METALLURGY AND MATERIALS SCIENCE

T.Y. B. Tech.

Effective from A. Y. 2013-14

INDEX

List of Abbreviations

Sr. No.	Abbreviation	Stands for:
1	DEC	Departmental Elective Course
2	PCC	Program Core Course
3	LC	Laboratory Course
4	HSSC	Humanities and Social Science Course
5	MLC	Mandatory Learning Course
6	LLC	Liberal Learning Course
7	OEC	Open Elective Course
8	SEC	Science Elective Course
9	BSC	Basic science Course

Program Education Objectives (PEOs):

1. To provide students with sound applied knowledge in Metallurgy and Materials Science. To provide students with a foundation in basic sciences, mathematics and engineering, necessary to formulate, solve and analyze engineering problems.
2. To enable students for successful careers in metallurgical, manufacturing industry that meet the needs of Indian and multinational companies and prepare them for higher studies.
3. To provide hands-on experimental skills, to work as part of team necessary for a professional life to work on multidisciplinary projects.
4. To promote student awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice.
5. To develop the students' abilities in communicating technical information and knowledge in both written and oral form.

Program Outcomes (POs):

a. Graduates will demonstrate basic knowledge in mathematics, science and engineering.

b. Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results.

c. Graduates will demonstrate the ability to perform experiments in metallurgy, characterization and proper material selection.

d. Graduates will demonstrate the ability to function on engineering and science laboratory teams, as well as on multidisciplinary projects.

e. Graduates will demonstrate the ability to identify, formulate and solve metallurgy and material science problems.

f. Graduates will demonstrate an understanding of their professional and ethical responsibilities.

g. Graduates will be able to communicate effectively in both verbal and written forms.

h. Graduates will have the confidence to apply engineering solutions in global and societal contexts.

i. Graduates should be capable of self-education and clearly understand the value of lifelong learning.

j. Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.

k. Graduates will be familiar with modern engineering software tools and equipment to analyze metallurgy and material science problems.

CURRICULUM STRUCTURE OF T. Y. B.TECH (Metallurgy)

Effective from A. Y. 2013-2014

I-Semester:

Sr. No.	Course Type/Code	Course	Contact Hours			Credits
			L	T	P	
1.	DE-09004	*Department Elective	3	-	-	3
2.	PCC/MT-09001	Transport Phenomena	3	1	-	4
3.	PCC/MT-09002	Extractive Metallurgy	3	-	-	3
4.	PCC/MT-09003	Modern Chemical Analysis of Materials	1	-	2	2
5.	BSC/AS- 09001	Applied Biology	3	-	-	3
6.	PCC/MT-09004	Polymers and Composites	3	-	-	3
7.	LC/MT-09005	Transport Phenomena Laboratory	0	-	2	1
8.	LC/MT-09006	Extractive Metallurgy Laboratory	0	-	2	1
9.	LC/MT-09008	Polymers and Composites Laboratory	0	-	2	1
10.	LLC/LL-09001	Refer to Annexure II	1	-	-	1
		Total	**17**	**1**	**8**	**22**

*Department Elective: Iron Making

II-Semester:

Sr. No.	Course Type/Code	Course	Contact Hours			Credits
			L	T	P	
1.	OEC/SEC	Open Elective/Science Elective Refer to Annexure I	3	-	-	3
2.	PCC/MT-09009	Foundry Technology	3	-	-	3
3.	PCC/MT-09010	Materials Characterization	3	-	-	3
4.	PCC/MT-09011	Structural Metallurgy	3	1	-	4
5.	PCC/MT-09012	Steel Making	3	-	-	3
6.	LC/MT-09013	Foundry Technology Laboratory	0	-	2	1
7.	LC/MT-09014	Materials Characterization Laboratory	0	-	2	1
8.	MT-09015	Mini Project	0	-	4	2
9.	MT-090016	Industrial Visit & Training	0	-	4	2
10.	MLC/ML-09001	Constitution of India	2	-	-	2
11.	HSSC/AS-09002	Humanities course	2	-	-	2
		Total	**19**	**1**	**12**	**26**

DE - 09004 Iron Making

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz–40 marks,
End - Sem Exam – 60 marks

Unit 1 **(6 hrs)**

Iron making: Historical, blast furnace process, Raw materials- iron ore, coke, fluxes, burden preparation

Unit 2 **(6 hrs)**

Treatment of iron ores: Agglomeration, sintering and pelletization. Coke making, coke oven gas & BF flue Gas, Chemical byproducts, gas cleaning system

Unit 3 **(6 hrs)**

Physical chemistry of blast furnace reactions, thermodynamic equilibria, chemical and thermal reaction zones, Reactions in stack, bosh and hearth, thermal efficiency, mass and enthalpy balances, gas flow, burden distribution and cohesive zone formation in BF

Unit 4 **(6 hrs)**

Construction of Blast furnace and accessories, B.F. operation, performance, gas utilization, Irregularities in B.F. operation, products: metal and slag, Mini-blast furnace, COREX process-principles of operation, techno-economical considerations.

Unit 5 **(6 hrs)**

Alternatives routes of iron production, low shaft furnace , electro thermal processes, Directly reduced iron (DRI) productions: Principles of operations, Physical chemistry of DRI processes, mechanism of sponge iron production, advantages and disadvantages, Processes such as – Rotary Kiln, MIDREX

Unit 6 **(6 hrs)**

Ferro-alloys production: Methods of production, Electric submerged arc furnace, metallothermic processes, Ferrochrome, Ferrosilicon, Ferromanganese, Ca-Si, Si-Mn

Text Books:

- R.H. Tupkary, V.R.Tupkary, An Introduction to modern Iron making, 3rd Edition, Khanna Publications, New Delhi, 2005.
- Ahindra Ghosh, Amit Chaterjee Iron and Steel making: Theory and practice, 2nd Edition, PHI learning Pvt. Ltd, New Delhi, 2011.
- A.K.Biswas: Principles of Blast Furnace Iron making, 1st Edition, SBA publications, Calcutta, 1984.
- F.P. Edneral, Electrometallurgy of Steel and Ferroalloys, Volume I and II, Fourth Russian Edition, 1979.

Reference Books:

- J.G.Peacey, W.G.Davenport, Daven Port, The iron Blast furnace: Theory and practice,Pregamon press, New York, 1979.
- Amit Chaterjee, Beyond the Blast furnace, CRC Press; 1st edition,1993
- National Steel Policy (NSP), Ministry of Steel, Government of India, 2012.

