Course Structure and Syllabus
of
B.Tech Programme
In

METALLURGICAL AND MATERIALS ENGINEERING

(Admission Batch: 2018-19 Onwards)

INDIRA GANDHI INSTITUTE OF TECHNOLOGY, SARANG
(An Autonomous Institute of Government of Odisha)
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INDIRA GANDHI INSTITUTE OF TECHNOLOGY, SARANG

Course Structure for 3rd Year B.Tech METALLURGICAL AND MATERIALS ENGINEERING

(Admission Batch: 2018-19 Onwards)

Fifth Semester				Sixth Semester			
Theory				**Theory**			
Course Code	**Course Name**	**L-T-P (Periods/ Week)**	**Credits**	**Course Code**	**Course Name**	**L-T-P (Periods/ Week)**	**Credits**
	Programme Core Subject			HSHM3306M/ HSHM3306	Enhancing Soft Skills and Personality	2-0-0	2
PCMT4306	Physical Metallurgy	3-0-0	3		***Programme Core Subject***		
PCMT4307	Iron Making	3-0-0	3	PCMT4309	Steel Making	3-0-0	3
PCMT4308	Non-Ferrous Extractive Metallurgy	3-0-0	3	PCMT4310	Mechanical Working & Testing of Materials	3-0-0	3
(Any One) PEMT5301/ PEMT5302/ PEMT5303/	***Programme Elective I*** Mineral Processing/ Fuel Technology/ Refractories and Furnaces	3-0-0	3	**(Any One)** PEMT5304/ PEMT5305/ PEMT5306	***Programme Elective II*** Instrumental Methods of Analysis/ Non Destructive Testing of Materials/ Polymer Technology	3-0-0	3
(Any One)	**Open Elective II** Refer List of Open Electives	3-0-0	3	**(Any One)**	**Open Elective III** Refer List of Open Electives	3-0-0	3
MCGN9305/ MCHM9306	**Mandatory Course V** Environmental Science/ Universal Human Values	2-0-0	0	MCHM9306 /MCGN9305	**Mandatory Course VI** Universal Human Values/ Environmental Science	2-0-0	0
Total (Theory)		**17**	**15**	**Total (Theory)**		**16**	**14**
Honours/ Minor		3-1-0	4	**Honours/ Minor**		3-1-0	4
HNMT0303	Material Failure and Analysis			HNMT0304	Secondary Steel Making		
MNMT0303	Mechanical Metallurgy			MNMT0304	Iron Making & Steel Making		
Practical/ Sessional				**Practical/ Sessional**			
PCMT7306	Heat Treatment Laboratory	0-0-3	2	PCMT7309	Advanced Materials Processing Laboratory	0-0-3	2
PCMT7307	Process Metallurgy Laboratory	0-0-3	2	PCMT7310	Computer Application in Metallurgy	0-0-3	2
PCMT7308	Mineral Processing & Fuel Testing Laboratory	0-0-3	2	HSHM3305	Business Communication & Interview Skills	0-0-3	1
				PJMT8301	Skill Project	0-0-3	2
Total (Practical/ Sessional)		**9**	**6**	**Total (Practical/ Sessional)**		**12**	**7**
TOTAL		**26**	**21**	**TOTAL**		**28**	**21**
TOTAL SEMESTER CREDITS: 21				TOTAL SEMESTER CREDITS: 21			
TOTAL CUMULATIVE CREDITS: 104				TOTAL CUMULATIVE CREDITS: 125			

OPEN ELECTIVE SUBJECTS

OPEN ELECTIVE-II (OE-II) 5th Semester						
Sl. No.	**Subject Code**	**Subject Name**	**Contact Hours**	**Credits**	**Departments to Teach the Subject**	**Students to whom Option is Open**
1	OECH6311	Petroleum Refinery Engineering	3-0-0	3	Chemical Engg.	All branches
2	OECH6330	Green Technology	3-0-0	3	Chemical Engg, Civil Engg.	All branches
3	OECE6312	Mechanics of Solids	3-0-0	3	Civil Engg.	All branches
4	OECS6203	OOPs Using C++	3-0-0	3	CSE	CH, CS, EC, MM, PD
5	OECS6331	Cloud Computing	3-0-0	3	CSE	All branches
6	OEEE6313	Digital Signal Processing	3-0-0	3	Electrical Engg.	All branches
7	OEEC6314	Industrial Automation with PLC and SCADA	3-0-0	3	ETC Engg.	All branches
8	OEME6316	Introduction to Composite Materials	3-0-0	3	Mech. Engg.	All branches
9	OEMT6315	Nanomaterials	3-0-0	3	MME	All branches
10	OEPD6317	Powder Metallurgy	3-0-0	3	Prod. Engg.	All branches
11	OEMA6207	Numerical Methods	3-0-0	3	Mathematics	CE, EE, ME
OPEN ELECTIVE-III (OE-III) 6th Semester						
Sl. No.	**Subject Code**	**Subject Name**	**Contact Hours**	**Credits**	**Departments to Teach the Subject**	**Students to whom Option is Open**
1	OECH6318	Food Biotechnology	3-0-0	3	Chemical Engg.	All branches
2	OECH6319	Fluidization Engineering	3-0-0	3	Chemical Engg.	All branches
3	OECE6320	Structural Dynamics and Earthquake Engineering	3-0-0	3	Civil Engg.	All branches
4	OECS6321	Data Science	3-0-0	3	CSE	All branches
5	OEEE6322	Sensors and Transducers	3-0-0	3	Electrical Engg.	All branches
6	OEEC6324	Mechatronics	3-0-0	3	ETC Engg.	All branches
7	OEHM6325	Marketing Management	3-0-0	3	Humanities	All branches
8	OEMA6326	Optimization in Engineering	3-0-0	3	Mathematics	All branches
9	OEME6327	Industrial Engineering and Operation Research	3-0-0	3	Mechanical Engg.	All branches
10	OEMT6328	Biomaterials	3-0-0	3	MME	All branches
11	OEPD6329	Operation Research	3-0-0	3	Prod. Engg.	All branches

CE:	Civil Engineering	CS, CSE:	Computer Science and Engineering
EE:	Electrical Engineering	EC, ETC:	Electronics and Telecommunication Engineering
ME:	Mechanical Engineering	MT, MME:	Metallurgical and Materials Engineering
CH:	Chemical Engineering	PD, Prod.:	Production Engineering
HM:	Humanities	MA:	Mathematics

INDIRA GANDHI INSTITUTE OF TECHNOLOGY, SARANG

B.TECH SYLLABUS
BRANCH: METALLURGICAL AND MATERIALS ENGINEERING
(Admission Batch: 2018-19 Onwards)
5th SEMESTER

PCMT4306	Physical Metallurgy	3-0-0	Credits 3

Objectives of the Course

1. To learn about the principles of alloy design, phase diagram and strengthening mechanisms in different metals and alloys.
2. To study the fundamental aspects of heat treatment and its influence on properties and applications
3. To obtain knowledge about the physical metallurgy of specific and important engineering materials such as ferrous and non-ferrous alloys

Detailed contents

Module 1: (12 hours)

Important phase changes in unary and binary systems; Types and interpretation of phase diagram; Utility of phase diagrams, Lever rule; Important phase diagrams in metallic and ceramic systems; Free energy Composition diagrams; Ternary phase diagrams; Isomorphous and eutectic Systems, microstructure changes during cooling, Strengthening mechanisms – solid solution, work hardening, precipitation hardening, dispersion strengthening.

Module 2: (12 hours)

Solidification, nucleation and growth mechanisms and kinetics; Alloy solidification – cellular and dendritic morphology; Eutectic and peritectic solidification. Application of solidification Precipitate growth; Age hardening; Spinodal decomposition; Precipitate coarsening. Order-disorder change, polymorphic change. Recrystallization, grain growth. Eutectoid transformation. Application of solid state precipitation. Pearlitic and bainitic transformations in steel; Martensite and martensitic changes in ferrous materials.

Module 3: (12 hours)

TTT and CCT diagrams, conventional heat treatment processes – annealing, normalizing, hardening and tempering. Hardenability, role of alloying elements in steels. Surface hardening and chemical treatment in steels. Thermo-mechanical treatment of steels; High temperature and low temperature Thermo-Mechanical treatment. Heat treatment of some Cu, Al and Ti based alloys.

Module 4: (06 hours)

Introduction to important ferrous alloys (stainless and special steels, cast irons), aluminium alloys, titanium alloys, copper base alloys, Superalloys, shape memory alloys – classification, heat treatment, properties and applications

Suggested Text Books:

1. Physical Metallurgy: Principles and Practice, V. Raghavan, PHI Learning, Delhi, 2008.
2. Physical Metallurgy Principles, R. Abbaschian, R. E. Reed-Hill, Cengage Learning,2009

Suggested Reference Books:

1. Physical Metallurgy Vols. I, II, III, R.W. Cahn and P. Haasen, North Holland, 1996.
2. Light Metals, I.J. Polmear, Elsevier, 2005

Course Outcomes:

By completing this course the student will have:

1. The ability to identify the concepts of alloy design, phase diagrams and strengthening mechanisms and apply them to materials systems
2. The knowledge of heat treatment and the resulting microstructure in materials
3. The knowledge of physical metallurgical aspects of important engineering alloys

PCMT4307	Iron Making	3-0-0	Credits 3

Objectives of the Course:

1. This course introduces the principles and practices of iron making.

Module-I **(12 hours)**

Raw materials and their properties: Iron ores, Limestones, Agglomerates and Coke.
Preparation of ores: sintering and palletizing, blast furnace burdening and distribution, testing of raw materials for blast furnace. Numerical problem solving: Material balance, Feasibility of reactions and chemical kinetics.

Module-II **(12 hours)**

Design: Blast furnace profile, stove and gas cleaning units; instrumentation, refractory used in blast furnace and stove. Reactions: Fe-C-O, Fe-O-H phase equilibria, Reactions in stack, bosh and hearth; formation of primary slag, bosh slag and hearth slag. Slag composition and its control, Metal-slag reactions, Control of hot metal composition.

Module-III **(12 hours)**

Process Control: Factors affecting fuel consumption and productivity, Recent developments in Blast furnace operations like, Bell-less top charging system, High top pressure, Humidified & Oxygen enriched blast and Auxiliary fuel injection through tuyers. Irregularities in blast furnace operation and their remedies.

Module-IV **(06 hours)**

Alternative routes of iron making: Introduction, Processes of Sponge Iron production; SL/RN, MIDREX, HyL processes. Smelting Reduction Processes; COREX, ROMELT, Hismelt.

Suggested Text Books:

1. Ahindra Ghosh and Amit Chatterjee: Iron making and Steelmaking Theory and Practice, Prentice-Hall of India Private Limited, 2008.
2. Dipak Mazumdar, A First Course in Iron and Steel Making, University Press-IIM-2015

Suggested Reference Books:

1. An introduction to modern steel making, R. H. Tupkary, Khanna Publishers (2000)
2. An introduction to modern iron making, R. H. Tupkary, Khanna Publishers (2004)

Course Outcomes:

After completing this course, the student should be able to:

1. Describe the physical and chemical processes that take place during iron making
2. Analyse the effect of change in process parameters in iron making
3. Describe the methods for control of quality in iron production
4. Solve numerical problems involving reaction kinetics and composition control

PCMT4308	Non-Ferrous Extractive Metallurgy	3-0-0	Credits 3

Objectives of the course

This course will extend the concepts of thermodynamics and kinetics to different processes for extraction of metals.

Module-I: (12 hours)

Fundamentals of Unit processes involved in Metal Extraction. Thermodynamic considerations and process selection in Pyro-metallurgical extraction of metals. Kinetics of leaching of ores; effect of various operating variables on leaching process; bio leaching. Principles involved in Electro-metallurgical extraction of metals.

Module-II: (12 hours)

Extraction of metals from oxide ores (Sn, Mg), Extraction of metals from Sulphide ores (Cu, Ni, Pb and Zn), Extraction of metals through halide route (Ti and Zr) Refining involving oxidation, chemical transport reactions, zone refining, distillation, etc. Ion exchange and solvent extraction processes and their application in extraction processes (Zr, V, Th, Nb, etc)

Module-III: (12 hours)

Electro winning and Electro refining of metals: From aqueous salts (Cu, Ni, Au, Ag) and From fused salts (Al and Mg)

Module-IV: (06 hours)

Environmental pollution and its address related to various metal extraction processes in general.

Suggested Text Books:

1. Principles of Extractive Metallurgy, H.S. Ray and A. Ghosh (1992), Wiley-Blackwell
2. Extraction of Non ferrous metals by H.S Ray, R. Sridhar, K.P Abraham

Suggested Reference Books:

1. Topics in non-ferrous extractive metallurgy, Burkin, Wiley-Blackwell (1980)
2. The Extraction and Refining of Metals, C. Bodsworth, CRC Press (1994)

Course Outcomes:

After completing this course, the student should be able to:

1. Apply principles of thermodynamics and kinetics to reactions involving extraction of metal
2. Analyse different extraction processes
3. Solve numerical problems involving thermodynamic and kinetic concepts of relevance to extractive metallurgy
4. Describe the effect of a change in process parameters of different extraction processes

PEMT5301	Mineral Processing	3-0-0	Credit-3

Objective of the Course:

1. Art of treating crude ores and mineral products in order to separate the valuable minerals from the waste rock, or gangue.
2. Size analysis is of great significance to determine the quality of grind and establish.
3. The degree of liberation of valuable minerals between them, as well as from the gangue at various particle sizes.

Module I: **(12 hours)**

Introduction: Introduction to mineral beneficiation, sampling, liberation studies and its importance. **Comminution:** Fundamentals of comminution, crushing, construction and operational features of jaw, gyratory, cone and roll crushers.

Grinding: Theory of ball mill, rod mill, critical speed of the mill, open circuit and closed circuit, circulating load.

Module II: **(12 hours)**

Size separation: Sieving and screening, laboratory sizing and its importance, representation and interpretation of size analysis data, industrial screening

Classification: Movement of solids in fluids, free setting and hindered settling of particles, different types of classifiers, e.g. sizing and sorting classifiers used in mineral industry. **Concentration:** Gravity separation, concentration criteria, jigging, flowing film concentration and tabling, dense media separation.

Module III: **(12 hours)**

Froth flotation: Theory, reagents used in floatation processes, machines and practice. Magnetic and electrostatic separation: Theory and application of magnetic and electrostatic separation techniques in mineral industry.

Dewatering and drying: Theory and practice of thickening; filtration and drying, **Flow sheets:** Typical flow sheets for beneficiation of iron, gold, copper, lead-zinc sulphide ores, rock phosphate, beach sand, uranium and other industrial minerals.

