M.Tech. in Materials Engineering

SEMESTER I

S.No.	Course Code	Course Name	Contact Hours			Credits
			L	T	P	
1	MM-601	Concepts in Metal and Ceramic	3	0	2	4
2	MM-602	Materials Characterization	3	0	2	4
3	MM-603	Thermodynamics of Materials	3	1	0	4
4	MM-604	Polymers and Composites Technology	3	0	2	4
5	MM-605	Physical and Mechanical Metallurgy	3	0	2	4
6	MM-606	Mathematics for Computational Materials Engineering	3	0	2	4
7	PGC-601	Research Methodology and IPR	2	0	0	2
		Total	20	1	10	26

SEMESTER II

S.No.	Course Code	Course	Contact Hours/week			Credits
			L	T	P	
1	MM 608	Fatigue, Fracture and Failure Analysis	3	1	0	4
2	MM 609	Materials Processing	3	0	2	4
3		Elective I (from Departmental Electives)	3	1	0	4
4		Elective II (from Departmental Electives)	3	1	0	4
5		Elective – III (from Open Electives)	3	1	0	4
6		Elective – IV (from Open Electives)	3	1	0	4
7	PGC-602	Audit Course	2	0	0	0
		Total	18	6	0	24

SEMESTER III

Sl. No.	Course Code	Course	Contact Hours /week		Credits
			L	T/P	
1	MM-651	M.Tech. Dissertation Phase I	28		14
		Total	28		14

SEMESTER IV

Sl. No.	Course Code	Course	Contact Hours /week		Credits
			L	T/P	
1	MM-652	M.Tech. Dissertation Phase II	28		14
		Total	28		14

List of Electives:

Sr. No.	Course Code	Electives from the Department
1.	MM 607	Introduction to Computational Materials Engineering
2.	MM 610	Nanomaterial and Their Applications
3.	MM 611	Non-Destructive Evaluations
4.	MM 612	Polymer blends and Nanocomposites
5.	MM 613	Biomaterials
6.	MM 614	Design of Materials
7.	MM 615	Magnetism and Magnetic Materials
8.	MM 616	Heat-treatment of Metals and Alloys
9.	MM 617	Materials for High -Temperature Applications
10.	MM 618	Advanced Steel Technology
11.	MM 619	Military Materials
12.	MM 620	Introduction to Corrosion
13.	MM 621	Welding Science and Technology

14.	MM 622	High temperature Corrosion
15.	MM 623	Corrosion mitigation
16.	MM 624	Advanced Coating
17.	MM625	Surface Science and Engineering
18.	MM 626	Reliability Engineering
19.	MM 627	Electrical and Electronic Materials

Program Outcomes (POs)

- **PO1:** An ability to independently carry out research /investigation and development work to solve practical problems
- **PO2:** An ability to write and present a substantial technical report/document
- **PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Program Specific Outcomes (PSOs)

On completion of M.Tech (Materials Engineering) programme graduates will be able to

- **PSO1:** To analyse and tackle the complex and diverse engineering problems by appropriate experimentation and interpretation, and, provide probable solutions by applying principles of Materials engineering in combination to the fundamental knowledge of basic sciences.
- **PSO2:** To be able to design and device new procedures to arrive at a solution for identifying or troubleshooting problems at fundamental/system/component level.
- **PSO3:** An ability to work together collaboratively in multidisciplinary teams to tackle multifaceted problems and pursue a bright career in Materials engineering and allied areas by demonstrating professional success at different platforms within industry, governmental bodies such as Defence Research and Development Organization & Tri -services (Army, Navy & Air force), Coast Guard, DGQA, DQA, and Defence Public Sector units.

➢ Course Structure:

Course Name: Concepts in Metal and Ceramic
Course Code: MM 601

Course Outcomes (CO):	
CO-1:	Understanding classifications and characteristics of materials

CO-2:	Analysis and properties of crystalline materials
CO-3:	Detailed overview of ceramics and their characteristics
CO-4:	Cognizance of dielectrics, refractories and their applications
CO-5:	Demonstration of Solid state, Sol-Gel, Hydrothermal and Co-precipitation process

	Syllabus Details
Unit I	Introduction, classification of materials; atomic structure, bonding in solids, bonding forces and energies; crystal structure, unit cells, crystal systems, crystallographic points, directions, and planes
Unit II	crystalline and non-crystalline materials, anisotropy; Structure of crystalline solids: metallic crystal structure
Unit III	ceramic materials, Basic properties, classification of ceramic materials– conventional and advanced, ceramic crystal structure, Defects in ceramics: types of defects, origin of point defects, defects and electron energy levels, defect equilibria in ceramic crystals, Phase equilibria in ceramics
Unit IV	Dielectrics: Dielectric strength, Loss factor. Equivalent circuit description of linear dielectrics, Power factor, Dielectric polarisation, Polarisation mechanisms, Applications. Refractories: Classification of Refractories, Applications. Glass: Definition of glass, Basic concepts of glass structure, Different types of glasses. Application of glasses.
Unit V	Practical: Solid state, Sol-Gel, Hydrothermal and Co-precipitation process

Textbooks

- *Materials Science and Engineering by William D. Callister, John Wiley & Sons, Inc.*
- *Elements of Materials Science and Engineering by Lawrence H. van Vlack.*

Reference Book(s):

- *Elements of Ceramics: F.H Norton*
- *Fundamentals of Ceramics: Barsoum*
- *Introduction to Ceramics: W.D. Kingery*
- *Physical Ceramics for Engineers: VanVlack*
- *Handbook of Ceramics: Editor S. Kumar Ceramic*
- *Materials for Electronics: R.C. Buchanon*

Course Name: Materials Characterization
Course Code: MM 602

Course Outcomes (CO):	
CO-1:	Illustrate the diffraction techniques and its interpretation.
CO-2:	Described several microscopy instruments and their imaging fundamentals
CO-3:	Summarized spectroscopy techniques and their applications

CO-4:	Understanding of thermal analysis techniques
CO-5:	Hands on experience of microscopy techniques and corrosion methods.