Outcomes:

This course attains the following outcomes:

- Students develop an ability to apply the knowledge of science (e.g. thermodynamics) for the extraction of iron from ore and therefore, this course makes the student technically sound in the area of iron production from iron ore.
- This course insists on the broad education necessary for developing alternate routes for iron-making because the blast furnace route demands resources like, coke, which is depleting rapidly across the world.
- This course recognizes the need for life-long learning so that the metallurgists will be familiar with the latest advances in the iron-making technology.

MT - 09001 Transport Phenomena

Teaching Scheme
Lectures: 3 hrs/week
Tutorial: 1 hr/week

Examination Scheme
100 marks: Continuous evaluation-
Assignments/Quiz –40 marks
End - Sem Exam – 60 marks

Unit 1 **(12 hrs)**

Introduction to various modes of heat transfer. Steady state condition - Fourier's law, Thermal Conductivity, Effect of variables on thermal conductivity, Critical thickness of insulation, shape factor in conduction, steady state heat conduction with heat generation, Heat conduction equations. Unsteady State Heat Conduction: Classification, Unsteady heat conduction in solids with infinite thermal conductivity, Lumped heat capacity analysis, unsteady heat conduction in solid with finite conduction and convection resistance in infinite thick solids with periodic variation and in solids with given temperature distribution, topic related to differential solution of problems.

Unit 2 **(6 hrs)**

Convection Heat Transfer: Linear & Turbulent Flow, Hydro-dynamic and Thermal boundary layer, Fluid flow through tubes, channels and other configuration pressure drop, natural convection, dimensionless number and Heat transfer, Dimensional analysis in convective heat transfer, Empirical correlation for natural and forced convection heat transfer for various configurations, liquid metal convection heat transfer.

(6 hrs)

Unit 3

Radiation Heat Transfer: Principles of radiation heat transfer, Terms in radiation, laws of radiation, Emissivity, Radiation heat transfer between black bodies, non - black bodies, radiation shape factors, shape factor algebra, Interchange factor, Radiation.

Unit 4 **(6 hrs)**

Continuum Hypothesis, Fluid static, Energy Balance, Bernoulli' principle, Basic definitions in flows, viscocity, shear stress as momentum flux. Shell balances. Friction and friction factor, concept of hydraulic radius, packed and fluidized beds. Compressible flow through pipes and nozzles, Differential balances, equation of continuity, Euler's equation, Navier-Stokes equation, macrobalances.

Unit 5 **(6 hrs)**

Basic kinetics laws, order and molecularity of reactions, rate constant, elementary & complex reactions, Rate limiting steps and Arrhenius equation, Theories of reaction rates – simple collision theory, activated complex theory, Concept of activation energy. Diffusion and diffusion coefficient, Unsteady state mass transfer, differential formulation of mass transfer, Convective mass transfer, mass transfer coefficient.

Text Books:

- F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass transfer, 5 th ed., john-Wiley publication, 2004.
- J.P. Holman, Heat Transfer: 9th ed. Tata Mc Graw Hill, New Delhi, 2002.
- S.P. Sukhatme, A Text Book on Heat Transfer 3rd Ed., University Press, 1996.
- G.H. Geiger and D.R. Poirier, Transport Phenomena in Materials Processing, TMS Warrandale, PA, 1998.
- J.R. Welty, R.E. Wilson and C.E. Wicks, Fundamentals of Momentum, Heat and Mass Transfer, Wiley, 1976.

Reference Books:

- K.J. Laidler, Theory of Chemical Reaction Rates, McGraw Hill, 1969.
- R.B. Bird, W.E. Stewart and N.E. Lightfoot, Transport Phenomena, Wiley, 1960.
- A.K. Mohanty, Rate Processes in Metallurgy Prentice Hall, New Delhi, 2000.
- J. Szekely, I.N.J. Themelis, Rate Phenomena in Process Metallurgy, Prentice Hall, New Delhi, 1970

Outcomes:

- Students are to know useful of constitutive laws applied to fluid flow, heat and mass transfer.
- Students will be able to identify the modes of heat transfer and its steady and unsteady state nature.
- Students will be able to develop empirical equations using the knowledge of dimensionless analysis approach (Buckingham theorem) for modelling certain physical phenomena.
- Students are in position to apply electrical circuit analogy and Kirchoff's law while finding out heat loss of the system.
- Students are able to determine the concentration profile and mass conduction equation analogous to heat conduction equation.
- Students will understand scope of the Renyold no for submerged body, flow over plate, flow through conduits and flow through porous bed.
- Students will able develop to design and fabricate energy efficient systems.
- Students will perform shell balances for heat, momentum and mass transfer to obtain differential equation describing the velocity, temperature and concentration gradient.
- Students will understand difference between Newtonian and non-Newtonian fluid.
- Students will able to use to Navier-Stoke equation for solving fluid problems.

MT - 09002 Extractive Metallurgy

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Quiz/Assignment –40 marks
End Sem exam – 60 marks

Unit 1 **(6 hrs)**

Locations of ore deposits of nonferrous metals and their production in India and abroad, Main approaches in extractive metallurgy: pyrometallurgy, hydrometallurgy and electrometallurgy. Thermodynamic considerations and process selection in extraction of metals, Study of free energy diagram, Leaching, bioleaching, precipitation of metals, reduction by gases

Unit 2 **(6 hrs)**

Extraction of Copper:
Copper ores, Locations of their deposits in India and abroad, Pyrometallurgical extraction of Copper thermal treatment, sulphation of oxides, oxidation of sulphides, matte formation, chlorination, fluorination, Copper loss in slag, Hydrometallurgical extraction of Copper, Newer routes

Unit 3 **(6 hrs)**

Extraction of Aluminium:
Aluminium ores, Locations of ores deposits in India and abroad, principle of electrolysis in winning, fused salt electrolysis, Bayer's process for production of alumina, Hall-Heroult process, Refining of Aluminium, Newer routes.

Unit 4 **(6 hrs)**

Extraction of Lead, Zinc and Nickel:
Lead and Zinc ores, Locations of ores deposits in India and abroad, Lead smelting, Pyrometallurgical extraction of Zinc, Hydrometallurgical extraction of Zinc, Imperial smelting process, Extraction processes of Nickel

Unit 5 **(6 hrs)**

Ore deposits of tin, magnesium, gold, zirconium, titanium, beryllium and uranium in India and abroad, Extraction of tin, magnesium, gold, zirconium, titanium, beryllium and uranium. ion-exchange and solvent extraction processes, Cementation and solvent extraction process.

