College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Metallurgy and Materials Science

Curriculum Structure & Detailed Syllabus (UG Program)

Second Year B. Tech.

(Revision: A.Y. 2019-20, Effective from: A.Y. 2020-21)

Sr. No.	Item	Page No
1	Program Education Objectives (PEOs) , Program Outcomes (POs) and Program Specific Outcomes (PSOs)	2
2	Correlation between PEOs , POs and PSOs	4
3	List of Abbreviations	5
4	Curriculum Structure	6-7
5	Detailed Syllabi	8-42

Program Education Objectives (PEOs):

I. Graduate will have in-depth knowledge of Metallurgy and Materials Science aspects such as scientific principles of fabrication, phase transformations, mechanical treatment, heat treatment, structure-property correlations and service behavior of various types of materials necessary to formulate, solve and analyze critical engineering problems.

II. Graduate will be able to make a successful career in metallurgical and manufacturing industry, academics, research and development that meet the needs of Indian and multinational companies.

III. Graduate will be capable of solving unfamiliar problems through literature survey, deciding a suitable research methodology and conducting interdisciplinary/collaborative-multidisciplinary scientific research as per the need.

IV. Graduate will achieve the art of reflective learning, build hands-on experimental skills, and become familiar with modern engineering software tools and equipments and able to work independently or as a part of a team for successful project implementations in his/her professional life.

V. Graduate will acquire leadership qualities, techno-economical and social considerations, an aptitude for life-long learning, and get introduced to professional ethics and codes.

VI. Graduate will develop the ability to effectively communicate technical information in both written and oral form.

Program Outcomes (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)

On completion of the B.Tech.(Metallurgical Engineering) degree, the graduates will be able to:

1. Design, develop and select new materials and processes to produce products with desired end properties, within optimum time and resources.
2. Apply modern software tools and quality control techniques to observe and understand the underlying mechanisms to perform structure - properties correlation, failure analysis, and provide solutions towards betterment of industry, R&D and society at large.

Correlation between the PEOs and the POs

PO / PEO	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO 2
I	✓	✓	✓		✓		✓							✓
II	✓	✓	✓	✓	✓	✓	✓					✓		✓
III	✓	✓	✓	✓	✓	✓						✓	✓	
IV				✓	✓				✓	✓	✓	✓	✓	
V							✓		✓	✓	✓			✓
VI	✓	✓	✓					✓						✓

Note: The cells filled in with ✓ indicate the fulfilment/correlation of the concerned PEO with the PO.

List of Abbreviations:

Sr. No.	Abbreviation	Title
1	BSC	Basic Science Course
2	ESC	Engineering Science Course
3	MLC	Mandatory Learning Course
4	SLC	Self-Learning Course
5	HSMC	Humanities/Social Sciences/Management Course
6	LLC	Liberal Learning Course
7	SBC	Skill Based Course
8	IFC	Interdisciplinary Foundation Course
9	IOC	Interdisciplinary Open Course
10	DEC	Department Elective Course
11	PCC	Program Core Course
12	LC	Laboratory Course

CURRICULUM STRUCTURE OF S. Y. B. TECH (Metallurgy and Materials Science)

Effective from A. Y. 2020-2021

Semester III (For Regular Students)

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	BSC/MA 20001	Ordinary Differential Equations and Multivariate Calculus	2	1	0	3
2	BSC/AS 20001	Biology for Engineers	3	0	0	3
3	IFC/ICE-(IF) 20002	Sensors and automation	1	0	2	2
4	SBC/MT 20005	Materials Testing Lab	0	0	2	1
5	PCC/MT 20001	Structure & Properties of Materials	2	1	0	3
6	PCC/MT 20002	Principles of Physical Metallurgy	3	0	0	3
7	PCC/MT 20003	Introduction to Ceramic Engineering	3	0	0	3
8	LC/MT 20004	Principles of Physical Metallurgy Lab	0	0	2	1
9	ESC/MT 20006	Mechanical Technology	3	0	0	3
10	LC/MT 20007	Mechanical Technology Lab	0	0	2	1
	Total: Lectures -Tutorials-Practicals (L-T-P)		17	2	8	
	Total Academic Engagement and Credits		27			23

Semester III [For Lateral Entry Students)

Sr. No.	Course Type/code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	BSC/ MA 20002	Linear Algebra and Univariate Calculus	4	1	0	5
2	BSC/AS 20001	Biology for Engineers	3	0	0	3
3	IFC/ICE-(IF) 20002	Sensors and Automation	1	0	2	2
4	SBC/MT 20005	Materials Testing Lab	0	0	2	1
5	PCC/MT 20001	Structure & Properties of Materials	2	1	0	3
6	PCC/MT 20002	Principles of Physical Metallurgy	3	0	0	3
7	PCC/MT 20003	Introduction to Ceramic Engineering	3	0	0	3
8	LC/MT 20004	Principles of Physical Metallurgy Lab	0	0	2	1
9	ESC/MT 20006	Mechanical Technology	3	0	0	3
10	LC/MT 20007	Mechanical Technology Lab	0	0	2	1
11	PCC/PH 20001	Foundation of Physics	3	0	0	3
	Total: Lectures -Tutorials-Practicals (L-T-P)		22	2	8	
	Total Academic Engagement and Credits		32			28

Semester IV (For Regular Students)

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	BSC/MA 20004	Vector Calculus and Partial Differential Equations	2	1	0	3
2	MLC 20001	Professional Laws, Ethics, Values and Harmony	1	0	0	0
3	HSMC/HS 20001	Innovation and Creativity	1	0	0	1
4	IFC/EE-(IF) 20001	Industrial Electronics and Electrical Drive Systems	1	0	1	2
5	SBC/MT 20008	Microproject	0	0	2	1
6	PCC/MT 20011	Fundamentals of Metal Working	3	1	0	4
7	PCC/Mt 20013	Metallurgical Thermodynamics and Kinetics	3	1	0	4
8	PCC/MT 20009	Polymer and Composites	3	0	0	3
9	LC/MT 20014	Modern Chemical Analysis Lab	0	0	2	1
10	LC/MT 20012	Fundamentals of Metal Working Lab	0	0	2	1
11	LC/MT 20010	Polymer and Composites Lab	0	0	2	1
	Total: Lectures -Tutorials-Practicals (L-T-P)		14	3	9	
	Total Academic Engagement and Credits		26			21

Semester IV (For Lateral Entry Students)

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	BSC/MA 20005	Multivariate Calculus and Differential Equations	4	1	0	5
2	MLC 20001	Professional Laws, Ethics, Values and Harmony	1	0	0	0
3	HSMC/HS 20001	Innovation and Creativity	1	0	0	1
4	IFC/EE-(IF) 20001	Industrial Electronics and Electrical Drive Systems	1	0	1	2
5	SBC/MT 20008	Microproject	0	0	2	1
6	PCC/MT 20011	Fundamentals of Metal Working	3	1	0	4
7	PCC/MT 20013	Metallurgical Thermodynamics and Kinetics	3	1	0	4
8	PCC/MT 20009	Polymer and Composites	3	0	0	3
9	LC/MT 20014	Modern Chemical Analysis Lab	0	0	2	1
10	LC/MT 20012	Fundamentals of Metal Working Lab	0	0	2	1
11	LC/MT 20010	Polymer and Composites Lab	0	0	2	1
	Total: Lectures -Tutorials-Practicals (L-T-P)		16	3	9	
	Total Academic Engagement and Credits		28			23

Semester III [M-Group]
(MA20001) Ordinary Differential Equations and Multivariate Calculus

Teaching Scheme:
Lectures: 2 hrs/week
Tutorials: 1hr/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course, students will be able to :

1. identify first order ordinary differential equations, tell Laplace transform formulae, define functions of several variables.
2. understand basic concepts of higher order ordinary differential equations, level curves and level surfaces.
3. solve linear differential equations using different methods, find Laplace transforms of functions using properties and theorems, evaluate directional derivatives and extreme values.
4. prove theorems, solve ordinary differential equations using Laplace transforms, identify orthogonal trajectories, optimize functions subject to given constraints.
5. apply concepts of ordinary differential equations and multivariate calculus to various applications including real life problems.

