nucleation, Mechanisms of growth. Rapid Solidification Processing. (8 hours)</td></tr>
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	Solid State Phase Transformations: Nucleation and growth Kinetics, homogeneous and heterogeneous transformation, Precipitation: Coherency, age hardening, particle Coarsening. Ostwald ripening, Order-disorder transformation, spinodal decomposition, massive transformations. (8 hours) Solid State Phase Transformations in steel: Reconstructive and displacive transformations; Pearlitic transformation: mechanism and kinetics: Johnson-Mehl equation, morphology of pearlite; Bainitic transformation: mechanism and kinetics; morphology of upper bainite and lower bainite; Martensitic transformation: Mechanism- diffusionless displacive nature; morphology of high carbon and low carbon martensite. (8 hours)
Text Books, and/or reference material	Text Books: 1. Phase transformations in metals and alloys- D.A. Potter and K.E. Easterling, CRC Press, 1992. 2. Transformations in Metals, P.G. Shewmon, Mc-Graw Hill, 1969. 3. Introduction to Physical Metallurgy – S. N. Avner, Tata McGraw Hill, 1997. 4. Physical Metallurgy – Peter Haasen, Cambridge University Press, 1996. 5. Physical Metallurgy Principles, R. E. Reed-Hill and R. Abbaschian, 3rd ed, PWS-Kent Publishing, 1992. 6. Physical Metallurgy for Engineers – A. G. Guy, Addison-Wesley Pub. Co., 1962. 7. Modern Physical Metallurgy, R. E. Smallman, Butterworths, 1963.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC403</td><td>Materials Characterization</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-302: Introduction to Metallurgy and Materials</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr B.K. Show & Dr S. Bera</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. Learn fundamentals of X-ray diffraction and electron microscopy.
II. Identify the crystal structure and index the diffraction patterns of different phases.
III. Learn the operational aspect of x-ray diffractometer and electron microscopes.
IV. Ability to analyze diffractograms of industrial samples to meet contemporary need.
V. Solve diffractograms of different difficulty levels through tutorials.
VI. Learn different applications of X-ray diffraction.
VII. Learn the development in X-ray diffraction and electron microscopy</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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.</td></tr>
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<tr><td colspan="7">Department of Computer Science and Engineering</td></tr>
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<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="4">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="4">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">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="6">• 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. [2]
• Sorting: Definition of sorting, internal and external sorts, Insertion Sort, Bubble Sort, Selection sort, Quick Sort, Merge Sort, Heap sort. [8]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">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.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CSS483</td><td>Data Structures Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">Knowledge of programming</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• 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.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMS451</td><td>Transport Phenomena Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</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">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr S Pramanik & Dr M.K. Mondal</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To correlate Fluid flow with Reynold's number.
CO2: Identify methods of heat transfer & mass transfer
CO3: To study flow through a packed bed
CO4: To measure friction factor during fluid flow
CO5: To measure losses for a fluid flow across various cross-section of a pipe.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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: Heat Transfer during solidification of Aluminium</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Textbook :
Fundamentals of Momentum, Heat, and Mass Transfer by Welty, Wicks, Wilson, and Rorrer</td></tr>
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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="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Prof. J. Maity & Dr. S. Bera</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. To investigate microstructure of plain carbon steels as a function of carbon content.
II. To compare the microstructures of different steels with different carbon content in view of the presence of different micro-constituents/phases.
III. To correlate the microstructures of different steels with properties in view of application.
IV. To investigate microstructure of different cast irons.
V. To compare the microstructures of different cast irons in view of the presence of different micro-constituents/phases.
VI. To correlate the microstructures of different cast irons with properties in view of applications.
VII. To understand the application of lever rule and phase rule.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">(i) Experiment 1: Investigations of the microstructures of pure metals (Fe, Cu, Zn, Al)

(ii) Investigation of the microstructures of carbon steels containing ~0.2%C, ~0.4%C, ~0.6%C, ~0.8%C, ~1.0%C, in correlation with phase equilibria in Fe-C system (Iron–Carbon phase diagram).
Experiment 2 (Part I): Microstructure of 0.2 wt.% C steel (4 hours)
Experiment 3 (Part II): Microstructure of 0.4 wt.% C steel (4 hours)
Experiment 4 (Part III): Microstructure of 0.6 wt.% C steel (4 hours)
Experiment 5 (Part IV): Microstructure of 0.8 wt.% C steel (4 hours)
Experiment 6 (Part V): Microstructure of 1.0 wt.% C steel (4 hours)

(iii) With regard to Fe-C-Si phase equilibria, investigation of the microstructure of different types of cast irons, viz. White Cast iron, Grey Cast iron, Spheroidal (Nodular) graphite cast iron and Malleable cast iron.
Experiment 8 (Part I): Microstructure of White Cast iron (4 hours)
Experiment 9 (Part II): Microstructure of Grey Cast iron (4 hours)
Experiment 10 (Part III): Microstructure of Spheroidal (Nodular) graphite cast iron (4 hours)
Experiment 11 (Part IV): Microstructure of Malleable cast iron (4 hours)
(iv) Experiment 12: Study of the precipitation hardening process in Duralumin (Al-4.5% Cu alloy) (3 hours)

(v) Experiment 13: Application of Lever Rule. (3 hours)

(vi) Experiment 14: Application of Phase Rule to different types of binary phase diagrams. (3 hours)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Textbook :
1. Phase transformations in metals and alloys- D.A. Potter and K.E. Easterling, CRC Press, 1992. 2. Introduction to Physical Metallurgy – S. N. Avner, Tata McGraw Hill, 1997.
3. Physical Metallurgy Principles, R. E. Reed-Hill and R. Abbaschian, 3rd ed, PWS-Kent Publishing, 1992.
4. Modern Physical Metallurgy, R. E. Smallman, Butterworths, 1963.</td></tr>
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Fifth Semester