Unit 6 **(6 hrs)**

Present scenario of production of above mentioned metals, refining by oxidation, chemical transport reactions, zone refining, distillation, degassing processes, Secondary metals. Recovery of metals from scrap and other secondary sources by pyro-, hydro- and electrometallurgy.

Text Books:

- H.S. Ray, R. Shreedhar and K.P. Abraham- Extraction of non-ferrous metals- affiliated East West press pvt. Ltd, Oscar Publications, New Delhi,2011.
- R D Pehlke, Unit Processes in Extractive Metallurgy- American Elsevier pub.Co.,Mishigan, 1973.
- J.J.Moore- Chemical metallurgy, Butterworth-Heineman,1981.
- J.D.Gilchrist- Extractive metallurgy- Pergamon Press, 1989.

Reference Books:

- W.G.Davenport,M.King,M.Schlesinger , A.K.Bishwas and - Extractive metallurgy of Copper,4th ed., Pergamon Press,2002.
- H.S.Ray, A.Ghosh, Processes in Extractive Metallurgy,New age international pvt.ltd,New Delhi, 2001.

Outcomes:

This course helps students to attain:

- Recognition of the need for, and an ability to engage in lifelong learning about extractive techniques
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental context in extraction of metals.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice need to be used in different extraction methods.

MT - 09003 Modern Chemical Analysis of Materials

Teaching Scheme
Lectures: 1 hrs/week
Laboratory: 2 hrs/week

Examination Scheme
Laboratory continuous evaluation
Term work –50 marks
End Sem exam – 50 marks

Unit 1: **(6 hrs)**

Wet methods vs instrumental methods. Various methods for carbon analysis. Electrogravimetry-principle, advantages, limitations and applications. Applications of IR Spectroscopy.

(6 hrs)

Unit 2:

Study of Indian standards for determination of various elements. Gas chromatography. Absorption and Emission Spectroscopy. Atomic Absorption Spectroscopy. Inductively Coupled Plasma. Analysis using X-Rays.

Text Books:

- S.P.Jain & B.C.Agarwal, A textbook of Metallurgical Analysis, 8th ed., Khanna Publishers, New Delhi, 2009.
- Dean J.A., Merritt L. L., Settle F.A., Williard H.H., Instrumental methods of Analysis 7th edition, CBS Publishers & Distributors, New Delhi,2009.

Reference Books:

- Vogel, Quantitative Inorganic Analysis, Seventh Edition, PEARSON EDUCATION, Prentice hall,2010

Term Work:
List of Experiments (Any Ten)

1. Estimation of carbon in steels by colorimeter.
2. Estimation of Fe from steel sample.
3. Estimation of Si in steels & cast iron
4. Estimation of Mn in steels & cast iron
5. Estimation of P in steels & cast iron
6. Estimation of Ni in steels & stainless steels
7. Estimation of Cr in steels & stainless steels
8. Estimation of Mo in steels & stainless steels
9. Estimation of Vanadium in alloy steel.
10. Estimation of Cu & Pb by Electro-gravimeter
11. Estimation of Carbon in steel and Cast iron by using Strohlien's apparatus
12. Estimation of Ni / Cu by Atomic Absorption Spectroscope
13. Study of FIVE Indian Standards related to chemical analysis of Elements.

Outcomes:

This Laboratory work enables student to expertise in analysis of elements in steel and cast iron.

- This course helps students, to design and conduct elemental analysis experiments from different materials.
- To make student aware about contemporary issues in analysis like analysis of Galvanised coating by AAS etc.

AS - 09001 Applied Biology

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Assignments /Quiz–40 marks,
End - Sem Exam – 60 marks

Unit 1 **(6 hrs)**
Origin of life. Molecules of life- biomolecules. Cell as the unit of life.
Development of cell theory. Cell types : prokaryotes and. eukaryotes; cell organelles, single cell to multi-cellular organism, tissue and organ level organization, organ systems
Structure of the cell membrane. Fluid mosaic model. Functions of plasma membrane; diffusion, osmosis, membrane transport through plasma membrane, ion channels and electrical properties.

Unit 2 **(6 hrs)**
Energy Transduction and Bioenergetics. Mitochondria, ATP, Chemiosmosis, ATPase,Cell to cell junction-gap junctions. Ultra structure of Chloroplast, photosynthetic electron transport, Calvin cycle
Cell architecture, cyto-skeletal components, microtubules and microfilaments,
motility and motor motions, actomyosin complex
Genomics and proteomics

Unit 3 **(6 hrs)**
Evolution of biological machines- Optimization of biological machines at different levels- molecular, cellular, organismal and populational; principles of generating diverse body plans and design in nature
Biomaterials. Applications of nanotechnology in biology. Biosensors & their application

Unit 4 **(6 hrs)**
Bioengineering- genetic engineering, protein engineering, tissue engineering and biochemical engineering.
Computational biology and bioinformatics

Unit 5 **(6 hrs)**
Biomechanics - fluid mechanics , examples in living world, aerodynamic, hydrodynamic and locomotion, mechanism of motion, friction and fracture. Application of biomechanics and biomaterials- Human body motion, use of prosthetics, rehabilitation application

Unit 6 **(6 hrs)**

Instrumentation in biology- spectroscopic methods, bioimaging using various techniques eg. MRI, CT scan ect.

Green environment- use of biotechnology in environmental engineering

References :

- Molecular Biology of Cell by Alberts.
- Biochemistry of Cell by Lehninger
- Plant Physiology by N.K.Sinha & Pandye
- Genes 8 by Benjamin Lewin
- A Text Book of Environmental Engineering by P. Venugopal Rao
- Animal Tissue Culture by Ian Freshlly

Course outcome

1.The students received knowledge about latest studies in biology like genetic & tissue engineering, stem cells, biomechanics, bioimaging, bio-nanotechnology etc.

2. The students understood the role of engineers in biology.

3.The students were provoked to make use of their engineering knowledge in different fields of biology.