Unit I: (11 Hrs)

Review of first order differential equations, Reduction of order, linear differential equations, homogeneous higher order linear differential equations, non-homogeneous higher order linear differential equations with constant coefficients and reducible to differential equations with constant coefficients (method of undetermined coefficients and method of variation of parameters), systems of differential equations, applications to orthogonal trajectories, mass spring systems and electrical circuits.

Unit II: (8 Hrs)

Laplace Transforms, its properties, Unit step function, Dirac delta functions, Convolution Theorem, periodic functions, solving differential equations using Laplace transform.

Unit III: (7 Hrs)

Functions of several variables, level curves and level surfaces, partial and directional derivatives, differentiability, chain rule, local extreme values and saddle points, constrained optimization.

Text Books:

- Thomas' Calculus (14^{th} edition) by Maurice D. Weir, Joel Hass, Frank R. Giordano, Pearson Education.
- Advanced Engineering Mathematics (10^{th} edition) by Erwin Kreyszig, Wiley eastern Ltd.

Reference Books:

- Calculus for Scientists and Engineers by K.D Joshi, CRC Press.
- A Course in Multivariate Calculus and Analysis by Sudhir Ghorpade and Balmohan Limaye, Springer Science and Business Media.
- Differential Equations with Applications and Historical notes by George Simmons, Tata Mc-Graw Hill publishing company Ltd, New Delhi.
- Advanced Engineering Mathematics by C.R. Wylie, McGraw Hill Publications, New Delhi.
- Advanced Engineering Mathematics (7^{th} edition) by Peter V. O' Neil, Thomson. Brooks / Cole, Singapore.
- Advanced Engineering Mathematics (2^{nd} edition) by Michael D. Greenberg, Pearson Education.
- Advanced Engineering Mathematics by Chandrika Prasad and Reena Garg, Khanna Publishing Company Private Limited, New Delhi.

Note 1 :

- To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
- To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
- To measure CO3, questions will be based on applications of core concepts.
- To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
- To measure CO5, some questions may be based on self-study topics and also comprehension of unseen passages.

Note 2 :

All the Course outcomes 1 to 3 will be judged by 75% of the questions and outcomes 4 and 5 will be judged by 25 % of questions.

(MA 20002) Linear Algebra and Univariate Calculus

S.Y. B. Tech. (for Students Directly admitted to S.Y. after their Diploma)

Teaching Scheme:
Lectures: 4 hrs/week
Tutorials: 1hr/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course students will be able to :

1. know matrices, linear equations, and determinants, recall basic vector algebra, differentiability of functions of single variable, and mean value theorems.
2. understand basic concepts such as vector spaces, linear dependence / independence of vectors, basis.
3. analyse and calculate eigen values, eigen vectors, rank nullity of a matrix, sketch function graphs, evaluate improper integrals, calculate integrals using special techniques, apply various tests of convergence.
4. prove theorems, evaluate length / area / volume using single integrals.
5. apply concepts of linear algebra and univariate calculus to various applications including real life problems.

Unit I: (15 Hrs)

Matrices and linear equations: basic properties of matrices, row operations and Gauss elimination, Determinants and their basic properties. Basic concepts in linear algebra: vector spaces, subspaces, linear independence and dependence of vectors, bases, dimensions. Rank of a matrix. Applications to systems of linear equations.

Unit II: (12 Hrs)

Rank-nullity theorem, Eigen values, Eigen vectors and their basic properties, diagonalization.

Unit III: (12 Hrs)

Review of limits, continuity and differentiability, Mean value theorems, Taylor's theorem, local extrema, increasing and decreasing functions, concavity, points of inflection.

Unit IV: (13 Hrs)

Surface area, integrals by special techniques: reduction formulae, arc length, solids of revolution, improper integrals, tests for convergence, Gamma and Beta functions.

Text Books:

- Thomas' Calculus (14^{th} edition) by Maurice D. Weir, Joel Hass, Frank R. Giordano, Pearson Education.

- Advanced Engineering Mathematics (10th edition) by Erwin Kreyszig, Wiley eastern Ltd.

Reference Books:

- Introduction to Linear Algebra (2nd edition) by Serge Lang, Springer.
- Elementary Linear Algebra (10th edition) by Howard Anton and Chris Rorres, John Wiley and sons.
- Calculus for Scientists and Engineers by K.D Joshi, CRC Press.
- A Course in Calculus and Real Analysis (1st edition) by Sudhir Ghorpade and Balmohan Limaye, Springer-Verlag, New York.
- Advanced Engineering Mathematics by C.R. Wylie, McGraw Hill Publications, New Delhi.
- Advanced Engineering Mathematics (7th edition) by Peter V. O' Neil, Thomson. Brooks / Cole, Singapore.
- Differential Calculus by Shanti Narayan, S. Chand and company, New Delhi.
- Applied Mathematics Vol. I (Reprint July 2014) by P.N. Wartikar and J.N. Wartikar, Pune Vidyarthi Griha Prakashan Pune.
- Advanced Engineering Mathematics by Chandrika Prasad and Reena Garg, Khanna Publishing Company Private Limited, New Delhi.

Note 1 :

- To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
- To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
- To measure CO3, questions will be based on applications of core concepts.
- To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
- To measure CO5, some questions may be based on self-study topics and also comprehension of unseen passages.

Note 2 :

All the Course outcomes 1 to 3 will be judged by 75% of the questions and outcomes 4 and 5 will be judged by 25 % of questions.

(AS 20001) Biology for Engineers

Teaching Scheme:
Lectures 3 hrs/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course, students will be able to :

1. correlate basic biological and engineering principles in the organizational structure of living systems at molecular, cellular and system level
2. appreciate the applications of energy transformations in biological systems in view of solving energy conservation targets
3. analyze information processing in biological systems
4. evaluate basic biological processes of transport, communication and defence mechanism with engineering perspectives
5. apply the modern developments in biology and engineering for society, human health and environmental sustainability.

Unit I: (6 Hrs)

Biomolecules and biopolymers: Structure and Function, Organic and inorganic molecules; Unique Properties of water, Vitamins and Minerals, Carbohydrates, Lipids, Amino Acids and proteins, Nucleic Acids (DNA and RNA)

Unit II: (6 Hrs)

Levels of organization of life: Cell as a basic unit of life, prokaryotic and eukaryotic cells, microbes, plant and animal cells; Cell organelles – structure and function; Cellmembrane, Levels of organization: cells, tissues, organs, systems & organism

Unit III: (6 Hrs)

Energy transformations in Chloroplast: Photosynthesis (photochemical & biochemical phase) and ATP generation, Aerobic and anaerobic systems. Energy transformations in Mitochondria: Cellular respiration (glycolysis and Kreb cycle) and ATP generation. Bioenergetics: Thermodynamic principles applied to biology, negative entropy changes in biological systems, Free Energy, Chemical Equilibrium.

Unit IV: (6 Hrs)

Expression and Transmission of Genetic Information: DNA replication, Enzyme driven Process of DNA cloning, Protein synthesis- Transcription & translation Techniques for optimization: At molecular level: Recombinant DNA Technology, DNA hybridization, PCR, DNA microarray

Unit V: (6 Hrs)

Transport Phenomena in Biological Systems: Membrane channels and ion channels; Fluid flow and mass transfer (nutrients & ions); In plants: Xylem and Phloem; In animals: Blood and Lymph

Transport of gases: Oxygen and Carbon Dioxide Heat Transport - Body temperature regulation. Communication: Cell junctions, Cell-cell communications– cell signaling, Hormones, Pheromones and cell behavior. Defense mechanisms: In plants: Herbivory, secondary metabolites in animals: Innate and Adaptive immune systems.