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<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 colspan="2">Developer</td><td colspan="6">Dr. Barnali Maji , Dr Susanta Pramanik, Dr Manab Mallik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• To understand different Manufacturing Processes
• Ability to design a mould for casting
• To understand the basics of Welding Metallurgy
• To have a overview of manufacturing by powder 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 Molding and Machine molding; 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.
2. M. C. Flemings: Solidification processing, McGraw-Hill, 1974.
3. Metals Handbook, Casting, vol. 15, 10th Edition, ASM International, Materials Park, Ohio, USA, 1998.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC502</td><td>Heat Treatment of Materials</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">PHC01: Engineering Physics</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr Durbadal Mandal & Dr. Manab Mallick</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: To learn different types of furnaces used in heat treatments and heating mechanisms.
CO 2: To understand the foundation of heat treatment processes affecting microstructure
CO3: Concept behind the microstructure under equilibrium and non-equilibrium cooling. To acquaint with TTT and CCT diagrams and associated microstructure under different industrial cooling conditions.
CO4: Significant roles of microstructural features on mechanical properties.
CO5: Heat transfer mechanism in heat treatment process and associated microstructure</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Objectives and Principles of heat treatment. Iron-Carbon Phase Equilibrium Diagram; Austenitisation, Transformation of austenite to pearlite, bainite and martensite; Characteristics of transformation products,. [6]
T-T-T-and C-C-T diagrams; Factors affecting T-T-T curves. Heat treatment processes: Different types of annealing, spheroidizing, normalsing, hardening, tempering, patenting, austempering, martempering, Sub-zero treatment. [12]
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 harenability, Heat Treatment Defects, Residual stresses developed upon heat treatment. [8]
Age Hardening : Basic requirements and steps. Heat treatment of non-ferrous metal and alloys -- Aluminium alloys, Magnesium alloys, Copper and its alloys, Titanium alloys, Ni and its alloys. [8]
Practical considerations in heat treatment: Accessories, Cooling media, Types of furnace and Furnace atmosphere. [2]
Surface heat treatment – Carburizing of steels, Cyniding and Carbonitriding, Nitriding, Flame hardening, Induction hardening, Laser hardening etc. [6]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
Text Books:
1. An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill Book Company.
2 ASM Metals Hand Book – Vol. IX, ASM International Materials Society.
3. Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, Charlie R. Brooks, ASM international, 1996.
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</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMC503</td><td>Fundamentals of Plastic Deformation & Strengthening of Materials</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">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr. Madan Mohan Ghosh & Dr. Manab Mallik</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">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 understand various mechanisms of strengthening
CO4: To correlate the fundamentals ideas of deformation and strengthening with the observations in materials testing and mechanical processing</td></tr>
<tr><td>Topics Covered</td><td colspan="6">1) 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]
2) 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]</td></tr>
</table>

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 • Mechanical Behavior of Materials, Second Edition, *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

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<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="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 colspan="2">Developer</td><td colspan="6">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• Learn fundamentals of physic-chemical principles of blast furnace iron making.
• To learn the design & operational aspects of blast furnace technology.
• Learn industrial applications of various modern developments in iron making.
• Solve operational problems of different difficulty levels in iron making
• To learn the development in alternative iron making processes.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Pig Iron production in India, Raw Materials – Valuation and preparation of chief raw materials, Methods of Agglomeration : sintering, pelletizing . Testing of raw materials. (16)
Blast furnace iron making : Design and construction of the blast furnace. Theory and practice of pig iron making – charge distribution, burden calculation. (10)
Physico-chemical aspects of blast furnace reactions,. Blast furnace slags. (13)
Developments in blast furnace practice. Blast furnace operation and irregularities. Blast furnace accessories: blowers, stoves, gas cleaning plants etc. (8)
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">TEXT BOOKS:
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

REFERENCE BOOKS:
1. Manufacture of Iron & Steel. Vol. I.- G. B. Bashforth.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMS551</td><td>Manufacturing Processes Lab - I</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</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">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr. Susanta Pramanik & Dr Barnali Maji</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• To understand the basics of metal Casting
• To design a pattern for a casting
• To understand casting defects and methods of elimination
• To understand the techniques of welding
• To understand the microstructures of three different zones of a welded portion</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMS552</td><td>Heat Treatment of Materials Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</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">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr Durbadal Mandal & Dr. Manab Mallik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To know the alteration of microstructure with cooling rates in a given plain carbon steel.
CO2: To compare the microstructures of different plain carbon steels cooled at a particular rate.
CO3: Comparison of microstructure of annlealed, normalized, hardened (cooled in oil and in brine) steels
CO4: To investigate microstructure and hardness of hardened and tempered steel.
CO5: Performing surface hardening (e.g. case carburizing) process and observation of microstructure and hardness measurement case carburised steel.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Acquaintance with Furnaces and their Operation [3]
Annealing, normalizing, hardening, and tempering treatments of plain carbon steels [12]
Annealing, normalizing, hardening, treatments of plain carbon steels [3]
Influence of underheating and overheating on microstructure and properties [3]
Jominy End Quench Test [3]
Determination of critical diameter of Steel by trial hardening method. [6]
Pack Carburizing of steels, Post-carburizing heat treatment, Measurement of case depth. [6]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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.
Reference Books:
1. Principles of Heat Treatment – R. C. Sharma, New Age International (P) Ltd.
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MMS553</td><td>Plastic Deformation & Strengthening of Materials Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</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">Nil</td><td colspan="6">EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr. Madan Mohan Ghosh & Dr. Manab Mallik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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 carry out cold working and annealing of ductile materials and evaluating the materials response
CO4: To correlate structure with the mechanical properties under different conditions of deformation</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">• 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</td></tr>
</table>

Sixth Semester

<table>
<tr><td colspan="8">Department of Humanities and Social Sciences</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>HSC631</td><td>Principles of Economics</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">NIL</td><td colspan="5">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• To review basic economic principles with students;
• To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works;
• To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">(A) Microeconomics
1. Economics: Basic Concepts (3)
2. Theory of Consumer Behaviour (3)
3. Theory of Production, Cost and Firms (3)
4. Analyses of Market Structures: Perfect Competition (3)
5. Monopoly Market (3)
6. General Equilibrium (3)
7. Welfare Economics (3)