4. The students made use of this knowledge in their different projects.

(Entire course should be taught at introductory level)

MT - 09004 Polymers and Composites

Teaching Scheme

Lectures: 3 hrs/week

Examination Scheme

100 marks: Continuous evaluation-
Quiz/Assignment –40 marks
End Sem exam – 60 marks

Unit 1 **(6 hrs)**

Polymers: Introduction, Classification of Polymers, Degree of Polymerization, Polymerization Reactions, Polymerization Mechanisms: Addition Polymerization, Copolymerization, Condensation Polymerization, Polymer Structures and Shapes, Cross Linking and Branching, Crystallinity and Stereo-Isomorphism in Polymers

Unit 2 **(6 hrs)**

General-Purpose Thermoplastics, Engineering Thermoplastics, Thermosetting Plastics (Thermoset), Elastomer (Rubbers), Structure-Property Relationship in Thermoplastics, Characteristics and Applications of Polymers, Processing of Plastic Materials: Processes Used for Thermoplastic and Thermosetting Materials

Unit 3 **(6 hrs)**

Deformation and Strengthening of Plastic Materials, Mechanical Properties: Creep and Fracture of Polymeric Materials, Visco-elasticity, Stress Relaxation, Glass Transition Temperature and Polymer Degradation

Unit 4 **(6 hrs)**

Composite Materials: Introduction, Reinforcements: Natural Fibers, Synthetic Fibers, Synthetic Organic and Inorganic Fibers, Particulate and Whiskers Reinforcements, Reinforcement-Matrix Interface

Unit 5 **(6 hrs)**

Particle Reinforced Composites: Large Particle Composites, Dispersion Strengthened Composites, Fiber Reinforced Composites: Influence of Fiber Length, Orientations and Concentrations, Fiber Phase, Matrix Phase, Processing of Fiber Reinforced Composites, Structural Composites, Rule of Mixture, Fracture Mechanics and Toughening Mechanisms

Unit 6 **(6 hrs)**

Composites with Metallic Matrices: Introduction, Metal Matrix Composite Processing, Interface Reactions and Properties of MMCs, Polymer Matrix Composites: Introduction, Polymer Matrices, Processing of PMCs, Ceramic Matrix Composites: Introduction, Processing and Structure of Monolithic Materials, Processing of CMCs

Text Books:

- V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, Polymer Science, New Age International (P) Limited Publishers, New Delhi, 1996.
- Premamoy Ghosh, Polymer Science and Technology of Plastics and Rubbers, Tata McGraw-Hill Publishing Company Limited, New Delhi,1990.
- F.L.Matthews, and R. D. Rawlings, Composite Materials, Engineering and Science, Woodhead Publishing Limited, Cambridge, England,1999.

Reference Books:

- Mel M. Schwartz (R), Composite Materials Handbook, Vol. II, Processing, fabrication and applications, 2nd Edition, McGraw-Hill, New York, 1992.
- K.K. Chawla, Composite Materials Science and Engg., 2nd Edition, Springer Verlag, 1998.
- D. R. Askland and P. P. Phule, The Science and Engineering of Materials, 4th Edition, Pacific Grove Publication, 2003.
- William F. Smith, Principles of Materials Science and Engineering, 3rd Edition, McGraw-Hill, 2002.
- William D. Callister, Jr, Materials Science and Engineering – An introduction, sixth edition, John Wiley & Sons, Inc. 2004.
- ASM Handbook, Vol. 21, ASM International, OH, USA.

Outcomes:

Students completing this course satisfactorily will have

- Basic knowledge of various polymers, their structures, properties and application.
- Knowledge of processing techniques of polymers
- Knowledge of metallic, ceramic and polymeric materials as a matrix materials in composites
- Knowledge of manufacturing, microstructure, properties and applications of PMCs, MMCs and CMCs.

MT - 09005 Transport Phenomena Laboratory

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Laboratory continuous evaluation
Term work - 50 Marks
End Sem exam - 50 Marks

Term Work:

List of Experiments:

1. Calibration of Thermocouples
2. Determination of Heat Transfer coefficients
3. Verification of Stokes Law
4. Estimation of Design parameters for atomizer for metal powder production.
5. Estimation of horse power of motor for overhead tanks using Bernoulli's theorem.
6. Estimation of radiation heat looses for liquid metal processing.
7. Mathematical modeling of phenomena such as densification of sintered compact, heat transfer and other metallurgical phenomena.
8. Numericals on basic principles of heat transfer by conduction, convection and radiation.
9. Estimation of activation energy of calcinations of carbonates.
10. Application of FEA for heat transfer phenomena

Outcomes:

- Students can apply constitutive laws to fluid flow, heat and mass transfer and will be able to solve engineering problems related to it.
- Students will be able to develop empirical equations using the knowledge of dimensionless analysis approach (Buckingham theorem) for modelling certain physical phenomena.
- Students will understand scope of the Renyolds number in various real life situations.
- Students will able develop to design and fabricate energy efficient systems.

MT - 09006 Extractive Metallurgy Laboratory

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Laboratory continuous evaluation
Term work - 50 Marks
End Sem exam - 50 Marks

Term Work:

List of Experiments:

1. Crushing of ores by Roll crushers and Jaw crushers
2. Iron ore separation by Flotation Bed.
3. Calcinations and Reducibility of iron ore.
4. Grinding, Screening and Sieving of copper ore.
5. Palletizing of Iron Ores
6. Numericals on nonferrous extraction.
7. Grinding of iron ore in a Ball mill
8. Principles of Magnetic Separation for iron Mineral.
9. Application of Electrostatic Separation for beneficiation.

Outcomes:

This course helps students to attain:

- An ability to design and conduct experiments as well as to analyse and interpret data like study of kinetics of cementation process, thermal decomposition of carbonates.
- An ability to design various processes in extraction methods to meet realistic constraints like economic, environmental and health and safety.
- Recognition of need for and an ability to engage in lifelong learning.
- Broad education is necessary to understand the impact of engineering solutions in a global economical and environmental.