	Syllabus Details
Unit I	Diffraction Techniques- Concepts of diffraction, scattering and radiation-matter interactions, X-ray diffraction: phase identification, strain and grain size determination
Unit II	Microscopy and Imaging- Fundamentals of Imaging: magnification, resolution, depth of field and depth of focus, aberration and astigmatism, SEM: imaging modes, image contrast, illustrative applications, Basic principle and components of TEM: Contrast mechanisms, bright field, dark field, TEM application in crystal defect analysis, Electro diffraction in TEM, STM and AFM
Unit III	Spectroscopic Techniques- Fundamental basis of Spectroscopic analysis EDS and WDS applications, X-ray Photoelectron Spectroscopy and Auger electron spectroscopy
Unit IV	Thermal Analysis Techniques- DSC, DTA, TGA and Dilatometry, Electrochemical polarization characterization, Electrochemical Impedance spectroscopy.
Unit V	Practical: XRD, TEM, SEM, Cyclic voltammetry, Tafel plot, and Salt Spray, weatherometer, cyclic corrosion test, cathodic protection monitoring, localised corrosion monitoring methods (SECM, SEVT)

Textbooks

- *Elements of X-ray Diffraction, B. D. Cullity, Prentice Hall, 2001*
- *Solid State Chemistry and its Applications, Anthony R. West, Wiley.*

Reference Book(s):

- *Materials Characterization, ASM Handbook Vol 10.*
- *Characterization of Materials, Vol 1, Elton N. Kaufmann*

Course Name: Thermodynamics of Materials
Course Code: MM 603

Course Outcomes (CO):	
CO-1:	Understand the basic principles of thermodynamic concepts
CO-2:	Learn the thermodynamic relations among variables and their transformations
CO-3:	Demonstrate basics of statistical thermodynamics
CO-4:	Analysing free energy equation and curves and its interpretation for single component system
CO-5:	Detailed understanding of binary system, phases formation and chemical potential

	Syllabus Details
Unit I	Simple and composite systems, phases, Internal energy, Enthalpy, Entropy, Gibbs Free energy, Specific heat, Laws of thermodynamics, Reversible and Irreversible processes, adiabatic work interaction.
Unit II	Generation of Auxiliary Functions: Legendre transforms, Coefficient relations, Maxwell's relations, Thermodynamic relations among state functions variables and its application to solids
Unit III	Statistical definition of temperature and entropy, Micro- and Macro-states, Maxwell- Boltzmann distribution, Thermodynamic equilibrium: stable equilibrium states, criteria for equilibrium
Unit IV	Free energy of single component system: Free energy as a function of temperature, Clausius-Clapeyron Equation, Driving force for solidification; Equilibrium vacancy concentration and Analysis of Magnetic transitions

Textbooks

- *David R. Gaskell, Introduction to the Thermodynamics of Materials, Taylor & Francis, 1798*
- *Ahindra Ghosh, Textbook of Materials and Metallurgical thermodynamics. Prentice Hall of INDIA 2003*

Reference Book(s):

- *R.T. DeHoff, Thermodynamics in Materials Science, McGraw-Hill, Singapore, 1993*
- *D. A. Porter and K. E. Easterling, Phase transformations in Metals and Alloys, Chapman and Hall, London, 1996*
- *Taiji Nishizawa, Thermodynamics of microstructures, ASM International*

Course Name: Polymer and Composite Technology
Course Code: MM 604

Course Outcomes (CO):	
CO-1:	Understanding classifications and characteristics of polymers
CO-2:	Analysis of the polymer properties
CO-3:	Conception of composite and nanofiller
CO-4:	Cognizance of Manufacturing of composites
CO-5:	Case studies of polymers and composites for Defence Applications

	Syllabus Details
Unit I	Polymers: Classification of Polymers, Co-Polymers, Thermoset and Thermoplastics, Crystalline and Amorphous Polymers, Polymerization, Degree of Polymerization, Glass transition temperature, Molecular weight of polymer and its determination by various techniques.

Unit II	Physical methods of polymer analysis such as IR, DSC, TGA, XRD etc., Viscoelasticity, Polymer blends and alloys: thermodynamics, morphology and properties
Unit III	Composites: Conventional polymer composites, Fiber reinforced composites, Nanofillers and their composites; Recycling of macro and micro polymer composites
Unit IV	Composite manufacturing techniques: Solution-cast, Melt-mixing, Extrusion, Compression molding, Resin transfer, Resin infusion, Vacuum casting and electrospinning.
Unit V	Defence Applications: Coatings (Superhydrophobic, Self-Healing), Fire retardant, Corrosion Resistant, EMI Shielding, Environmental responsive polymers (Self-healing, Phase change and Shape Memory), Polymer composites in aerospace applications. Service life prediction methodologies of polymers and composites

Textbooks

- *V.R. Gowariker, Polymer Science, Wiley Eastern, 1995*
- *F. N. Billmeyer, Textbook of Polymer Science, Wiley Interscience, 1971.*

Reference Book(s):

- *Kumar and S. K. Gupta, Fundamentals and Polymer Science and Engineering, Tata McGraw-Hill, 1978*
- *Epel, J.N.:Engineering Plastics, Engineering Materials Handbook, ASM International 1988.*
- *Brydson, A.J. : Plastics Materials, Princeton, N.J., 1966*

Course Name: Physical and Mechanical Metallurgy
Course Code: MM 605

Course Outcomes (CO):	
CO-1:	Identify the defects in metals and phases in Fe-FeC diagram with TTT and CCT diagrams
CO-2:	Analysis of defects transfer in crystal structure
CO-3:	Conception of several strengthening mechanisms
CO-4:	Cognizance of strength testing in materials and dependent phenomenon
CO-5:	Case studies of metallurgy testing techniques

	Syllabus Details
Unit I	Crystal defects/imperfection in Metals, dislocations, burger vectors, dislocations multiplications, dislocation interactions, stacking faults, Phase rule, Phase diagram, Eutectic, Fe-FeC diagram, TTT and CCT diagrams for carbon steel

Unit II	Plastic deformation in single crystal, critical resolved shear strength, deformation
Unit III	Strengthening mechanisms: Solid solution strengthening, strengthening from grain boundaries, strains hardening, strain ageing, annealing of cold worked materials, strengthening from particles, precipitation hardening
Unit IV	Hardness and tensile testing, stress-strain relationships, effect of strain, strain rate and temperature on flow stress, nanoindentation, High temperature deformation and Creep, Superplasticity
Unit V	Practical: Metal Polishing and Etching, Optical Microstructural Characterization, Wear and friction, hardness testing

Textbooks

- *Mechanical Metallurgy, G.E. Dieter, McGraw-Hill book company, 1988*

Reference Book(s):

- *Mechanical behaviour of Materials, Williams F Hosford, Cambridge University press, 2005*
- *Materials Science and Engineering by William D. Callister, John Wiley& Sons, Inc.*
- *Physical Metallurgy Principles, Robert E Reed Hill, Cengage Learning, Inc publications, 1992*
- *Physical Metallurgy, Vijendra Singh, Standard Publishers Distributors, 2010.*

Course Name: Mathematics for Computational Materials Engineering
Course Code: MM 606

