Model Curriculum of Engineering & Technology PG Courses [Volume-I]
Course Structure for M. Tech. (METALLURGY)
M. Tech. Semester - 1

Course Number	Subject	Scheme Of Studies Per Week			Credits
		L	T	P	
1CS01	**Program Core - I:** Advances in Materials Testing	3	0	0	3
1CS02	**Program Core - II:** Advances in Metal Casting	3	0	0	3
1CSxx	**Program Elective - I:** 1. Advances in Ferrous Metal Production 2. Phase Transformations in Metals & Alloys 3. Alloy Steels	3	0	0	3
1CSxx	**Program Elective - II:** 1. Light Metals and Alloys 2. Advances in Metal Forming 3. Advanced Physical and Mechanical Metallurgy	3	0	0	3
1Axxx	**Research Methodology and IPR**	2	0	0	2
1Axxx	**Audit Course - I**	2	0	0	0
1CS03	**Laboratory - 1:** Materials Testing Lab	0	0	4	2
1CS04	**Laboratory - 2:** Metal Casting Lab	0	0	4	2
	Total Credits:				18

Model Curriculum of Engineering & Technology PG Courses [Volume-I]

Course Structure for M. Tech. (METALLURGY)

M. Tech. Semester – 2

Course Number	Subject	Scheme Of Studies Per Week			Credits
		L	T	P	
2CS05	**Program Core - III:** Advances in Metal Joining	3	0	0	3
2CS06	**Program Core - IV:** Corrosion Engineering	3	0	0	3
2CSXX	**Program Elective - III:** 1. Advances in Non-Destructive Testing Methods 2. Advances in Non -Ferrous Metals Production 3. Strengthening Mechanisms	3	0	0	3
2CSXX	**Program Elective - IV:** 1. Particulate Material Technology 2. Nuclear Metallurgy 3. Ferro Alloy Technology	3	0	0	3
2AXXX	**Audit Course - II**	2	0	0	0
2CS07	**Laboratory - 3:** Metal Joining Lab	0	0	4	2
2CS08	**Laboratory - 4:** Corrosion Engineering Lab	0	0	4	2
2CS09	**Mini Project with Seminar**	2	0	0	2
	Total Credits:				18

*** Students be encouraged to go to Industrial Training/ Internship for at least 6 to 8 weeks during semester break.**

Model Curriculum of Engineering & Technology PG Courses [Volume-I]

Course Structure for M. Tech. (METALLURGY)

M. Tech. Semester - 3

Course Number	Subject	Scheme Of Studies Per Week			Credits
		L	T	P	
3CSXX	**Program Elective V:** 1. Surface Engineering 2. Materials Characterization Techniques 3. Nano Materials	3	0	0	3
3CSXX	**Open Elective:** Composite Materials	3	0	0	3
3CS10	Dissertation-I / Industrial Project	0	0	20	10
	Total Credits:				16

*** Students going for Industrial Project/Thesis will complete these courses through MOOCs**

Course Structure for M. Tech. (METALLURGY)
M. Tech. Semester - IV

Course Number	Subject	Scheme Of Studies Per Week			Credits
		L	T	P	
	Dissertation II	0	0	32	16
	Total Credits:				16

ADVANCES IN MATERIALS TESTING
(Program Core – I)

M.Tech, ET. I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:

1. Obtain a working knowledge of various hardness testing machines BHN, VHN, RHN.
2. To gain and understanding of the response of various metals under the application of stress and/or temperature.
3. Obtain a working knowledge of creep and fatigue and analysis of data.

UNIT–I

Introduction, Importance of testing, Hardness Test: Methods of hardness testing – Brinell, Vickers, Rockwell and Nanoindentation hardness.

The Impact Test: Notched bar impact test and its significance, Charpy and Izod Tests, fracture toughness testing - COD and CTOD tests, significance of transition temperature curve.

UNIT-II

The Tension Test: Engineering stress-strain and True stress-strain curves. Tensile properties, conditions for necking. Stress-Strain diagrams for steel, Aluminum and cast iron.