Module IV: **(06 hours)**

Agglomeration techniques: Sintering, palletizing, briquetting and their applications in ferrous and non-ferrous metal industries, testing of agglomerates. Important mineral deposits in India

Suggested Text Books:

1. Principle of Mineral Dressing by A. M. Gaudin
2. Ore Dressing by S.K. Jain.

Suggested Reference Books:

1. Mineral Processing Technology by Berry A Willis
2. Text Book of Ore Dressing by R. H. Richards and C. E. Locks
3. Element of Ore Dressing by A.E. Taggart
4. Handbook of Mineral Dressing- Ores and Industrial Minerals by A.E. Taggart.
5. Textbook of Ore Dressing by S.J. Trusscott.

Course Outcomes:

On successful completion of the course students will be able to:

1. Students will possess the knowledge needed to design a mineral processing operation that ensures maximum profitability for a mining company while achieving the required product quality specifications.
2. Students will understand the methodology used to select the appropriate unit operations, determine the optimum operating conditions and select the required size of the unit.
3. A knowledge of product quality assurance programs that includes the monitoring of plant efficiency will be demonstrated.

PEMT5302	Fuel Technology	3-0-0	Credits 3

Objectives of the Course:

To know primary energy resources of the world and India (Coal, Petroleum and Natural Gas).

Module-I: (12hours)

Classification of fuels; solid, liquid and gaseous, primary and secondary fuels. Coal: Rank, coking and non-coking coals; Characterization of coal properties (caking and swelling indices, calorific value, proximate and ultimate analyses, etc.); Selection of coal for metallurgical industries and thermal power plants, coal washing and blending, washability curves; Coal carbonization, operational features of modern coke ovens. Testing and properties of coke, char and graphite.

Module-II: (12hours)

Fuel calorimetry; Testing of fuels; Definition and principle of combustion of fuels; Combustion calculations.

Module-III: (12hours)

Alternative sources of energy - ferrocoke, formed coke, charcoal, solar, wind, tidal, etc. and their suitability for metallurgical and power industries; Renewable and non-renewable sources of energy; Activated carbon and its uses.

Module-IV: (06 hours)

Properties and uses of gaseous fuels like coke oven gas, blast furnace gas, basic oxygen furnace gas, producer

gas etc. Petroleum coke and its utilization in metallurgy; Solid energy wastes and their possible industrial applications.

Suggested Text Books:

1. Fuels and Combustion by S. Sarkar, Orient Longman Ltd., Mumbai.
2. Fuel, Furnaces and Refractories by O.P Gupta

Suggested Reference Books:

1. Fuels and Combustion by S.P. Sharma and C. Mohan, Tata McGraw-Hill
2. Elements of Fuel Technology by G.W. Himus

Course Outcomes:

After completing this course, the student should be able to:

1. Characterize coal properties and analyse how it is selected for metallurgical industries and thermal power plants
2. To analyse which gaseous fuel is more beneficial and why?
3. Know how alternate sources of energy are suitable for metallurgical and power industries. Solve numerical problems of combustion calculation

PEMT5303	Refractories and Furnaces	3-0-0	Credits 3

Objectives of the Course:

1. To study the various types of furnaces employed in metallurgical operations
2. To study important refractories used in metallurgical furnaces.

Module-I **(12 hours)**

Classification of refractories, raw materials, manufacture, testing and properties of heavy and special refractories, silica, siliceous aluminosilicate, high alumina, magnesite, chrome, chrome-magnesite, dolomite, forsterite, chemically bonded basic, carbon and insulating refractories and special purpose oxides, carbide nitride refractories. Binary phase diagrams of Al_2O_3-SiO_2, CaO-MgO, CrO_3-MgO and MgO-SiO_2 systems. Refractory mortars and cements, Refractory castables, selection of refractories for coke oven ,iron blast furnace, copper convertor ,soaking reheating furnaces and heat treatment furnaces, electric are furnace.

Module-II **(12 hours)**

Classification of furnaces: basis and uses. Mechanism of combustion, ignition temperature. Flames: Flame propagation, flame speed and inflammability limits, types of flames; premixed and diffusion flames and their characteristics. Combustion control; variables of control, viz.: temperature, pressure and gas ratio control, modes or combustion control. Theoretical, adiabatic & true flame temperature.

Available heat and factors affecting it. Heat losses in furnaces: Heat balance and furnace efficiency. Liquid and gaseous fuel burners: methods of atomization, types of liquid fuel burners and principle of design. Low pressure, high pressure and injection type gaseous fuel burners and principles of their design.

Module-III (12 hours)

Recuperators; types and availability. Temperature distribution in different types of recuperators, AMTD and LMTD. Heat transfer and principle of design. Regenerators: Temperature distribution heat transfer and principles of design. Electric heating: Principles of resistance, arc and induction heating. Principles of resistor design. Selection of power for arc furnace and frequency for induction furnaces. Basic design for generation of low pressure, rotary mechanical pumps and diffusion pumps. Pressure measuring gauges. Laboratory furnaces; oil fired furnaces, muffle furnaces, salt and lead bath furnaces. Heating of bodies in furnaces.

Module-IV (06 hours)

Types of drafts, natural, induced and forced. Chimney calculations. Description, operation, instrumentation and control of soaking pits, reheating furnaces, and annealing furnaces (hood annealing and continuous annealing).

Suggested Text Books:

1. Fuels, Furnaces and Refractories by J.D. Gilchrist.
2. Refractories manufacture properties and uses by M.L. Mishra

Suggested Reference Books:

1. Refractories manufacture properties and application by A.R. Chesti
2. Fuels and Combustion by S. Sarkar, Orient Longman Ltd., Mumbai.

Course Outcomes:

After completing this course, the student should be able to:

1. Describe the working features of various metallurgical furnaces.
2. Describe the methods for selection and synthesis of refractories for various applications.
3. Solve numerical problems on combustion calculation and chimney calculation.

MANDATORY COURSE

MCGN9305	Environmental Science	2-0-0	Credit-0

Unit 1: Multidisciplinary nature of environmental studies
Definition, scope and importance), Need for public awareness.
Renewable and non-renewable resources
Natural resources and associated problems, role of an individual in conservation of natural resources, equitable use of resources for sustainable lifestyles.

Unit 2: Ecosystems
Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the following ecosystems:-

a. Forest ecosystem
b. Grassland ecosystem
c. Desert ecosystem
d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 3: Biodiversity and its conservation

- Introduction – Definition: genetic, species and ecosystem diversity.
- Bio geographical classification of India
- Biodiversity at global, National and local levels.
- India as a mega-diversity nation
- Hot-sports of biodiversity.
- Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts.
- Endangered and endemic species of India
- Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Unit 4: Environmental Pollution Cause, effects and control measures of :-
Air pollution, water pollution, soil pollution, noise pollution, nuclear hazards and solid waste Management: Causes, effects and control measures of urban and industrial wastes, Disaster management: floods, earthquake, cyclone and landslides.

Unit 5: Social Issues and the Environment
Sustainable development, water conservation, rain water harvesting, resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion.

Text Books

1. Environmental Science And Engineering by Rajesh Gopinath N. Balasubramanya, Cengage India.
2. Fundamental Concepts in Environmental Studies by Dr. D.D. Mishra S. Chand Publication.
3. Basic environmental Sciences for undergraduates by Dr. Sohini Singh, Dr. Tanu Allen and Dr. Richa K. Tyagi, Vayu education of India.

MANDATORY COURSE

MCHM9306	Universal Human Values	2-0-0	Credit-0

Objective:

1. To help students distinguish between values and skills, and understand the need, basic guidelines, content and process of value education.
2. To sensitize the student towards issues in society and nature.
3. To Strengthen self-reflection to know what the students 'really want to be' in their life and profession.
4. To understand harmony at all the levels of human living, applying the understanding of harmony in existence in their profession and lead an ethical life.

Module I **10 Hours**

1. Need, basic guidelines, content and process for Value Education, Self-Exploration– content and process;

2. Happiness and Prosperity- A look at basic Human Aspirations, Right understanding, Relationship and Physical Facilities for Human Aspirations.

3. Method to fulfill the human aspirations: understanding and living in harmony at various levels.

Module II **10 Hours**

1. Human being as a co-existence of the sentient 'I' and the material 'Body', Self ('I') and 'Body' - *Sukh* and *Suvidha*

2. Body as an instrument of 'I' (I being the doer, seer and enjoyer), the characteristics and activities of 'I' and harmony in 'I',

3. Harmony of I with the Body: *Sanyam* and *Swasthya*; Needs of Body and Psyche: *Sanyam* and *Swasthya*

Module III **12 Hours**

1. Harmony in the Family, values in human-human relationship; Trust (*Vishwas*) and Respect (*Samman*) as the foundational values of relationship, meaning of *Vishwas* and *Samman*

2. Harmony in the society: *Samadhan, Samridhi, Abhay, Sah*-astitva, universal harmonious order in society- family to world family, harmony in the Nature : recyclability and self-regulation in nature

3. Natural acceptance of human values, Ethical Human Conduct, and Humanistic Education,

Module IV **08 Hours**

1. Competence in Professional Ethics: professional competence for augmenting universal human order, people-friendly and eco-friendly production systems, technologies and management

2. Strategy for transition from the present state to Universal Human Order

3. Being socially and ecologically responsible engineers with mutually enriching institutions and organizations.

Text Book:

1. R R Gaur, R Sangal, G P Bagaria, 2009, A Foundation Course in Human Values and Professional Ethics.

References Books:

1. A Nagraj, 1998, Jeevan Vidya Ek Parichay, Divya Path Sansthan, Amarkantak.
2. A N Tripathy, 2003, Human Values, New Age International Publishers.
3. B P Banerjee, 2005, Foundations of Ethics and Management, Excel Books

Course Outcome:

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

1. Distinguish between values and skills; understand the need, basic guidelines, content and process of value education.
2. Distinguish between the Self and the Body; understand the meaning of Harmony in the Self the Co-existence of Self and Body.
3. Understand the value of harmonious relationship based on trust, respect and other naturally acceptable feelings.
4. Distinguish between ethical and unethical practices, and start working out the strategy to actualize a harmonious environment.

HONOURS

HNMT0303	Material Failure and Analysis	3-1-0	Credits 4

Objectives of the Course:

1. To highlight factors governing the failure of materials and types of failure
2. To evaluate the mechanisms and environmental effects associated with failure
3. To identify various failures in heat treatments, and deformation processing, and methods to prevent them.

Module-I **(12 hours)**

Aims of failure analysis, Methodology of Failure Analysis, Tree analysis. Prime factors in the premature failure of metallic components and structures, Tools and techniques in failure analysis, Sources of Failures, Steps in Failure Analysis, preservation and preparation of samples for failure analysis.

Module-II **(12 hours)**

Types of failures: ductile, brittle, fatigue, creep, corrosion, wear etc., fractography, mixed mode and fatigue failures

Module-III **(12 hours)**

Failure mechanisms, Embrittlement phenomena, environmental effects, Failures due to faulty heat treatments, Failures in metal forming and weldments.

Module-IV **(06 hours)**

Case studies in failure analysis: Case histories of component failures. Typical case studies of failure of important components such as gears, shafts, pressure vessels etc. Prevention of failures.

Suggested Text Books:

1. Dieter G.E., Mechanical Metallurgy, McGraw-Hill Company.
2. Hertzberg R W., Deformation and Fracture Mechanics of Engineering Materials.

Suggested Reference Books:

1. Failure Analysis & Prevention (Vol. - X), Metal Hand Book, ASM Publication
2. Mobley R.K., Root cause failure analysis.

Course Outcomes:

After completing this course, the student should be able to:

1. The ability to identify the types of failures in engineering components under service
2. Knowledge of the tools and techniques to perform failure analysis
3. The skill set to perform fractographic analysis after various failures
4. The ability to identify different failure mechanisms resulting from manufacturing processes

MINOR

MNMT0303	Mechanical Metallurgy	3-1-0	Credits 4

Objectives of the course: To develop the knowledge about the essential elastic-plastic behavior and properties of engineering materials such as fracture and creep etc.

Module-I **(10 Hours)**

Introduction: Theory of elasticity and plasticity, Generalised Hooke`s law, stress-strain relationship. Mechanism and crystallography of slip and twinning. Plastic response of materials-a continuum approach: classification of stress-strain curves, yield criteria. Concept of critical resolved shear stress. Deformation of single crystals and polycrystals. Hall – Petch relationship. Role of grain boundaries in deformation, strengthening mechanisms.

Module- II **(12 Hours)**

Dislocation Theory: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation, intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of

dislocations.

Fracture: Mode and mechanism of fracture, Griffith`s theory, Ductile to brittle transition. Transition temperature phenomena, Factors affecting transition temperature, Fracture mechanism, strain energy release rate, stress intensity factor, plane strain fracture toughness.

Module- III (12 Hours)

Fatigue: Fatigue testing methods and machines. Stress controlled and strain controlled fatigue. Analysis of cyclic stress –strain data. Mechanism of fatigue crack, nucleation and propagation.

Creep: Generation and analysis of creep and rupture data. Dislocation and diffusion mechanisms of creep. Grain boundary sliding and migration. Deformation mechanism maps. Effect of metallurgical and test variation on creep and fracture. Superplasticity, Parametric methods for prediction of long time properties.

Module- IV (8 Hours)

Tension test- Engineering & true stress-strain curves, evaluation of tensile properties, Tensile instability, Effect of strain-rate & temperature on flow properties.

Hardness tests- Brinell, Rockwell, Vickers, Meyer, Knoop, etc., relationship with flow curve.

Compression Test- Comparison with tension, phenomenon of buckling & barreling.

Bend Test- Pure bending & flexure formula.

Impact Test- Notched bar impact tests, transition Temperature & metallurgical factors affecting it.

Books for reference:

1. Dieter G. E., Mechanical Metallurgy, McGraw-Hill.
2. Hertzberg R.W., Deformation and Fracture Mechanics of Engineering Materials John Wiley.
3. Meyers M. A. and Chawla K. K., Mechanical Behaviour of Materials.
4. Courtney T.H., Mechanical Behaviour of Materials.

Course Outcomes: Upon completion of this class, students are expected to

1. Understand concept of elasticity and plasticity of materials and calculations of same using appropriate equations.
2. Explain the concept of dislocation & deformation behavior of single crystal and polycrystalline materials & and identification of dislocation and reactions.
3. Understand the deformation process & types. Significance of deformation mechanisms maps. To determine the different properties of the materials.

PRACTICAL / SESSIONAL

PCMT7306	Heat Treatment Laboratory	0-0-3	Credits 2

Objectives of the course: To demonstrate the microstructure of different metals and alloys qualitatively as well as quantitatively.