Unit VI: **(6 Hrs)**

Engineering perspectives of biological sciences: Biology and engineering crosstalk – At cell level: Hybridoma Technology ,At tissue level: Plant Tissue Culture, Animal Tissue Culture; Tissue Engineering: Principles, methods and applications Introduction to Biomimetics and Biomimicry, nanobiotechnology

Reference Books:

- Lodish H, Berk A, Zipursky SL, et al. (2000) Molecular Cell Biology. W. H.Freeman.
- Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2000). Lehninger principles of biochemistry. New York: Worth Publishers.
- Rao CNR, et.al. Chemistry of Nanomaterials: Synthesis, Properties andApplications.
- Eggins BR. (1006) Biosensors: An Introduction. John Wiley & SonsPublishers.
- Palsson B.O. and Bhatia S.N. (2009) Tissue Engineering. Pearson.
- Yoseph Bar-Cohen (2005). Biomimetics- Biologically Inspired Technologies
- Joseph D. Bronzino, John Enderle, Susan M. Blanchard (1999) Introduction to Biomedical Engineering.
- Routledge Taylor and Francis group (2012). Introduction to Bio-medical Engineering technologies

Table 1.1: For Teachers: Additional topics to be discussed with students in accordance with relevant biological topics (in branch-wise manner)

Disease/ Disorder	Physiology	Diagnosis	Therapeutics		Medical procedure
			Biomaterials	Instrumentation	
Cardiovascular disease	Heart – electrical stimulation and mechanical pumping	ECG, Angiography	Stents for angioplasty	Heart lung machines	Angioplasty, By-pass surgery
Bone/skull injuries	Biomechanics of musculo-skeletal system	Medical imaging technologies Arthroscopy	Prosthetics	Arthroscopy Biomechanics Prosthetics	Joint replacement Total hip Replacement Rehabilitation engg
Kidney disorders	Functioning of Kidney	Medical imaging technologies	Filtration membranes	Dialyser	Dialysis

[ICE(IF)-20002] Sensors and Automation

(Offered by Department of Instrumentation and Control)

Teaching Scheme:
Lectures 1 hr/week
Practical: 2 hrs/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course, students will be able to :

1. Interpret the characteristics of the transducers/sensors
2. Select transducers/sensors for specific applications
3. Understanding of working principle of Programmable Logic Controller (PLC) and Distributed Control Systems (DCS)
4. Understanding the concept of Industrial Automation

Unit I: (7 hrs)

Basics of Sensors: Concepts and terminology of transducer, sensor, sensor classifications and characteristics (Static and dynamic), Working principle, characterization and applications of: strain gauges, LVDT, capacitive, RTD, thermocouple, thermistor, Solid-State, pressure, optical, chemical sensors, integration of sensors for IOT and Industry 4.0 applications.

Unit II: (7 hrs)

Industrial Automation: Industrial Automation: concept, automation components, necessity and working principle, block schematic of Programmable Logic Controller (PLC). Input & Output modules (AI, DI, AO, DO), Introduction to Ladder Programming, introduction to Distributed Control Systems (DCS). Industrial automation leads to Industrial IOT and Industry 4.0.

List of Practical

1. Case study /Characterization of RTD/semiconductor Temp IC
2. Characterization of level sensors
3. Characterization of strain gauge/ Displacement measurement using LVDT/ Encoders
4. Characterization of PH, Conductivity, color sensor
5. Introduction to PLC programming languages (ladder programming)
6. Ladder Programming for relay, coil, On/OFF, Sequencing of motors
7. Ladder Programming with Timers/Counters
8. Ladder Programming for Pick and Place type of robotics application.

Text Books:

- B. C. Nakra and K. K. Choudhari, "Instrumentation Measurements and Analysis" by, Tata McGraw Hill Education, Second ed., 2004.
- C.D. Johnson, "Process Control Instrumentation Technology" , Pearson Education Limited , eighth ed., 2014

(MT 20005) Materials Testing Laboratory

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme:
Continuous evaluation: 40 Marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of the laboratory work, students will demonstrate the ability to:

1. Perform tensile and compression test on universal testing machine and analyze the results obtained.
2. Select and perform appropriate hardness test for a given material.
3. Identify the situation under which impact testing would be needed and able to perform the test.
4. Perform torsion and bend tests.
5. Select the appropriate non-destructive test and perform it.

List of Experiments / Assignments:

1. Study of universal testing machine: Principle and Construction.
2. Tensile Test: to conduct tensile test on standard of M.S./C.I. Plotting of stress- Strain curves and comparison of test results.
3. Study the effect of gauge length on percent % elongation.
4. Study of Hardness Testing Machines such as I) Brinell II) Vickers III) Poldi.
5. Study of Rockwell /Rockwell superficial hardness testing machines and testing various materials with these machines using different loads and indenters (i.e. scales).
6. Study of microhardness and Shores Scleroscope techniques.
7. Compression Test on C.I. /Aluminium or Brass.
8. Study of the effect of L/D ratio on the compression test results.
9. Study of pendulum impact testing machine and conducting impact test on samples of various materials /with different notches and interpretation of results.
10. Torsion test on wire samples of mild steel/spring steel.
11. Bend test on steel plate and bar samples.
12. Study of dye penetrant, magnetic particles, eddy current, radiography, ultrasonic methods.

(MT20001) Structure and Properties of Materials

Teaching Scheme:
Lectures: 2 hrs/week
Tutorials: 1hr/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course, students will be able to :

1. Understand basic structure of engineering materials.
2. Understand theoretical basis of mechanical, electrical, magnetic, optical, thermal and dielectric properties.
3. Analyze, interpret and solve materials design problems.
4. Correlate structure of materials with their properties.

Unit I: (7 Hrs)

Classification of engineering materials, levels of structure, structure-property relationships in materials, primary and secondary bonds, variation in bonding character and properties, Space lattice, metal structures, unit cells, crystallographic directions and planes, Miller indices, single crystal, polycrystalline materials, anisotropy and non-crystalline solids.

Unit II: (7 Hrs)

Metallic crystal structures: FCC, BCC and HCP, linear and planar densities, polymorphism and allotropy, Point, line, planar and surface imperfections, atomic vibrations, screw and edge dislocations, mixed dislocations, energy of dislocations, the force required to move dislocation and multiplication of dislocations.

Unit III: (7 Hrs)

Atomic model of elastic behavior, the modulus as a design parameter, rubber like elasticity, relaxation processes, spring-dashpot models, micro plasticity of crystals, slip systems, critical resolved shear stress and schmid's law, mechanism of plastic deformation and twinning.

Unit IV: (7 Hrs)

Engineering and true stress strain diagrams, yield and tensile strength, compression and shear strength, ductility and brittleness, hardness, stiffness, resilience, toughness, fatigue and creep resistance, ductile and brittle fracture, transition temperature, Material testing standards, Non-destructive testing- Magnetic particle, Dye penetrant, Sonic, Ultrasonic, Radiography, Eddy current testing.

Unit V: (7 Hrs)

Resistivity range, the free electron theory, conduction by free electrons, energy gap in solids, super conducting phenomenon, magnetic moments due to electron spin, ferromagnetism and related phenomena, dielectric properties.

Unit VI: (7 Hrs)

Refractive index, reflectance, transparency, translucency and opacity, colour and luminescence, heat capacity, thermal expansion, thermal conductivity and thermal shock.

Text Books

- V. Raghavan, "Materials Science and Engineering", Prentice Hall of India Publishing Sth Edition 2006.
- Askeland & Phule, "Material Science & Engineering of materials 4th Edition, 2003.
- W.D. Callister, "Materials Science and Engineering", 8th Edition, 2006.

Reference Books:

- W. F. Smith - Foundation of Materials Science and Engineering, McGraw-Hill International, 5"Edition, 2009, New York.
- S. O. Kasap - Principles of Electronic Materials and Devices. Tata McGraw-Hill Publication, 3Edition, 2006, New York
- K. Schroder, Electronic Magnetic and Thermal properties of Solids, Marcel Dekker, 1" Edition,1978, New York.

(MT20002) Principles of Physical Metallurgy

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course, students will be able to :

1. Describe techniques used for quantitative metallography.
2. Draw the equilibrium diagram, identify the various phases and calculate the relative amounts of phases for binary and ternary alloy system.
3. Draw and label Iron -Iron carbide diagram and iron -Graphite phase diagram and define various phases associated with it.
4. Develop structure and properties correlation for various steels and cast irons.
5. Classify Copper base, Aluminum base, Magnesium base and Titanium base alloys and predict their microstructures.