UNIT-III

Fatigue Test: Introduction, Stress cycles, S-N Curve, Effect of mean stress, Mechanism of fatigue failure, Effect of stress concentration, size, surface condition and environments on fatigue.

UNIT–IV

Creep and Stress Rupture: Introduction, The creep curve, Stress-rupture test, Structural changes during creep, Mechanism of creep deformation, theories of creep. Fracture at elevated temperature.

UNIT–V

NDT: Principle, Operation, Advantages and Limitations of Liquid Penetrant, Magnetic Particle, Radio graphy and Ultrasonic tests.

Text Books:

1. Mechanical Metallurgy – G. E. Dieter, Third edition, published by Newyork Mc Graw Hill,1986.
2. Testing of Metallic Materials - A.V.K. Suryanarayana.

Reference Books:

1. Mechanical Metallurgy – White & Lemay.
2. Structure and properties of materials by Wulff, John, 1903- ed

Course Outcomes:

At the end of the course the student will be able to:

1. Classify mechanical testing of ferrous and non-ferrous metals and alloys.
2. Identify the testing methods for obtaining strength and hardness.
3. Able to construct and study the stress strain diagrams.
4. Examine the mechanisms of materials failure through fatigue and creep.
5. Learn finding the defects using NDT techniques.

ADVANCES IN METAL CASTING
(Program Core – II)

M.Tech, ET. I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:

This course is mainly intended to

1. Introduce and explain various moulding, casting techniques and equipment used.
2. Principles of Solidification of casting, defects in castings and their remedies are also dealt in detail.
3. Different types of pattern materials using for casting.

UNIT-I

Pattern materials, types of patterns and pattern allowances, Mould and Core making materials and their characteristics. Recent developments in castings: Full mold casting, Investment casting, Continuous casting, Vacuum casting.

UNIT-II

Riser design shape, size and placement. Effective feeding distances for simple and complex shapes. Use of chills. Gating design, Factors involved in Gating design, Types of gates, gating ratio.

UNIT-III

Solidifications of Metals, Nucleation and growth in metals and alloys. Freezing of alloys centreline feeding resistance. Rate of solidification, Solidification Time and Chvorinov rule. Metal-mould reactions. Directional solidifications.

UNIT-IV

Additive manufacturing: Principles and technology of 3D printing, Advantages, limitations.

UNIT-V

Melting and quality control of cast iron, steel and aluminium. Defects arising with various casting processes, their identification and preventing methods.

Text Books:

1. Castings, by John Campbell, Professor of Casting Technology, University of Birmingham, UK, 2nd edition, Elsevier.
2. Foseco Ferrous Foundryman's Handbook, by John R. Brown.

Reference Books:

1. Understanding Additive Manufacturing Rapid prototyping, Rapid Tooling, Rapid Manufacturing, by Andreas Gebhardt published by Hanser, 1 edition year 2011.
2. Principle of metal casting by Richard W Heine, Carl R Loper and Philip C Rosenthal, published by Tata Mc Graw Hill, first edition.
3. Richard A. Flinn, ―Fundamentals of Metals Casting, published by Addison Wesley.
4. Amitabha Ghosh, ― Manufacturing Science, Affiliated East West Press, 2nd edition.
5. P.N Rao, ―Manufacturing Technology: Foundry, Forming and Welding 4e (Vol-I), published by Tata McGraw-Hill Education.

Course Outcomes:

This course would pave a platform for students to develop a thorough understanding on:

1. The casting technology.
2. Solidification of metals and alloys.
3. Knowledge about nucleation and growth.
4. Advantage and limitations of conventional manufacturing techniques.
5. Designing pattern techniques for different material with suitable materials
6. Advanced techniques in casting.

ADVANCES IN FERROUS METAL PRODUCTION
(Program Elective – 1)

M.Tech, ET. I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:
1. To learn alternate routes of iron making based on coal based and gas based processes.
2. Gain knowledge about important smelt reduction processes.
3. To enhance the technical knowledge in secondary steel making processes.