List of suggested experiments:

1. Annealing treatment of a cold worked steel and comparison of the annealed microstructure with the cold worked structure.
2. Normalizing treatment of steel and comparison of the microstructure with annealed structure.
3. To study the recrystallization behaviour of pure metal (iron / copper).
4. To study the effect of time and temperature on grain size of a metal (grain growth) (iron/ copper).
5. To study the nucleation rate and growth rate of pearlite in eutectoid steel.
6. To study the susceptibility of a steel to harden by quenching (hardenability) by Jominy test
7. To study the microstructure of carbon steels, tool steels, stainless steels and other high alloy steels.
8. To carry out age hardening of non ferrous alloys.
9. Determination of hardenability of steels.

Course Outcomes: Upon completion of this class, students are expected to

1. Demonstrate the microstructure of metals and alloys as qualitatively and quantitatively using different tools.
2. Selection and identification of metals and alloys for different industrial applications.

PCMT7307	Process Metallurgy Laboratory	0-0-3	Credits 2

Objectives of the course: To demonstrate the kinetics of different materials qualitatively as well as quantitatively.

List of suggested experiments:

1. Isothermal Kinetic study of limestone decomposition.
2. Devolatilization kinetics of Coal.
3. To study the decomposition of calcium carbonate and determination of equilibrium constant and free energy change.
4. To determine the partial molal volume of each component in a solution of water and ethanol.
5. To study the effect of temperature on % reduction of iron ore pellet.
6. To study the effect of time on % reduction of iron ore pellet

7. Pelletization of iron ore fines, firing of pellets and measurement of their crushing strengths.
8. Oxidation kinetics of copper sulfide.
9. Kinetic studies of oxidation of copper.
10. Kinetic studies of reduction of iron ores.
11. Kinetic studies of decomposition of magnesium carbonate.
12. To study the flow of gases through beds of solid particles.

Course Outcomes: Upon completion of this class, students are expected to

1. Demonstrate the kinetics of different materials as qualitatively and quantitatively using different tools.
2. Selection and identification of materials for different industrial applications.

PCMT7308	Mineral Processing & Fuel Testing Laboratory	0-0-3	Credits 2

Objectives of the course: To demonstrate the beneficiation different ores using different processes and determine the calorific values of different fuels qualitatively as well as quantitatively.

List of suggested experiments:

1. Physical examination and identification of minerals.
2. Crushing of ore/ coal in a jaw crusher and to study the size analysis of the product.
3. To study the jaw crusher and determine the actual capacity and reduction ratio.
4. Verification of Rittinger's Law of crushing in a jaw crusher.
5. Crushing of ore/ coal in a roll crusher and to study the size analysis of the product.
6. Crushing of ore/ coal in a gyratory crusher / pulveriser and to study the size analysis of the product.
7. Crushing of ore/ coal in a cone crusher and to study the size analysis of the product.
8. To study the effect of grinding with grinding time in cylindrical ball mill and rod mill.
9. To separate coal from a mixture of coal and stones or quarts by zigging and determine the weight fractions of the products.
10. Proximate analysis of coal and coke.
11. To determine calorific value of coal and coke using bomb calorimeter.
12. To determine bulk density of coal sample.
13. To determine true density of coal sample.
14. To determine shatter and abrasion indices of coal and coke.
15. To determine flash point and fire point of a given sample such as kerosene oil, diesel, petrol by

Pensky-Marten's apparatus or Cleveland open cup apparatus.

16. To determine viscosity of oil by Engler viscometer and the water number in the apparatus.
17. To determine effect of temperature on kinematic viscosity of glycerene by Redwood viscometer.

Course Outcomes: Upon completion of this class, students are expected to

1. To encourage team skills in planning and carrying out the experiments required to improve the ores recovery efficiency and profitability
2. To determine the calorific values of different fuels qualitatively as well as quantitatively
3. Selection and identification of ores and fuels for different industrial applications.

OPEN ELECTIVE-II (OE-II) 5th Semester

OECH6311	Petroleum Refinery Engineering	3L-0T-0P	3 Credits

Course objectives: The objectives of this course are

1. Indicate what crude oils consists of and how crude oils are characterized based on their physical properties.
2. Demonstrate how a petroleum refinery works and sketch a flow diagram that integrates all refining processes and the resulting refinery products.
3. Examine how each refinery process works and how physical and chemical principles are applied to achieve the objectives of each refinery process.

Module-1 **(4 weeks/12 Hours)**

Overview of Petroleum Refinery its Products and Properties

Unit I (6 Hours/ 2 weeks): Origin and formation of petroleum, reserves and deposits of the world, Indian petroleum industries, Composition and Compounds of Petroleum, Crude pre-treatment: Desalting and Dehydration, Petroleum Refinery Units.

Unit II (6 Hours/ 2 weeks): Properties of Crude oil, Test Methods for Gasoline and Diesel, Refinery Products: Gasoline and its Specification, Distillate Fuels, Residual Fuel Oils, LPG, ASTM and TBP Distillation, Octane and Cetane number.

Module-2 **(4 weeks/12 Hours)**

Refinery Processes Units

Unit III (6 Hours/ 2 weeks):Coking and Thermal Processes, Catalytic Cracking

Unit IV (6 Hours/ 2 weeks): Catalytic Hydrocracking, Hydro processing and Resid Processing.

Module-3 **(4 weeks/12 Hours)**

Refinery Processes Units

Unit V (6 Hours/ 2 weeks): Hydro treating, Catalytic Reforming and Isomerization

Unit VI (6 Hours/ 2 weeks): Alkylation and Polymerization, Visbreaking.

Module-4 **(2 weeks/6 Hours)**

Treatment of Products

Unit VII (6 Hours/ 2 weeks): Treatment of products, additives, blending of gasoline. Treatment of gasoline, kerosene, lubes and lubricating oils, waxes.

Text book :

1. 'Petroleum Refining: Technology and Economics', 5th ed. by J H Gary, G E Handwerk, and M J

Kaiser, CRC Press.

Reference Books :

1. 'Modern Petroleum Refining Processes', 6th ed. by B K B Rao, Oxford & IBH.
2. 'Petroleum Refinery Engineering', W L Nelson, McGraw-Hill.
3. 'Handbook of Petroleum Processing', 2nd ed. by S A Treese, P R Pujado and D S J Jones, Springer.

Course Outcomes (CO):

At the end of the course, students

1. Have introductory information about petroleum and refinery.
2. Learn the history of refinery development and composition of petroleum.
3. Learn refinery products, test methods and petroleum properties.
4. Should have knowledge about the different process units involved in refinery to get the valuable products like Gasoline, Diesel etc. that can be directly use by the consumers.

OECH6330	GREEN TECHNOLOGY	3L-0T-0P	3 Credits

Objectives:

1. To present different concepts of green technologies.
2. To acquire principles of Energy efficient technologies.
3. To learn the importance of green fuels and its impact on environment.

Module-1 **(4 weeks/12 Hours)**

Unit I: Principles of green technology and engineering.

Unit II: Principles of atom and mass economy, E-factor.

Module-2 **(4 weeks/12 Hours)**

Unit III: Design of greener and safer chemicals, Solvent-free methods: Microwave, Ultraviolet, and Solar.

Unit IV: Green catalysts: ionic liquids, zeolites, photo catalyst, PEG, nano catalyst, and biocatalyst.

Module-3 **(4 weeks/12 Hours)**

Unit V: Green solvents: Supercritical fluids, fluorous phase, and non-aqueous solvents.

Unit VI: Scale-up effect, reactors, separators, Process intensification.

Module-4 **(2 weeks/6 Hours)**

Unit VII: Bio-conversion of renewable. Comparison of green fuels with conventional fossil fuels with reference to environmental, economical and social impacts.

Reference Books:

1. Handbook of Green Chemistry, Vol. 1 to 9 by P T Anastas, Wiley VCH.
2. Green Chemistry and Engineering: A Practical Design Approach by C J González and D J C Constable, Wiley.

3. Green Chemistry and Engineering: A Pathway to Sustainability by A E Marteel Parrish and M A Abraham, Wiley.
4. Green Chemistry for Environmental Sustainability by S K Sharma and A. Mudhoo, CRC Press.
5. Green Engineering: Environmentally Conscious Design of Chemical Processes by D T Allen and D R Shonnard, PHI.

Course outcomes:

1. Enlist different concepts of green technologies in a project.
2. Understand the principles of Energy efficient technologies.
3. Recognize the benefits of green fuels with respect to sustainable development.

OECE6312	Mechanics of Solids	3-0-0	Credit-3

Module – I

Stress, St. Venant's principle, Principle of Superposition, Strain, Hooke's law, Modulus of Elasticity, Stress-Strain Diagrams, Working Stress, Factor of safety, Strain energy in tension and compression, Resilience, Impact loads, stresses due to freely falling weight.

Analysis of Axially Loaded Members: Composite bars in tension and compression - temperature stresses in composite rods, Shear stress, Complimentary shear stress, Shear strain, Modulus of rigidity, Poisson's ratio, Bulk Modulus, Relationship between elastic constants.

Analysis of Biaxial Stress. Plane stress, Principal stress, Principal plane, Mohr's Circle for Biaxial Stress.

Strain Deformation: Two dimensional state of strain, Mohr's circle for strain, Principal strains and principal axes of strain, strain measurements, Calculation of principal stresses from principal strains.

Module – II

Stresses in thin cylinders, thin spherical shells under internal pressure -wire winding of thin cylinders. Thick cylinders subjected to internal and external pressures, compound cylinders. Torsion in solid and hollow circular shafts, Twisting moment, Strain energy in shear and torsion, strength of solid and hollow circular shafts. Stresses due to combined bending and torsion, Strength of shafts in combined bending and twisting.

Module – III

Theory of Columns: Eccentric loading of a short strut, Long columns, Euler's column formula, Lateral buckling, Critical Load, Slenderness ratio. Close - coiled helical springs.

Theories of failure: Maximum principal stress theory, maximum shear stress theory, maximum strain theory, total strain energy theory, maximum distortion theory, octahedral shear stress theory graphical representation and comparison of theories of failure.

Module IV

Unsymmetrical bending: Properties of beam cross selection, slope of neutral axis, stresses and deflection in unsymmetrical bending, shear centre.

Curved Beam: Bending of beam with large initial curvature, Stress distribution in beam with rectangular, circular and trapezoidal cross section, stresses in crane hooks, ring and chain links.

Text Books/Reference Books:

1. Elements of Strength of Materials by S.P. Timoshenko and D.H. Young, Affiliated East-West Press
2. Strength of Materials by G. H. Ryder, Macmillan Press
3. Strength of Materials by James M. Gere and Barry J. Goodno, Cengage Learning
4. Mechanics of Materials by Beer and Johnston, Tata McGraw Hill
5. Mechanics of Materials by R.C. Hibbeler, Pearson Education
6. Mechanics of Materials by William F. Riley, Leroy D. Sturges and Don H. Morris, Wiley Student Edition
7. Mechanics of Materials by James M. Gere, Thomson Learning
8. Engineering Mechanics of Solids by Egor P. Popov, Prentice Hall of India
9. Strength of Materials by S.S. Rattan, Tata McGraw Hill
10. Strength of Materials by R. Subramaniam, Oxford University Press
11. Advanced mechanics of solids by L.S. Srinath, McGraw Hill.
12. Advanced mechanics of materials, Kumar & Ghai, Khanna Publishers.

OECS6203	OOPs Using C++	3-0-0	Credit-3

Course Objective:

This course is aimed at mastering object oriented programming technique in software development and demonstrates these techniques in solution to different types of problems.

Module –I **(10 Hours)**

Introduction to OOP, OOP Concepts, Overview of C++, C++ fundamentals, Classes, Objects, Inline functions, function Overloading, Scope Resolution Operator, Constructors ,Destructors, Static Members, Passing objects to functions, Function returning objects.

Module – II **(10 Hours)**

Arrays, Pointers, this pointer, References, Dynamic memory Allocation, functions Overloading, Default arguments, Overloading Constructors, copy constructors, Pointers to Functions, Ambiguity in function overloading.

Module –III **(10 Hours)**

Operator Overloading, Overloading of some special operators, Inheritance, Types of Inheritance, Protected members, Polymorphism, Virtual base Class, Virtual functions, Pure virtual functions, Abstract classes.

Module – IV **(8 Hours)**

Class template, Generic classes, Function template, generic functions, Exception Handling, Exception handling options, Streams, Formatted I/O, C++ File I/O, Array based I/O, Standard Template Library (STL).

Text Books

1. H. Schildt - C++ The Complete Reference, 4th Edition, Tata McGraw-Hill, New Delhi.

Reference Books

1. A. N Kanthane, Object Oriented Programming with ANSI & Turbo C++, Pearson Education, New Delhi.
2. Object Oriented Programming with C++, E. Balagurusamy, Mcgraw Hill Education
3. Object Oriented Programming in C Robert Lafore – SAMS Publishing.

Course Outcomes: Students will be able to -

1. Familiar with issues with software design.
2. Be familiar to key concepts of object oriented programming.
3. Have knowledge about C++ concepts related to good modular design.
4. Implement patterns involving realization of abstract interfaces and polymorphism.
5. Learn how to utilize Exceptions and standard template library.

OECS6331	CLOUD COMPUTING	3-0-0	Credit-3

Course Objective: This course gives students an insight into the basics of cloud computing along with virtualization, cloud computing is one of the fastest growing domain from a while now. It will provide the students basic understanding about cloud and virtualization along with it how one can migrate over it.

Module-I **10 Hrs**

Evolution of Computing Paradigms - Overview of Existing Hosting Platforms, Grid Computing, Utility Computing, Autonomic Computing, Dynamic Datacenter Alliance, Hosting/ Outsourcing, Introduction to Cloud Computing, Workload Patterns for the Cloud, "Big Data", IT as a Service, Technology Behind Cloud Computing,

Module-II **10 Hrs**

A Classification of Cloud Implementations- Amazon Web Services - IaaS, The Elastic Compute Cloud (EC2), The Simple Storage Service (S3), The Simple Queuing Services (SQS), VMware v Cloud - IaaS, v Cloud Express, Google AppEngine - PaaS, The Java Runtime Environment.

Module-III **10 Hrs**

The Python Runtime Environment- The Datastore, Development Workflow, Windows Azure Platform - PaaS, Windows Azure, SQL Azure, Windows Azure AppFabric, Salesforce.com - SaaS / PaaS, Force.com, Force Database - the persistency layer, Data Security, Microsoft Office Live - SaaS, LiveMesh.com, Google Apps -

SaaS, A Comparison of Cloud Computing Platforms, Common Building Blocks.