(B) Macroeconomics
1. Introduction to Macroeconomic Theory (3)
2. National Income Accounting (3)
3. Determination of Equilibrium Level of Income (3)
4. Money, Interest and Income (3)
5. Inflation (3)
6. Unemployment (3)
7. Multiplier (3)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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. SoumyenSikder: Principles of Macroeconomics</td></tr>
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<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>MMC601</td><td>Steel Making</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 colspan="2">Developer</td><td colspan="6">Dr. Susanta Pramanik & Dr Manas Kumar Mondal</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• Learn fundamentals of physico-chemical principles of steel making.
• Identify the techniques to manufacture inclusion free steel .
• To learn the design & operational aspects of steel making technology.
• Ability to analyze steel making processes to meet the current need.
• Learn various modern developments in steel making.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Historical Perspective, An Overview of Modern Steel making. (1)
Steelmaking Fundamentals - Chemical Reactions Equilibria - Carbon - Oxygen Reaction - Phosphorous - Oxygen Reaction - Manganese - Oxygen Reaction - Silicon - Oxygen Reaction - Sulphur - Oxygen Reaction (Desulphurization) - Iron-Oxygen Reaction - Slag Formation (10)
The LD Steelmaking (Practice) process - The LD Converter - Lance - LD Shop Layout - Charge Calculations - Feed Materials - Physico - Chemical Characteristics of LD Steelmaking - Description of a Typical Heat (9)
Bottom Blown Steelmaking -The Evolution of Combination Blown Steelmaking and its Distinctive Features. (2)
Steelmaking in Electric Arc Furnaces (EAF) - Construction of an Arc Furnace - Operation - Steelmaking in EAF - Eccentric Bottom Tapping - Comparison with Oxygen Steelmaking Developments in EAF steelmaking Technology. Alloy Steelmaking in EAF with Some Examples. (12)
Refractory in steelmaking - Requirements of refractory Material - Various Refractory Materials (1)
Secondary Steelmaking: Deoxidation - Techniques of Deoxidizer Addition - Physical and Chemical Interaction between Solid Additions and Steel Melt - Types of Deoxidation - Deoxidation Kinetics and Products. Ladle Metallurgy : V.A.D ; V.O.D ; R H (12)
Vacuum Degassing - Principles - Degassing Techniques (2)
Ingot Casting and its Defects (1)
Continuous Casting - Process description - Continuous Casting Products and Casting Defects - Near net shape Casting (3)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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.
REFERENCE BOOKS:
1. Turkdogan, E.T., A Text Book of Steelmaking, Academic Press, London, 1997.
3. Ghosh, A., Secondary Steelmaking, CRC Press, Boca Raton, 2000.</td></tr>
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<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>MMC602</td><td>Mechanical Working of Materials</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</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC503 : Fundamentals of Plastic Deformation & Strengthening of Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr. Madan Mohan Ghosh</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">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
CO4: To know about the applications of different metal forming processes</td></tr>
<tr><td>Topics Covered</td><td colspan="6">
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.
[6 h]
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.
[10 h]
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.
[10 h]
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.
[8 h]
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.
[6 h]
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.
[5 h]
7) Drawing: Different types of drawing processes, analysis of wire drawing and tube drawing, limit of drawability, residual stresses in drawn products.
[3 h]
8) Sheet - Metal Forming: Various sheet-metal forming processes, stretch forming, deep drawing, limiting draw ratio, forming limit criteria, defects in sheet-formed products.
[8 h]
</td></tr>
</table>

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

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<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>MMS651</td><td>Mineral Beneficiation Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</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">MMC-303: Non - Ferrous Metallurgy</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• To correlate crushing of a material with different crushers
• To facilitate fine crushing in a ball mill
• To separate the fines from different sizes
• To use the effect of cyclone for separation of microfines
• To separate sulphide ores by froth floatation unit</td></tr>
<tr><td>Topics Covered</td><td colspan="6">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 : To perform Sieve shaking of the fines generated from Ball Mill
Experiment-4 : To Separate Micro fines in a Cyclone Separator
Experiment-5 : Froth Floatation
Experiment-6 : Jigging
Experiment-7 : Separation magnetic and nonmagnetic fines in a magnetic separator.
Experiment-8 : Separation of Material in a double-decker screen.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">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)
Reference books:
1. F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York</td></tr>
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<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>MMS652</td><td>Mechanical Working of Materials Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</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">EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr. Madan Mohan Ghosh</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">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 evaluate the quality of the rolled and forged products in terms of microstructure and mechanical properties
CO4: To assess and understand the factors affecting the quality of the products</td></tr>
<tr><td>Topics Covered</td><td colspan="6">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</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">• 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., London, 1963</td></tr>
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<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>MMS653</td><td>Materials Characterization Lab-I</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</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-403: Materials Characterization</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr B.K. Show & Dr S. Bera</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. Learn fundamentals of X-ray diffractometer and electron microscopes.
II. Identify the crystal structure and index the X-ray diffraction patterns of different phases.
III. Learn the operational aspect of X-ray diffractometer and electron microscopes.
IVAbility to analyze diffractograms of industrial samples to meet contemporary need.
V. Determination of particle size from the X ray diffractogram..
VI. Become intimately familiar with macrofractographic and microfractographic analysis of different failed components using Scanning Electron Microscope.
VII. Learn to index selected area diffraction patterns (SADP) from TEM.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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.</td></tr>
</table>

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>MSC731</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>
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<table>
<tr><td colspan="7">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>MMS751</td><td>Manufacturing Processes Lab - II</td><td>PCR</td><td>0</td><td>0</td><td>1</td><td>4</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">MMC403 and MMC501</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr. Manab Mallik</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Learn science and technological aspects of the Powder production by Chemical reduction and Ball milling
CO2: Evaluate structure and physical properties of the synthesized powder
CO3: Demonstrate the effect of compaction pressure, particle geometry, binders and lubricant on the green strength
CO4: To study the effect of compaction pressure on densification
CO5: Learn various sintering techniques to produce net shape product
CO6: Examine microstructural, physical and mechanical properties of sintered products
CO7: Explore powder-processing-property relationship through laboratory assignment.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">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]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">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>
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<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>MMS752</td><td>Materials Characterization Lab - II</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</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">MMC-503: Fundamentals of Plastic Deformation and Strengthening of materials</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr B.K. Show & Dr M. Mallik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. Learn fundamentals of tribological behavior of materials and NDT methods.
II. Identifying the mechanism of wear.
III. Learn the operational aspect wear machines and NDT instruments.
IV Ability to analyze the fracture/wear mode to meet contemporary need.
V. Determination strain hardening exponent from tensile test.
VI. Learn the effect of strain rate on tensile behavior of steels.
VII. Learn to calculate fracture toughness by indentation technique.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:

1. Mechanical Metallurgy by George Dieter</td></tr>
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<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>MMS753</td><td>Ferrous Process Metallurgy Lab</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</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">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr. Susanta Pramanik & Dr M.K. Mondal</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1:To understand the method of agglomeration of iron ore fines in three different routes
CO2:To compare the different properties in green and indurated condition of different routes of agglomeration
CO3:To study the fluid dynamics in a cold model of B.O.F
CO4:To study the turbulence in a water model Of CC tundish
CO5:To have the ability of solving industrial problems</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Experiment -1: To Perform sintering of iron ore fines in laboratory Sintering Machine (3h)
Experiment-2: To perform the properties of sinter produced (3h)
Experiment -3: To manufacture iron ore fines Pellets in a disc pelletizer (3h)
Experiment-4: To study the green and indurated properties of pellets (3h)
Experiment -5: To manufacture Briquettes of iron ore fines. (3h)
Experiment-6: To 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 (3h)
Experiment -7 : To study the effect of inclusions in single strand continuous casting model (3h)
Experiment-8 : To study the effect of Dams on the flow characteristics in single strand continuous casting model (3h)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steel making, Prentice Hall of India, New Delhi, 2008.</td></tr>
</table>

ELECTIVE SUBJECTS: Depth Electives - I & II

<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>MME610</td><td>Engineering Materials</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">PHC01: Engineering Physics</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr Durbadal Mandal & Dr. Manab Mallick</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn basis of classification and different types of Engineering Materials.
CO 2: To understand the variation of microstructure with composition and heat treatment microstructure
CO3: Role of alloying elements in alteration of phase diagram and associated materials microstructure and property.
CO4: To acquaint with the physical, mechanical and electrochemical properties of materials.
CO5: To understand microstructure-property relationship for various engineering applications</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Various Classes of Engineering Materials: Factors affecting selection of Engineering Materials-Service requirements, fabrication requirements and economic requirements. [2]
Study of the industrially important steels, their mechanical and thermal treatment and uses: Plain carbon steels, Dual Phase Steels and High Strength Low alloys (HSLA) Steels. [8]
Effect of Alloying Elements in Steel. Alloy Steels: Manganese Steels, Hadfield manganese Steel. Heat Resistant and Stainless Steels, Tool and Die Steels, High speed tool steel (HSTS), Maraging Steels. [12]
Study of Nonferrous Alloys, their mechanical and thermal treatment: Brasses, Bronzes, Bearing Metals, Light alloys based on Aluminium and Magneium, Titanium Base alloys, Ni base alloys, Lead and tin base babbits. [12]
Cryogenic and High temperature Materials, Alloy cast irons, Special purpose materials, such as, Materials for Aerospace, Nuclear Reactors etc. Electrical and Magnetic Materials. [6]</td></tr>
</table>

Text Books, and/or reference material	**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). **Reference books**: 7. Materials Science and Engineering by Raghavan - Prenctice Hall of India Ltd. 8. Physical Metallurgy of Engineering Materials by N. R. petty, Allen Unwin (1968) 9. Light Alloys: Metallurgy of the light Metals by I. J. Polmser-Edwaraed annord. 10. The Super alloys by C. T. Sims and W. C. Hegel –Wily-Interscience.

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<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME611</td><td>Electronic and Thermal Properties of Materials</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">PHC01: Engineering Physics</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr. Madan Mohan Ghosh</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the physics behind the functional properties of materials
CO2: To understand fundamentals of electrical properties of materials
CO3: To understand fundamentals of thermal properties of materials
CO4: To correlate the fundamental concepts of electronic and thermal properties with the observed functional behaviours of materials</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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; galvanoelectric 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]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">• 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</td></tr>
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<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>MME612</td><td>Alternative Routes of Iron Making</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</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC-504: Iron Making,
MMC-301: Thermodynamics & Kinetics of Engineering Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• Understanding the different routes of Iron Making
• Understanding the Reaction Kinetics of Smelting Reduction
• Understanding the Environmental Impact for Alternative routes.
• Understanding alternative routes with Respect to Indian Conditions
• Understanding the technical problems associated with production of DRI.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">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 Indian conditions (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)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">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.

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.</td></tr>
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<tr><td colspan="7">Department of Metallurgical and Materials Engineering</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME613</td><td>Production of Ferroalloys</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>40</td><td>3</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">MMC-301: Thermodynamics & Kinetics of Engineering Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• To understand the use of Ferro alloys in the production of Steel
• To understand the technology for production of ferro alloys
• To understand the reaction mechanism during production of ferro alloys
• To understand the different design parameters of furnace
• To understand the environmental concern during production of ferroalloys</td></tr>
<tr><td>Topics Covered</td><td colspan="6">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]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">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. Eliutin, State Scientific and Technical Pub. House for Literature on Ferrous and Nonferrous Metallurgy, 1957.

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.</td></tr>
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<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME614</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 colspan="3">Developer</td><td colspan="5">Dr. S. Bera</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. Learn the history of nano-technology
II. Uses of nano-technology in nature
III. Different types of nano-materials, their advantages and disadvantages
IV. Synthesis and characterization of nano materails
V. Effect of particle/grain refinement on electrical, magnetic and optical properties
VI. Application of nano-materials, uses of nano-technology in environment and our daily life
VII. Tutorials, problems and solutions etc.</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 route, top down and bottom up approach). Characterization of nano-materials by different techniques. [12 h]