UNIT-I
Basics of iron and steel productions. The need for alternative Iron units. Fundamentals of direct reduction, applications of DRI.

UNIT-II
Coal based DR processes: Rotary Kiln, Fast met, ITMK 3 process.
Gas based DR processes: HYL process, Finmet, HIB process.

UNIT-III
Smelting Reduction Processes: Introduction, need and significance of smelting reduction. Classification of SR processes. Raw materials, advantages and limitations, fundamentals of SR process, Details about COREX, Fast melt processes.

UNIT –IV
Secondary Steel Making process: Introduction, objectives, types, advantages and limitations. Stirring techniques, synthesis, slag refining, injection metallurgy.

UNIT-V
Vacuum treatment of steel, RH process and DH process, post solidification treatments, ESR and VAR processes.

Text Books:
1. Amit Chatterjee: Beyond the Blast Furnace, CRC press, 1992.
2. Sponge Iron Production by direct Reduction of Iron oxide, by Amit chatterjee. PHI learning Pvt Ltd. M.D.2nd Edition.

Reference Books:
1. Hot Metal production by smelting reduction of Iron oxide, by Amit Chatterjee. PHI learning Pvt Ltd.
2. Steel making – A.K. Chakrabarti. PHI .
3. Ahindra Ghosh: Secondary steel Making – Principles and Applications, CRC press, 2001.

Course Outcomes:

At the end of the course, student will be able to gain

1. Comprehensive understanding of alternate routes to iron making concomitant to kinetics of reduction of oxides of iron.
2. Analyze the different coal based and gas based DR processes.
3. Knowledge about smelt reduction processes.
4. Knowledge about Corex process.
5. Knowledge about the importance of secondary steel making processes and types of processes.
6. Importance of vacuum in iron making & steel making.

PHASE TRANSFORMATIONS IN METALS & ALLOYS
(Program Elective - 1)

M.Tech, ET. I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:

1. This course is mainly designed to impart knowledge about thermodynamics and phase diagrams concerning single and binary components, and various interfaces.
2. Gain knowledge about solidification and structure development of metals and alloys.
3. Enhance technical knowledge about diffusion and diffusionless transformations.

UNIT–I

Thermodynamics and phase Diagrams: Single component systems, Binary solutions, Equilibrium in Heterogeneous systems, Binary phase Diagrams.

UNIT–II

Crystal Interfaces and Microstructures: Interfacial free energy, Solid/ Vapour interfaces, Boundaries in single-phase solid, Interfaces in solids, Interface migration.

UNIT–III

Solidification: Nucleation in pure metals, Growth of a pure solid, Alloy solidification, solidification of Ingots and castings, solidification of fusion welds.

UNIT–IV

Diffusion Transformation in solids: Homogeneous nucleation, Heterogeneous Nucleation, Precipitate growth, Overall Transformation kinetics, Precipitation in Age–hardening alloys, Spinodal decomposition, Cellular precipitation, Eutectoid Transformations, Massive Transformations, and Ordering Transformations.

UNIT–V

Diffusionless Transformations: Characteristics, Martensite crystallography, Theories of Martensite Nucleation, Martensite growth, Tempering of Ferrous Martensite.

Text Books:

1. Phase Transformations in metal and Alloys: D.A. Porter and K.E.Easterling, Second edition, Reprint 2001.
2. Phase Transformations in Materials by Gernot Kostorz.

Reference Books:

1. Physical Metallurgy –V. Raghavan.
2. Physical Chemistry for Metallurgist - J. Mackowick.
3. Foundations of Materials Science and Engineering – WF Smith.

Course Outcomes:

At the end of the course the student will be able to:

1. Understand the thermodynamic principles in phase diagrams.
2. Get familiarize with single and binary components and various crystal interfaces.
3. Understand the theory of nucleation and growth kinetics of solidification.
4. Apply the fundamentals of phase transformation to steels and other engineering materials.
5. Understand the diffusion kinetics in phase transformations.
6. Understand the characteristics of diffusionless transformations.