Module-IV **8 Hrs**

Cloud Security – Infrastructure security – Data security – Identity and access management Privacy- Audit and Compliance.

Text Book:

1. Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, "Distributed and Cloud Computing
2. from Parallel Processing to the Internet of Things", Morgan Kaufmann, Elsevier, 2012

Reference Books

1. Barrie Sosinsky, "Cloud Computing Bible" John Wiley & Sons, 2010
2. Tim Mather, Subra Kumaraswamy, and Shahed Latif, "Cloud Security and Privacy An Enterprise Perspective on Risks and Compliance", O'Reilly 2009

OEEE6313	Digital Signal Processing	3-0-0	3 Credits

Course Objectives:

To impart knowledge about the following topics:

1. Signals and systems & their mathematical representation.
2. Discrete time systems.
3. Transformation techniques & their computation.
4. Filters and their design for digital implementation.

MODULE I **(12 Hours)**

Introduction:

Classification of systems: Continuous, discrete, linear, causal, stability, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, aliasing effect.

The Z-Transform and Its Application:

Z-transform and its properties, inverse z-transforms; difference equation–Solution by z-transform, application to discrete systems-Stability analysis, frequency response–Convolution.

MODULE II **(12 Hours)**

The Discrete Fourier Transform: Its Properties and Applications:

Frequency-Domain Sampling and Reconstruction of Discrete-Time Signals, The Discrete Fourier Transform, The DFT as a Linear Transformation, Relationship of the DFT to other Transforms; Properties of the DFT: Periodicity, Linearity, and Symmetry Properties, Multiplication of Two DFTs and Circular Convolution, Additional DFT Properties; Linear Filtering Methods Based on the DFT: Use of the DFT in Linear Filtering, The Discrete Cosine Transform: Forward DCT, Inverse DCT, DCT as an Orthogonal Transform.

Implementation of Discrete-Time Systems:
Structure for the Realization of Discrete-Time Systems, Structure for FIR Systems: Direct-Form Structure, Cascade-Form Structures, Frequency-Sampling Structures;
Structure for IIR Systems: Direct-Form Structures, Signal Flow Graphs and Transposed Structures, Cascade-Form Structures, Parallel-Form Structures.

MODULE III (12Hours)

Discrete Fourier Transform &Computation:
Discrete Fourier Transform-properties, magnitude and phase representation-Computation of DFT using FFT algorithm–DIT &DIF using radix 2 FFT–Butter fly structure.

Design of Digital Filters:
FIR & IIR filter realization–Parallel & cascade forms. FIR design: Windowing Techniques–Need and choice of windows–Linear phase characteristics. Analog filter design–Butterworth and Chebyshev approximations; IIR Filters, digital design using impulse invariant and bilinear transformation Warping, pre warping.

MODULE IV (6Hours)

Adaptive Filters:
Application of Adaptive Filters: System Identification or System Modeling, Adaptive Channel Equalization, Adaptive Line Enhancer, Adaptive Noise Cancelling; Adaptive Direct-Form FIR Filters-The LMS Algorithm: Minimum Mean Square Error Criterion, The LMS Algorithm.

Text Books:

1. Digital Signal Processing Principles, Algorithms and Applications, J. G. Proakis and D. G. Manolakis, 4th Edition, Pearson.
2. S. K. Mitra, "Digital Signal Processing: A computer based approach", McGraw Hill, 2011.
3. Digital Signal Processing, S. Salivahan, A. Vallavraj and C. Gnanapriya, TMH.

Reference Books:

1. Digital Signal Processing, Manson H. Hayes, Schaum's Outlines, TMH.
2. Digital Signal Processing: A Modern Introduction, Ashok K Ambardar, Cengage Learning.
3. Modern Digital Signal Processing, Roberto Cristi, Cengage Learning.
4. Digital Signal Processing: Fundamentals and Applications, Li Tan, Jean Jiang, Academic Press, Elsevier.
5. A.V. Oppenheim and R. W. Schafer, "Discrete Time Signal Processing", Prentice Hall, 1989.
6. L. R. Rabiner and B. Gold, "Theory and Application of Digital Signal Processing", Prentice Hall, 1992.
7. J. R. Johnson, "Introduction to Digital Signal Processing", Prentice Hall, 1992.
8. D. J. De Fatta, J. G. Lucas and W. S. Hodgkiss, "Digital Signal Processing", John Wiley & Sons, 1988.

Program Outcomes:

1. Ability to understand the importance of Fourier transform, digital filters.
2. Ability to acquire knowledge on Signals and systems & their mathematical representation.
3. Ability to understand and analyze the discrete time systems.
4. Ability to analyze the transformation techniques & their computation.

5. Ability to understand the types of filters and their design for digital implementation.

OEEC6314	Industrial Automation with PLC & SCADA	3-0-0	Credits 3

COURSE OBJECTIVES

1. Gain the Knowledge of various skills necessary for Industrial applications of Programmable logic controller (PLC)
2. Understand the basic programming concepts and various logical Instructions used in Programmable logic controller (PLC)
3. Solve the problems related to I/O module, Data Acquisition System and Communication Networks using Standard Devices.

MODULE-I (12 Hours)

Unit 1

What is A PLC, Technical Definition of PLC, What are its advantages, characteristics functions of A PLC, Chronological Evolution of PLC, Types of PLC, Unitary PLC, Modular PLC, Small PLC, Medium PLC, Large PLC.

Unit 2

Block Diagram of PLC: Input/output (I/O) section, Processor Section, Power supply, Memory central Processing Unit: Processor Software / Executive Software, Multi asking, Languages, Ladder Language.

MODULE-II (12 Hours)

Unit 3

Bit Logic Instructions: introduction: Input and Output contact program symbols, Numbering system of inputs and outputs, Program format.

Unit 4

Introduction to logic: Equivalent Ladder diagram of AND gate, Equivalent ladder diagram of or Gate, equivalents Ladder Diagram of NOT gate, equivalent ladder diagram of XOR gate, equivalent ladder diagram of NAND gate, equivalent ladder diagram of NOR gate, equivalent ladder diagram to demonstrate De Morgan theorem. Ladder design. Examples: Training Stopping, Multiplexer, DE multiplexers

MODULE-III (12 Hours)

Unit 5

PLC Timers and Counters: On Delay and OFF delay timers, Timer-on Delay, Timer off delay, Retentive and non-retentive timers. Format of a timer instruction. PLC Counter: Operation of PLC Counter, Counter Parameters, Counters Instructions Overview Count up (CTU) Count down (CTD).

Unit 6

PLC input output (I/O) modules and power supply: Introduction: Classification of I/O, I/O system overview, practical I/O system and its mapping addressing local and expansion I/O, input-output systems, direct I/O, parallel I/O systems serial I/O systems.

MODULE-IV (8 Hours)

Unit 7

SCADA Systems

Introduction, definition and history of Supervisory Control and Data Acquisition, typical SCADA System Architecture, Communication Requirements, Desirable properties of SCADA system, Features, advantages, disadvantages and applications of SCADA. SCADA Architecture (First generation-Monolithic, Second Generation-Distributed, Third generation-Networked Architecture), SCADA systems in operation and control of interconnected power system, Power System Automation, Petroleum Refining Process, Water Purification System.

Text Books:

1. Madhu Chhanda Mitra,S.S Gupta, "PLC and Industrial automation",Pernram International pub. (Indian) Pvt. Ltd., 2011.

Reference Books:

1. Ronald L Krutz, "Securing SCADA System", Wiley Publication, 2012.
2. Gary Dunning, "Introduction to Programmable Logic Controllers", Thomson, 2nd edition, 2006.

Course Outcomes:

1. Understand the basic programming concepts and various logical Instructions used in Programmable logic controller (PLC).
2. Compute the extent and nature of electronic circuitry in Programmable logic controller (PLC) and SCADA including monitoring and control circuits for Communication and Interfacing.

OEME6316	Introduction to Composite Materials	3-0-0	Credit-3

Course objective:

1. Introduce students to the concepts of modern composite materials.
2. Equip them with knowledge on how to fabricate and carry out standard mechanical test on composites.
3. To make student understand the basic stress and strain relations in composite materials.

Module I (10hours)

Introduction: Classification and characteristics of composite materials, mechanical behaviour of composites, constituents, Reinforcements, Matrices, Fillers, Additives, Applications and advantages of composites. Processing – Pultrusion; Filament winding; Prepreg technology; Injection & compression moulding; Bag moulding; Resin transfer moulding.

Module II (12hours)

Macromechanics of a Lamina: Stress strain relations of anisotropic materials - Engineering constants for orthotropic materials, Stress strain relations for specially orthotropic lamina. Transformation relationships for a lamina of arbitrary fibre orientation.

Module III (12hours)

Micromechanics of a Lamina: Rule of mixture; Volume & mass fractions; Density & void content. Evaluation of the nine mechanical and four hygrothermal constants: four elastic moduli(Strength of Materials Approach), five strength parameters, two coefficients of thermal expansion and two coefficients of moisture expansion of

a unidirectional lamina from the individual properties of the fiber and the matrix**.**

Module IV **(10hours)**

Analysis: Classical lamination theory; Stress analysis of composite laminates; Failure predictions – Maximum stress theory; Maximum strain theory; Tsai-Hill theory; Modes of failure of composites; First ply failure; Partial ply failure; Total ply failure.

Text Books:

1. Mechanics of Composite Materials, R.M. Jones, Mc. Graw Hill Book Co.
2. Mechanics of Composite Materials, A. K. Kaw, CRC Press.
3. Mechanics of composite materials & structures, M Mukhopadhay, Universities Press.

COURSE OUTCOME

1. (Knowledge based) identify and explain the types of composite materials and their characteristic features;
2. Understand the differences in the strengthening mechanism of composite and its corresponding effect on performance and application;
3. Understand and explain the methods employed in composite fabrication;
4. Appreciate the theoretical basis of the experimental techniques utilized for failure mode of composites.
5. (Skills) develop expertise on the applicable engineering design of composite;
6. Learn simple micromechanics and failure modes of composites.

OEMT6315	Nanomaterials	3-0-0	Credits 3

Objectives of the Course:

To recognize the differences between nanomaterials and conventional materials and to become familiar with a wide range of nanomaterials, their synthesis, characterization, properties and applications.

Module 1: **(12 Hours)**

Introduction: Types of nanomaterials, emergence of nanotechnology, bottom-up and top-down approaches, challenges in nanotechnology. Nanoparticles: synthesis of metallic nanoparticles, semiconductor nanoparticles, oxide nanoparticles (sol-gel processing); vapour phase reactions, solid phase segregation. Nanowires: Synthesis of nanowires by evaporation – condensation growth, VLS or SLS growth, high energy ball milling, cryo rolling, and equal channel angular extrusion, template based synthesis, electrospinning, types of lithography. Thin Films: fundamentals of film growth, PVD, CVD and ALD.

Module-II **(12 Hours)**

Specific nano materials and their applications: Carbon nanostructures (Nanotubes, nanohorns, graphene, buckyballs etc.), Semiconducting nanomaterials – Quantum confinement, Quantum wells, quantum wires and quantum dots. Magnetic nanomaterials – super paramagnetism Ferroelectric, nano ceramics Super plasticity Nanocomposites and their types.

Module III: **(12 Hours)**

Thermodynamics of nanomaterials, Mechanical property aspects of nanomaterials, inverse Hall-Petch relationship, nano indentation, electrical properties of nanomaterials, optical properties of nanomaterials, magnetic properties of nanomaterials, Characterization techniques from the perspective of nanomaterials: BET, XRD, SEM, TEM, AFM, EDS, WDS, LEED, XPS etc.

Module IV: **(06 Hours)**

Application of nanomaterials such as medicine, energy, environment, information and communication technology.

Suggested text books:

1. Rishal Singh, S.M. Gupta, Introduction to nanotechnology, Oxford university press, (2016).
2. Dieter Vollath._ Nanomaterials: An Introduction to Synthesis, Properties and Applications, Second Edition. Published 2013 by Wiley-VCH Verlag GmbH & Co. KGaA.

Suggested reference books:

1. Charles Poole and Frank Owens, Introduction to Nanomaterials, Wiley 2007
2. Cao G., Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press
3. Gagotsi Y., Nanomaterails Handbook, (Ed.), Taylor and Francis.
4. Edlstein and Cammarate, Nano Materials Synthesis, Properties and Applications.
5. Bandyopadyay A.K., Nano Materials, New age Publications.
6. Pradeep T., Nano - The Essentials, TMH.
7. Koch,C. Nanostructured Materials: Processing, Properties and applications, William Andrew Publishing.

Course Outcomes

After completing this course, the student should be able to:

1. Indicate the differences between nanomaterials and conventional materials
2. Indicate how specific synthesis techniques can result in nanomaterials
3. Give examples of specific nanomaterials and explain the scientific reasons for the properties displayed by them
4. Describe how specific characterization techniques can be used to analyze nanomaterials

OEPD6317	POWDER METALLURGY	3L-0T-0P	3 Credits

Course Objective

The course is a specialized course of the metallic materials area. The scope is to provide the necessary knowledge on the metallic part production by metal powders. It covers subjects such as metal powder characterization, metal powder production methods, and powder metallurgy processing steps.

Module I **[12]**

Introduction Historical and modern developments in Powder Metallurgy. Advantages, limitations and applications of Powder Metallurgy. Basic Steps for Powder Metallurgy. Characteristics of metal powder Chemical composition, Particle size, shape and size distribution, Characteristics of powder mass such as apparent density, tap density, flow rate, friction index. Properties of green compacts and sintered compacts

Module II **[10]**

Powder Characterization Powder conditioning, fundamentals of powder compaction, density distribution in green compacts, compressibility, green Strength, pyro phorocity and toxicity.

Module III **[10]**

Powder Compaction Methods Basic aspects, types of compaction presses, compaction tooling and role of lubricants, Single and double die compaction, isostatic pressing, Hot pressing. Powder Forming Powder rolling, powder forging, powder extrusion and explosive forming technique

Module IV **[10]**

Sintering Definition, stages, effect of variables, sintering atmospheres and furnaces, Mechanism, liquid-phase sintering, Secondary operations. Sintered Products Study of sintered bearings, cutting tools, metallic filters, friction and antifriction parts and electrical contact materials. Defects in Powder metallurgy processed materials and their processing to minimize defects: Friction stir processing etc.

Text Books:

1. Introduction to Powder Metallurgy, A. K. Sinha, Dhanpatrai Publication.
2. Powder Metallurgy: Science, Technology, and Materials, Anish Upadhyaya, Gopal Shankar Upadhyaya, CRC Press
3. Powder Metallurgy, ASM Handbook, Vol-VII.