5. Application of nano-science and technology, 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. Introductio to Nanotechnology – C.P. Poole, F.J. Owens, Wiley Interscience, 2003</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME615</td><td>Ceramic Technology</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">MMC302</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr. Manab Mallik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Describes generic classification of ceramics and their specific engineering applications.
CO2: 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, as well as processing techniques of ceramics
CO5: Solve problems of fabrication of high performance ceramic parts</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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:
1.D.W. Richerson: Modern Ceramic Engineering, , CRC Press, Third Edition, 2005.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME616</td><td>Solidification Phenomena</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="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC501: Manufacturing Processes</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1:To understand solidification theories to industrial processes
CO2:To understand the macroscopic phenomena along with microstructure and defects
CO3:To predict microstructures as a function of process parameters
CO4:To apply the concept of solidification in additive manufacturing processes
CO5:To understand solidification of alloys in different industrial conditions</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Properties of metals and alloys before and during solidification. Surface phenomena. Basic terms, surface energy, surface tension, wetting angle. Wetting speed. Classification and influence of wetting. [8h]
Rapid solidification processes (RSP). Classification of high cooling rates. Conventional and unconventional effects. Undercooling and recalescence. Amorphous state. Glaze-ability. [8h]
Processing of alloys in the semi-solid state. Rheology. Newton's law of viscosity. Newtonian and non-Newtonian materials. Distribution of non-Newtonian materials, physical models of materials and their rheograms. The apparent viscosity. Thixotropy. Flow situations. Submersible rotational viscometry. 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). Theories of solid solution morphology spheroidization. Types of alloys suitable for SSM. Case studies of selected castings. [8h]
Pressure solidification processes (PSP). Effect of pressure on the primary crystallization, change the thermo-physical properties, cooling rate and the induction of force induced solidification flow. Possible flow situations in conventional and unconventional solidification processes. Changes of the primary structure obtained by the action of high external pressure during solidification. Alloys used in PSP. Practical use of the rheological behavior of the alloys in the solidification processes and its importance. Case studies of selected castings. The perspective of solidification processes. [8h]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">TEXT BOOKS:
1. Principles of Solidification by Laurens Katgerman
2. Modelling the Flow and Solidification of Metals by T. A Smith
3. Physical Metallurgy- Principles and Practise by A Raghaban

REFERENCE BOOKS:
1. Kirkwood, D.H. – Suéry, M. – Kapranos, P. – Atkinson, H.V. – Young,K.P. Semi-solid processing of Alloys. Springer .</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME617</td><td>Metal Joining Processes</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 (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MMC501 : Manufacturing Processes</td><td colspan="5">CT + EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr. Barnali Maji</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn fundamentals of different types of joining processes
CO2: To study the physical and mechanical aspects of fusion and HAZ zones
CO3: To inspection of different defects formed during welding.
CO4: To understand microstructure-property relationship of welded joint for various engineering applications.
CO5: Overall idea about different heat treatments required in various welded materials.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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.</td></tr>
</table>

ELECTIVE SUBJECTS: Depth Electives - III, IV, V

<table>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME710</td><td>Functional Materials</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">MMC-302: Introduction to Metallurgy and Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr. S. Bera</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. Learn the fundamentals of Materials Science
II. Concept of bonding, basics of crystallographic structures, points, directions and planes
III. Structure, properties and applications of ceramic materials
IV. Structure, properties and applications of polymer materials
V. Basics of electrical, magnetic and optical properties
VI. Types and applications of electrical and magnetic materials and materials for optical devices, other functional materials
VII. Tutorials, problems and solutions etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamentals of atomic structure- chemical bonding-crystal structure-property correlation; classification of different functional materials. [6 hours]

Opto-electronic Materials: Optical properties of semiconductors, absorption and emission processes, Electronic materials such as GaAs and GaN. [6 hours]

Sensor Materials: Metal oxide based sensors, Principles of operation, Solid electrolyte sensors, Oxygen sensors, Optical Sensors, Thermal Sensors and Magnetic Sensors, Thermistors and related sensors. [6 hours]

Shape memory and Superelastic alloys: shape memory effect, thermodynamic aspects and micromechanism of martensitic transformation, Stress induced martensitic transformation and superelasticity, Ni-Ti and Ni-Al based alloys and their applications. [8 hours]

Biomaterials: Concept and assessment of biocompatibility, materials for biomedical applications: Ti-alloys, stainless steel etc. [8 hours]

Nanomaterials, Smart materials, Metal foams, Nanofluids, Carbon nanotubes, Metal Hydride, Hybrid nanocomposites, Nanoporous materials, Nano coatings. [8 hours]</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Materials Science and Engineering An Introduction – William D. Callister, Jr., John Wiley & Sons, Inc., 2007 2. Materials; Engineering, Science, Processing and Design – Michael Ashby, Hugh Shercliff and David Cebon 3. Introduction to Magnetic Materials – B. D. Cullity and C. D. Graham

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME711</td><td>Fatigue, Creep and Fracture</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">MMC-302: Introduction to Metallurgy and Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr B.K. Show</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. Acquire fundamental understanding of the fracture of solid materials.
II. Develop detailed understanding of fracture mechanics, creep, and fatigue.
III. Learn about large variety of fracture mechanisms and fracture modes associated with failure.
IV. Become intimately familiar with macrofractographic and microfractographic analysis of failures.
V. Actively take part in failure analysis of failed components.
VI. Solve problems on fatigue life and different design problems.
VII. Ability to analyze and solve industrial problems to meet the contemporary need.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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; 2 h
Fracture toughness testing of metals: K_{1C}, CTOD and J_{1C}. 3h</td></tr>
</table>

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.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME712</td><td>Computational Materials Engineering</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">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr. Madan Mohan Ghosh</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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
CO4: To know about multiscale modelling and simulation for materials design</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
</table>