ALLOY STEELS
(Program Elective – 1)

M.Tech, ET. I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:
This course deals with:
1. Describe the physical metallurgy of steels and alloy steels.
2. Explain the microstructure and properties of steels and alloy steels.
3. Make judgments on microstructural evolution and properties developed in alloy steels.

UNIT – I
Low-carbon Mild steels: Introduction. Cold forming steels, High strength packing steels; HSLA steels; Low-carbon Ferrite pearlite steels, structure property relationships, strengthening mechanisms, Formability of HSLA steels.

UNIT – II
Medium- High carbon ferrite-pearlite steels – structure property relationships, Bainitic steels, Low-carbon bainitic steels requirements, development and choice of alloying elements, Mechanical properties, microstructure and impact properties, High-Carbon bainitic steels.

UNIT – III
Ultra-high strength steels: Classification and applications. Description steels tempered at low temperatures, secondary hardening, thermo-mechanical treatments, rapid austenitizing treatments, structure-property relationships in tempered martensite, cold-drawn pearlite steels, maraging steels.

UNIT – IV
Stainless steels: Classification, Composition, role of alloying elements, Heat treatment, microstructure and applications.

UNIT- V
Tool steels and Heat resistant steels: Classification, Composition, role of alloying elements, Heat treatment, microstructure and applications.

Text Books:
1. Physical Metallurgy and the Design of steels: F. B. Pickering, Applied Science publisher, London, 1978.
2. The physical Metallurgy of steels: W. C. Leslie by Hempisphere Publishers Corporation, 1981.

Reference Books:

1. Alloys Steels – Wilson.
2. Heat Treatment of steels – Rajan & Sharma.

Course Outcomes:

1. Develop an appreciation for the microstructural complexity in alloys and how simple analytical solutions are often adequate to cope with these problems and know their limitations.
2. Know the importance of structure - property correlation study in HSLA, Ultra high strength steels etc.., and their suitable applications.
3. Select suitable materials for corrosion resistance applications.
4. Analyze the importance of composition, heat treatment and microstructure effects on properties and uses of tool steels and heat resistant steels.
5. Able to apply the knowledge gained on microstructural evolution and its stability to optimize the processing routes for specific applications.

LIGHT METALS AND ALLOYS
(Program Elective – II)

M.Tech, ET. I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:

This course is mainly intended to deal with:

1. To demonstrate various alloy systems and their phase diagrams.
2. To highlight the importance of alloy selection.
3. To demonstrate the influence of composition, processing and microstructural effect on properties of the non ferrous alloys.

UNIT-I

Aluminium alloys: Classification, Properties and applications, Physical metallurgy of Al-Cu alloys, Al-Mg alloys, Al-Zn alloys, Al-Mn alloys, Al-Si alloys, and Al-Li alloys, Ternary phase diagrams: Al-Cu-Mg alloys, Al-Si-Mg alloys and Al-Zn-Mg alloys.

UNIT-II

Magnesium Alloys: Classification, properties and applications, Alloying elements to magnesium and their purpose, Designation of magnesium alloys, Temper designation of magnesium alloys, Precipitation hardening in Magnesium alloys, Mg-Al-Zn alloys, Corrosion resistance of Mg-alloys.

UNIT-III

Titanium alloys: Classification, properties and applications, Interstitial solid solutions of titanium, Strengthening mechanisms of Titanium alloys. Titanium alloys for aerospace and aero engine applications.

UNIT-IV

Alpha Ti alloys, Beta Ti-alloys, Alpha plus Beta Ti alloys, Ti-6Al-4V, Ti-8Al-1Mo-1V, Ti-13V-11Cr-3Al alloys. Heat treatment and thermomechanical processing of alpha, alpha-beta and beta titanium alloys.

UNIT-V

Beryllium alloys: Classification properties and applications, Processing of Beryllium alloys, Al-Be alloys, Corrosion resistance of Beryllium alloys.