Reference Books:

1. Powder Metallurgy: Science, Technology and Applications, P. C. Angelo, R. Subramanian
2. Powder Metallurgy, W.D. Jones
3. Principles of Powder Metallurgy, T. Shukerman
4. Handbook of Powder Metallurgy :- H.H. Hausner

Course Outcomes:

Upon successful completion of the course, student will able to:

1. Acquire the knowledge of Powder Metallurgy History, Applications and its importance.
2. Measure the various powder characteristics like apparent density; tap density, flow rate, friction index.
3. Acquainted the knowledge of metal powder production methods.
4. Aware about the powder characterization techniques.
5. Understand the basic methods of Powder compaction for green compact.

OEMA6207	Numerical Methods	3-0-0	Credit-3

Module –I **(12 Hours)**

Number system, Floating point arithmetic, Errors, truncation error, Bisection method, Scant method, Regula-Falsi Method, Newton-Raphson method, Muller method, Rate of Convergence,

Lagranges's interpolation, Newton divided difference interpolation, Newton's forward and backward interpolation, Piecewise and Spline interpolation.

Module -II : **(12 Hours)**

Numerical integration: Romberg integration, Gaussian Quadrature (2-point, 3-point), Newton- Cotes rules.

Numerical solution to ordinary differential equations: Taylor's series methods, Euler method, modified Euler method Runge - Kutta methods, predictor- corrector method, multistep methods.

Module -III: **(8 Hours)**

Matrix eigen value problem, power method, Rayleigh Quotient, shifted power method, inverse power method, QR method.

Module IV: **(8 Hours)**

Parabolic Partial Differential Equation: Explicit Method, Implicit method, Crank-Nicolson method. Hyperbolic Partial Differential Equation: Explicit Method, Implicit method. Elliptic Partial Differential Equation: Finite-difference method.

Text Books

1. Jain M.k, Iyengar S.R.K & Jain R.K, Numerical methods for Scientific and Engineering Computation, 6th Edition,New Age International(P) Ltd.
2. Atkinson Kendall E, An introduction to Numerical Analysis, 2ndEdition, John Wiley & Sons

Reference Books

1. Fusset L.V, Applied numerical Analysis Using MATLAB,2nd Edition, PEARSON
2. Chapra Steven C & Canale Raymond P., Numerical methods for Engineers, 7th Edition, McGraw Hill Education.

INDIRA GANDHI INSTITUTE OF TECHNOLOGY, SARANG

B.TECH SYLLABUS
BRANCH: METALLURGICAL AND MATERIALS ENGINEERING
(Admission Batch: 2018-19 Onwards)
6th SEMESTER

HSHM3306	Enhancing Soft Skills and Personality	2-0-0	Credit-2

Course Objective

The course aims to cause an enhanced awareness about the significance of soft skills in professional and inter-personal communications and facilitate an all-round development of personality. Hard or technical skills help securing a basic position in one's life and career. But only soft skills can ensure a person retain it, climb further, reach a pinnacle, achieve excellence, and derive fulfillment and supreme joy. Soft skills comprise pleasant and appealing personality traits as self-confidence, positive attitude, emotional intelligence, social grace, flexibility, friendliness and effective communication skills. The focus of this course is on interpersonal and management skills.

Module I **10 Hours**

- Highlights of Developing Soft Skills and Personality Course-1-24
- Highlights of Developing Soft Skills and Personality Course-25-48
- Definitions and Types of Mindset
- Learning Mindsets
- Secrets of Developing Growth Mindsets
- Importance of Time and Understanding Perceptions of Time
- Using Time Efficiently
- Understanding Procrastination
- Overcoming Procrastination
- Don't Say "Yes" to Make Others Happy!

Module II: **10 Hours**

- Types of People
- How to Say "No"
- Controlling Anger
- Gaining Power from Positive Thinking-1
- Gaining Power from Positive Thinking-2
- What Makes Others Dislike You?
- What Makes Others Like You?-1
- What Makes Others Like You?-2
- Being Attractive-1
- Being Attractive-2

Module III **10 Hours**

- Common Errors-1
- Common Errors-2

- Common Errors-3
- Common Errors-4
- Common Errors-5
- Humour in Communication
- Humour in the Workplace
- Function of Humour in the Workplace
- Money and Personality
- Managing Money

Module IV **10 Hours**

- Health and Personality
- Managing Health-1: Importance of Exercise
- Managing Health-2: Diet and Sleep
- Love and Personality
- Managing Love
- Ethics and Etiquette
- Business Etiquette
- Managing Mind and Memory
- Improving Memory
- Care for Environment
- Highlights of the Course

Books for Reference:

1. Dorch, Patricia. What Are Soft Skills? New York: Execu Dress Publisher, 2013.
2. Kamin, Maxine. Soft Skills Revolution: A Guide for Connecting with Compassion for Trainers, Teams, and Leaders. Washington, DC: Pfeiffer & Company, 2013.
3. Klaus, Peggy, Jane Rohman & Molly Hamaker. The Hard Truth about Soft Skills. London: Harper Collins E-books, 2007.
4. Petes S. J., Francis. Soft Skills and Professional Communication. New Delhi: Tata McGraw-Hill Education, 2011.
5. Stein, Steven J. & Howard E. Book. The EQ Edge: Emotional Intelligence and Your Success. Canada: Wiley & Sons, 2006.

PCMT4309	Steel Making	3-0-0	Credits 3

Objectives of the Course:

This course introduces the principles and practices of iron making.

Module-I **(12 hours)**

Introduction: History of steel making, principles of steel making reactions viz. decarburization, desulphurization, dephosphorisation, silicon and manganese reactions. Slag theories: Molecular and ionic theories; interpretation of the above reactions in terms of ionic theory of slag. Open Hearth steel making

practices. L.D. Process: Design of converter and lance; quality of raw materials charged, operation, control of bath and slag composition, chemical reactions involved, temperature and residual bath oxygen control, use of oxygen sensor; some characteristics of L.D blow vi z. emulsion formation, slopping, manoeuvring lance height for dephosphorisation and decarburization. Catch Carbon technique. Recovery of waste heat.

Module-II (12 hours)

OBM/Q-BOP process: Concept and operation of the process. Mixed / Combined blowing processes: Oxygen top blowing with inert gas purging at bottom; oxygen top blowing with inert and oxidizing gases at bottom, oxygen top and bottom: status in India. Electric arc furnace: Advantages, charging, melting and refining practices for plain carbon and alloy steel; uses of DRI in arc furnace and its effect on performance. UHP electric arc furnace with D.C supply, single graphite electrode, oxygen lancing, oxyfuel burner, water cooled panel and computer control. Combination of blast furnace: EAF. Duplex processes of stainless steel making using VOD, AOD and CLU. Induction Furnace: Special features, advantages and limitation.

Module-III (12 hours)

Deoxidation of liquid steel: Requirements of deoxidizers, deoxidation practice, Stoke's law, use of complex deoxidizers.. Killed, semi killed and rimming steel. Secondary refining of steel: Objectives; principles of degassing different industrial process such as DH, RH, VAD, SD, LF, and ESR; limitations and specific applications. Inclusions and their influence on quality of steel

Continuous Casting of steel: Advantages; types of machines; mould lubrication and reciprocation. Development in C.C. Techno logy with respect to productivity, quality and energy conservation; Near Net Shape Casting.

Module-IV (6 hours)

Pollutant emissions from steel making processes and their control. Management of wastes from steelmaking operations. Numerical problem solving on material balance.

Suggested Text Books:

1. Ahindra Ghosh and Amit Chatterjee: Iron making and Steel making Theory and Practice, Prentice-Hall of India Private Limited, 2008.
2. Dipak Mazumdar, A First Course in Iron and Steel Making, University Press-IIM-2015

Suggested Reference Books:

1. An introduction to modern steel making, R. H. Tupkary, Khanna Publishers (2000)
2. An introduction to modern iron making, R. H. Tupkary, Khanna Publishers (2004)

Course Outcomes:

After completing this course, the student should be able to:

1. Describe the physical and chemical processes that take place during iron making
2. Analyse the effect of change in process parameters in iron making
3. Describe the methods for control of quality in iron production
4. Solve numerical problems involving reaction kinetics and composition control

PCMT4310	Mechanical Working & Testing of Materials	3-0-0	Credits 3

Objectives of the Course:
To become familiar with different metal forming techniques and testing to get exposed to the concept and procedures associated with working analysis.

Module-I **(12 Hours)**

Introduction:- Classification of Forming Processes, Mechanism of metal working, Flow stress determination, Temperature in metal working, Strain-rate effect, Metallurgical structure, Friction and lubrication, Deformation-zone Geometry, hydrostatic pressure, Workability, residual

Classification of Forging Processes, forging in plane strain, Open-die forging, Closed-die forging, Forging loads in closed-die forging, forging defects, Residual stresses in forging. stresses.

Module-II **(12 Hours)**

Classification of Rolling Processes, Types of rolling mills, Hot rolling, Cold rolling, Rolling of bars and shapes, Forces and Geometrical relationships in rolling, Analysis of rolling loads: Rolling variables, Defects in rolled products, Rolling mill control, Theories of Cold-rolling and hot-rolling. Classification of Extrusion Processes, Hot extrusion, Deformation, Lubrication and Defects in extrusion, Analysis of extrusion process, Cold extrusion and Hot forming, Hydrostatic extrusion, Extrusion of tubing, Seamless pipe.

Module-III **(12 Hours)**

Drawing of Rods, Wires and Tubes: Rod and Wire drawing, Analysis of wire drawing, Tube drawing, Analysis of tube drawing, Residual stresses in rod, wire and tubes. Sheet-Metal Forming: Sheet metal forming methods, Shearing and blanking, Bending, Stretch forming, Deep drawing, Forming limit criteria, Defects in formed parts.

Module-IV **(06 Hours)**

National and International Standards for Mechanical tests, Hardness Tests- Brinell, Rockwell, Vickers, Meyer, Knoop, etc., relationship with flow curve. Compression Test- Comparison with tension, phenomenon of buckling & barreling.Torsion Test- Stresses for elastic & plastic strain, Torsion vs. Tension. Bend Test- Pure bending & flexure formula. Impact Test- Notched bar impact tests, transition temperature & metallurgical factors affecting it.

Suggested Text Books:

1. G. E. Dieter and David Bacon, Mechanical Metallurgy, McGraw-Hill, 1988, 3ed
2. A.V.K. Suryanarayana. Testing of Metallic materials, BS publication

Suggested Reference Books:

1. Hertzberg R.W., Wiley J., Deformation and Fracture Mechanics of Engineering Materials.
2. Meyers M. A. and Chawla K. K., Mechanical Behaviour of Materials.
3. Courtney T.H., Mechanical Behaviour of Materials.
4. DeGarmo E. P., Black J. T and Kohser R. A., Materials and Processes in Manufacturing(8^{th} Edition), Prentice Hall of India, New Delhi (ISBN 0-02-978760).

5. Ghosh A. and Mallik A.K., Manufacturing Science, Affiliated East-West Press Pvt.. Ltd..New Delhi.
6. Benedict. G.F. and Dekker M., Non traditional Manufacturing Processes, Inc. New York (ISBN 0-8247-7352-7).

Course Outcomes:

1. To gain an understanding and appreciation of the breadth and depth of metal working processes
2. Determine the strong interrelationships between material properties and deformation processes
3. Identification of metal working parameters such as friction, temperature, the resistance of the material etc.,
4. To determine the different properties of metallic materials necessary for producing efficient, accurate and defect free product.

PEMT5304	Instrumental Methods of Analysis	3-0-0	Credits 3

Objectives of the Course:

To become familiar with instrumental method of analysis and to get exposed to the concept and procedure associated with analysis.

Module I: **(12 hours)**

Thermal Analysis: Thermogravimetry, differential thermal analysis, differential scanning calorimetry, temperature modulated DSC, dynamic mechanical thermal analysis, hyphenated techniques

Module II: **(10 hours)**

Surface Characterization: X-ray photoelectron spectroscopy, scanning tunnelling microscopy, atomic force microscopy,

Module III: **(10 hours)**

Electron microscopy principles and comparison between electron microscopy and scanning probe microscopy, sample preparation techniques for electron microscopy

Module IV: **(10 hours)**

Spectro analytical methods: Introduction, Beers law, selection rules, IR spectroscopy, UV-visible spectroscopy, atomic absorption spectrometry

Suggested Text Books:

1. J. W. Robinson, E. M. S. Frame, and G. M Frame II, Undergraduate Instrumental Analysis, 6th Edn., Marcel Dekker, 2005

Suggested Reference Books:

1. D. A. Skoog, F. J. Holler and T. A. Nieman, Principles of Instrumental Analysis, 4th Edn. Harcourt, 2001
2. J. D. Menczel, R. B. Prime, Thermal Analysis of Polymers , Wiley, 2009

3. G. H. Michler, Electron Microscopy of Polymers, 1st ed., Springer Verlag, 2008

Course Outcomes:

1. Acquire knowledge of the basic principles of all instrumentation techniques
2. Gain knowledge on sample preparation and calibration methods for different analysis techniques.
3. Understand the interpretation methods of various instruments.
4. Study reverse engineering of products, including metals, polymers, ceramics, composite, and biomedical applications

PEMT5305	Non Destructive Testing of Materials	3-0-0	Credits 3

Objectives of the course: To become familiar with NDT techniques and to get exposed to the concept and procedure associated with failure analysis.

Module-I **(10 Hours)**

Liquid Penetration Test (LPT), and Magnetic Particle Testing (MPT): Visual examination; liquid penetrant testing – procedure; penetrant testing materials, penetrant testing method –sensitivity; application and limitations; magnetic particle testing; definition and principle; magnetizing technique, procedure, equipment sensitivity and limitation;.

Module-II **(10 Hours)**

Radiography – basic principle, electromagnetic radiation in film, radiographic imaging, inspection techniques, applications, limitations, real time radiography, safety in industrial radiography **Eddy current testing** – principle, instrument techniques, sensitivity application, limitation;

Module-III **(10 Hours)**

Ultrasonic testing – basic properties of sound beam, ultrasonic transducers, inspection methods, technique for normal beam inspection, flaw characterization technique, ultrasonic flaw detection equipment modes of display, immersion testing, advantage, limitations; **acoustic emission testing** – principles of AET and techniques.

Module-IV **(12 Hours)**

Application of NDT to finished products: and selection of NDT methods – defects like casting defects, forging and rolling defect, extrusion defect, drawing defect, grinding cracks, heat treating cracks, service defects; selection of NDT methods- VE, LPT, MPT, ECT, RT, UT, AET and thermography; selection of instrumentation for various NDT methods; reliability in NDT.