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

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME713</td><td>Fuel, Furnace and Refractories</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">MMC-301: Thermodynamics & Kinetics of Engineering Materials</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. To evaluate the property of Fuel
II. Understanding the different energy sources_ Conventional and Non- Conventional
III. Understanding the Environmental Impact for usage of all
IV. Understanding the design of furnace with respect to usage of fuel and Refractories
V. Understanding the different properties and usage of it n different areas</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Definition, Comparative study of solid, liquid and gaseous fuels. Constitution, classification and grading of coal. (4h)
Testing of fuels like: Grindability, Caking properties, calorific value, Proximate and ultimate analysis, Flash and Fire point, viscosity. Non-conventional Energy Resources like Nuclear fuel, Solar, Wind, Geo-thermal, Bio-mass, Hydrogen (6h)
Carbonization of coal: Coke making and by-products. Producer gas, Water gas, Natural gas, LPG, Blast furnace gas, Coke oven gas, LD gas Gobar Gas. Storage of fuels. Combustion of fuels and problems based on air supplied, excess air and products of combustion. (10h)
Definition and Classification of Furnaces, Batch furnaces, Continuous furnaces. (5h)
Construction and working of furnaces like Cupola, Induction furnace, Arc furnace, Resistance furnace, Pit furnace, Rotary furnace, Muffle furnace etc. (6h)
Evolution of heat and flame temperature. Available heat. Natural, forced, induced and balanced draft. Chimney height, Heat losses in furnaces and minimization. Waste heat recovery. (7h)
Nature and Type of Refractories, Manufacture of Common Refractories ; Properties of refractories; Lay out of Refractories in a furnace. (10h)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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
4. Industrial Furnaces - Vol. I & II, W. Trinks and M. H. Mawhiney, Wiley</td></tr>
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<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) and end assessment (EA))</td></tr>
<tr><td colspan="2">MMC302</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr. Manab Mallik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learn science and technological aspects of the Powder Metallurgy Techniques.
CO2: Describes generic approaches to powder production and the basic principle associated with appropriate fabrication techniques.
CO3: Emphasis is put on methods for those types of metal powders which are commercially important.
CO4: The contemporary need can be met by the ability to analyze the industrial processes.
CO5: Learn various techno-economic aspects of powder metallurgy processing.
CO6: Solve problems of near net shape fabrication of powder metallurgy parts
CO7: Explore powder-processing-property relationship through assignment/ group task.</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>
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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>39</td><td>3</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">Metallurgical Thermodynamics and Kinetics, Transport Phenomena in Metallurgical Process</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">M. K. Mondal</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learn fundamentals of physico-chemical principles of Secondary steel making.
CO2: Identify and solve reaction kinetics and mechanisms..
CO3: To learn the design & operational aspects of Vacuum technology.
CO4: Ability to analyze industrial processes to meet the current need.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Brief review of fluid flow, thermodynamics and primary steel making processes, , composition of the crude steel, need for secondary refining, 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 de-oxidisers; 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)
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)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Principles and Practices in Iron and Steelmaking – A. Ghosh, and A. Chatterjee.
2. Secondary Steelmaking – A. Ghosh
Reference Books:
1. Making, Shaping and Treating of Steel (Steelmaking and Refining), 10th Edition, 1985, AISE, Pittsburgh.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME716</td><td>Composite Materials</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-302: Introduction to Metallurgy and Materials</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Prof. J. Maity & Dr. S. Bera</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. Learn the fundamentals of composite materials, classification of composite materials
II. Improvement of properties
III. Metal matric composites (MMCs)
IV. Solid and liquid state synthesis of MMCs
V. Joining of metal matrix composites
VI. Field of application
VII. Tutorials, problems and solutions etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Course assessment methods: Mid semester examination and End semester examination
Introduction: Classification of composites on the basis of matrix, ex-situ or in-situ synthesis, type of reinforcement etc.; Metal matrix composite, polymer matrix composites, ceramic matrix composite and carbon-carbon composite; application of different composite materials. (8 hours)

Different routes of composite synthesis: casting route, powder metallurgy route and other routes. (4 hours)

Powder metallurgy processed Composite: high energy milling, Mechanical alloying: Fundamentals and parameters; Compaction and Sintering: material dependent routes and process parameters; Recent trends- Spark plasma sintering, Equal channel angular pressing etc.; process parameter-structure-property correlation. (12 hours)

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 Lanxide process)- principle of molten metal infiltration-capillary flow of molten metal; Spray process (Osprey process and rapid solidification process); In-situ production of dispersoids-XD process; evolved microstructure: structural defects in cast metal matrix composites- porosity, particle segregation (macrosegregation and microsegregation), interfacial reaction and particle degradation; structure-property correlation. (12 hours)

Joining of metal matrix composites, limitations of conventional fusion welding, Application of transient liquid phase (TLP) diffusion bonding, basic mechanism and different stages of TLP bonding process for monolithic and composite system, process parameters of TLP bonding, joint efficiency. (4 hours)</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Metal Matrix Composites - Chawla and Chawla, Springer, 2006. 2. 'Joining of aluminium based metal matrix composites'- Joydeep Maity, in 'Engineered Metal Matrix Composites: Forming Methods, Material Properties and Industrial Applications', Editor: Luca Magagnin, 2012, NOVA Science Publishers, Inc., New York, USA, pp 329-354. 3. Materials Science and Engineering:An Introduction - William D. Callister, Jr., John Wiley & Sons, Inc., 2007. 4. Fundamentals of Metal-Matrix Composites - Andreas Mortensen and Alan Needleman, Butterworth-Heinemann, 1993. 5. An Introduction to Composite Materials –Derek Hull, Cambridge University Press, 1981. 6. Composite Materials –Deborah D.L. Chung, Springer, 2009. 7. Metal-Matrix composite – P.K. Rohatgi, Defence Science Journal, Vol 43, No 4, October 1993, pp 323-349. 8. Y. B. Liu, S. C. Lim, L. Lu, M. O. Lai, Recent development in the fabrication of metal matrix-particulate composites using powder metallurgy techniques, Journal of MateralsScience 29 (1994) 1999-2007.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME717</td><td>Corrosion Engineering</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="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">CYC-01: Engineering Chemistry</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">K.S. Ghosh</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: To learn Fundamentals of Corrosion Engineering
CO2: To understand of Different Forms of Corrosion and their Mechanism.
CO3: To know the Principles of Corrosion Prevention or Combat
CO4: Techniques to acquaint with Actual Corrosion Testing
CO5: To understand the Principles, Mechanism and Prevention of High Temperature Corrosion</td></tr>
</table>

Topics Covered	Introduction: Definition of corrosion, Cost of Corrosion, corrosion damage, environments, classification of corrosion. [1 hour] 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. [12 hours] 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. [12 hours] Corrosion Prevention: Materials selection, alteration of environments, design,inhibitors, cathodic and anodic protection, coatings – electroplating. [5 hours] 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 hours] 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. [4 hours]
Text Books, and/or reference material	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

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME718</td><td>Energy and environment in metallurgical industries</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Name of the developer</td><td colspan="6">Dr. Arup Kumar Mandal</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">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 renewable energy sources and their uses
CO5: To learn about the recycling methods of wastes materials generated in metallurgical industries</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">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</td></tr>
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ELECTIVE SUBJECTS: Depth Electives - VI