Course Outcomes (CO):	
CO-1:	Understand the basics of Linear Algebra
CO-2:	Recognize the principles of advanced calculus
CO-3:	Introduce vector calculus
CO-4:	Utilise numerical methods to solve differential equations

	Syllabus Details
Unit I	Algebra of real matrices: Determinant, inverse and rank of a matrix; System of linear equations (conditions for unique solution, no solution and infinite number of solutions); Eigenvalues and eigenvectors of matrices; Properties of eigenvalues and eigenvectors of symmetric matrices, diagonalization of matrices; Cayley-Hamilton Theorem.
Unit II	Limit, Continuity and differentiability; Maxima and minima; Partial derivatives; Total derivative.
Unit III	Gradient, divergence and curl; Line integrals, and Green's theorem.
Unit IV	Concepts of discretization in space/time, implicit, explicit; Taylor's series; Solution to ODEs; Classification of second order linear partial differential

	equations; Method of separation of variables: One dimensional heat equation and two-dimensional Laplace equation.

Textbooks

- *Advanced engineering mathematics: Kreyszig; Wiley.*
- *Advanced engineering mathematics: Jain/Iyenger; Narosa*

Reference Book(s):

- *Advanced engineering mathematics: Peter V. O'Neil Cengage Learning*
- *Advanced engineering mathematics: Alan Jeffery; Academic Press*

Course Name: Introduction to Computational Materials Engineering
Course Code: MM 607

Course Outcomes (CO):	
CO-1:	Understand the basics of programming
CO-2:	Implement the analytical and numerical solution to partial differential equations utilised in Materials Engineering
CO-3:	Analyze the mesoscopic modelling techniques
CO-4:	Understand the principles of data-driven modeling

	Syllabus Details
Unit I	Review the fundamentals and applications of programming in high level languages such as Python / MATLAB and low-level languages such as C / C++
Unit II	Introduction to modeling and simulations: Analytical solution of first-order nonlinear differential equation followed by their numerical solution; Numerical solution of Fickian laws in 1D (using low-level language) and 3D (using advanced solvers); Random Walker model
Unit III	Sampling methods to obtain numerical solution and its application to solve ferromagnetism in statistical mechanics; Diffuse-interface mesoscale models: Cahn-Hilliard model
Unit IV	Data driven modeling: Supervised and Unsupervised models, Fitting and visualization of multidimensional data; Data analytics using principal component analysis

Textbooks

- *Introduction to Computational Materials Science – Richard LeSar, Cambridge University Press (2013). ISBN: 9781316614877*

Reference Book(s):

- *Mathematical Methods for Physics and Engineering, 3rd Edition – R.F. Riley, M.P. Hobson, S.J. Bence, Cambridge University Press (2012). ISBN: 9780521139878*

- *Integrated Computational Materials Engineering (ICME) for Metals – Mark F. Horstemeyer, TMS (2012). ISBN: 9781118022528*
- *Integrative Computational Materials Engineering : Concepts and Applications of a Modular Simulation Platform – Georg J. Schmitz and Ulrich Prahl, Wiley-VCH Verlag GmbH & Co (2012). ISBN: 9783527330812*

Course Name: Fatigue, Fracture and Failure Analysis
Course Code: MM 608

Course Outcomes (CO):	
CO-1:	Detailed introduction to fatigue failure of materials
CO-2:	Analyze the effect of fatigue crack propagation and improving fatigue life
CO-3:	Conception of fracture mechanics
CO-4:	Conceptualize stresses induced during brittle fracture
CO-5:	Understanding fracture toughness in metals and alloys

	Syllabus Details
Unit I	Stress cycles, Interpretation of Fatigue Data. Endurance Limit, Effect of Mean Stress on Fatigue, Cyclic Stress-Strain Curve, Low Cycle Fatigue, Plastic Strain & Fatigue Life,
Unit II	Effect of Structural Features, Fatigue Crack Propagation, Stress Concentration & Fatigue, Size & Surface Effect, Effect of Metallurgical Variables & Enhancement of Fatigue Life,
Unit III	Classification of Fracture, Theoretical Strength of Metals, Griffith Theory of Brittle Fracture, Metallographic features of Fracture, Fractography
Unit IV	Dislocation Theory of Brittle Fracture, Effect of Tri-axial Stress, Strain Energy Release Rate, Stress Intensity Factor,
Unit V	Fracture Toughness & Design, KIC, CTOD, J-Integral, R-Curve, Toughness of Metals & Alloys. Stress corrosion cracking.

Textbooks

- *Mechanical Metallurgy, 3rd Ed, George E Dieter, Mc-Graw Hill, New York, 1986.*

Reference Book(s):

- *Deformation and fracture mechanics of engineering materials, 4th Ed., R. W. Hertzberg, John Wiley & Sons, 1995.*
- *Elementary engineering fracture mechanics By David Broek Noordhoff 1974.*
- *Fatigue and Fracture of Metals, W. M. Murray, John Wiley, 1952.*

Course Name: Materials Processing
Course Code: MM 609

Course Outcomes (CO):	
CO-1:	Understand the processing of polymers
CO-2:	Analyse the processing of ceramics
CO-3:	Comprehend the processing of metals
CO-4:	Identify the metal forming processes
CO-5:	Demonstration of various processing units

	Syllabus Details
Unit I	**Processing of Polymers**- Extrusion, compounding, fiber spinning, injection moulding, compression moulding, Additive manufacturing
Unit II	**Processing of ceramics**- Compaction, moulding, sintering, refractory manufacturing processes, glass manufacturing techniques.
Unit III	**Processing of Metals**- Casting, Hot working, Cold working, Rolling, Annealing, Forging, Extrusion,
Unit IV	Wire drawing, Sheet metal forming, Joining Techniques, Friction stir welding, Powder Metallurgy
Unit V	Practical: Metal processing- rolling, annealing; polymer processing-Extrusion and compression molding, electrospinning

Textbooks

- *Mechanical Metallurgy, 3rd Ed, George E Dieter, Mc-Graw Hill, New York, 1986.*
- *Manufacturing Processes and Materials for Engineers, L. E. Doyle, 1975. Powder*

Reference Book(s):

- *Metallurgy, Applications, Advantages and Limitations, Klar, Erhard, ASM, 1983, Ohio.*
- *Plastics Processing Data Handbook (2nd Edition), Rosato, Dominick, 1997.*
- *Plastic Injection Molding: Manufacturing by Douglas M. Bryce, 2007.*
- *Concise encyclopedia of plastics, Rosato, Marlene G, 2005*
- *Extrusion: the definitive processing guide and handbook, Giles, Harold F.; Wagner, John R.; Mount, Eldridge M, 2005.*