Unit I: **(7 Hrs)**

Metallography: Specimen preparation for microscopic examination for different metals and alloys, electrolytic polishing, etching and mounting techniques, metallurgical microscope, Quantitative Metallography, volume fraction of phases by area, linear analysis, point counting methods for grain size and phase measurements, grain size significance and measurement, macroscopic examination methods, types of non metallic inclusions rating.

Unit II: **(7 Hrs)**

Solid Solutions and Phase diagrams: Solid solution and intermediate phases, Gibb's phase rule, phase equilibria, alloy phases and compounds, Cooling curves, Hume Rothery's rule of solid solution formation, Solidification, Binary equilibrium diagrams and related microstructures, Lever rule application, numerical for phase analysis, Non equilibrium cooling of alloys, Ternary diagrams-simple.

Unit III: **(7 Hrs)**

Iron-Carbide system: Iron-Iron carbide equilibrium diagram, critical temperatures, plain carbon steels, slow cooling of steels and cooling curves, effect of impurities, property variation with microstructure, classification and specifications of steels.

Isothermal transformation diagrams: Plotting, Transformation to pearlite, bainite and martensite, Continuous cooling transformation diagram, Effect of carbon, grain size and alloying elements, importance of IT and CCT diagrams to heat treatment.

Unit IV: **(7 Hrs)**

Cast Irons: Fe-Graphite diagram, Factors controlling microstructure, Types of cast irons: gray, White, malleable cast, Nodular, Chilled and Mottled cast iron, Step bar test, Alloy cast irons: Ni hard, Ni resist, Silal, Austempered ductile iron.

Unit V: **(7 Hrs)**

Copper and Copper Base Alloys: Phase diagrams of Cu based alloys: brasses, bronzes, Sn Bronzes, Si Bronzes, Al Bronzes, Be Bronzes, Microstructure, Properties and applications of various types of brasses and bronzes, Cupronickel and nickel silvers.

Unit VI: **(7 Hrs)**

Light metal alloys: Classification and temper designation of aluminium alloys, precipitation hardening of Al-Cu system, Modification treatment of Al-Si system, classification, properties and applications: Magnesium & its alloys, Titanium & its alloys.

Text Books:

- S. H. Avner, Introduction to Physical Metallurgy, Tata McGraw-Hill Education, 1997.
- Askeland & Phule, Material science & Engineering of materials,4th edition, Thomson Publication,2003.
- R. A. Higgins, Engineering Metallurgy: Applied Physical Metallurgy Volume -I, R.E. Krieger Publishing Company, 1983.

- Vijendra Singh, Physical Metallurgy, Standard Publishers Distributors, 2005.
- V. Raghvan, Physical Metallurgy, PHI learning Pvt. Ltd.,Second edition 2006.
- W.F.Smith, Principles of Material Science and Engineering, 2nd edition, McGraw-Hill Companies; 1990.

Reference Books:

- Robert E. Reed Hill, Physical Metallurgy Principles, 2nd edition, Van Nostrand, 1972.
- ASM Handbook Volume 9: Editor George F. Vander Voort, ASM International, 2004.
- ASM Handbook Volume 3: Alloy Phase diagram, ASM International, 1992.

(MT20003) Introduction to Ceramic Engineering

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course, students will be able to :

1. know the importance of chemistry/stoichiometry, bonding, crystal structure and microstructure of ceramic materials in arriving at the final properties,
2. learn the ceramic processing techniques starting from powder making to fabrication the finished products,
3. analyze and solve the problems related to ceramics engineering
4. comprehend microstructures of advanced ceramics
5. understand the important properties and applications of ceramics.

Unit I: (7 Hrs)

Introduction to ceramics: definition of ceramics, Comparison of properties with metals and polymers, electronegativity, introductory band theory, important ceramics structures, coordination, ionic radii, Kroger Vink notation of point defects, defect reactions, stoichiometry calculations, density-theoretical and experimental density calculations, concept of energy well and its applications.

Unit II: (7 Hrs)

Phase equilibria: Phase rule, one component system displacive and reconstructive transformation, binary system - eutectic & incongruent melting, phase separation, solid solutions, free energy composition and temperature diagram.Zirconia phase diagram study and its transformation toughening.

Unit III: (7 Hrs)

Ceramic powder processing methods: Ball milling, Chemical vapour deposition, Sol-gel, Polymer pyrolysis, Co-precipitation, Spray Drying/pyrolysis, powder characterization methods: Laser particle size analyzer, BET surface analysis, introduction to XRF and XRD methods.

Unit IV: (7 Hrs)

Forming methods: Conventional compaction route (ceramics route) and Novel processing techniques to finished products - Slip and Tape casting, gel casting, CIP, HIPping, extrusion, injection moulding and spray forming, DMO and RBAO.

Unit V: (7 Hrs)

Sintering theory and microstructure development: Initial, intermediate and final stage, Different mass transport mechanisms, Sintering parameters-Materials and Processing, Role of defects during sintering, Solid and liquid phase sintering, Grain growth and Ostwald ripening, pore-grain boundary interactions, Reaction sintering, sintering of nanomaterials, Characterization methods like dilatometry to determine sintering temperature, compressive strength, 3-4 point bend test and Weibull modulus.

Unit VI: (7 Hrs)

Important ceramics - prop. and appl.: Structural, Ionic conducting, Dielectric - ferroelectric and piezoelectric, Thermal (including furnace refractories), Magnetic &Optical ceramics.

Texts/References:

- C. Barry Carter, M. Grant Norton, Ceramic Materials- Science and Engineering, Second Edition, Springer New York, 2013
- M. N. Rahaman, Ceramic Processing and Sintering, 2nd edition, Marcel Dekker Inc., NY, 2003.
- W.D. Kingery, H.K. Bowen and D.R. Uhlman, Introduction to Ceramics, Ceramic Science and Technology, John Wiley and Sons, Singapore, 1991.
- M.W. Barsoum, Fundamentals of Ceramics, 2nd edition, IoP Publications, UK, 2003
- C.J. Brinker, D.E.Clark, and D.R. Ulrich, Better Ceramics through Chemistry, North Holland,1984.
- F.F.Y. Wang, Ceramic Fabrication Processes, Academic Press, 1976.
- J. Reed, Introduction to Principles of Ceramic Processing, 2nd Ed., John Wiley & Sons1995

(MT 20004) Principle of Physical Metallurgy Laboratory

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme:
Continuous evaluation: 40 Marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of laboratory work, students will demonstrate the ability to:

1. Prepare the samples for microscopic examination and understand the concepts of quantitative metallography.
2. Identify the microstructures of various ferrous and nonferrous alloys and develop structure and properties correlation for various applications.
3. Analyse the microstructures of different metals and alloys using optical microscopy and image analysis software for characterization

List of Experiments:[Any 08 Experiments]

1. Preparation of specimens for microscopic examination: steels, copper alloys and aluminium alloys, cast irons.
2. Preparation of specimen for microscopic examination by hot mounting and cold mounting methods.
3. Study of etching mechanism of single phase and two phase alloys and preparation of etching reagents for plain carbon steel, cast iron, copper base alloys and aluminium alloys.
4. Study of Metallurgical microscope.
5. Observation and drawing of different morphologies of grains: equiaxed dendrites, columnar dendrites, cellular structure, equiaxed grains, polygonal grains, elongated grains.
6. Grain size measurement by ASTM comparison method, Heyn's Intercept method, Jefferies planimetric method.
7. Observation of microstructures using image analyzer, Quantitative Metallography software, models and tools for grain size, shape, phases distribution and porosity.
8. Observation and description of microstructures of annealed plain carbon steels.
9. Observations and description of microstructures belonging to various cast irons.
10. Observations and description of microstructures belonging to various brasses, bronzes, wrought and cast aluminium alloys.
11. Student will bring unknown metallic sample; prepare it for metallographic observation; observe and describe the microstructure with identification of phases present in it.