Suggested Text Books:

1. Baldev Raj, Jayakumar T., Thavasimuthu M., "Practical Non-Destructive Testing", Narosa Publishing, 1997.
2. Das A.K., "Metallurgy of Failure Analysis", TMH, 1992.

Suggested Reference Books:

1. Hull, "Non-Destructive Testing", ELBS Edition, 1991
2. Halmshaw R., - "Non-Destructive Testing", Edward Arnold.
3. Rolfe T., Barson J., "Fracture and Fatigue Control and Structure – Application of Fracture Mechanics", Prentice Hall.

Course Outcomes:

The student will be able to describe and select specific Non-Destructive techniques to predict maintain and test for reliability/maintainability and quality of equipment, components and/or structures to maintain safe, effective and efficient operation

PEMT5306	Polymer Technology	3-0-0	Credits 3

Objectives of the course: To become familiar with polymer processing, properties and their applications in the engineering.

Module I: **(12 hours)**

Fundamentals of polymer science , Different types of polymerization and their mechanism; Nomenclature of polymers; Polymer molecular architecture; Bulk, suspension, emulsion and solution crystallinity; Thermal transitions in polymers

Module II: **(12 hours)**

Polymeric materials , Property Requirements and Polymer Utilization; Thermoplastics - Commodity and engineering plastics; Thermosets; Elastomers; Natural rubber and synthetic rubbers Thermoplastic elastomers; Blends & reinforced polymers

Module III: **(12 hours)**

Polymer Reactions, Polymer Modification; Polymer degradation, Viscoelastic behaviour of plastics; Time – temperature superposition; Stress-strain behaviour;; Methods to improve mechanical properties;

Module IV: **(06 hours)**

Properties of polymers, Basics of polymer rheology; Permeability; electrical; optical and flammability properties Compounding and processing of polymers, Plastics Technology; Fiber Technology; Elastomer technology

Suggested Text Books:

1. F. W. Billmeyer Jr., Textbook of polymer science, John Wiley, New York, 1996.

Suggested Reference Books:

1. R. O. Ebewele, Polymer Science and Technology, 1st Ed., CRC Press, Boca Raton, 2000.
2. V. R. Gowariker, N.V. Viswanathan, J. Sreedhar, Polymer Science, 1st Ed., New Age International, New Delhi, 2011.

3. S. L. Rosen, Fundamental Principles of Polymeric Materials, 2nd Ed., John Wiley, New York, 1993.
4. J. R. Fried, Polymer Science and Technology, 2nd Ed., Prentice Hall of India, New Delhi, 2005.
5. M.P. Stevens, Polymer Chemistry-an Introduction, 3rd Ed., Oxford University Press, New York, 199

Course Outcomes:

Students will be able to

1. Identify suitable polymer(s) for a given application
2. Understanding properties of a polymer by relating them to its structure
3. Identifying a suitable molding and forming process for a given application
4. applying **fundamentals in real life situations**

MANDATORY COURSE

MCGN9305	Environmental Science	2-0-0	Credit-0

Unit 1: Multidisciplinary nature of environmental studies

Definition, scope and importance), Need for public awareness.

Renewable and non-renewable resources

Natural resources and associated problems, role of an individual in conservation of natural resources, equitable use of resources for sustainable lifestyles.

Unit 2: Ecosystems

Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the following ecosystems:-

a. Forest ecosystem
b. Grassland ecosystem
c. Desert ecosystem
d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 3: Biodiversity and its conservation

- Introduction – Definition: genetic, species and ecosystem diversity.
- Bio geographical classification of India
- Biodiversity at global, National and local levels.
- India as a mega-diversity nation
- Hot-sports of biodiversity.
- Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts.
- Endangered and endemic species of India
- Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Unit 4: Environmental Pollution Cause, effects and control measures of :-

Air pollution, water pollution, soil pollution, noise pollution, nuclear hazards and solid waste Management: Causes, effects and control measures of urban and industrial wastes, Disaster management: floods, earthquake,

cyclone and landslides.

Unit 5: Social Issues and the Environment

Sustainable development, water conservation, rain water harvesting, resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion.

Text Books

1. Environmental Science And Engineering by Rajesh Gopinath N. Balasubramanya, Cengage India.
2. Fundamental Concepts in Environmental Studies by Dr. D.D. Mishra S. Chand Publication.
3. Basic environmental Sciences for undergraduates by Dr. Sohini Singh, Dr. Tanu Allen and Dr. Richa K. Tyagi, Vayu education of India.

MANDATORY COURSE

MCHM9306	Universal Human Values	2-0-0	Credit-0

Objective:

1. To help students distinguish between values and skills, and understand the need, basic guidelines, content and process of value education.
2. To sensitize the student towards issues in society and nature.
3. To Strengthen self-reflection to know what the students 'really want to be' in their life and profession.
4. To understand harmony at all the levels of human living, applying the understanding of harmony in existence in their profession and lead an ethical life.

Module I **10 Hours**

1. Need, basic guidelines, content and process for Value Education, Self-Exploration– content and process;

2. Happiness and Prosperity- A look at basic Human Aspirations, Right understanding, Relationship and Physical Facilities for Human Aspirations.

3. Method to fulfill the human aspirations: understanding and living in harmony at various levels.

Module II **10 Hours**

1. Human being as a co-existence of the sentient 'I' and the material 'Body', Self ('I') and 'Body' - *Sukh* and *Suvidha*

2. Body as an instrument of 'I' (I being the doer, seer and enjoyer), the characteristics and activities of 'I' and harmony in 'I',

3. Harmony of I with the Body: *Sanyam* and *Swasthya*; Needs of Body and Psyche: *Sanyam* and *Swasthya*

Module III **12 Hours**

1. Harmony in the Family, values in human-human relationship; Trust (*Vishwas*) and Respect (*Samman*) as the foundational values of relationship, meaning of *Vishwas* and *Samman*

2. Harmony in the society: *Samadhan, Samridhi, Abhay, Sah*-astitva, universal harmonious order in society- family to world family, harmony in the Nature : recyclability and self-regulation in nature

3. Natural acceptance of human values, Ethical Human Conduct, and Humanistic Education,

Module IV **08 Hours**

1. Competence in Professional Ethics: professional competence for augmenting universal human order, people-friendly and eco-friendly production systems, technologies and management

2. Strategy for transition from the present state to Universal Human Order

3. Being socially and ecologically responsible engineers with mutually enriching institutions and organizations.

Text Book:

1. R R Gaur, R Sangal, G P Bagaria, 2009, A Foundation Course in Human Values and Professional Ethics.

References Books:

1. A Nagraj, 1998, Jeevan Vidya Ek Parichay, Divya Path Sansthan, Amarkantak.
2. A N Tripathy, 2003, Human Values, New Age International Publishers.
3. B P Banerjee, 2005, Foundations of Ethics and Management, Excel Books

Course Outcome:

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

1. Distinguish between values and skills; understand the need, basic guidelines, content and process of value education.
2. Distinguish between the Self and the Body; understand the meaning of Harmony in the Self the Co-existence of Self and Body.
3. Understand the value of harmonious relationship based on trust, respect and other naturally acceptable feelings.
4. Distinguish between ethical and unethical practices, and start working out the strategy to actualize a harmonious environment.

HONOURS

HNMT0304	Secondary Steel Making	3-1-0	Credits 4

Objectives of the Course:

This course introduces the principles and practices of secondary steel making.

Module-I **(12 hours)**

Secondary steel making principles and practices: Objectives and techniques adopted in secondary steel making. Ladle metallurgy: Outline of inert gas stirring: CAS/CAS (OB), Ladle furnace, vacuum degassing of steel and related processes.

Module-II **(12 hours)**

Transport phenomena in ladles: Role of slag and powders in inclusion control: Desulphurization, Dephosphorisation. Modification of inclusion morphologies, production of ultra low carbon, ultra low sulphur, ultra low phosphorus and inclusion free steels.

Module-III **(12 hours)**

Tundish metallurgy: Evaluation of tundish hydrodynamic performances: Solidification phenomena: Conventional, continuous and near net shape casting phenomena. Powder injection systems. Production of alloy steel through post solidification treatments (VAR, ESR);

Module-IV **(6 hours)**

Refractories used in secondary steel making furnaces, their properties and selection criteria. Process selection in secondary steel making.

Suggested Text Books:

1. Ghosh A., Secondary Steelmaking- principle & Applications, CRC Press.
2. Ghosh A., Principles of Secondary Steelmaking Processing and Casting of Liquid Steel, Oxford & IBH Publication.

Suggested Reference Books:

1. Ghosh Ahindra, Chatterjee A., Iron making and Steel making Theory and Practices, PHI

Course Outcomes:

After completing this course, the student should be able to:

1. Describe the physical and chemical processes that take place during steel making.
2. Analyse the effect of inclusion control on steel properties.
3. Describe process selection in secondary steel making.

MINOR

MNMT0304	Iron Making and Steel Making	3-1-0	Credits 4

Objectives of the course:

This course introduces the principles and practices of iron making and steelmaking

Module-I **(16 hours)**

Blast furnace profile, Fe-C-O, Fe-O-H phase equilibria, Reactions in stack, bosh and hearth; formation of primary slag, bosh slag and hearth slag. Slag composition and its control, Metal-slag reactions, Control of hot metal composition. Process Control: Factors affecting fuel consumption and productivity, Recent developments in Blast furnace operations like, Bell-less top charging system, High top pressure, Humidified & Oxygen enriched blast and Auxiliary fuel injection through tuyers

Module-II **(16 hours)**

Sponge Iron making: Coal based processes: Rotary kiln process, Rotary hearth furnace process (Fastmet process, ITmk3 process). Gas based processes –Finmet process, Midrex process, HYL processes (HYL -III & HYL –IVM processes). Smelting Reduction (SR): Fundamental of SR, Classification and important SR processes: COREX process, Finex process, Hismelt process, Romelt process.

Module-III **(16 hours)**

Steel making reactions (C, Si, Mn, S, P), Primary steel making processes: Hearth (LD, OBM) and Hearth (EAF) processes, Deoxidation, Degassing and injection metallurgy.

Module-IV **(8 hours)**

Non-metallic Inclusions, Material balance in Iron and steel making processes, Feasibility of reactions and chemical kinetics, Pollution Control in Integrated steel plants.

Suggested Text books:

1. Ahindra Ghosh and Amit Chatterjee: Iron making and Steel making Theory and Practice, Prentice-Hall of India Private Limited, 2008.
2. Dipak Mazumdar, A First Course in Iron and Steel Making, University Press-IIM-2015

Suggested Reference Books:

1. An introduction to modern steel making, R. H. Tupkary, Khanna Publishers (2000)
2. An introduction to modern iron making, R. H. Tupkary, Khanna Publishers (2004)

Course Outcomes:

After completing this course, the student should be able to:

1. Describe the physical and chemical processes that take place during iron making and steel making
2. Analyse the effect of change in process parameters in iron making and steel making processes
3. Describe the methods for control of quality in iron and steel production
4. Solve numerical problems involving reaction kinetics and composition control

PRACTICAL / SESSIONAL

PCMT7309	Advanced Materials Processing Laboratory	0-0-3	Credits 2

Objectives of the course: To demonstrate the different sintering and processing methods qualitatively as well as quantitatively

List of suggested experiments:

1. Effect of compacting pressure on bulk density of metal powders.
2. Characteristic features of sintering of metal powder compacts.
3. Synthesis of nano alumina (Al_2O_3) powders by Sol-Gel Processing.
4. Synthesis of Titanium dioxide (TiO_2) powders by Sol-Gel Processing.
5. Synthesis of zirconia (ZrO_2) powders by Sol-Gel Processing.
6. Synthesis of calcium titanate ($CaTiO_3$) powders by Sol-Gel Processing
7. Synthesis of barium titanate ($BaTiO_3$) powders by Sol-Gel Processing
8. Synthesis of calcium titanate ($CaTiO_3$) powders using high energy ball mill.
9. Synthesis of barium titanate ($BaTiO_3$) powders using high energy ball mill.
10. To produce Fe_2O_3 powders using high energy ball mill and wet magnetic separation.
11. To synthesis of hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_3$) by solution precipitation
12. To produce Cu-Zn-NiO alloys using high energy ball mill
13. To produce Fe-C- Si metallic alloys using high energy ball mill
14. To produce Al-Si metallic alloys using high energy ball mill
15. To produce high entropy alloys through varying alloy addition to Fe, Ni, Ti base metallic materials using induction melting and arc melting.

Course Outcomes: Upon completion of this class, students are expected to

1. Understand the terminologies used in the sintering of materials
2. Demonstrate the different processing methods of materials
3. Selection and identification of materials for different industrial applications

PCMT7310	Computer Application in Metallurgy	0-0-3	Credits 2

Objectives of the course: To understand the fundamentals of data analysis and curve fitting techniques used for different metallurgical processes using software tools.

List of suggested experiments:

1. Numerical methods for solution of ordinary differential equations. Application of regression analysis and curve fitting techniques
2. Computer applications for energy & material balance in B.F. and BOF Steel making processes.
3. Numerical solution of partial differential equations pertinent to heat, mass & momentum transfer.
4. Computer applications in solidification, potential energy diagrams and experiments in metallurgy
5. Computer application in laboratory screen analysis.
6. Computer program to integrate a specific heat equation over the temperature range 298.19° K to 2500° K. Up to nine phase changes may be involved at various temperatures.
7. A computer program to calculate for different flotation products; the iron assay, wt % recovery, % iron recovery on the basis of head assay, % Fe recovered on the basis of flotation feed.
8. Analysis of test data using software.

Course Outcomes: Upon completion of this class, students are expected to

1. Understand the fundamentals of computer application of data analysis with appropriate equations.
2. Understand the basic numerical methods and their solutions for different metallurgical problems using software tools.
3. Selection and identification of problems for different industrial applications

HSHM3305	Business Communication & Interview Skills	0-0-3	Credit-1

COURSE OBJECTIVES

1. To develop communicative competence in prospective engineers.
2. To train them to participate in Group Discussion, presentation & face interview
3. To understand team dynamic & effectiveness.
4. To learn leadership qualities and practice them.
5. To develop basic personality traits.

Detailed Syllabus

Emphasis will have to be given to practice sessions in the class room by the learners

Module –I **(08 Hours)**

1. Soft Skills: An introduction-Definition and Significance of Soft Skills; Importance and Measurement

of Soft Skill Development, Role of effective communication in professional life.
2. Self-Discovery: Discovering the Self; Beliefs, Values, Attitude, Virtue,
3. Being Creative: Out of the box thinking, Lateral Thinking and its use.