Course Name: Nanomaterial and Their Applications
Course Code: MM 610

Course Outcomes (CO):	
CO-1:	Learn the strategies for synthesis of nanomaterials

CO-2:	Classification of nanomaterials and analysis of the defects in crystalline nanomaterials
CO-3:	Analyze the structure property variation when reduced to nanoscale.
CO-4:	Understanding thermodynamics of nanomaterials
CO-5:	Case studies of nanomaterials in Defence applications

	Syllabus Details
Unit I	Overview of Nanostructures and Nanomaterials; Synthesis of Nanomaterials: Types and strategies for synthesis of nanomaterials;
Unit II	Crystalline nanomaterials and defects therein; Hybrid nanomaterials; Multiscale hierarchical structures built out of nanosized building blocks (nano to macro); Nanomaterials in Nature: Nacre, Gecko, Teeth; Nanostructures: Carbon Nanotubes, Fullerenes, Nanowires, Quantum Dots.
Unit III	Cells response to Nanostructures; Surfaces and interfaces in nanostructures, Ceramic interfaces, Superhydrophobic surfaces, Grain boundaries in Nanocrystalline materials, Defects associated with interfaces;
Unit IV	Thermodynamics of Nanomaterials; Overview of properties of nanostructures and nanomaterials; Overview of characterization of nanostructures and nanomaterials; Deformation behaviour of nanomaterials: Fracture and creep; Nanomechanics and nanotribology; Electrical, Magnetic and Optical properties;
Unit V	Applications of Nanotechnology in various fields: Defence, Aerospace and Marine Nanotechnology, Renewable energy, solar energy, fuel cells, Reinforcement in Ceramics, Drug delivery, Electronics etc.

Textbooks

- *T. Pradeep, NANO: The Essentials, Tata McGraw-Hill Publisher, 2007. ISBN-13:978- 0-07-061788-9.*

Reference Book(s):

- *K. Haghi, G. E. Zaikov, Advanced Nanotube and Nanofiber Materials, Nova Science Publishers Inc, 2012*
- *Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications, Cambridge University Press, 2008*

Course Name: Non-Destructive Evaluations
Course Code: MM 611

Course Outcomes (CO):	
CO-1:	Detailed introduction to handy NDT (Non-destructive techniques)
CO-2:	Cognizance of Eddy current and ultrasonic testing
CO-3:	Conception of acoustic emission and radiography techniques

CO-4:	Understanding automated NDT techniques
CO-5:	Case studies on NDT techniques application

	Syllabus Details
Unit I	Visual Inspection, Liquid Penetrant Testing, Magnetic Particle Testing,
Unit II	Eddy Current Testing, Ultrasonic Testing,
Unit III	Acoustic Emission Technique, Radiography Technique
Unit IV	Residual Stress Analysis, In-situ Metallography, Automation and Robot in NDT
Unit V	Case study: Grain Size, Weldment and other Structural Components.

Textbooks

- *Non-destructive Testing of welds, Baldev Raj, C.V. Subramanian and T. Jayakumar, Narosa Publishing House, 2000, Delhi.*

Reference Book(s):

- *International Advances in non-destructive testing, (Ed.) W. J. Mcgonnagle, Gordon and Breach Science Publishers, 1981, NY.*
- *Non-destructive Testing, Views, Reviews, Previews, (Ed.) L.L. Alston, Oxford University Press, 1970*
- *Nondestructive Evaluation and quality control, ASM handbook, Volume 17, ASM International*

Course Name: Polymer Blends and Nanocomposites

Course Code: MM 612

Course Outcomes (CO):	
CO-1:	Detailed introduction to polymer blends and nanocomposites with miscible and phase separated thermodynamic aspects
CO-2:	Classified polymer blends and composites
CO-3:	Conception of nanostructured materials and interface of reinforced materials
CO-4:	Demonstrated several processing methods for polymer blends
CO-5:	Case studies of polymer nanocomposites in defence applications

	Syllabus Details
Unit I	Introduction to polymer blends and composites, nanostructured materials and nanocomposites Thermodynamical aspects of polymer miscibility, mixing, factors governing miscibility, immiscible polymers and phase separation. Importance of interface on the property development, compatibilizers and compatibilization.
Unit II	Blends of amorphous & semi-crystalline polymers, inter-penetrating networks, thermoplastic and thermoset blends, rubber toughened polymers, particulate and fiber reinforced composites.
Unit III	Nanostructured materials like nanoclay, carbon nanotubes, graphene, magnetic nanoparticles etc. and polymer nanocomposites. Surface treatment of the

	reinforcing materials and interface/interphase structures of composites/nanocomposites.
Unit IV	Various processing techniques like solution mixing, melt processing. Physical and thermo-mechanical properties of polymer blends, composites and nanocomposites.
Unit V	Potential Applications in Defence.

Textbooks

- *Textbook of Polymer Science, Fred W. Billmeyer (Wiley)*
- *Polymer alloys and blends by L A Utracki*

Reference Book(s):

- *Polymer nanocomposites: processing, characterization, and applications by Josheph H. Koo (McGraw-Hill Nanoscience and Technology)*

Course Name: Biomaterials
Course Code: MM 613

Course Outcomes (CO):	
CO-1:	Detailed discussion of biomaterials along with applications
CO-2:	Elaborate the classification of biomaterials
CO-3:	Cognizance of nanobiomaterials
CO-4:	Project several utilizations of biomaterials
CO-5:	Case studies of biomaterials for medical applications

	Syllabus Details
Unit I	Introduction to biomaterials, Tissue Engineering, Biocompatibility, Biodegradation Biofluids and medical devices, Biostructures
Unit II	Ceramic based biomaterials, metallic biomaterials, polymer-based biomaterials, Biofluidic, medical devices, Biostructures
Unit III	Nano-biomaterials: Self-assembly of nanomaterials, hydrophilic, hydrophobic and surfaces, biomimicking
Unit IV	Medical imaging, electrospinning of scaffold structures, Additive manufacturing of medical devices, biofluidics and biostructure
Unit V	Case studies: Lotus leaf, Gecko feet, Nacre/Bone. Application of nanocomposite biomaterials: artificial biomaterials, antidrag coatings, self-cleaning surfaces, sensors, Riboswitches

Textbooks

- *Biomaterials- An Introduction, Joon Park- Publisher Springer*

Reference Book(s):

- *Biomaterials- Principals and Applications- Joon Park- CRC Press*
- *Handbook of Biomaterial Properties- Garth Hastings- Springer*
- *Handbook of Biomaterials Properties- William Murphy- Springer*
- *Handbook of Biomaterial Properties- Jonathan Black- Chapman and Hall*