(MT20006) Mechanical Technology

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course students will be able to :

1. Understand the material requirements for various components of power producing and power absorbing devices.
2. Apply their knowledge towards solving the numerical based on I.C. Engine, Compressors, Steam turbines and other systems.
3. Understand machine tools, mechanism and accessories used in various manufacturing processes.
4. Get awareness about the importance of limit, fit and tolerances in while designing a system.
5. Understand the importance of Metallurgical engineer while designing systems in view of new/alternative materials.

Unit I: (7 Hrs)

IC Engines: Air standard Otto, Diesel cycles, systems classifications of I.C. engines such as fuel supply system for SI & CI engines, ignition system, cooling system, lubrication system, Performance of IC Engine –Indicated power, Brake power, Thermal efficiency, Specific fuel consumption.

Unit II: (7 Hrs)

Fuels: Boilers & steam Turbines: Boilers: Classification, Essential of a good boiler, Mounting and accessories, Efficiency calculations. Steam turbines: Types, construction, Working, Compounding, Velocity diagram, Calculation of diagram efficiency.

Unit III: (7 Hrs)

Compressor: Uses of compressed air. Reciprocating compressors- effect of clearance, FAD calculation, efficiency calculation, multistaging, Rotary compressors-elementary treatment. Gas Turbine: Classification, Brayton cycle, thermal efficiency.

Unit IV: (7 Hrs)

Pumps & Water turbine: Pumps: Rotary & reciprocating pumps-construction & operation, pumps performance, their selection. Water Turbine: Types, constructional details.

Unit V: (7 Hrs)

Machining of Materials: Machining basics, tool geometry, depth of cut, feed, speed, chip formation, machine tools like lathe, turning, knurling, screw cutting, drilling, milling, planning, grinding machines, factors affecting machinability, coolants, non-conventional machining processes like EDM, ECM, water jet and ultrasonic cutting.

Unit VI: **(7 Hrs)**

Metrology: Interchangeability, limits, fits and tolerance, linear measurement, comparators, slip gauges, angular measurements, screw thread measurements, Surface roughness measurements, interferometer, profile projector.

TEXT BOOKS:

- R.K. Rajput, "Thermal Engineering", Laxmi Publications.
- Modi, Seth, Hydraulicsand Hydraulics Machinery.
- R. K. Jain, "Engineering Metrology", Khanna Publisher, Delhi.
- Nakra Choudhary, "Instrumental Measurement and analysis", Tata McGraw Hill.
- D. S. Kumar, "Mechanical measurement and control", Metropolitan N Delhi.
- Chapman, „Workshop technology vol. I, II& III, Edward Arnold Publication Ltd. London
- Hajara Chaudhary S.K., „Workshop Technology, Vol.I & II", Media Prom & Publication, Mumbai.
- R. K. Jain, „Production technology", Khanna Publications.

REFERENCE BOOKS:

- Y.A. Cengel, "Thermodynamics – an Engineering approach", Tata McGraw Hill.
- Eastop, Mc"conkey, "Applied Thermodynamics", Addison Wesley Longman
- Publishers.
- IS codes for vernier caliper, micrometers, slip gauges, angle gauges, limits, fits, tolerances, gauges, geometrical tests etc.
- Collette & Hope, "Engineering Measurement", ELBS publisher
- HMT Hand book- Production Technology
- P. C. Sharma, „ Production Engineering", Khanna Publications.

(MT 20007) Mechanical Technology Laboratory

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme:
Continuous evaluation: 40 Marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of laboratory work, students will demonstrate the ability to:

1. Perform various calculations related to working of boiler, brake thermal effciency, injector pump
2. Use surface engineering/characterization techniques like surface roughness measurement, interferometer etc.

List of Experiments:

1. Study of Solex carburettor & Bosch type fuel injector pump.

2. Test on Diesel/Petrol engine to determine BP, BSFC, Brake thermal efficiency

3. Study of boiler mountings & accessories
4. Trial on reciprocating air compressor
5. Trial on centrifugal pump
6. Machining on Lathe, milling machine and drilling machine
7. Surface roughness, Angular, screw thread measurement (Any Two)
8. Interferometer, profile projector measurements (Any Two)

(PH 20001) Foundation of Physics

(for Students Directly admitted to S.Y. after their Diploma)

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Unit I: (7 Hrs)

Oscillations, Waves & Light: SHM, characteristics of SHM, Waves, Travelling waves and its equation, Types of waves, Principle of Superposition, Stationary waves, Light as an EM Wave, graphical representation of EM wave, Interference of light due to thin film (uniform thickness), Antireflection coating, Total Internal reflection, Introduction to Optical fiber and its design.

Unit II: (7 Hrs)

Atomic Nucleus and Nuclear energy: Atomic Nucleus, Nuclear force, Static properties of nucleus, Mass defect and Binding energy, Law of radioactive decay, Half-life, Applications of radioactivity, Nuclear reactions, Q-value of nuclear reaction, Nuclear fission, chain reaction and Nuclear energy.

Unit III: (7 Hrs)

Electrostatics: Coulomb's law in vector form, the electric field, Continuous charge distribution (Line, Surface& Volume)**,** Divergence of E, application of Gauss's law (simple 2 D problems)**,** The curl of E (Faraday's Law), the concept of electric potential V, Potential due to continuous charge distribution.

Unit IV: (7 Hrs)

Magneto statics: Steady state current (line current, Surface current and volume current), current densities, Magnetic field due to steady current (Biot-Savart's law), divergence and curl of B, Statement of Ampere's Law (with simple examples).

Unit V: (7 Hrs)

Elements of Thermodynamics: Concept of Temperature, Terminology in Thermodynamics, Thermodynamic work, Caparison for Heat and Work, First Law and its applications, Heat engine and Thermal efficiency, Second law, Entropy, Disorder of system, Third law and Principle of Unattainability Absolute Zero (Nernst's Theorem).

Unit VI: (7 Hrs)

Modern physics: Drawbacks of Classical Mechanics, Plank's quantum hypothesis, Dual nature of matter, De-Broglie's hypothesis, light as a particle (Compton's experiment), De-Broglie's wavelength, Heisenberg's uncertainty principle (position and momentum), Wave function, its properties, conditions and its physical significance, Free particle solution of wave function.

References Books:

- Engineering Physics, Avadhanulu and Kshirsagar.
- Halliday-Resnick (Sixth edition) "Optics", Brij Lal (S. Chand publication)
- Classical Electrodynamics, David Griffith (Pearson India limited)
- H.C. Verma & Halliday-Resnick (Sixth edition), B. B. Laud
- Modern Physics, S. Chand Publication.
- Concepts of Modern Physics, Arthur Beiser, Tata McGraw – Hill Edition.

Semester IV [M-Group]

(MA 20004) Vector Calculus and Partial Differential Equations

Teaching Scheme:
Lectures: 2 hrs/week
Tutorials: 1hr/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course students will be able to :

1. know and recall double / triple integrals, vector differentiation, vector integration, partial differential equations.
2. understand basic concepts of co-ordinate systems, iterated integrals, gradient, divergence and curl.
3. evaluate multiple integrals, find area / mass / volume using multiple integrals, evaluate line integrals and surface integrals.
4. prove theorems, apply Green's / Stoke's / Divergence theorem to different type of problems, model one dimensional heat / wave equations, solve partial differential equations.
5. apply concepts of vector calculus and partial differential equations to various applications including real life problems.

Unit I: **(10 Hrs)**

Double integrals in Cartesian and polar co-ordinates, iterated integrals, change of variables, triple integrals in Cartesian, spherical and cylindrical co-ordinates, substitutions in multiple integrals, Applications to Area, Volume, Moments and Centreof Mass.

Unit II: **(7 Hrs)**

Vector differentiation, gradient, divergence and curl, line and surface integrals, path independence, statements and illustrations of theorems of Green, Stokes and Gauss, arc length parameterization, applications.

Unit III: **(9 Hrs)**

Partial differential equations with separation of variables, boundary value problems: vibrations of a string, heat equation, potential equation, vibrations of circular membranes.