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME810</td><td>Experimental Techniques in 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="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">PHC01: Engineering Physics</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">Dr Durbadal Mandal</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: To Learn science and technological aspects of different experimental Techniques that used for characterisation of materials.
CO 2: Basic principle associated with microstructural analysis by Optical and Electron microscopy. To learn EDS and WDS analysis – concept of ratemeter, counter, crystal spectrometer, photomultiplier.
CO3: Learn fundamental to identify flaws through different NDT techniques
CO4: To learn fundamental of spectrometer to find out the chemical composition of metallic materials and their significant
CO5: Dilatometric methods – thermal expansion and volume changes associated with phase transformation, differential roller dilatometer</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Optical Methods: Fundamental of image formation, Different aberration in optical systems, Optical microscopy, characteristic of microscope, different conditions of image formation such as bright field, dark field, oblique illumination. Special Techniques in Metallography: Polarized beam, Phase Contrast, Differential Interference Microscopy, Fluorescents microscopy, Principles of above techniques and their applications. Quantitative Metallurgy and Image analysis, Applications Developments for Quantitative Image analysis in Metallurgy. [10]
Basic principle of Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), secondary electron, back scattered electron, Diffraction pattern analysis, energy dispersive X-ray spectroscopy (EDS), Wavelength dispersive spectrometer analysis (WDS), electron back scattered diffraction (EBSD), electron probe micro analysis (EPMA). Fundamental of Atomic Force microscopy, Basic theory, Image formation and its applications. [8]
Techniques for chemical analysis: Atomic absorption spectrometer, Emission spectroscopy & direct reading spectrometer, Mass spectrometer. [4]
Thermal analysis of phase transformations: Thermal Analysis techniques: Principle, Working and application of DTA, TGA, DSC and Thermo-mechanical Analysis, Principles and Applications. [2]
Principle of magnetic characterization, characterization of soft magnet and hard magnets. Application . [4]
NDT: Basic principle of Dye Penetrant testing,, Types of dye methods and application, Developer application and Inspection, Magnetic particle testing, Basic theory of magnetism, Magnetization methods, Field indicators, Particle application, Inspection. Eddy current testing, Basic principle; Faraday’s law, Inductance, Ultrasonic testing: Basics of ultrasonic waves, Pulse and beam remarks, Radiographic testing, Basics, different isotopes and different techniques to identify</td></tr>
</table>

	the flaws. [10]
Text Books, and/or reference material	**Text Books**: 1. Experimental Techniques in Physical Metallurgy, V.T. Cherepin & A.K. Malik, I.I.T., Bombay. 2. Thermal Analysis By Bernhard Wiindrelich Academic Press. 3. Image Analysis & Metallography. (Microstructural Science Vol.-17) ASTM 1989. 4. 1. F. Weinberg, Editor, Tools & Techniques in Physical Metallurgy, Vol. I & Vol. II, Marcel Dekker, 1970. 5. J.M. Walls, Editor, Methods of Surface Analysis : Techniques & Applications, Cambridge University Press, 1990. 6. An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill Book Company.

<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>MME811</td><td>FEM Modelling and Simulation for Materials Design</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">XEC01: Engineering Mechanics, MMC503: Fundamentals of Plastic Deformation and Strengthening of Materials</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr. Madan Mohan Ghosh</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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
CO4: To explore the continuum mechanics based materials design</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">• 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</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME812</td><td>Mathematical Modelling and Simulation</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="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Transport Phenomena in Metallurgical Process</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="5">M. K. Mondal</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: Learn fundamentals of Modeling.
CO2: Identify nature of engineering problems and solving by numerical methods
CO3: Design of prototype
CO4: Learn computer applications of Fluid flow, heat transfer and mass transfer</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Review of Fluid Flow, heat transfer and Mass tranfer, Type of Models, Advantages of Mathematical Model, Types of Mathematical model, Method of predication, 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, Centeral difference expression for a non uniform 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: gaussion elimination, Tri-diagonal matrix algorithm (TDMA), Gauss-Seidel iterative method, 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)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Finite difference Method in heat transfer- M. N. Ozisik
2.Computational Fluid dynamics and heat transfer – P.S. Ghoshdastidar
3. Modeling of Steelmaking Processes – D. Mazumdar and James W. Evans
Reference Books:
1. Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers– R. Pratap.
2. Numerical Methods for Engineers - D. Vaughan Griffiths and I.M. Smith.</td></tr>
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<tr><td colspan="8">Department of Metallurgical and Materials Engineering</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MME813</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">Name of the developer</td><td colspan="6">Dr. Arup Kumar Mandal</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 modern techniques of agglomeration
CO4: To learn about the 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 techniquesconsidering sizing operations. [8hrs]
Agglomeration: Purpose, technological appraisal of various methods with merits anddemerits, bonding mechanism. [3hrs]
Sintering: Process, mechanism, factors affecting sinter quality, fluxed sinter, sintermineralogy, sintering machine design, process control.[5hrs]
Pelletizing: Process, green ball formation and growth, additives and their effect, pelletdrying and hardening (cold and hot), pelletizing machine types, design, pellet firingsystems. [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 andworld, 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>

Width Electives to be offered by MME Dept.

Width Electives Basket I

<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>XEO441</td><td>Brain to Mind Creation</td><td>Width Elective</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="4">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">BTC01: Life Science</td><td colspan="4">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="4">Dr Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• Introduction of Human Brain and Its Processes
• Understanding the issues of mind and consciousness.
• Understanding the Physics and Electrochemical Reactions in Brain
• Understanding the Behavioral Pattern of a Human Being</td></tr>
<tr><td>Topics Covered</td><td colspan="6">➢ Brain to Mind-- and how do we know it---(essentially single neuron to multiple). 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 (10)
➢ Cognition, Memory, Emotion -- Normal and Pathology . (14)
➢ Sleep and Brain and Future-- with interactive session (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">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), Nicole M. Gage
4) Principles of Neural Science, Fifth Edition by Eric R. Kandel and James H. Schwartz</td></tr>
</table>

Width Electives Basket II

<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>MMO541</td><td>Basic Manufacturing Process</td><td>Width Elective (Except MM & ME students)</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="4">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">PHC01, CYC01, XEC01</td><td colspan="4">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="4">Dr Durbadal Mandal and Dr Barnali Maji</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: To understand the different crystal structure in view of translational periodicity and symmetry.
CO2: To learn the presence of different kinds of defects in crystal so as to relate their effect on material properties.
CO3: To learn fundamentals of casting as manufacturing process.
CO4: To learn fundamentals of metal forming like equilibrium of force equation, different bulk forming process such as forging, rolling etc and localized forming operation like sheet metal forming
CO5: To understand principles and theory, mechanism and key variables of different joining processes.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books
1. Rajender Singh: Introduction to Basic Manufacturing Processes & Workshop Technology, New Age International (P) Limited, Publishers, 2006.
2. Metals Handbook, Casting , vol. 15, 10th Edition, ASM International, Materials Park, Ohio, USA, 1998.
Reference Books
1. O. P. Khanna: Foundry technology, 17th Edition, Dhanpat Rai Publications, 2011.
2. George. E. Dieter : Mechanical Metallurgy, McGraw-Hill Co. Company.</td></tr>
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Width Electives Basket III