Course Name: Design of Materials
Course Code: MM 614

Course Outcomes (CO):	
CO-1:	Principles of solid-state diffusion, their equation along with solution.
CO-2:	Applications of several mechanical alloys and their phase diagrams
CO-3:	Cognizance of phase transformations processes
CO-4:	Understanding ceramics and statistics of brittle fracture
CO-5:	Demonstration of Solid state, Sol-Gel, Hydrothermal and Co-precipitation process

	Syllabus Details
Unit I	Diffusion: First and Second law of diffusion, Solution to diffusion equations and error function, Types of diffusion, Kirkendall effect and applications
Unit II	Metals and Metal Structures: Generic classes of Metallic alloys and applications, Equilibrium shapes of grains and phases; Case studies in phase diagrams: Soft solders, Zone Refinement of Semiconductors, Bubble free Ice
Unit III	Diffusive and Displacive Transformations: Kinetics of nucleation, diffusive and Martensitic phase transformations; Case Studies in Phase Transformations: Fine grain castings, Rapid solidification and amorphous materials; Light alloys: Age-hardening and thermal stability
Unit IV	Mechanical properties of Ceramics, Statistics of Brittle fracture: Flaw size and dispersion of strength, Weibull distribution, Design of pressure windows
Unit V	Composites: Fibrous, particulate and foamed composites, Improving stiffness, strength and toughness. Case studies in Defence applications: Turbine blades, bullet-proof vests, uses of metal matrix composites and carbon-carbon composites.

Textbooks

- *Engineering Materials 1 Michael F. Ashby and David R. H. Jones; Butterworth-Heinemann, Elsevier Publications*
- *Engineering Materials 2 Michael F. Ashby and David R. H. Jones; Butterworth-Heinemann, Elsevier Publications*

Reference Book(s):

- *D. A. Porter and K. E. Easterling, Phase transformations in Metals and Alloys, Chapman and Hall, London, 1996*

- *Physical Metallurgy Principles, Robert E Reed Hill, Cengage Learning, Inc publications, 1992*

Course Name: Magnetism and Magnetic Materials
Course Code: MM 615

Course Outcomes (CO):	
CO-1:	Brief introduction to moment of magnetic materials
CO-2:	Analysis of traditional types of magnetism
CO-3:	Conception of effects of magnetism and application
CO-4:	Cognizance of material characteristics affecting on magnetism
CO-5:	Understand different types of magnetic materials

	Syllabus Details
Unit I	Moment of a current loop, Orbital angular momentum and magnetic moments, Spin magnetic moment, gyromagnetic ratio, Vector atom model
Unit II	Classical diamagnetism, Superconductors, Paramagnetic moments, classical paramagnetic.
Unit III	Weiss molecular field, Brillouin function and spontaneous magnetization, Curie Weiss law, Magnetocaloric effect, Exchange interaction, Spin waves, Antiferromagnetism and Néel temperature, Exchange Bias effect and applications, Ferrimagnetism: Spinel structure and Ferrite moments
Unit IV	Uniaxial and Cubic anisotropy, Shape anisotropy, Crystal field effects, Origin of magnetic domains, Equilibrium domain size and domain wall, Néel and Bloch Walls
Unit V	Differentiation between Soft and hard magnetic materials, Finemet alloys, Rare earth permanent magnets, Magnetostriction: TERFNOL-D, Multiferroics, Magnetic Anomaly Detection.

Textbooks

- *Introduction to Magnetic Materials, B. D. Cullity and C. D. Graham; IEEE Press, A. Jon Wiley & Sons Publications*

Reference Book(s):

- *Fausto Florillo, Measurement and Characterization of Magnetic Materials, Elsevier Academic Press, 2004*
- *Modern magnetic Materials: Principles and applications Robert C. O□Handaley; Wiley-Interscience Publications*
- *Physics of magnetism and Magnetic materials*
- *K. H. J. Bushaw and F. R. de Boer; Kluwer Academic Publishers*

Course Name: Heat-treatment of Metals and Alloys
Course Code: MM 616

Course Outcomes (CO):	
CO-1:	Explore several heat treatment processes and TTT curve.
CO-2:	Analyse the case hardening heat treatment processes
CO-3:	Comprehend the advanced heat treatment methods
CO-4:	Identify different heat treatment process for specific metals
CO-5:	Demonstration of after effects of heat treatment

	Syllabus Details
Unit I	Steel Heat-Treatment, Annealing, Stress relief annealing, Process Annealing, Normalizing, Spheroidizing, Tempering, Quenching, Hardening, TTT Curve, Hardenability
Unit II	Case hardening, carburizing, Nitriding, Boronizing
Unit III	Flame hardening, Induction hardening, Laser hardening, Electron beam hardening
Unit IV	Heat treatment of Aluminum, Titanium and Magnesium Alloys
Unit V	Deformation and annealing.

Textbooks

- *Heat Treatment Principles & Techniques, TV Rajan, CP Sharma & Ashok Sharma Prentice Hall of India, New Delhi, 2007.*
- *Metallurgy for Engineers-EC Rollason, 4th Ed, Edward Arnold, UK, 1973.*
- *Introduction to Physical Metallurgy, S H Avner, TATA Mc-Graw Hill, New Delhi, 2001.*

Reference Book(s):

- *Engineering Physical Metallurgy by Yuri Lakhtin, Moscow, MIR Publishers, 1963.*
- *Grain boundary migration in metals: thermodynamics, kinetics, applications, G. Gottstein & L. Shvindlerman, Boca Raton (FL), CRC, 1999.*

Course Name: Materials for High -Temperature Applications
Course Code: MM 617

Course Outcomes (CO):	
CO-1:	An introduction to high temperature materials: Alloys and non-metals and their property requirements
CO-2:	Concept of creep and high temperature oxidation behaviour and their mitigation.
CO-3:	Case study 1: High speed steels: their application, process and properties
CO-4:	Case study 2: Ni based Superalloys as aero-engine applications, their structures and processing
CO-5:	Identified advanced structural ceramics for high temperature application

	Syllabus Details

Unit I	Melt processing of Superalloy, Single crystal Superalloy, Processing of Superalloy, Alloying effect.
Unit II	Oxide Dispersion Strengthened alloys. Powder Metallurgy
Unit III	High temperature deformation, Room and high temperature Wear, Advanced coating materials, High Entropy Alloys
Unit IV	Fiber Reinforced Composite Superalloy
Unit V	Processing and properties of advanced Structural Ceramics