MT - 09008 Polymers and Composites Laboratory

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Laboratory continuous evaluation
Term work - 50 Marks
End Sem exam - 50 Marks

Term Work:

List of Experiments:

1. To Cast Thin Polymer Film Using Film Casting Method
2. Fabrication of Composites by Injection Molding Process
3. Fabrication of Composite Compacts by Hot Compaction Process
4. To Measure Density of Composites by Archimedes's Principle

5. Impact Properties of Polymer and Composites by Izod Impact Test
6. To Measure Hardness of Polymers and Composites by Durometers and Micro hardness Tester
7. To Measure Melt Flow Index (MFI) of Polymer and Composites
8. Tensile Properties of Rubber, Polymers and Fiber Reinforced Composites
9. Optical Microstructure of Composites
10. Tribological Properties of Polymer Based Composites
11. Characterization of Composites by XRD
12. Characterization of Fractured Composites by SEM
13. To study Vicat Softening Point Apparatus.
14. Numerical Based on Syllabus
15. Rapid Prototyping

Outcomes:

Students completing this course satisfactorily will have

- Basic knowledge of processing of polymers and composite materials
- Knowledge of determination of mechanical properties of polymer and composite materials
- Knowledge of calculating theoretical and experimental density and also porosity content of composite materials
- Basic knowledge of determination of electrical (conductivity) and thermal (MFI) properties of composite materials.

MT - 09009 Foundry Technology

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Assignments/Quiz – 40 marks
End Sem exam – 60 marks

Unit 1 **(4 hrs)**

Basic sand casting process, pattern, mould, core, gating, riser, casting yield, Classification of casting processes, Types of Foundries, General layout and sections in foundries, Patterns and Cores – Selection of parting line, allowances on pattern, pattern materials, color coding, core plates, core-boxes – metallostatic pressure, design of core print, chaplets)

Unit 2 **(4 hrs)**

Mold making - Green sand moulding, dry sand moulding, molding sands, Properties of foundry sands and their testing, additives, Sand Control, core sands, mould compaction machines, Jolt, jolt-squeeze, high pressure molding, sand slinger, refractory coatings, Venting, molding boxes, chills ,roll of additives & technical terms in sand like Total clay, active clay, latent clay, dead clay etc

Unit 3 **(6 hrs)**

Special molding and casting processes - CO_2-Silicate process, Coremaking- Introduction to modern core sand binders like ,hot box, cold box, ester & Shell moulding, Evaporative Pattern (EPC) and Vacuum-sealed (V-) processes, Plaster mould, Ceramic mould, Investment casting, Die casting process – gravity die, pressure die, low pressure die and squeeze casting, Introduction to Mold & Core coatings, their significance in getting satisfactory casting quality.Testing of coatings.

Unit 4 **(9 hrs)**

Melting furnaces,– Cupola and its types, Cupola charge calculations, chill testing of C.I., rotary furnace, induction furnaces, Arc furnace, holding furnaces, inoculation, fluxes, degassing, use of vacuum, de-oxidation practices in steel and cast iron foundry, converters for SG iron making, effects of melt Fluidity and its testing. Foundry refractory.

Unit 5 **(9 hrs)**

Solidification of metals and alloys, long freezing range and short freezing range alloys, Directional Solidification, Constitutional super-cooling, Segregation, Modes of solidification - planner, cellular, dendritic modes, Casting feeding – shrinkage, riser and chills, Cain's formula, NRL method, Inscribed circle method, modulus method, padding, Gating systems- fluid flow, Pressurized and non-pressurized gating systems, metal filtration, Software for casting process.

Unit 6 **(4 hrs)**

Shakeout, cleaning, fettling, finishing and heat treatment of casting, salvage of defective castings, Nature and causes of Casting defects, their remedial measures, Casting design, Quality control and assurance, Casting evaluation, statistical quality control, Inspection and testing of castings. Aluminium alloy, Magnesium alloy, copper alloy and special alloy foundry practice.

Text Books:

- P.L. Jain- Principles of Foundry Technology, 4th ed.,Tata-McGraw-Hill, New Delhi , 2003.
- A.K. Chakabarti, Casting Technology and cast alloys, Prentice-Hall of India, 2005.
- R.W. Hiene, C.R. Loper and P.C. Rosenthal, Principles of Metal Casting, Tata-McGraw-Hill, Reprint 1998.

Reference Books:

- Peter Beeley, Foundry Technology, 2nd ed., Butterworth-Heinemann, Oxford, 2001.
- ASM Handbook, Vol. 15, ASM International, OH, USA.

Outcomes:

This course helps students to attain:

- An ability to apply knowledge of mathematics, science, and engineering in casting

process
- An ability to design and conduct experiments, as well as to analyze and interpret data.
- A recognition of the need for, and an ability to engage in lifelong learning in foundry practices
- An ability to identify, formulates, and solves engineering problems related to various casting processes.

MT - 09010 Materials Characterization

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Assignments/Quiz – 40 marks
End Sem exam – 60 marks

Unit 1 **(8 hrs)**

X-ray Diffraction: Production and properties of x-rays, Absorption of x-rays and filters, diffraction of X-rays through crystals. Bragg's law, structure factor calculations for simple, body centered, and face centered cubic crystal structures, Laue and Powder methods, Indexing of powder photographs, Determination of lattice parameters of cubic metals and alloys using powder method. Stereographic projection. Some simple applications of X-rays to metallurgical problems such as determination of lattice strains, crystallite size, and residual stresses.

Unit 2 **(8 hrs)**

Scanning electron microscope (SEM), interaction of electrons with matter, optics of SEM, image formation, resolving power, modes of operation, magnification, depth of focus, methods of specimen preparation, Applications of SEM.

Unit 3 **(8 hrs)**

Transmission electron microscope (TEM), elements of electron optics, resolving power, image formation, contrast mechanism, bright field and dark field images, selected area diffraction, techniques of specimen preparation, applications of TEM.

Unit 4 **(8 hrs)**

Micro-analysis by EDX, WDX, EELS, and EPMA, Surface analysis by XPS, Auger Electron Spectroscopy (AES), Scanning probe microscope: Scanning-Tunneling Microscope (STM) and Atomic Force Microscope (AFM).

Unit 5 **(8 hrs)**

Thermal analysis techniques; Basic principles and applications of thermogravimetry analyzer (TGA)/differential thermogravimetry analysis (DTG), differential thermal analyzer (DTA), differential scanning calorimeter (DSC), dilatometer etc.,

Basic concept of electrical resistivity, effect of temperature, processing and strengthening on the resistivity of metals and alloys.