Module-II (12 hours)

1. Public Speaking: Skills, Methods, Strategies and Essential tips for effective public speaking.
2. Teamwork and Leadership Skills: Concept of Teams; Building effective teams; being a team player, Concept of Leadership and developing Leadership skills
3. Group Discussion: Importance, Planning, Elements and Skills. GD as part of a selection process: Evaluation and Analysis

Module-III (12 hours)

1. Interview Skills: Interviewee-in-depth perspectives, Types of Interview- In Campus / Onsite/ Telephonic, Before, During and After the Interview. Tips for Success.
2. Presentation Skills: Types, Content, Audience Analysis, Essential Tips-Before, During and After, Overcoming Nervousness/ reducing stage fright, visualization strategies, on camera techniques.
3. Preparing Curriculum Vitae, Resume, Bio-data, Job Application

Module-IV (08 hours)

1. Stress/ Time Management: Definition, Nature, types, Symptoms and Causes; Stress Analysis Models and Impact of Stress; Measurement and Management of Stress. Effective utilization of Time as a resource, Managing Time
2. Leadership and Assertiveness Skills: A Good Leader; Leaders and Managers; Types of Leadership behavior; Assertiveness Skills.
3. Emotional Intelligence: Meaning, Features, Intrapersonal and Management Excellence; Strategies to enhance Emotional Intelligence.

Reference Books:

1. Managing Soft Skills for Personality Development-edited by B.N. Ghosh, McGraw Hill India, 2012.
2. English and Soft Skills-S.P. Dhanavel, Orient Blackswan India, 2012.
3. Personality Development and Soft Skills by Barun Mitra OUP
4. Communication Skills second edition Kumar Lata OUP
5. Crash Course in Personal Development- Brian Clegg Kogan Page Publication
6. Lateral Thinking by Edward De Bono Penguin Books

COURSE OUTCOMES

By the end of course, students shall be able to:

1. Understand the significance and essence of a wide range of soft skills. Learn how to apply soft skills in a wide range of routine social and professional settings.
2. Learn how to employ soft skills to improve interpersonal relationships. Learn how to use soft skills to enhance employability and ensure workplace and career success.
3. Participate in different types of Group Discussions/ Activities effectively, presenting a topic and face interviews with confidence.

OPEN ELECTIVE-III (OE-III) 6th Semester

OECH6318	Food Biotechnology	3L-0T-0P	3 Credits

Objective of the course: To study the aspects of production, composition and design of food products.

Module-I **(12 Hours/4 Weeks)**

Unit – 1 (6 Hours/2 Weeks) Food quality and Production technology: Analysis of food, major ingredients present in different product, Food additives: colour, flavour, vitamins, Single cell protein, mushroom.

Unit – 2 (6 Hours/2 Weeks) Fermentative production of food, Pickling and alcoholic beverages, genetically manipulated crops-based food, oriental foods, probiotics and prebiotics in food products.

Module-II **(12 Hours/4 Weeks)**

Unit – 3 (6 Hours/2 Weeks) Technology for improved process: Enzyme in bakery, fermented cereal products, Enzymes in fat/oil industries, Protease in cheese making, enzymes in beverage production.

Unit – 4 (6 Hours/2 Weeks) Utilization of food waste for production of value-added products, enzymes in sugar syrup, genetically modified food.

Module-III **(12 Hours/4 Weeks)**

Unit – 5 (6 Hours/2 Weeks) Food spoilage and control: Spoilage of food, Microbiology of water, meat, milk, vegetables, microbial safety of food products.

Unit – 6 (6 Hours/2 Weeks) Chemical safety of food products, heavy metal, fungal toxins, pesticide and herbicide contamination, Food preservatives and additives, Post-harvest technology for food preservation.

Module-IV **(6 Hours/2 Weeks)**

Unit – 7(6 Hours/2 Weeks) Canning, dehydration, ultrafiltration, sterilization, irradiation.

Text Books

1. Modern Food Microbiology, 7th ed. by J M Jay, M J Loessner, and DA Golden, Springer.
2. Food Microbiology, 5th ed. by W C Frazier and D C Westhoff, McGraw-Hill.
3. Prescott & Dunn's Industrial Microbiology by G Reed, CBS.
4. Technology of Food Preservation, 4th ed. by N W Desrosier and J N Desrosier, Avi Publishing Co Inc.
5. Introduction to Food Engineering, 5th ed. by R P Singh and D R Heldman, Academic Press.

Course Outcomes:

At the end of the course, the student should be able to

1. Understand the process used to enhance the production, nutritional value, safety and taste of food.
2. Know about the modern biotechnological techniques applied to food science.
3. Know about improving crops so that they need fewer pesticides.
4. Design product & functionality, understand food innovation and marketing.
5. Gain knowledge about the rapid detection techniques of foodborne pathogens and chemical senses.

6. Know about the requirements for careers in the dynamic food sector as well as for research and development.

OECH6319	Fluidization Engineering	3L-0T-0P	3 Credits

Course objectives: The objectives of this course are to introduce

1. Basics of fluidization and various industrial application of fluidization;
2. Various fluidization regime, classification of particles;
3. Describe the staging of fluidized bed reactor.

Module-1 **(4 weeks/12 Hours)**

Basics of fluidization, types, behaviour, and parameters

Unit I (6 Hours/2 weeks): Introduction to fluidization, types of fluidization, gross behavior of fluidized beds, minimum fluidization velocity.

Unit II (6 Hours/2 weeks): Pressure drops in fluidized beds, bed voidage, transport disengaging height, viscosity and fluidity of beds, bubble behavior, bed expansion, distributor design.

Module-2 **(4 weeks/12 Hours)**

Mathematical treatment and calculations

Unit III (6 Hours/2 weeks): Simple mathematical treatment, Solid transport: flow and fluidized solids, solids transfer, terminal velocity, particle entrainment and elutriation.

Unit IV (6 Hours/2 weeks): Simple calculations relating to solid transport.

Module-3 **(4 weeks/12 Hours)**

Heat and mass transfer in fluidized beds

Unit V (6 Hours/2 weeks): Heat and mass transfer in fluidized beds: Heat transfer mechanism, principles of gas-solid and bed surface transfer, heat transfer to liquid fluidized systems.

Unit VI (6 Hours/2 weeks): Generalized correlation for fluidized bed mass transfer and its limitations.

Module-4 **(2 weeks/6 Hours)**

Semi-fluidization and fluidized bed reactors

Unit VII (6 Hours/2 weeks): Semi-fluidization: principles, estimation of various bed parameters, Industrial applications; Design of fluidized bed reactors: Concept of RTD, basic design principles for fluidized bed.

Text books :

1. 'Fluidization Engineering', 2nd ed. by D Kunii and O Levenspiel, Butterworth Heinemann.

Reference Books :

1. 'Fluidization' by M Leva, McGraw-Hill.
2. 'Fluidization' by J F Davidson and D Harrison, Academic Press.

Course Outcomes (CO):

At the end of the course, students would be able to understand about

1. Concept of fluidization
2. Applications of fluidization
3. Semi-fluidization
4. Fluidized bed reactors

OECE6320	Structural Dynamics and Earthquake Engineering	(3-0-0)	Credit-03

Module I

Elements of Earthquake origin & Propagation: Elements of Seismology, Earthquakes, Structure of the Earth, History of the Earth, Earthquake Mechanism, Propagation of Seismic Waves, Earthquake Phenomena, Earthquake Measurements, Definitions of magnitude, intensity, epicentre etc; Plate tectonics, seismographs, liquefaction, Types, effects and controlling factors

Module II

Theory of Vibration Effects: Dynamic Loads. D'Alembert's Principle and inertia forces, Stiffness and flexibility of elastic structures, Theory of Vibrations, Free vibrations of single and multiple degree freedom systems, computations of dynamic response to time dependent forces, mass and stiffness matrices, natural frequencies, Plate Tectonics Theory.

Module III

Earthquake Resistant Design: Principles of Earthquake Resistant Design, Response spectrum theory. Time – Acceleration method, Application of response spectrum theory to seismic design of structures.

Module IV

Earthquake Damages: Earthquake Damages to Various Civil Engineering Structures, Case Histories Earthquake, Earthquake response of structures, Soft storey collapse, Slender structures, unsymmetrical structures. Methods of disaster prevention: Earthquake resistant building Regulations, specification, guidelines for construction – Materials selection.

Reference Books

1. A K. Chopra (2003), Dynamics of Structures-Theory and Applications to Earthquake Engineering, Second Edition, Prentice-Hall India Pvt Ltd.
2. Pauley & Priestly (1995), Seismic design of reinforced concrete and masonry buildings, John Wiley & Sons.
3. Stratta. J.L. (2000), Manual of Seismic Design, Prentice-Hall India Pvt Ltd.
4. Kramer. S.L. (2000), Geotechnical Earthquake Engineering, Prentice-Hall India Pvt Ltd.
5. Agarwal & Shrinkhardo (2006), Earthquake Resistant design of structures, Prentice-Hall India.

OECS6321	Data Science	3-0-0	Credit-03

Prerequisite:
Brief knowledge in programming in C, C++ with great interest in quantitative/statistical analysis and a student having degree in BTech in any branch of Engineering, MCA, M.Tech, MS having occasionally programming knowledge may enrol for this subject. As this is just an introductory to data science techniques even a simple graduate student may take this course.

Module I: **10 Hrs.**
Benefits and uses of data science and big data, Data Science steps, Facets of data, Structured data, Unstructured data, Natural language , Machine-generated data, Graph-based or network data, Audio, image, and video, Streaming data, The data science process, Setting the research goal, Retrieving data, Data preparation, Data exploration, Data modelling or model building, Presentation and automation, The big data ecosystem and data science, Distributed file systems, Distributed programming framework, Data integration framework, Python Environment set-up, Jupyter overview, Python Numpy, Python Pandas, Python Matplotlib.

Module II: **8 Hrs.**
An introduction to R, Data structures in R, Data visualization with R, Data analysis with R, Data science using MS-excel, Important statistical concepts used in data science, Difference between population and sample, Types of variables, Measures of central tendency, Measures of variability, Coefficient of variance, Skewness and Kurtosis, Normal distribution, Test hypotheses, Central limit theorem, Confidence interval, F-test, T-test, Chi-square test, Type I and II errors, Student's T distribution.

Module III: **10 Hrs.**
Regression, ANOVA,R square, Correlation and causation, Exploratory data analysis, Data visualization, Missing value analysis, The correction matrix, Outlier detection analysis, Supervised machine learning, Python Scikit tool, Neural networks, Support vector machine, Logistic and linear regression, Decision tree classifier, Tableau, Working with Tableau, Deep diving with data and connection, Creating charts, Mapping data in Tableau, Dashboards and stories.

Module IV: **10 Hrs.**
Machine learning on cloud, ML on cloud platform, ML on AWS, ML on Microsoft Azure, Understanding NoSQL databases and why they're used today, Identifying the differences between NoSQL and relational databases, Defining the ACID principle and how it relates to the NoSQL BASE principle, Learning why the CAP theorem is important for multi-node database setup, Applying the data science process to a project with the NoSQL database Elastic search, The rise of graph data bases, graph mining, test mining and analysis, Natural Language Toolkit(NLTK),Data visualization to the end user, Dashboard development tools.

Text Books:
There is no text book for the course. A teacher may use lecture notes and videos, read research papers and Web Pages, which will be freely available on internet websites.

Reference Books:
1. Introducing Data Science BIG DATA, MACHINE LEARNING, AND MORE, USING PYTHON TOOLS by DAVY CIELEN ARNO, D. B. MEYSMAN and MOHAMED ALI, MANNING

SHELTER ISLAND
2. Introduction to Probability – By Joseph K. Blitzstein and Jessica Hwang
3. R for Data Science: Import, Tidy, Transform, Visualize, and Model Data 1st Edition, by Hadley Wickham
4. Python Data Science Handbook, Jake Vander Plas*, O'reilly*
5. Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems 2nd Edition, Aurélien Géron (Author),O'reilly

OEEE6322	Sensors and Transducers	3-0-0	3 Credits

Module -I **[12 Hours]**

Elements of a general measurement system; Static Characteristics: systematic characteristics, statistical characteristics, calibration; Dynamic characteristics of measurement systems: transfer functions of typical sensing elements, step and frequency response of first and second order elements, and dynamic error in measurement systems. **(Bentley: Chapters 1-4)**

Techniques for dynamic compensation, Loading Effects and Two-port Networks
(Bentley: Sections 4.4 and 5.1-5.2)

Module-II **[12 Hours]**

Sensing elements: Resistive sensing elements: potentiometers, Resistance Temperature Detector (RTD), thermistors, strain gages. Capacitive sensing elements: variable separation, area and dielectric;

Inductive sensing elements: variable reluctance and LVDT displacement sensors; Electromagnetic sensing elements: velocity sensors. **(Bentley: Sections 8.1 to 8.6)**

RVDT, Hall Effect sensors **(Bentley: Sections 8.3 and 8.10)**

Piezoelectric sensing elements, Piezo-resistive sensing elements.
(Bentley: Sections 8.7 and 8.8)

Module-III **[12 Hours]**

Signal Conditioning Elements: Deflection bridges: design of resistive and reactive bridges, push-pull configuration for improvement of linearity and sensitivity.

Amplifiers: Operational amplifiers-ideal and non-ideal performances, inverting, non-inverting and differential amplifiers, instrumentation amplifier, filters. A.C. carrier systems, phase sensitive demodulators and its applications in instrumentation
(Bentley: Sections 9.1 to 9.3; Ghosh: Sections 15.1 and 15.2)

Current transmitters, Oscillators and resonators **(Bentley: Sections 9.4 and 9.5)**

Module-IV **[6 Hours]**

Thermoelectric sensing elements: laws, thermocouple characteristics, installation problems, cold junction compensation.

IC temperature sensor Elastic sensing elements: Bourdon tube, bellows, and diaphragms for pressure sensing, force and torque measurement.

(Ghosh: Section 10.3 to 10.4)

Text Books:

1. Principles of Measurement Systems- J.P. Bentley (3/e), Pearson Education, New Delhi, 2007.
2. Introduction to Measurement and Instrumentation- A.K. Ghosh (3/e), PHI Learning, New Delhi, 2009.

Reference Books:

1. Measurement Systems Application and Design- E.O. Doeblin (4/e), McGraw-Hill, International, NY.
2. Instrumentation for Engineering Measurements- J.W. Dally, W.F. Riley and K.G. McConnel (2/e), John Wiley, NY, 2003.
3. Industrial Instrumentation- T.R. Padmanabhan, Springer, London, 2000.