Text Books:

1. Light alloys: Metallurgy of the light metals by I. J. Polmear.
2. Introduction to Physical Metallurgy – S.H. Avner.

Reference Books:

1. Heat treatment, structure and properties of Non ferrous alloys- Charlie Brooks, ASM Metals Park, Ohio, USA.
2. Engineering Physical Metallurgy – Lakhtin.
3. ASM Metals Handbook Vol-1 & 2.
4. Metallurgical abstracts on light metals and alloys Keikinzoku Shōgakukai, Light Metal Educational Foundation., 1999.

Course Outcomes:

At the end of the course, the student will be able:

1. Able to classify Aluminum alloys and understand the importance of structure - property correlation in binary and ternary alloys.
2. Knowledge of Magnesium and Zinc alloys and their applications.
3. List out the properties of Titanium and its alloys and comprehend their usage.
4. Analyze the importance of properties and applications of Beryllium alloys.
5. Can develop and design stronger and safer new light weight alloys with the knowledge of metal properties for specialized applications with minimum consumption of materials.
6. Able to understand the strengthening mechanisms of titanium alloys.

ADVANCES IN METAL FORMIMNG
(Program Elective – II)

M.Tech, ET. I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:
1. Gain an understanding of fundamentals of metal working.
2. Analyze the behavior of metals during plastic deformation.
3. Obtain a working knowledge of forging, rolling, extrusion, drawing, Sheet metal forming and other processes.

UNIT-I
Forging: Forging types of presses and hammers. Classification: Open die forging and Closed die forging; die design, forging in plane strain, calculation of forging loads; forging defects - causes and remedies, residual stresses in forging. New technologies: Liquid metal forging, isothermal forging, No draft forging, roll forging, Lubrications in forging, forging defects and the remedies

UNIT-II
Rolling: Classification of rolling processes, types of rolling mills, hot and cold rolling, rolling of bars and shapes forces and geometrical relationship in rolling, analysis of rolling load, torque and power, rolling mill control, Process variables, redundant deformation. Roll flattening, Roll camber – its effect on rolling process; mill spring; Automatic gauge control - Roll pass classification & design. Lubrication in rolling: rolling defects - causes and remedies.

UNIT-III
Extrusion and Drawing: Direct and indirect extrusion, variables affecting extrusion, deformation pattern, equipments, port-hole extrusion die, hydrostatic extrusion, defects and remedies, simple analysis of extrusion, tube extrusion and production of seamless pie and tube, drawing of rods, wires and tubes.

UNIT-IV
Sheet metal forming and other processes: Forming methods - Shearing, blanking, bending, stretch forming, deep drawing. Types of dies used in press working, defects in formed part, sheet metal formability, formability limit diagram.

UNIT-V
High velocity forming- principles, comparison of high velocity and conventional Forming processes. Explosive forming, Magnetic pulse forming, Electro-hydraulic Forming. Microforming, Electro Magnetic forming, Microcoining, microextrusion, Microbending, Stretch forming, coining, embossing, curling, spinning, flow forming, advantages, limitations and application of the process.

Text Books:
1. Mechanical Metallurgy, Dieter G. E., McGraw-Hill Co., SI Edition, 1995.
2. Metal Forming - Processes and Analysis, Avitzur, Tata McGraw-Hill Co., New Delhi, 1977.

Reference Books:

1. Metal Forming Processes, Nagpal G. R., Khanna Pub., New Delhi, 2000.
2. Handbook of Metal Forming, Kurt Lange, Society of Manufacturing Engineers. Michigan, USA, 1988.
3. Manufacturing Technology, P. N. Rao, Tata McGrawHill
4. Principles of industrial metal working process, G. W. Rowe, Edward Arnold

Course Outcomes:

At the end of the course the student will be able to:

1. Identify the behavior of metals under the various modes of deformation.
2. To use mechanics of metal working principles suitable for various mechanical working operations.
3. Identify and adopt a particular deformation process to obtain the required product.
4. Study of formability limit diagram.
5. Comparison of conventional & high velocity forming processes.