<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>XEO741</td><td>Human Resource Management</td><td>Width Elective</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">Nil</td><td colspan="5">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="5">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">I. To understand the different aspects of Human resource in an organization
II. To understand the theory of motivation
III. To establish a relationship between job characteristics model and expectancy of a person
IV. To solve different case studies of organization
V. To understand the correlation of work –rewards- stress.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Studying of Characters of individuals in terms of Behavioural Pattern. [4h]
Framework of human resource development: influences on employee behaviour, learning and HRD, assessing HRD needs, designing and implementing HRD programs, evaluating HRD programs. [5h]
Recruitment Methods and its policy. [3h]
Applications of human resource development: employee socialization and orientation, skills and technical training, coaching and performance management, mentoring, employee counselling and wellness services. [7h]
Career management and development, management development; Organization development and change; Contemporary issues: knowledge management and learning organizations, competency mapping, and intellectual capital management. [9h]
Motivation and Study of Performance appraisal methods. [3h]
Wage Theory And its application. [2h]
BPR, TQM and empowerment, stress and time management. [4h]
Trade unions and its role in HRM. [2h]
HRM in the text century. [1h]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT BOOKS:
David A. DeCenzo and Stephen P. Robbins, Human Resource Management, Prentice hall of India.
REFERENCE BOOKS:
1. Ghosh A.K., Human Resource Management, Manas Publications, 2007.
2. Dessler G. Fundamentals of Human Resource Management Pearson Education; First edition, 2010.</td></tr>
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Width Electives Basket IV

<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>MMO841</td><td>Material Science</td><td>Width Elective</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">PHC01: Engineering Physics, CYC01: Engineering Chemistry</td><td colspan="6">CT+EA</td></tr>
<tr><td colspan="2">Developer</td><td colspan="6">Dr Barnali Maji</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Learn science and technological aspects to a design problem involving materials.
CO2: Describes generic classification of materials and their specific engineering applications.
CO3: Emphasis is put on such engineering materials which are traditionally and commercially important.
CO4: The existing industrial materials problem can be analyzed.
CO5: Learn various techno-economic aspects of materials science.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Solid Engineering Materials- their classification and characteristic properties.
Atomic bonding in solids: Primary interatomic bonding and secondary bonding. (4)
Structures of solids: Crystal structures, crystal system/lattices, crystallographic planes and directions, interstitial sites, crystallinity in metals, ceramics, semiconductor, and polymers. Microstructures and metallography. Amorphous and glassy state. (3)
Solidification of pure metals: Homogeneous and Heterogeneous nucleation process, cooling curve, concept of supercooling, microstructures of pure metals. (3)
Imperfection of solids: Point, line, planar and volume. Fundamentals of plastic deformation of metals, deformation by slip and twin, plastic deformation in polycrystalline metals, concept of cold working, preferred orientations. Annealing: Recovery, recrystallization and grain growth, hot working. (4)
Properties of materials: Definition, units and common tests conducted to evaluate important engineering properties. (2)
Binary phase diagrams: Isomorphous, eutectic, eutectoid, peritectic, and peritectoid systems, effect of non-equilibrium cooling, coring and homogenization. (5)
Iron cementite diagram: Construction and interpretation of Fe-Fe_3C and Fe Graphite diagrams. Microstructure and properties of different alloys in steel and cast iron, their microstructures and typical uses. (5)
Heat treatment: Concept of heat treatments of steels- annealing, normalizing, hardening and tempering. Effect of common alloying elements in steel, concept of hardenability, factors effecting it. Variation of steels and specification of steels. (5)
Physical metallurgy of common non-ferrous alloys: Cu, Al and Ni based alloys. Microstructures and heat treatment of common alloys of these systems. (5)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. W. D. Callister, Materials Science and Engineering an Introduction, Wiley, New York (2003).
2. V. Raghavan, Materials Science and Engineering, Prentice Hall India, New Delhi, (1998).
3. K. K. Chawla, Composite Materials, Springer, New York (2001).
Reference Books:
1. O.P. Khanna, A Text Book of Material Science and Metallurgy, Dhanpat Rai Publications (2005)</td></tr>
</table>

Width Electives Basket V

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>XEO841</td><td>Leadership and Corporate Strategy</td><td>Width Elective</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="4">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Nil</td><td colspan="4">CT+EA</td></tr>
<tr><td colspan="3">Developer</td><td colspan="4">Dr. Susanta Pramanik</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• To understand the nature of leadership within human Behaviour
• To understand the nature of group working
• To understand ethics and human values
• To understanding the sustainability and growth by innovation in life
• To understand the skills of running a business</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Introduction : The nature of Leadership; the nature of Managerial work, Effective Leadership Behaviour ; Participative Leadership [4]
Dyadic Role Making; Power and Influence; Managerial Traits and Skills [4]
Charismatic and Transformational Leadership [2]
Leadership in terms and Decision groups; Strategic Leadership by Executives [3]
Developing Leadership Skills ; Ethical Leadership and Diversity [2]
Issues about research methods in leadership [1]
Entrepreneurship: Introduction; Advantages of entrepreneurship; TE Analysis; Pitfalls of Entrepreneurship, difference between a entrepreneur and leader ; qualities of an entrepreneur [4]
Strategic Management Process: Vision, Mission, SWOT Analysis; Defining goals and objectives; key success factors for management. [6]
Pricing Policy; Process of budget [2]
Advertisement: Role and methods , the seven tests and pricing [1]
Marketing : 4 P's of marketing Mix ; Balance Scorecard [2]
Case studies: Selective cases with hands on exercises. [6]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">TEXT BOOKS
1. GARY YUKL. Leadership in Organizations ; Pearson Education, Third Impression, 2008
2. Thomas .W Zimmereer and Norman M. Scarborough. Essentials of Entrepreneurship and Small Business Management; Pearson Education; Second Impression, 2007.

REFERENCE BOOKS:
1. Debasis Chatterjee; "Light the fire in your Heart "; Full Circle Publishing House.</td></tr>
</table>