Text Books:

- P.E. Flewitt, R.K. Wild, Micro structural Characterization of Metals and Alloys, Institute of Metals, London, 1986.
- P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, 3rd Ed., Taylor and Francis, London.
- Edited by E. Metcalfe, Microstructure Characterization – The Institute of Metals, USA.
- B.D. Cullity, Elements of X-ray Diffraction (For X-rays), 3rd ed., Prentice-Hall, Upper Saddle River 2001.
- V. T. Cherepin and A.K. MalIik – Experimental techniques in Physical Metallurgy, Asia Publishing House.
- George L. Kehl - Principles of Metallographic Laboratory Practice - Eurasia Publishing house Pvt. Ltd. (For Dilatometry, Thermal analysis and resistivity).
- BL Gabriel - SEM - A Users Manual for Material Science - American Society for Metals.
- Thomas & M.T. Goringe, Transmission Electron Microscopy of Materials, John Wiley, 1979.
- L.E. Murr, Electron and Ion Microscopy and Microanalysis, Marcel Dekker, 1991.

Reference Books:

- ASM Metals Handbook, 9th Edition, Vol.10 - Materials Characterisation - ASM International Publication, 1980

Outcomes:

- After the course, students will be able to utilize the knowledge of optical microscope, electron microscopes, thermal analysis techniques in analyzing the materials fully.
- Students will be able to analyze, interpret and present observations on the grain size of steels.
- Students will be able to prepare powder samples for transmission electron microscope.
- Students will know the basic concept of x-ray diffraction and interpretation of XRD patterns. They will determine the lattice constant, crystal structure and type of phase.
- Students will be able to interpret thermogram obtained from TGA/DTA/ DSC/dilatometer etc.

MT - 09011 Structural Metallurgy

Teaching Scheme
Lectures: 3 hrs/week
Tutorial:1 hr/week

Examination Scheme
100 marks: Continuous evaluation-
Assignments/ Quiz – 40 marks
End Sem exam – 60 marks

Unit 1 **(7 hrs)**

Dislocation Theory:
Methods of Observation of Dislocations, Elastic Properties of Dislocations, Strain Energy of Dislocations, Forces On and Between Dislocations, Dislocations in FCC and other crystal structure, Climb and cross slip of Dislocations Multiplication of Dislocations, Dislocation Pile Ups, Strengthening by Dislocations, Work Hardening.

Unit 2 **(7 hrs)**

Strengthening Mechanisms:
Strengthening by Grain Boundaries, dislocation model of small angle grain boundary, Yield Point Phenomenon, Strain Ageing, Solid Solution Strengthening, Strengthening from Fine Particles, Fiber Strengthening, Strengthening due to Point Defect

Unit 3 **(7 hrs)**

Diffusion in Solids:
Types of diffusion, Fick's Laws of Diffusion, Solution of Fick's Laws and their Applications to various Metallurgical Processes-carburising ,diffusion couples, semiconductors etc., Kirkendall Effect, Diffusion paths along grain boundaries and free surfaces

Unit 4 **(7 hrs)**

Nucleation and Growth:
The nucleation, growth and overall transformation kinetics, Homogeneous and Heterogeneous Nucleation , the glass transition, recovery recrystalization and grain growth , Order-Disorder transformations-dislocations and stacking fault in ordered structure
.

Unit 5 **(8 hrs)**

Kinetics and Solid State phase transformation:
Transformations in steels-Pearlitic and Bain tic transformation
Martens tic transformation-Bain distortion ,nature and multiplicity of habit planes , ,stabilization, Dimensional changes , Iron –nickel martensitic transformation
Precipitation and Age Hardening - Study of Al-Cu system, theories of Structural Changes During Aging

Unit 6 **(6 hrs)**

Creep resistant alloys:
Creep Mechanism, creep curve, Relation between dislocation density and stress, Super plasticity, Shape Memory alloys.

Text Books:

- Dieter George E. - Mechanical Metallurgy, McGraw Hill. London, 1988.
- Robert Reed - Hill - Physical Metallurgy Principles, Thomson/Brooks/Cole,2005
- Hayden, Moffat and Wolff - The structure and Properties of Materials,Vol-III (Mechanical Behavior), Wiley Eastern Pvt. Ltd,1991
- V.Raghvan- Material Science and Engineering,PHI,2004
- V.Raghvan –Solid State phase Transformation, PHI, 2010.

Reference Books:

- Brophy, Rose and Wolff - Thermodynamics of Structure, Vol-II, Wiley Eastern Pvt. Ltd, New Delhi,1964.
- Porter,Easter ling Sherif -Phase transformation in Metals and Alloys-CRC Press,2009.
- Thomas H.Courtney-Mechanical Behavior of Materials-Waveland Press USA,2005.

Outcomes:

- This course is one of the most fundamental courses in Metallurgical engineering rather Materials Science.
- This subject helps students understand the relation between Structure and Properties of Material right from atomic level to microscopic level.
- It enables students take decisions in order to modify-improve properties as per the requirement of application.

MT - 09012 Steel Making

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation-
Quiz/Assignment – 40 marks
End Sem exam – 60 marks

Unit 1 **(6 hrs)**

History of Steel Making, from Bessemer Steel Making to present day equipment and practices. Integrated and Mini Steel Plants in India. Indian steel; Scenario as at present. Principles guiding Steel Plant location

Unit 2 **(6 hrs)**

Physical Chemistry of Steel Making: Thermodynamic and Kinetics of Refining Reactions, Carbon Reaction, Phosphorus Reaction, Sulphur Reaction, Silicon Reaction, Refining Slags and its

Properties. Importance and Mechanism of Decarburization Reaction. Reaction at Slag Metal interface

Unit 3 **(6 hrs)**

Basic Oxygen Steel Making: BOF practice, Equipment, Operation and Process, slag Metal reactions in B.O.F. Raw material and flux practices. Modifications and further Development in Conventional BOF. Oxygen Lance: Design, Construction and Operation. Top and Bottom Blow processes, Its advantages and disadvantage.

Unit 4 **(6 hrs)**

Electric Steel Making: Details of Electric Arc Furnaces, Its Variations. Sequence of EAF Operations. Various additions at Different Stages, Slag Control. UHP Arc Furnaces. Arc Furnace practices for Carbon and Low Alloy Steels

Unit 5 **(6 hrs)**

Secondary Steel Making Processes, Ladle Furnaces (L.F.), Vacuum Systems and Vacuum treatment of Steel. Gases in steel. LF-VD processes and AOD, VOD, VAD techniques, R-H degasers. Ladle Stirring and its Advantages. ESR-Principle and Technology. Deoxidation – Theory and practice, Floatation's of products, Modifications of Inclusions. Injection Metallurgy.