ADVANCED PHYSICAL AND MECHANICAL METALLURGY
(Program Elective – II)

M.Tech, ET. I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:

1. To highlight the importance of solidification, crystallographic texture and structure – property correlations.
2. To develop a fundamental understanding of stress-strain behaviour, fracture mechanisms.
3. To familiarize with effect of cold working, annealing and phase transformations.
4. To understand order-disorder transformations and principles of metal forming techniques.

UNIT-I

Solidification and solidification structures, interfaces, crystallographic texture, residual stresses, structure - property correlations.

UNIT-II

Recovery, re-crystallization and grain growth: property changes, driving forces, N - G aspects, annealing twins, texture in cold worked and annealed alloys, Polygonisation.

UNIT-III

Phase transformations: thermodynamic basics.
Austenite – Pearlite transformation, Bainite transformation, Martensitic transformation, Order-disorder Transformations.

UNIT-IV

Plasticity and work hardening: fundamentals, stress - strain behaviour, fracture mechanisms.

UNIT-V

Yield criteria for deformation of materials, Variables of metal forming (Temp, Strain rate, friction and lubrication), Formability Limit Diagram.

Text Books:

1. T. H. Courtney, Mechanical Behaviour of Materials, McGraw-Hill, 2nd Ed., 2000.
2. R.W. Cahn, P. Haasen and E.J. Kramer, (Eds.), Materials Science and Technology: A Comprehensive Treatment, VCH, Weinheim, Germany, 1993.

Reference Books:

1. R. E. Smallman and A. H. W. Ngan, Physical Metallurgy & Advanced Materials, 7th Ed., Elsevier, 2007.
2. J. W. Martin, R. D. Doherty and B. Cantor, Stability of Microstructures in Metallic Systems, 2nd Ed.,Cambridge University Press, UK, 1997.
3. D. A. Porter, and K. E. Easterling, Phase Transformations in Metals and Alloys, Van Nostrand
   Reinhold, UK, 1986.
4. C. R. Calladine, Plasticity for Engineers – Theory and Applications, Horwood, Chichester, England, 2000.
5. B. Verlinden, J. Driver, I. Samajdar, R.D. Doherty, Thermo-Mechanical Processing of Metallic
6. Materials, Pergamon Materials Series, Series Ed. R.W. Cahn, Elsevier, Amsterdam, 2007.

Course Outcomes:

At the end of the course the student will be able to:

1. Identify the solidification structures and gain a basic knowledge about crystallographic texture.
2. Awareness of cold worked and annealed properties of given alloys.
3. Understanding of basic thermodynamics required for phase transformations.
4. Gain knowledge about phase transformations and order-disorder transformations.
5. Gain knowledge about stress-strain behaviour and fracture mechanisms under various conditions.
6. Gain a basic knowledge about principles of metal forming techniques and formability limit diagrams.

RESEARCH METHODOLOGY AND IPR

M.Tech, ET. I-Sem

L	T	P	C
2	0	0	2

Pre-Requisites: Nil.

Course Objectives:

1. To understand the research problem
2. To know the literature studies, plagiarism and ethics
3. To get the knowledge about technical writing
4. To analyze the nature of intellectual property rights and new developments
5. To know the patent rights

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. 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.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”

REFERENCES:

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Asimov, "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
7. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Course Outcomes

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

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

AUDIT COURSE – I

M.Tech, ET. I-Sem

L	T	P	C
2	0	0	0

Pre-Requisites: Nil.

Course Objectives:

Course Outcomes:

MATERIALS TESTING LAB
(LABORATORY - I)

M.Tech, ET. I-Sem

L	T	P	C
0	0	4	2

Pre-Requisites: Advances in Materials Testing.

Course Objectives:

Students will be able to:

1. Demonstrate skill in using different hardness testing machines.
2. Explain the rationale for using particular loads in testing fatigue and tensile properties of materials.
3. Use the standard specimens in determining toughness and ductility of materials.