Text Books:

- Thomas' Calculus (14^{th} edition) by Maurice D. Weir, Joel Hass, Frank R. Giordano, Pearson Education.
- Advanced Engineering Mathematics (10^{th} edition) by Erwin Kreyszig, Wiley eastern Ltd.

Reference Books:

- Advanced Engineering Mathematics by C.R. Wylie, McGraw Hill Publications, New Delhi.
- Functions of several variables by Wendell Fleming, Springer-Verlag, New York.
- Partial Differential Equations (4^{th} edition) by Fritz John, Springer.
- Advanced Engineering Mathematics (7^{th} edition) by Peter V. O' Neil, Thomson.Brooks / Cole, Singapore.
- Advanced Engineering Mathematics (2^{nd} edition) by Michael D. Greenberg, Pearson Education.
- Advanced Engineering Mathematics by Chandrika Prasad and Reena Garg, Khanna Publishing Company Private Limited, New Delhi.

Note 1 :

- To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
- To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
- To measure CO3, questions will be based on applications of core concepts.
- To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
- To measure CO5, some questions may be based on self-study topics and also comprehension of unseen passages.

Note 2 :

All the Course outcomes 1 to 3 will be judged by 75% of the questions and outcomes 4 and 5 will be judged by 25 % of questions.

(MA 20005) Multivariate Calculus and Differential Equations

(for Students Directly admitted to S.Y. after their Diploma)

Teaching Scheme:
Lectures: 4 hrs/week
Tutorials: 1hr/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcome:

At the end of this course, students will be able to :

1. know first order ordinary differential equations, list Laplace transform formulae, define functions of several variables, double / triple integrals, vector differentiation, vector integration, and partial differential equations.

2. understand basic concepts of higher order ordinary differential equations, level curves and level surfaces, co-ordinate systems, iterated integrals, gradient, divergence and curl.
3. solve linear differential equations using different methods, find Laplace transforms of functions using properties and theorems, evaluate directional derivatives and extreme values, evaluate multiple integrals, find area / mass / volume using multiple integrals, evaluate line integrals and surface integrals.
4. prove theorems, solve ordinary differential equations using Laplace transforms, apply Green's / Stoke's / Divergence theorem to different type of problems, model one dimensional heat / wave equations, solve partial differential equations.
5. apply concepts of multivariate calculus and differential equations to various applications including real life problems.

Unit I: **(9 Hrs)**

Review of first order differential equations, linear differential equations, homogeneous higher order linear differential equations, non-homogeneous higher order linear differential equations with constant coefficients (method of undetermined coefficients and method of variation of parameters).

Unit II: **(7 Hrs)**

Laplace Transforms, its properties, Unit step function, Dirac delta functions, Convolution Theorem, periodic functions, solving differential equations using Laplace transform.

Unit III: **(7 Hrs)**

Functions of several variables, level curves and level surfaces, partial and directional derivatives, differentiability, chain rule, local extreme values and saddle points.

Unit IV: **(12 Hrs)**

Double integrals in Cartesian and polar co-ordinates, iterated integrals, change of variables, triple integrals in Cartesian, spherical and cylindrical co-ordinates. application to area ,mass and volume.

Unit V: **(10 Hrs)**

Vector differentiation, gradient, divergence and curl, line and surface integrals, path independence, statements and illustrations of theorems of Green, Stokes and Gauss.

Unit VI: **(7 Hrs)**

Partial differential equations with separation of variables, boundary value problems: vibrations of a string, one dimensional heat equation.

Text Books:

- Thomas' Calculus (14th edition) by Maurice D. Weir, Joel Hass, Frank R. Giordano, Pearson Education.
- Advanced Engineering Mathematics (10thedition) by Erwin Kreyszig, Wiley eastern Ltd.

Reference Books:

- Calculus for Scientists and Engineers by K.D Joshi, CRC Press.
- A Course in Multivariate Calculus and Analysis by Sudhir Ghorpade and Balmohan Limaye, Springer Science and Business Media.
- Differential Equations with Applications and Historical notes by George Simmons, Tata Mc-Graw Hill publishing company Ltd, New Delhi.
- Functions of several variables by Wendell Fleming, Springer-Verlag, New York.
- Partial Differential Equations (4th edition) by Fritz John, Springer.
- Advanced Engineering Mathematics by C.R. Wylie, McGraw Hill Publications, New Delhi.
- Advanced Engineering Mathematics (7th edition) by Peter V. O' Neil, Thomson.Brooks / Cole, Singapore.
- Advanced Engineering Mathematics (2nd edition) by Michael D. Greenberg, Pearson Education.
- Advanced Engineering Mathematics by Chandrika Prasad and Reena Garg, Khanna Publishing Company Private Limited, New Delhi.

Note 1 :

- To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
- To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
- To measure CO3, questions will be based on applications of core concepts.
- To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
- To measure CO5, some questions may be based on self-study topics and also comprehension of unseen passages.

Note 2 :

All the Course outcomes 1 to 3 will be judged by 75% of the questions and outcomes 4 and 5 will be judged by 25 % of questions.

(MLC 20001) Professional Laws , Ethics, Values & Harmony

Teaching Scheme:
Lectures: 1 hr/week

Examination Scheme:
Continuous Evaluation: 100 marks
Presentation/Test/Assignment

Course Outcome:

At the end of this course students will be able to :

1. Comprehend the need and importance of Law - for individuals, Companies , society and the nation.
2. Relate laws like The Contract Law, Workplace Law , IPR… to the Engineering Profession.
3. Appraise the importance of being a law-abiding person by understanding the correlation between Rights, Duties and Responsibilities.
4. Self-explore by using different techniques to live in harmony at various levels.
5. Analyze themselves and understand their position with respect to the moral and ethical character needed for a successful and satisfactory work life.

Unit I: (2 Hrs)

Significance of Law :Concept, need, framework of law; Types of laws for individuals and companies; Importance of law to the citizens, business , society and the nation; Law of Torts and the basics to protect oneself and the company.

Unit II: (3 Hrs)

Law for Engineers: Relevance of law to the Engineers; Engineering profession, business and Contract Law. Law affecting the Workplace : Responsibilities / Duties of Employers / Employees;Hiring Practices Introduction to Intellectual Property Law (IPR)

Unit III: (1 Hr)

Code of conduct : Professional Code of Conduct for Engineers; Correlation between Rights, Duties and Responsibilities Relationship between Law and Ethics.

Unit IV: (2 Hrs)

Self Awareness : Understanding oneself and others; Johari Window- Concept, explanation, implementation

Unit V: (2 Hrs)

Needs ans self :Needs and its importance; Creating goals and managing needs to systematical actualization

Unit VI: (2 Hrs)

Ethics and Values : Professional ethics and their importance for students; Understanding the importance of values & their application in everyday life

Reference Books:

- Business Law- By Saroj Kumar
- Law of Contract- By Avtar Singh
- Business Law- By G K Kapoor
- Business & Commercial Laws – By Sen & Mitra
- Business Law for Engineers -by Calvin Frank Allen
- Hilgard, E. R.; Atkinson, R. C. & Atkinson, R.L. (1975). *Introduction to Psychology*. 6th Edition. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.
- Govindarajan, M; Natarajan, G. M. & Senthilkumar, V.S. (2013). *Professional Ethics & Human Values*. Prentice Hall: New Delhi
- Gogate, S. B. (2011). Human Values & Professional Ethics. Vikas Publishing: New Delhi.
- Jayshree Suresh, Raghavan B.S.(2016). Human Values & Professional Ethics: S Chand & Company.Pvt.Ltd: New Delhi.

(HS 20001) Innovation and Creativity

Teaching Scheme:
Lectures: 1 hr/week

Examination Scheme:
To be declared by the teacher

Course Outcomes:

At the end of the Course, Student will be able to:

1. Discover the creative / innovative side within herself/himself.
2. Hone entrepreneurial and leadership skills within his/her personality.
3. Develop new ways of thinking and Learn the entire innovation cycle from Ideation to Go-To-Market.
4. Study frameworks, strategies, techniques and business models for conceived ideas.
5. Develop skills for evaluating, articulating, refining, and pitching a new product or service.