Unit 6 **(6 hrs)**

Continuous Casting (C.C.) and Ingot Casting. Ingot Casting: Types of Moulds, Advantages and Disadvantages. Ingot Defects and Remedies. Continuous casting: C.C. machines with its various units and types.C.C. of Blooms, Slabs and Thin slabs EM S of Moulds . Reoxidation prevention methods during Steel Casting. Advantage of C.C. Environmental issues related to Steel Making

Text Books:

- R.H.Tupkary,V.R.Tupkary, An introduction to modern Steelmaking, 7th Edition, Khanna Publications, Delhi, 2012.
- Ahindra Ghosh, Amit Chaterjee Iron and Steel making: Theory and practice,2nd Edition, PHI learning Pvt. Ltd, New Delhi,2011.
- V.Kudrin, Steel Making, 1st ed., Mir Publisher, Moscow, 1985.

Reference Books:

- G.R. Bashforth- Manufacture of Iron and Steel, Vol. I & II, Asia Publishing House, Mumbai,
- Darken and Gurry- Physical Chemistry of Metals, Mc Graw Hill, 1953.
- W.R. Irving, Continuous Casting,Maney Publishing, 1993.
- National Steel Policy (NSP), Ministry of Steel, Government of India, 2012.

Outcomes:

This course attains the following outcomes:

- This course teaches the student to apply/correlate the concepts of metallurgical thermodynamics for sound understanding of the steel making process.
- This course insists on the broad education necessary for developing alternate economical routes for the production of sophisticated grades of alloy-steels.
- This course teaches students to formulate, solve and the, predict the steel-making related problems, e.g. influence of pressure on the composition of steel or refractory linings in VOD process, predicting the ingot casting defects on the basis of steel-composition and processing etc.
- This course recognises the need for life-long learning so that the metallurgists will be familiar with the latest advances in the steel-making technology.

MT - 09013 Foundry Technology Laboratory

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Laboratory continuous evaluation
Term work - 50 Marks
End Sem exam - 50 Marks

Term Work:

List of Experiments:

a) Sand testing:
   1) Sand cleaning, conditioning and blending.
   2) Sieve shaker, AFS grain fineness number.
   3) Moisture content, Mould ability, Flowability, Friability mold Hardness.

b) Metal melting in crucible Muffle or Induction furnace, molten metal additions.

c) Pattern and core making, preparation of core sand and its testing
   e.g. Hardness, Flowability, Mouldability, etc. Baking of cores in ovens.

d) Fluidity Test.

e) Visit to at least one foundry around Pune

Outcomes:

This course helps students to attain:

- An ability to apply knowledge of mathematics, science and engineering in foundry practice
- An ability to design and conduct experiments as well as to analyze and interpret data
- Recognition of the need for and an ability to engage in lifelong learning of various casting methods.
- An ability to identify , formulate and solve engineering problems

MT - 09014 Materials Characterization Laboratory

Teaching Scheme
Laboratory: 2 hrs/week

Examination Scheme
Laboratory continuous evaluation
Term work - 50 Marks
End Sem exam - 50 Marks

Term Work:

List of Experiments:

1. Grain size measurement by various techniques.
2. Determination of particle size using optical microscope.
3. Determination of resistivity of metal/alloy using digital multimeter
4. Determination of conductivity of metals/alloys as per IACS standard.
5. Determination of crystal structure of metal or single phase alloy from X-ray diffraction (XRD) pattern.
6. Identification of an unknown specimen using XRD pattern.
7. Determination of crystallite size of nanomaterials using X-ray diffraction
8. Determination of linear coefficient of thermal expansion (CTE) of materials using dilatometer.
9. Thermogram curves (TGA/DSC/DTA) of metal/alloys/polymers.
10. Numerical on X-ray diffraction techniques.
11. Surface morphology and fractography by SEM.
12. Determination of % filler (or reinforcement) content in polymers using TGA.

Outcomes:

- The laboratory provides the students with the know-how and the methodological tools for the characterization of materials.
- Students will be able to analyzing particle size and grain size of materials.
- Students will be able to determine the electrical conductivity of the metals.
- Students will be able to determine the CTE of the metals, alloys and polymers using dilatometer.
- Students will be able to determine the lattice constant, crystal structure and type of phase using XRD patterns.

MT - 09015 Mini Project

Teaching Scheme
Laboratory: 4 hrs/week

Examination Scheme
Term work - 50 Marks
End Sem exam - 50 Marks

The students shall be assigned a small project, which will test their creativity in the area of design and development, Setting of new experiments. It should form a part of literature and feasibility survey. The outcome of mini-project should preferably lead to a major project. Collection of samples for metallography laboratory, cold models concerned with metallurgical processes. Mini-project can be the stage-I of the major project where literature survey and experimental-planning for the major project will be the main goals. At the end of semester student shall submit a detail write-up on the project work undertaken by them including literature survey from reputed journals, proceedings, conferences, problem definition, objective of project, experimental planning/methodology. Evaluation will be on the basis of the attendance, set up created and seminars delivered/oral examination given by the students.

Outcomes:

The outcome of mini-project should preferably lead to a major project. This course attains the following outcomes:

- This course teaches the student to demonstrate their knowledge in science and engineering.
- Students demonstrate the ability to design, perform experiments independently in metallurgy, characterize and can propose proper material and/or process selection.
- Students will demonstrate the ability to function on engineering and science laboratory teams, as well as on multidisciplinary projects. Students also learn their professional and ethical responsibilities.
- Students develop an able to communicate effectively in both verbal and written forms.

MT - 09016 Industrial Visit and Training

Teaching Scheme
Industrial visit: Minimum 3/semester
Industrial training: 4 to 6 weeks

Examination Scheme
Term work: 100 Marks

The students shall make minimum 3 visits related to metallurgical field. They will submit the visit report consisting of various aspects such as company's product, plant layout, new processes or methods adapted, role of metallurgist in the organization.
The students will undergo industrial training for the period between 4 to 6 weeks. The training may be completed within the summer or winter vacation. The training report will be submitted along with the training certificate from the company. The report should consist of assignment undertaken during training, company profile, products, layout and other relevant details.

Outcomes:

This course helps to students to correlate theoretical and practical approach and helps students to attain:

- An ability to design system or process to meet desired needs within realistic constraints such as social , ethical and manufacturability.
- An understanding of professional and ethical responsibility
- An ability to function on multidisciplinary teams.