Textbooks

- *Superalloys, supercomposites and super ceramics, ed. J. K Tien and T. Caulfield, Academic Press, 1989, Boston.*
- *High temperature structural materials, R. W. Cahn, Chapman and Hall, 1996, London.*

Reference Book(s):

- *Materials for High Temp. Engg. Applications, G. W. Meetham and M.H. Van de Voorde, Springer, 2000, Berlin.*
- *Friction, wear and Lubrications, K.C. Ludema, CRC Press, 1996.*
- *Powder Metallurgy: Science, Technology, and Materials Anish Upadhyaya and G. S. Upadhyaya, Taylor & Francis, 2011*

Course Name: Advanced Steel Technology
Course Code: MM 618

Course Outcomes (CO):	
CO-1:	Comprehend different strengthening mechanisms in steel
CO-2:	Introduce low carbon steel and their characteristics
CO-3:	Explore medium and high carbon steel along with their transformations
CO-4:	Importance of pearlite microstructures
CO-5:	Applications of special steel materials like bainite and case studies for defence applications

	Syllabus Details
Unit I	Strengthening mechanisms: Work hardening, Solid solution strengthening, Grain size refinement, Dispersion strengthening
Unit II	**Low Carbon steels:** Austenite to ferrite transformation, High strength low alloys steels, Interstitial free steels, Dual phase and TRIP steels
Unit III	**Medium and high carbon steels:** Austenite to pearlite transformation, Ferritic-pearlitic microstructures in medium carbon steels, Austenite to Cementite transformation, **Unit 4:** Fully pearlitic microstructures: Rail steels, high strength steel wires
Unit IV	**Fully pearlitic microstructures:** Rail steels, high strength steel wires

Unit V	**Special steels: Bainite:** Upper and lower Bainite microstructures, Bainite transformation mechanisms and transition, nanostructured Bainite; Maraging steels, Stainless steel, TWIP steels, Case studies for defence applications.

Textbooks

- *Steels: Processing, Structure, and Performance, George Krauss; ASM International*

Reference Book(s):

- *Steels: Microstructure and Properties HKDH Bhadeshia and Sir R. Honeycomb; Butterworth-Heinmann, Elsevier Publications*

Course Name: Military Materials

Course Code: MM 619

Course Outcomes (CO):	
CO-1:	An overview of special materials requirements for military applications.
CO-2:	Requirement of materials, their properties and processes for armor protection systems.
CO-3:	Discussion of specific required for ammunition applications and their properties and processes.
CO-4:	Special alloys and their stringent properties required for building fighter aircraft.
CO-5:	Special steels and their process for naval vessels.

	Syllabus Details
Unit I	Overview metallic materials for military application, needs of complex metals and alloys required for modern and sophisticated warfare weapons systems. Conventional alloys for military application: Functional requirements of cartridge case and manufacture, Brass and steel cartridge cases, Cased ammunition. Steel shell bodies – High explosive squash head, Steel guns barrels- Direct fire tank guns, Indirect fire artillery guns, Alloys for military bridges: Mild steel- Bailey bridge and heavy girder bridge, Aluminum alloy – Medium girder bridge and BR 90.
Unit II	Special Alloys for Armour applications: Rolled Homogeneous Armour steels: Kanchan armour for Arjun tank, Steel armour plate, Aluminum alloy armour for light armoured vehicles, Body armour.
Unit III	Alloys for ammunition applications: Ferrous fragmenting projectiles: Cast iron mortar bomb bodies, Steel 155 mm anti-personnel artillery shell body. Conical shaped charge weapon system, Hydrodynamic penetration, Copper charge penetrators. Kinetic energy penetrators: Armour piercing fin stabilised discarding Sabot, Tungsten heavy alloys as long rod penetrator, Recent development

Unit IV	Alloys for aerospace applications: Materials required for engine parts, Superalloys for high temperature applications, Single crystal blades made of Ni based super alloys, Aerospace grade low density high strength Ti and Al alloys, Ultra-high-strength steel with the toughness for missile applications.
Unit V	Special alloys for naval applications: Special alloys with functional properties: Advanced magnetic materials - Ultra high energy product permanent magnets, emerging materials such as nanomaterials and smart materials

Textbooks

- *Alistair Doig, Military metallurgy, Maney publishing, 2002*

Reference Book(s):

- *Physical Metallurgy Principles, Robert E Reed Hill, Cengage Learning, Inc publications, 1992*
- *Physical Metallurgy, Vijendra Singh, Standard Publishers Distributors, 2010.*
- *Paul J Hazell, Armour Materials Theory and Design, CRC Press, 20*

Course Name: Introduction to Corrosion
Course Code: MM 620

Course Outcomes (CO):	
CO-1:	Introduction to thermodynamics of corrosion
CO-2:	Identification of electrode kinetics and polarisation
CO-3:	Cognizance of mixed potential theory
CO-4:	Recognized different forms of corrosion
CO-5:	Case studies of environmental factors causing corrosion

	Syllabus Details
Unit I	What is corrosion – definition & fundamentals, Importance & Economic Impact of Corrosion, Thermodynamics of Corrosion, Electrochemical principles of Corrosion, Potential versus pH (Pourbaix) diagrams – Calculation & Construction of E – pH diagrams & its practical use. Copper, Aluminium & general corrosion diagram, Mixed Potential or Evans diagram & its application.
Unit II	Electrode Kinetics and Polarization Phenomenon: Electrode – Solution interface – Definition & types of polarization. Exchange current density and polarization relationships. Polarization techniques – corrosion rate determination
Unit III	Mixed Potential concepts and Basics. Mixed potential theory – bimetallic couples. Activation and diffusion controlled mixed electrodes. Origin of electrochemical noise and its application.
Unit IV	Forms of Corrosion – Uniform, Localized & Metallurgical influenced – Pitting, Crevice, Galvanic & Intergranular Corrosion, Mechanically Assisted, Environmentally Induced & Microbiologically influenced Corrosion.

Unit V	Nernst equation, EMF Series and Galvani Series, Stern-Gary eqn. Mechanical and environmental factors affecting corrosion, materials selection for different Defence applications. Passivity, trans passivity and breakdown, corrosion resistant and high temperature resistant materials.