Syllabus:

Introduction to Innovation, Personal thinking preferences, ‘Innovation’ mind set, Everyday creativity and eliminating mental blocks, Introduction to Innovation, Creative thinking techniques, Innovation types, Idea management and approaches, Teaming techniques for creativity, Idea Conception, Idea Scoping, Self-Evaluation, Idea Brainstorming sessions, Idea Verification, Market Evaluation, Concept Evaluation, Idea Verification, Prototype Evaluation, Protection/Patent review, Innovation Case Study, Idea Presentations, Idea Incubation, Product and Market Plan, Product and Market Development, Innovation Case Studies, Idea Incubation and Product Launch, Marketing and selling, Post Launch Review

Reference Books:

- Jeff Dyer, Hal Gregersen, Clayton M. Christensen, "The Innovator's DNA: Mastering the Five Skills of Disruptive Innovators, Harvard Business Review Press, 2011.
- Paddy Miller, Thomas Wedell-Wedellsborg, "Innovation as Usual: How to Help Your People Bring Great Ideas to Life , Harvard Business Review Press, Kindle Edition.

[(EE(IF)-20001)] INDUSTRIAL ELECTRONICS AND ELECTRICAL DRIVE SYSTEMS

Teaching Scheme:
Lectures: 1 hr/week
Practical: 2hrs/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of this course, the students should be able to,

1. Select a suitable power electronics converter for various industrial applications.
2. Choose the electrical motors and drive for various industrial application.
3. Understand and analyse various industrial electronics systems.
4. Use an appropriate sensor for various industrial applications.

Unit I: (3 Hrs)

Power Electronics Converters: SCR, MOSFET, IGBT: characteristics, triggering, ratings and applications. Basics of controlled rectifiers with RL and RLE loads, DC to DC converters (buck, boost and buck-boost), inverters (bridge, stepped wave, SPWM), four quadrant operation, UPS, THD and filtering requirements.

Unit II: (3 Hrs)

Electrical Motors : Operation, types, characteristics, control and applications of: DC, induction and synchronous motors. Construction, working, characteristics, control and applications of:- stepper motors, servomotors, reluctance motors, AC series motors, BLDC motor and PMSM motor.

Unit III: (4 Hrs)

Electrical Drives: Basics of electric drives, AC motors drive and DC motor drives, four quadrant operation, choice of electrical drives, load speed-torque characteristics. Electrical drives for various applications like rolling mills, cranes, winches, traction, shear press, mechanical press, power mills, textile industry, coal and mining industry.

Unit IV: **(4 Hrs)**

Industrial Applications and Instrumentation :Principle of electric welding and heating, ultrasonic testing, LASER applications, electronic ignition systems. Smoke, temperature, pressure, vibrations, displacement, flow, level detectors, basics of actuators and sensors, Introduction to PLC, concept of computerized controllers.

References:

- Industrial Electronics: Chute & Chute: Electronics in Industry, Tata McGraw Hill.
- M.H. Rashid, Power Electronics –Devices Circuits and Applications. 4th edition.
- Harish C. Rai: Industrial and Power Electronics (Umesh Publication, Delhi).
- C. S. Rangan, Sharma, Mahi: Instrumentation, devices and system (WIE).
- Curtis Johnson: Process Instrumentation, Prentice Hall of India. Electrical Drive Systems:
- Pillai S. K.: First course in Electrical Drives – Wiley Eastern.

List of Experiments:

Minimum 8 experiments are to be performed from following list:

1. To obtain the characteristics of SCR, MOSFET and IGBT
2. To perform triggering of SCR, MOSFET and IGBT
3. Controlled rectifiers with RL and RLE loads
4. Perform buck, boost and buck-boost converter operation
5. Study of inverters (bridge, stepped wave, SPWM)
6. To perform four quadrant operation
7. Study of UPS system.
8. Perform load test on three phase squirrel cage induction motor.
9. Perform no load and blocked rotor test on three phase squirrel cage induction motor to estimate the equivalent circuit parameters, losses and efficiency.
10. Speed control of three phase squirrel cage and slip ring induction motor
11. Perform the load test on the synchronous motor
12. Plot the characteristics of servomotors.
13. Perform the load test on the permanent magnet synchronous motor.
14. Speed control of permanent magnet brushless dc motor.
15. Demonstration of electric welding, heating and electronic ignition systems.
16. Study of smoke, temperature, pressure, vibrations, flow, level detectors.
17. Study of PLC.

(MT 20008) Micro-Project

Teaching Scheme:
Practical: 2hrs/week

Examination Scheme:
Continuous evaluation: 40 Marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of this course, the students should be able to:
1. Identify, formulate, review research literature, and analyze complex engineering problems .
2. Design solutions for complex engineering problems .
3. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools .
4. Function effectively as an individual, and as a member or leader in diverse teams in multidisciplinary projects.

Syllabus:
In this course a group of students is expected to rework an established idea or their own idea based on their understanding of the fundamental courses they have learnt till 3rd and ongoing 4th semester. They can also demonstrate an established concept through the basic understanding of the concept involved, design and fabrication of the physical part, model or assembly. They can be asked to undertake a part of the ongoing projects in any of the labs of the department involving these aspects or it can be even interdisciplinary or industry collaborated work. It can also be fast fabrication of a physical part, model or assembly using 3D computer aided design (CAD). A good understanding of sequence of steps to be followed in establishing certain concept is expected from the students. The work will be assessed through term work comprising of continuous assessment and end semester oral examination.

(MT 20011) FUNDAMENTALS of METAL WORKING

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

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of this course, the students should be able to,
1. Understand the mechanism of plastic deformation.
2. Classify metal forming processes.
3. Compile advantages and limitations of metal forming processes and evaluate the force required for deformation of material by various metal forming operations.

4. Compute stresses developed in component of different shapes under variety of loading condition.

5. Evaluate principle stresses in 2 Dimension and 3 Dimension state of stress.

Unit I: (8 Hrs)

Classification of forming processes , cold, hot and warm working processes, Plastic deformation, flow curve metallurgical structure, friction and lubrication, hydrostatic pressure and workability, Forces and geometrical relations in rolling, Projected length of contact, Neutral point, Forward slip and backward slip, Rolling force and rolling load, Angle of contact and angle of friction, Material spread in rolling, Torque and horsepower in rolling, Problems and defects in rolled products.

Unit II: (8 Hrs)

Forging, Classification of forging processes, Forging equipment, Forging in plane strain, Open and closed die forging, Calculations of forging loads in closed die forging, Significance of flow lines, Residual forces in forging, Forging defects, Drawing of rods wires and tubes, Analysis of tube drawing, Temperature increase in wire drawing, Die wear, Water-cooling of dies. Residual stresses in drawn products.

Unit III: (8 Hrs)

Extrusion, Classification of extrusion processes, Extrusion equipment. Hot and Cold extrusion. Deformation and lubrication in extrusion, Analysis of extrusion process, Hydrostatic extrusion. Extrusion of tubing, Extrusion defects, Sheet metal forming and forming methods, Rubber forming, Shearing and blanking, Bending, Stretch forming, Deep drawing, Forming limit criteria, Defects in formed parts. Finite Element methods in metal forming operations.

Unit IV: (10 Hrs)

Types of loading in materials used in engineering, Basic ideas about stress, direct stress, and shear stress, Hooke's law for three dimensions, Stresses and strains in bodies under variety of loads and with varying dimensions, Thin cylinders under pressure, Hoop stress and longitudinal stress.

Unit V: (11 Hrs)

Bending stresses in beams, Torsion of shafts and springs, Concept and determination of two dimensional principal planes and principal stresses, maximum shear stress, Mohr's circle of stress- two dimensions, numerical problems based on analytical and Mohr's circle method.