ML-09001 Constitution Of India

Teaching Scheme
Lectures : 2 hrs/week

Examination Scheme
20 marks: Continuous evaluation-
Asignments /Quiz
End - Sem Exam – 30 Marks

Unit 1 **(5 hrs)**

Preamble to the constitution of India. Fundamental rights under Part – III – details of Exercise of rights, Limitations & Important cases.

Unit 2 **(5 hrs)**
Relevance of Directive principles of State Policy under Part – IV. Fundamental duties & their significance.

Unit 3 **(4 hrs)**

Union Executive – President, Prime Minister, Parliament & the Supreme Court of India.

Unit 4 **(4 hrs)**
State executive – Governors, Chief Minister, State Legislator and High Courts.

Unit 5 **(4 hrs)**
Constitutional Provisions for Scheduled Castes & Tribes, Women & Children & Backward classes. Emergency Provisions.

Unit 6 **(4 hrs)**
Electoral process, Amendment procedure, 42nd, 44th, 74th, 76th, 86th and 91st Constitutional amendments.

Text Books:

1. Durga Das Basu: "Introduction to the Constitution of India" (Students Edn.) Prentice – Hall EEE, 19th/20th Edn., 2001.
2. "Engineering Ethics" by Charles E.Haries, Michael. S.Pritchard and Michael J.Robins Thompson Asia, 2003-08-05.

Reference Books:

1. "An Introduction to Constitution of India" by M.V.Pylee, Vikas Publishing, 2002.

Outcomes:

At the end of this course students will be aware about the Constitution:

- Appreciate the complexity of implementation of any law.
- Appreciate the roles and functions of various high officials.
- Know about Fundamental rights of citizens of India.
- Understand the Electoral process.
- Understand the provisions made for special groups and categories in the constitution

AS -09002 Humanities course/Applied Psychology

Teaching Scheme
Lectures : 4 hrs/week
Practical : 2hrs/week

Examination Scheme
100 marks:
Assignments /Practical(T1 and T2)- 40 Marks,
End - Sem Exam – 60 Marks

Unit 1 **(4 hrs)**

Introduction to Psychology:
Definition, Nature and Aims, Counseling, Industrial and Social Psychology, Creativity and its application.
Mind Mapping and Problem Solving, Self Awareness, Johari window.

Unit 2 **(6 hrs)**

Personality:
Carl Jung's type theory, Bandura's Social learning, Big Five model Indian Perspective on Personality- Panchakosh Model, SWOT analysis, life planning, emotional intelligence.

Unit 3 **(8 hrs)**

Organizational Behaviour:
Behaviour at workplace (personality, attitude and perceptions), Motivation, Job satisfaction, Leadership and Group dynamics, Engineering Psychology (Ergonomics), Man-machine relation, Group dynamics, Transactional analysis

Unit 4 **(4 hrs)**

Stress Management:
Nature, types and causes of stress, General Adaptation Syndrome (GAS), Coping with Stress-Cognitive, Emotional, and Behavioural techniques, Type A and B theory.

Text Books

1. Morgan, C.T., King, R.A., Weisz, J.R., & Schopler, J. (2001). *Introduction to Psychology*. 7th Edition. New Delhi: Tata McGraw Hill
2. Schultz, D. & Schultz, S. E. (2002). *Psychology and Work Today*. 8th Edition. Pearson Education

Reference Book

1. Hilgard, E. R., Atkinson, R. C., Atkinson, R.L. (1975). *Introduction to Psychology*. 6th Edition. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.
2. Golman, Daniel. (1998). *Working with Emotional Intelligence*. Bloomsbury Publishing Plc.
3. Matthewman, L., Rose, A., & Hetherington, A. (2009). *Work Psychology*. Indian Edition. Oxford University Press.

Practical Work

Teaching Scheme
Practical: 2 hrs/week

Examination Scheme
Term-work: 50 Marks
Oral: 50 Marks

List of Experiments:

1: Self Awareness (20 Marks) **(4 hrs)**

Aims/Objectives for the Year- Newspaper Activity, SWOT analysis, Personal Effectiveness Scale, Johari Window.

2: **Level of Adjustment (10 Marks)** **(6 hrs)**

Adjustment Inventory By M.L. Saxena, Interpretation and Explanation

3: Stress and Personality (15 Mark) **(8 hrs)**

Student's Stress Scale by Dr. Manju Agrawal, Type A- B theory and test, Interpretation and Explanation

4:Emotional Quotient (5 Mark) **(4 hrs)**

Concept of EQ, EQ test by N.K.Chadha, Interpretation and Explanation

Outcomes:

After successful completion of the course students will be able-

1. To understand different aspects of their personality and to learn various life skills
2. To strengthen the skills required in industrial/workplace settings
3. To overcome stressful situations effectively with the help of psychological approach
4. To improve their social interactions.

Annexure I

List of Open Elective/Professional Science courses offered by ALL Departments

Sr. No	Department	Course
1	Civil	Finite Elements in Engineering
2	Mechanical	1. Unconventional Machining Processes 2. Modern Control Systems 3. Power Plant Engineering
3	Electrical	1. Industrial Drives 2. Control System Engineering
4	Electronics and Telecommunication	Electronic Communication Systems
5	Metallurgy and Material Science	Composite Materials
6	Instrumentation and Control	Industrial Automation
7	Production	1. Introduction to ERP 2. Operations Efficiency
8	Computer Engineering	Information Systems
9	Information Technology	Information Systems
10	Applied Science	1. Humanities Course 2. Constitution of India
11	Innovation Centre	Liberal Learning Course

Annexure II

List of Liberal Learning courses offered at Institute Level

- **Agricultural** – Animal Science, Forestry, Horticulture, Floriculture, Sustainable Agriculture, Veterinary
- **Arts** – Graphic Design, Interior Design, Fashion Design
- **Basic Sciences** – Astronomy, Astro- Physics, Biology, Genetics, Kinesiology, Microbiology, Neuro Sciences.
- **Business** – Administration, Communication, Entrepreneurial studies, Hostel Management, Marketing.
- **Defense Studies** - Military Studies, Naval Studies, Air Force Studies, War strategies.
- **Education** - Education policies, Engineering Education, Teacher Training.
- **Environmental Sciences** – Ecology, Meteorology
- **Linguistics** – Word Language
- **Medicine** – Health Studies Nutrition and dietetics
- **Performing Arts**- Music, Dance Theatre, Cinema
- **Philosophy**- Religious Studies
- **Sports and Athletics**