Textbooks

- *Mars G. Fontana, Corrosion Engineering, 3rd Ed., McGraw-Hill, Singapore, 1987*

Reference Book(s):

- *H.H. Uhlig and R.W. Revie, Corrosion and its control, 3rd Ed., John Wiley, Singapore, 1991*

Course Name: Welding Science and Technology
Course Code: MM 621

Course Outcomes (CO):	
CO-1:	Analyse the welding processes
CO-2:	Understand the physics of welding
CO-3:	Correlation of metallurgy and welding
CO-4:	Understand the welding of various alloys
CO-5:	Analyse the failures in welding and their remedies

	Syllabus Details
Unit I	Classification of welding processes, study of welding arc characteristics, metal transfer during arc welding, heat flow in welding, Chemical reactions in welding, weld pool solidification, effect of welding process parameters on the macro-and micro-structure of weld metal.
Unit II	Thermal cycles in the heat affected zone. Phase transformations in the weld metal and the heat affected zone. High power density processes such as laser and electron beam welding.
Unit III	Welding metallurgy under high cooling rates. Phenomena of hot-cracking and cold cracking. Residual stresses and distortion during and after welding, Fatigue and fracture of weldments. Sensitized phenomena
Unit IV	Application of above principles to welding of carbon and alloy steels, cast irons, stainless steels, aluminum and titanium alloys. Weld decay, problems associated with welding of metals and alloys. Stabilized alloy
Unit V	Pre and post welding Heat treatment processes, Failure analysis

Textbooks

- *K. Easterling, Introduction to Physical Metallurgy of Welding, Butterworths Pub., 1983.*

Reference Book(s):

- *Sindo Kou, Welding Metallurgy, John Wiley & Sons, New York, 1987.*
- *S.A. David (Ed.), Advances in Welding Science and Technology, American Society for Metals, Ohio, 1986.*

Course Name: High Temperature Corrosion
Course Code: MM 622

Course Outcomes (CO):	
CO-1:	Brief introduction to free energy, partial pressure and related diagrams
CO-2:	Analysis of thermodynamics of high temperature gases with metals
CO-3:	Conception of effects of defect interaction kinetics
CO-4:	Cognizance of corrosion characteristics affecting metals
CO-5:	Understand different applications of high temperature corrosion
CO-6:	Measurement of degradation of materials in high temperature applications
CO-7:	Understanding high temperature corrosion testing

	Syllabus Details
Unit I	Free energy, Partial pressure, Ellingham diagram
Unit II	Introduction, high temperature gaseous reaction (dry), single metal-single oxidant systems, aspects of thermodynamics, kinetics, transport properties, scale morphologies, electrochemical emphasis, various forms of high temperature corrosion including molten salt corrosion, thermodynamic phase stability in metal/gas systems-predominance area diagrams;
Unit III	Theory of point defects in corrosion products, defect interactions, scale growth kinetics and mechanisms, Wagner's parabolic scale growth process, other types of kinetics laws and mechanisms, morphological aspects in the growth of thick scales.
Unit IV	Corrosion product evaporation, analyses of kinetic data; alloy oxidation-kinetics, mechanisms, morphology, hot corrosion of metals and alloys-mechanisms and examples.
Unit V	High temperature corrosion in various applications
Unit VI	Measurements of High – Temperature Degradation, High Temperature Corrosion & Degradation Processes.
Unit VII	High Temperature Corrosion Testing

Textbooks

- *Per Kofstad, High Temperature Corrosion, Elsevier Applied Science, 1988.*
- *U.R. Evans, Corrosion and Oxidation of Metals, Arnold Publ., London, 1981.*

Reference Book(s):

- *N. Birks and G.H. Meier, Introduction to Oxidation of Metals, Edward Arnold, London, 1983.*
- *A.S. Khanna, Introduction to High Temperature Oxidation and Corrosion, ASM International, Materials Park, Ohio, 2002.*
- *Phase transformation in metals and alloys, Porter and Easterling.*

Course Name: Corrosion Mitigation
Course Code: MM 623

Course Outcomes (CO):	
CO-1:	Understand importance of protective coating process and their classification
CO-2:	Knowledge of the fundamentals and applications of coating techniques
CO-3:	Cognizance of factors affecting cathodic and anodic protection
CO-4:	Demonstrated corrosion protection in extreme environmental conditions
CO-5:	Case studies for Defence Applications

	Syllabus Details
Unit I	Protective Coatings – Introduction, coatings & Coating Processes, Supplementary protection systems, Surface preparation. Classification of inhibitors, Corrosion inhibition Mechanism, Selection of an inhibitor system
Unit II	Requirement of protective coatings, classification of organic and inorganic coatings, metallic coatings, electrodeposition and electroless coatings. Paint coatings for corrosion protection, role of resins, pigment, additives and solvents, Advanced coatings (CVD, ALD and PVD).
Unit III	Cathodic and Anodic Protection – principles & classifications, mechanism of Cathodic and anodic protections – influencing factors and Monitoring
Unit IV	Corrosion protection in extreme environment such as nuclear irradiation, high pressure etc.
Unit V	Case studies relevant to Defence Applications: (Superhydrophobic coatings, anti-barnacles coating, corrosion control of underground pipelines, storage tanks, overhead pipelines, offshore structures, ship hulls, risers, reinforced bars and concrete structures

Textbooks

- *Corrosion: Environment and Industries, Metals Handbook, Vol. 13c, Park Ohio, 1984, 10th Ed., ASM Metals, Ohio, 1987.*
- *N.D. Tomashov, Theory of Corrosion and Protection of Metals, Macmillan, 1967.*
- *M.G. Fontana, Corrosion Engineering, 3rd Ed., McGraw-Hill, 1985. 4. H.H. Uhlig, Corrosion & Corrosion Control, Wiley, 1985.*

Reference Book(s):

- *R. Lambourne and T.A. Strivens, Paint and Surface Coatings, Ellis Horwood D, Chichster, 1987.*
- *C.G. Munger, Corrosion Prevention by Protective Coatings, NACE Pub., Houston, 1984.*
- *Surface Finishing, Cleaning & Coatings, ASM Handbook, Vol. 5, 1994.*
- *J. Biesiek and J. Weber Portcullis, Electrolytic and Chemical Conversion Coatings, Red Hill Press, 1976.*
- *F.A. Lowenheim, Electroplating: Fundamentals of Surface Finishing, McGraw-Hill, New York, 1978.*

Course Name: Advanced Coatings
Course Code: MM 624

Course Outcomes (CO):	
CO-1:	Recognized requirements of protective coatings and their classification
CO-2:	Reviewed commonly used coating methods
CO-3:	Conception of coating application of material surface
CO-4:	Understanding importance of coating to underground surfaces, offshore structures, etc.
CO-5:	Case studies on advanced coating application