Unit VI: (11 Hrs)

System of a body under three dimensional stresses. Matrix representation of the state of stress under three dimensions, determination of principal stresses, principal planes and maximum shear stress for three dimensional state of stress, Yielding criteria

Text Books:

- George E. Dieter, Mechanical Metallurgy, SI Metric Edition,1988, McGraw-Hill Book Company.
- Ghosh A., Mallik A.K., Manufacturing Science, 1985, Affiliated East-West Press (P) Ltd., New Delhi.
- Serope kalpakjian, Steven R. Schmid, Manufacturing Engineering and Technology, International Edition, Fourth Edition, 2001, Prentice Hall International.
- Metal Forming Process, Nagpal G.R., First Edition, 2000, Khanna Publishers, New Delhi.

REFERENCE BOOKS:

- Mechanical Working of Metals, Harris J. N., 1983 Jan 01, Pergamon Press, Elmsford, NY.
- ASM Metals Handbook Vol. 14A: Metal Working: Bulk Forming, Materials Park, Ohio.
- Hosford W.F Caddell, Metal Forming Mechanics and Metallurgy, Prentice Hall, 1983.

(MT 20013) METALLURGICAL THERMODYNAMICS and KINETICS

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

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of this course, students will able to

1. Understand applications of laws of thermodynamics in metallurgy and material science
2. Determine the heat of reaction using Kirchhoff's equation, calculate change of internal energy, entropy and enthalpy and determine the adiabatic flame temperature of the reaction
3. Determine the activity of solute in dilute as well as concentrated solutions and understand the meaning of ideal, regular and real solutions.
4. Determination of thermodynamic quantities using reversible electrochemical cell and calculate the potential of electrolytic cells.
5. Understand reaction kinetics in metallurgical reactions.

Unit I: (10 Hrs)

Thermodynamics systems, Classification, thermodynamic variables, State functions, Process variables, Extensive and intensive properties, Energy and first law of thermodynamics, Heat capacity, Enthalpy, Heat of reactions, Hess's law, Kirchoff's equation, Thermochemistry.

Unit II: (10 Hrs)

Second law of thermodynamics, Entropy, Effect of temperature on entropy, Statistical nature of entropy, Combined statements of first and second law of thermodynamics, Gibbs' free energy, Helmholtz's free energy, Maxwell's equations, Gibbs-Helmholtz equation, Clausius-Ciapeyron's equation and its application to phase changes, Free energy as criterion for equilibrium and its applications to metallurgical reactions, Third law of thermodynamics.

Unit III: (10 Hrs)

Activity, Equilibrium constant, Le –Chatelier's principle, Chemical potential, Law of mass action, Effect of temperature and pressure on equilibrium constant, Vant Hoff's isotherm, Free energy-temperature diagrams, oxygen potential and oxygen dissociation pressure, Gibb"s phase rule and its applications, Free energy composition diagram, Ellingham diagrams.

Unit IV: (10 Hrs)

Solutions, Partial molar quantities, Ideal solutions, Raoult's law, Non ideal solutions, Gibbs-Duhem equation, Free energy of formation of solution, Regular solutions, application to phase equiibria, excess thermodynamic quantities, application of principles of thermodynamics of solution to design of high strength bainitic steels and high entropy alloys

Unit V: (10 Hrs)

Electrochemical cell, Determination of thermodynamic quantities using reversible electrochemical cell, EMF cell, electrode potential, Electrode potential-pH diagrams and their applications.

Unit VI: (6 Hrs)

Thermodynamics of crystalline defects: surfaces and interfaces of solids, vacancies and interstitials in solid metals Reaction kinetics: Arrhenius equation, order of reactions

TEXT BOOKS:

- D.R.Gaskell, Introduction to Thermodynamics of Materials, III Edition, MCGraw Hill Book Co.Inc.
- Ahindra Ghosh, Text book of Materials & Metallurgical Thermodynamics, Prentice Hall India.
- S.K. Bose and S.K. Roy, Principles of Metallurgical Thermodynamics, 1^{st} Edition, Universities Press, Hyderabad.

REFERENCE BOOKS:

- L.S.Darken and R.W.Gurry, Physical Chemistry of Metals, McGraw- Hill, 1958.
- R.H.Parker, An Introduction to Chemical Metallurgy: Pergamon Press, Inc.
- G.S.Upadhya and R.K.Dubey, Problems in Metallurgical Thermodynamics and Kinetics, Pergamon Press, Inc.

(MT 20009) Polymers and Composites

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Test 1: 20 marks
Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of this course, students will able to

1. Explain basic structures of polymers, their properties and applications.
2. Select appropriate techniques for processing of polymers.
3. Distinguish between metal, ceramic and polymer matrix composites along with advantages and limitations of each of these.
4. Correlate the microstructure of composite materials to their properties.

Unit I: (7 Hrs)

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

Unit II: (7 Hrs)

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

Unit III: (7 Hrs)

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

Unit IV: (7 Hrs)

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

Unit V: **(7 Hrs)**

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

Unit VI: **(7 Hrs)**

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

Text Books:

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

Reference Books:

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

(MT 20014) Modern Chemical Analysis Laboratory

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme:
Continuous evaluation: 40 Marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of the laboratory work, students will demonstrate the ability to:

1. Design and conduct elemental analysis experiments from different materials.
2. Perform contemporary analysis techniques like analysis of galvanized coating

List of Experiments / Assignments: (Any 08 experiments)

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

(MT 20012) Fundamentals of Metal Working Laboratory

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme:
Continuous evaluation: 40 Marks
End Sem. Exam: 60 marks

Laboratory Outcomes:

At the end of the laboratory work, students will demonstrate the ability to:

1. To perform various metal working operations such as rolling, forging, extrusion, wire drawing, sheet metal forming and analyze the data.
2. To evaluate the effect of cold working and hot working on microstructure and mechanical properties of steel and copper base alloys
3. To correlate the structure property relationship associated with different metal working processes.
4. To solve numerical based on strength of materials, plastic deformation and metal working processes.

List of Experiments/Assignments: (Any 08 experiments)

1. Assessment of non metallic inclusions in steels as per ASTM E 45.
2. Effect of cold rolling and process annealing on microstructure and mechanical properties of Copper base alloys, Plain carbon steel and Stainless steel.
3. Effect of hot working on microstructure and mechanical properties of Copper base alloys, Plain carbon steel and Stainless steel.
4. Study of open die and closed die forging processes. To perform open die forging of steel samples.
5. Observations of flow line pattern of forged part.
6. Study of rolling mills, effect of rolling parameters on final product, defects in rolled products and their remedial measures.
7. To study and perform sheet metal forming operations like deep drawing, stretch forming, shearing, blanking and bending.
8. To determine formability of sheet metal using cupping test.
9. Metal Forming Process Simulation using Finite element method.
10. Study of extrusion of aluminium and its alloys.
11. Numerical based on strength of material, plastic deformation and metal working processes.

(MT 20010) Polymers and Composites Laboratory

Teaching Scheme:
Practical: 2 hrs/week

Examination Scheme:
Continuous evaluation: 40 Marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of the laboratory work, students will demonstrate the ability to:

1. Select appropriate process for processing of polymers.
2. Determine the mechanical properties of polymers and composites.
3. Calculate theoretical and experimental density of polymers and composites.
4. Evaluate electrical and thermal properties of polymers and composites.

List of Experiments/Assignments: (Any 08 experiments):

1. To Cast Thin Polymer Film Using Film Casting Method.
2. Fabrication of Composites by Injection Moulding Process.
3. Fabrication of Composite Compacts by Hot Compaction Process.
4. To Measure Density of Composites by Archimedes's Principle.
5. Impact Properties of Polymer and Composites by Izod Impact Test.
6. To Measure Hardness of Polymers and Composites by Durometers and Micro hardness Tester.
7. To Measure Melt Flow Index (MFI) of Polymer and Composites.
8. Tensile Properties of Rubber, Polymers and Fiber Reinforced Composites.
9. Study of Optical Microstructure of Composites.
10. Study of Tribological Properties of Polymer Based Composites.
11. Characterization of Composites by XRD.
12. Characterization of Fractured Composites by SEM.
13. To study Vicat Softening Point Apparatus
14. Numericals Based on rule of mixture and inverse rule of mixture.