OEEC6324	Mechatronics	3-0-0	Credits 3

COURSE OBJECTIVES

1. Understand key elements of Mechatronics system, its block diagram representation.
2. Understand principles of sensors, transducers, encoders and actuators and its characteristics.
3. Understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial applications.
4. Understand the system modelling and analysis in time domain and frequency domain.

MODULE-I **(12 Hours)**

Unit 1

Fundamental of Mechatronics: Definition and concepts of Mechatronics, Conventional system vs. mechatronic system, Evolution of Mechatronics.

Unit 2

Hardware components for Mechatronics. Need and Role of Mechatronics in Design, Manufacturing and Factory Automation.

MODULE-II **(12 Hours)**

Unit 3

Sensors:

An introduction to sensors. Principle of operation, Difference between transducer and sensors. Sensor types- Transducer signal conditioning sensor, velocity and motion sensor, force sensor, fluid pressure sensor, liquid

flow sensor, liquid level sensor, temperature sensor.

Unit 4

Transducers:

Introduction to transducers. Transducer types – photo emissive transducer, photo conductive transducer, photovoltaic transducer, thermistors, thermocouple, inductive transducer, capacitive transducer, piezoelectric transducer, hall effect transducers, ionization transducer, Use of sensor and transducer for specific purpose in mechatronics.

MODULE-III (12 Hours)

Unit 5

Actuators and encoders:

Electric motors: D.C. Motors, Stepper motor. Hydraulic actuators, Pneumatic actuators. Principle of operation of encoders, Types of encoders- incremental encoder, optical encoder, bimetallic strip encoder, strain gauge encoder, load cell encoder.

Unit 6

Programmable Logic Controller:

Basic Structure- Programming: Ladder diagram Timers, Internal Relays and Counters - Shift Registers - Master and Jump Controls, data handling, Analog input / output , PLC Selection &Application.

MODULE-IV (8 Hours)

Unit 7

MEMS and Microsystems:

Overview of MEMS and Microsystems. Micromachining techniques: silicon as a material for micromachining, photolithography, thin film deposition, doping, wet and dry etching, surface and bulk micromachining, wafer bonding, packaging.

Microsystems modelling and Design:

Mechanics of deformable bodies. Energy method. Estimation of stiffness and damping for different microstructures. Modelling of electromechanical system, it's analysis in time domain and frequency domain, pull-in voltage. Applications of MEMS.

Text Books:

1. Mahalik N.P, "Mechatronics: Principles, Concepts and applications", Tata McGraw Hill, 3rd edition (Indian), 2012.
2. Appu Kuttan, "Introduction to Mechatronics", Oxford University, 2007.

Reference Books:

1. RK Rajput, "A Textbook of Mechatronics", S. Chand Publishing, 1st Edition, 2007.
2. Ananthasuresh & Gopalkrishnan, "Micro and Smart Systems", Wiley India, 2012
3. A. Smaili& F Mrad, "Applied Mechatronics", Oxford University Press, 1st Edition 2007.
4. S. D. Senturia, "Microsystem Design", Springer, 1st edition 2nd reprint 2004

Course Outcomes:

1. To model, analyze, and control engineering systems.
2. Identify sensors, transducers, and actuators to monitor and control the behaviour of a process or product.
3. Develop PLC programs for a given task.
4. Evaluate the performance of mechatronics systems.

OEHM6325	MARKETING MANAGEMENT	3-0-0	Credit-3

Course Objectives

1. To understand the concepts of marketing management
2. To learn about marketing process for different types of products and services
3. To understand the tools used by marketing managers in decision situations
4. To understand the marketing environment

Course Content

UNIT 1: Basic Concepts of Marketing

Definition, Concept of Exchange-Needs & Wants, Marketing Concept, Process ,Marketing environment, Elements of macro and micro environment, Competition analysis, Factors contributing to competition, Porters five forces model, identifying and analyzing competitors, Marketing planning process, Market research and information system, Research process, consumer behavior, factors influencing consumer behavior.

UNIT 2: Market segmentation, targeting and positioning

Definition, Bases of segmenting consumer and industrial market, Target market strategies, Market positioning, Market demand forecasting :forecasting tools, short term tools, Moving average and exponential smoothing methods, Long term forecasting tools- time series analysis, Econometric method, Qualitative methods– Buying intention survey, sales force opinion, Delphi techniques, Product planning-Product planning and new product planning process.

UNIT 3: Price decision

Objectives and factors influencing price, Pricing methods and strategies, Integrated marketing communication (IMC), Concept of IMC, The marketing communication process, Promotion mix, Elements of promotion mix, Channel of distribution: types of intermediaries, functions of distribution channels, channel levels, physical distribution, supply chain management (basic only)

Text Books

1. Kotler, P., Keller, K. L., Koshy, A., & Jha, M. (2012), Marketing Management A South Asian Perspective, 14th Edition, Pearson Education, New Delhi.
2. Ramaswamy, V. S., & Namakumari, S. (2017), Marketing Management: Indian Context with Global Perspective, McGraw hill.

Reference Books

1. Kotler, Philip. Marketing Management, Millennium Edition. Intl ed. US: Prentice Hall, 2002.ISBN: 8120316096.
2. Principles of Marketing, Kotler and Armstrong, Pearson, 12th edition., 2008, ISBN: 978-81- 317-1547-5

Course Outcomes

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

CO 1. Demonstrate strong conceptual knowledge in the functional area of marketingmanagement.
CO 2. Demonstrate effective understanding of relevant functional areas of marketing management and its application.
CO 3. Demonstrate analytical skills in identification and resolution of problems pertaining to marketing management

OEMA6326	Optimization in Engineering	3-0-0	Credit-3

Module-I. **(12 Hours)**

Idea of Engineering optimization problems, Classification of optimization algorithms, modeling of problems and principle of modeling. Linear programming: Formulation of LPP, Graphical solution, Simplex method, Big-M method, Revised simplex method, Duality theory and its application, Dual simplex method, Sensitivity analysis in linear programming.

Module-II. **(12 Hours)**

Transportation problems: Finding an initial basic feasible solution by Northwest Corner rule, Least Cost rule, Vogel's approximation method, Degeneracy, Optimality test, MODI method, Stepping stone method. Assignment problems: Hungarian method for solution of Assignment Problems Integer Programming: Branch and Bound algorithm for solution of integer Programming Problems.

Module-III. **(13 Hours)**

Non-linear programming: Introduction to non-linear programming. Unconstraint optimization: Fibonacci and Golden Section Search method. Constrained optimization with equality constraint: Lagrange multiplier, Projected gradient method. Constrained optimization with inequality constraint: Kuhn-Tucker condition, Quadratic programming.

Module-IV. **(8 Hours)**

Queuing models: General characteristics, M/M/1 model, Limited queue capacity, multiple server, Finite sources, Queue discipline. Introduction to Genetic Algorithm.

Text Books:

1. A. Ravindran, D. T. Philips, J. Solberg, Operations Research- Principle and Practice, Second edition, Wiley India Pvt. Ltd.
2. Prabhakar Pai, Operation Research, Oxford University Press.

3. H.A. Taha, A.M. Natarajan, P. Balasubramanie, A. Tamilarasi Operations Research, Pearson Education, Eighth Edition.

Reference Books:

1. Stephen G. Nash, A. Sofer Linear and Non-linear Optimization, McGraw Hill, 2nd Edition.
2. A. Ravindran, K.M. Ragsdell, G.V. Reklaitis, Engineering Optimization, Wiley India Pvt. Ltd, Second edition.
3. F.S. Hiller, G.J. Lieberman, Operations Research, Tata McGraw Hill, Eighth Edition. .

OEME6327	Industrial Engineering and Operation Research	3-0-0	Credit-3

Product Design and Development: Principles of good product design, tolerance design; quality and cost considerations; product life cycle; standardization, simplification, diversification, value engineering and analysis, concurrent engineering; comparison of production alternatives.

Work System Design: Taylor's scientific management, Gilbreths's contributions; productivity – concepts and measurements; method study, micro-motion study, principles of motion economy; work measurement –time study, work sampling, standard data, PMTS; ergonomics; job evaluation, merit rating, incentive schemes, and wage administration.

Facility Design: Facility location factors and evaluation of alternate locations; types of plant layout and their evaluation; computer aided layout design techniques; assembly line balancing; materials handling systems.

Operation Research: Linear programming – problem formulation, simplex method, duality and sensitivity analysis; transportation and assignment models; network flow models, constrained optimization and Lagrange multipliers; Markovian queuing models; dynamic programming; simulation – manufacturing applications. Engineering Economy and Costing: Elementary cost accounting and methods of depreciation; break-even analysis, techniques for evaluation of capital investments, financial statements, time-cost trade-off, resource levelling. Production control: Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality; aggregate production planning; master production scheduling; MRP and MRP-II; routing, scheduling and priority dispatching; Push and pull production systems, concept of JIT manufacturing system; Logistics, distribution, and supply chain management;
Inventory – functions, costs, classifications, deterministic inventory models, quantity discount; perpetual and periodic inventory control systems.
Project management – PERT and CPM.

Text Book:

1. Production & operations management, K. Aswathappa, K.S. Bhat, Himalaya Publishing House, edition 2012.
2. R. Paneerselvam, Production operations Management
3. Operations Research, D.S.Hira, Gupta, S Chand Publisher
4. Industrial Engineering & Management, O P Khanna, Dhanpat Rai & Sons

5. WORK STUDY & amp; TIME STUDY,ILO

OEMT6328	Biomaterials	3-0-0	Credits 3

Objectives of the Course:

1. To introduce the student to the range of biomaterials and the science and engineering of biomaterials.
2. To understand constraints associated with the use of biomaterials

Module 1: **(12 Hours)**

Introduction to basic concepts of Materials Science, Salient properties of important material classes Property requirement of biomaterials, Concept of biocompatibility, Structure and properties of biological cells & tissues, Cell fate processes (cell migration, cell differentiation, cell apoptosis, cell division), Cell signaling processes, Cell-material interactions and foreign body response

Module 2: **(12 Hours)**

Bone tissue–structure, bone tissue-property, assessment of biocompatibility of biomaterials, in vitro biochemical assays (cellular adhesion, cellular viability using MTT, osteogenic differentiation- ALP assay; Biomineralisation - Osteocalcin assay), In vivo testing and histocompatibility assessment, Genotoxicity assessment,

Module 3: **(12 Hours)**

Important biometallic alloys: Ti-based, stainless steels, Co-Cr-Mo alloys Bioinert, Bioactive and Bioresorbable ceramics**,** Processing and properties of different hydroxyapatite (HA)-based biocomposites, Synthesis of biocompatible coatings on structural implant materials, Fabrication of porous scaffold materials using electrospinning and 3D printing, Microstructure and properties of glass-ceramics; biodegradable polymers, Processing and Properties of some Polymer-based Biocomposites,

Module 4: **(06 Hours)**

Design concept of developing new materials for bio-implant applications

Suggested Text Books:

1. Introduction to Biomaterials: Basic Theory with Engineering Applications; C.L Agrawal, J.L. Ong, Mark R Appleford, Gopinath Mani, Canbridge University Press, 2013

Suggested Reference Books:

1. Biological Performance of Materials: Fundamentals of Biocompatibility (Third Edition, Revised and Expanded); Author: Jonathan Black; Publisher - Marcel Dekker, 1999
2. Biomaterials Science and Biocompatibility; Authors: Frederick H. Silver and David L. Christiansen; Publisher: Springer-Verlag New York, 1999
3. Biomaterials Science: An Introduction to Materials in Medicine; Editors: Buddy D. Ratner, Allan S. Hoffman, Fredrick J. Schoen and Jack E. Lemons; Publisher: Elsevier Inc., 2004
4. Molecular Biology of the Cell; Fourth edition; Authors: Bruce Alberts, Alexander Johnson, Julian

Lewis, Keith Roberts and Peter Walter; Publisher: Taylor & Francis, New York, 2002
5. B. Basu, D. Katti and Ashok Kumar; Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA, September, 2009.

Course Outcomes:

After completing the course, the student will be able to:

1. Explain the types of Biomaterials and their relative advantages and disadvantages
2. Indicate the constraints placed on the use of materials in biological environments
3. Explain the characterization of materials from the perspective of application as a
4. Biomaterial

OEPD6329	OPERATION RESEARCH	3L-0T-0P	3 Credits

Course Objective

Ability to understand and analyze managerial problems in industry so that they are able to use resources (capitals, materials, staffing, and machines) more effectively; knowledge of formulating mathematical models for quantitative analysis of managerial problems in industry; skills in the use of Operations Research approaches and computer tools in solving real problems in industry; Mathematical models for analysis of real problems in Operations Research. Identify and develop operational research models from the verbal description of the real system.

Module I **[12]**

Introduction: Definition, Characteristics and phases, Applications of OR. Linear Programming: Problem Formulation, Graphical solution, Simplex method - Artificial variables technique (i.e. Big M method only) - Duality principle, simple problems on dual formulation only, sensitivity analysis.

Module II **[10]**

Transportation Model: Formulation, IBFS-North West Corner method, LCEM, VAM, Unbalanced transportation problem, Optimality test by MODI method.

Assignment Model - Formulation - Optimal solution by Hungarian method – Unbalanced Assignment problem- Restricted case.

Module III **[10]**

Queuing Models: Introduction – Kendall's Lee notation- single channel with infinite population, Multichannel with infinite population

Networking Model: PERT, CPM

Module IV **[08]**

Theory of Games: Introduction-classification of games- 2 person zero sum games- Assumptions -solution of games with saddle points - Rectangular games without saddle points, dominance principle - 2 X 2 games by Algebraic method, m X 2 & 2 X n games by graphical method.

Text Books:

1. Operation Research by Panarsalvam
2. Operation Research by Kalavathy

Reference Books:

1. Hiller & Libermann, "Introduction to Operations Research", 8th ed., Tata McGraw Hill, 2010.
2. D.S. Hira and R.K. Gupta, "Operations Research", 5th ed., S.Chand & Co., 2008.
3. Taha, "Introduction to Operations Research." 8th ed., PHI Publications, 2008.
4. S.D. Sharma, "Operations Research", 8th ed., Kedarnath Publishers, 2007.

Course Outcomes:

Upon successful completion of the course, student will able to:

1. Recognize the importance and value of Operations Research and mathematical modelling in solving practical problems in industry.
2. Formulate a managerial decision problem into a mathematical model;
3. Understand Operations Research models and apply them to real-life problems;
4. Use computer tools to solve a mathematical model for a practical problem.
5. Cognitive skills (thinking and analysis)
6. Be able to build and solve Transportation Models and Assignment Models.
7. Be able to understand the characteristics of different types of decision.