	Syllabus Details
Unit I	Requirement of protective coatings, classification of organic, polymeric and inorganic coatings, conversion coatings, metallic coatings, electrodeposition and electroless coatings.
Unit II	Paint coatings for corrosion protection, role of resins, pigment, additives and solvents.
Unit III	Application techniques: Surface preparation and its importance in coating, role of coating selection & design of coating, failure mechanism, maintenance coatings, industrial paint systems, modern paint coating systems and specific examples.
Unit IV	Coatings for underground pipelines, storage tanks, overhead pipelines, offshore structures, ship hulls, risers, reinforced bars and concrete structures. Testing and evaluation. TBC, EBC
Unit V	Case studies

Textbooks
- *R. Lambourne and T.A. Strivens, Paint and Surface Coatings, Ellis Horwood D, Chichster, 1987.*
- *2. C.G. Munger, Corrosion Prevention by Protective Coatings, NACE Pub., Houston, 1984.*

Reference Book(s):
- *3. Surface Finishing, Cleaning & Coatings, ASM Handbook, Vol. 5, 1994.*
- *4. J. Biesiek and J. Weber Portcullis, Electrolytic and Chemical Conversion Coatings, Red Hill Press, 1976.*

- *5. F.A. Lowenheim, Electroplating: Fundamentals of Surface Finishing, McGraw-Hill, New York, 1978.*

Course Name: Surface Science and Engineering
Course Code: MM 625

Course Outcomes (CO):	
CO-1:	Represented theory of surface reconstructions and its characteristics
CO-2:	Learn the effect of theoretical and experimental evaluation of surface energy of substrate surface structure
CO-3:	Demonstrate thermodynamics of solid liquid and solid gas interfaces
CO-4:	Analyzed wear mechanisms and their categorization
CO-5:	Fundamentals and applications of surface coating techniques

	Syllabus Details
Unit I	Theory of surface reconstructions, electronic properties of surfaces, interfaces and overlayers. Characterisation of surfaces by photons, electrons and ions as probes.
Unit II	The effect of substrate surface structure on the overlayer properties. Theoretical and experimental evaluation of surface energies
Unit III	Solid-liquid and solid-gas interfaces-surface potentials, colloids, sedimentation, adsorption and reaction on surfaces. Damage of the surfaces by corrosion and wear.
Unit IV	Wear mechanisms and categories of wear. Surface modifications by diffusion, heat treatment and by coatings, Surface Processing laser, electrons and ions
Unit V	Physical and vapour deposition, CVD, ion-implantation, thermal spray coating.

Textbooks
- *M. Prutton, Surface Physics, 2nd Ed., Clarendon Press, Oxford, 1983.*
- *A.W. Adamson, Physical Chemistry of Surfaces, 3rd Ed., Wiley, 1976.*

Reference Book(s):
- *K.G. Budinski, Surface Engineering for Wear Resistance, Prentice-Hall, 1988.*
- *K.H. ZumGahr, Microstructure and Wear of Materials, Elsevier, 1987.*

Course Name: Reliability Engineering
Course Code: MM 626

Course Outcomes (CO):	
CO-1:	Detailed overview of probability theory
CO-2:	Assessed fundamentals of FMEA techniques
CO-3:	Inspected Design of Experiments analysis of variance technique
CO-4:	Investigated future of product liability
CO-5:	Cognizance of product development and its application

	Syllabus Details
Unit I	Basic Probability Theory Basic concepts, Rules for combining Probabilities of events, Failure Density and Distribution functions, Bernoulli's trials, Binomial distribution, Expected value and standard deviation for binomial distribution – Examples
Unit II	Failure Mode and Effect Analysis (FMEA) Basic Principles and General Fundamentals of FMEA Methodology
Unit III	Design of Experiments Analysis of Variance Technique-Strategy of Experimental Design
Unit IV	Product Liability and Planning History, Product Safety Law, Product Liability Law, The future of product Liability- Prevention. Degree of Novelty of a Product, Product Life Cycle, Company Goals and Their Effect. Solution Finding Methods- Conventional Methods, Intuitive Methods, Discursive Methods, Methods for Combining Solutions- Examples.
Unit V	Product Development Process General Problem-Solving Process- Flow of Work During the Process of Designing, Activity Planning, Timing and Scheduling, Planning Project and Product Costs, Effective Organization Structures- Interdisciplinary Cooperation, Leadership and Team Behaviour.

Textbooks

- *G. Haribaskaran, Probability, Queuing Theory & Reliability Engineering, Laxmi publications, Second Edition.*
- *D. H. Besterfield, Glen H. Besterfield and M. Besterfield-Sacre, Total Quality Management, Pearson Publications, Third Edition*

Reference Book(s):

- *E. Walpole, H. Myers and L. Myers, Probability and Statistics for engineering and Scientists, Pearson Publications, Eighth Edition.*
- *BrendBretsche, Reliability in Automotive and Mechanical Engineering, Springer Publications.*
- *G. Pahl, W. Bietz, J. Feldhusen and K. H. Grote, Engineering Design a Systematic approach, Springer Publications, Third Edition.*
- *V. Sankar, System Reliability Concepts, Himalaya Publishing House, 2015.*
- *Roy Billinton and Ronald N. Allan, Reliability Evaluation of Engineering Systems, Reprinted in India B. S. Publications, 2007.*

E. Balagurusamy, Reliability Engineering, Tata McGraw Hill, 200

Course Name: Research Methodology and IPR
Course Code: PGC-601

Course Outcomes (CO):	
CO-1	Understanding the fundamentals of research and its methodology

CO-2	Choose the appropriate research design and develop appropriate research hypothesis for a research project
CO-3	Knowledge of manuscript preparation, patents and Intellectual property
CO-4	Technology transfer and application of IPR in various domains

	Syllabus Details
Unit I:	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations
Unit II:	Effective literature studies approaches, analysis Plagiarism, Research ethics,
Unit III	Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee
Unit IV	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.
Unit V	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications
Unit VI	New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References Textbooks:

- *Stuart Melville and Wayne Goddard, "Research methodology: an introduction for*
- *science & engineering students'"*
- *Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"*
- *Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for*
- *beginners"*
- *Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.*
- *Mayall, "Industrial Design", McGraw Hill, 1992.*
- *Niebel, "Product Design", McGraw Hill, 1974.*
- *Asimov, "Introduction to Design", Prentice Hall, 1962.*
- *Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.*
- *T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008*

Course Name: Audit Course
Course Code: PGC-602

	Syllabus Details
Unit I:	English for Research Paper Writing
Unit II:	Disaster Management
Unit III	Sanskrit for Technical Knowledge
Unit IV	Value Education
Unit V	Constitution of India
Unit VI	Pedagogy Studies
Unit VII	Stress Management by Yoga
Unit VIII	Personality Development through Life Enlightenment Skills