List of Experiments:

1. Tensile Testing (Room Temperature and High Temperature)
   To determine the
   i. Elastic modulus
   ii. Yield and Ultimate tensile strength
   iii. Breaking stress
   iv. Percentage Elongation
   v. Percentage reduction in area, of a given specimen.
2. Compression Testing at room temperature:
   To determine the mechanical properties of materials under compression conditions.
3. Three Point Bend Testing:
   To measure the specimen's flexural strength, modulus etc..
4. Low Cycle Fatigue:
   To determine the fatigue properties of a given material under fatigue condition.
5. High Cycle Fatigue:
   To determine the fatigue properties of a given material under fatigue condition.
6. Creep Test:
   To study the creep properties and practice the testing procedure.
7. Fracture Mechanics (K_{1C},J_{1C}) at room temperature:
   To study the fracture mechanism of the specimen.

Course Outcomes:

After completing the course, the student will be able:

1. Explain the methods of destructive testing (Tensile testing, Compression testing, Three point bend testing, Low cycle fatigue High cycle fatigue, Creep testing and Fracture mechanics.
2. Analyze, interpret and present the observation from the tests conducted.
3. Can prepare formal laboratory reports describing the experimental and the results obtained.
4. Solve material problems associated with testing.

METAL CASTING LAB
(LABORATORY - II)

M.Tech, ET. I-Sem

L	T	P	C
0	0	4	2

Pre-Requisites: Advances in Metal Casting

Course Objectives:

1. To give basic idea of different mould sands and binders used to prepare green sand.
2. Operate instruments to find different properties of green sand.
3. Handling of NDT equipment and determine flaws in material.

List of Experiments:

1. Preparation of gating system using green sand.
2. Study of particle size distribution of the sand.
3. Study of the variation of permeability of the green sand with clay and water.
4. Determination of the variation of sand properties like green hardness, green compact strength with additives in sands.
5. Determination of the variation of hot compact hardness and hot shear strength with additives in sands.
6. Determination of clay content in sand.
7. Determination of the shatter index of green sand.
8. Preparation of aluminium coatings.
9. Charge calculations and melting practice of cast iron in a cupola.
10. Preparation of CO_2 moulds.
11. Making of pipes by centrifugal casting process.
12. Non-destructive testing of a few cast iron components.

Course Outcomes:

1. Able to determine the green sand properties.
2. Able to operate basic furnaces.
3. Knowledge about particle size distribution calculation.
4. Learn about the NDT techniques and able to conduct.

ADVANCES IN METAL JOINING
(Program Core – III)

M.Tech, ET. II-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:

1. To develop understanding of metallurgical fundamentals of welding with regard to heat flow, and phase transformations during welding.
2. To study Welding of ferrous metals and alloys.
3. To study Welding of non ferrous metals and alloys.
4. To gain a knowledge about quality control methods in welded joints.

UNIT–I

Heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry, plate thickness, preheat, calculation of heat input and heat affected zone width.

UNIT–II

Flux assisted GTAW process, friction welding processes, friction stir welding and friction surfacing, microwave Joining and hybrid welding.

UNIT–III

Weld metal solidification - Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating- weldability of carbon steels and low alloy steels.

UNIT–IV

Welding of stainless steels use of Schaffler and Delong diagrams, welding of cast irons, welding of aluminum alloys.

UNIT–V

Welding of titanium alloys and welding of dissimilar metals. Weld defects: Causes and remedial measures, Weldability tests - effect of metallurgical parameters.

Text Books:

1. Linnert G. E.,'Welding Metallurgy', Volume I and II, 4th Edition, AWS, 1994.
2. Granjon H., 'Fundamentals of Welding Metallurgy', Jaico Publishing House, 1994.

Reference Books:

1. Kenneth Easterling, 'Introduction to Physical Metallurgy of Welding', 2nd Edition, Butterworth Heinmann, 1992.
2. Saferian D., 'The Metallurgy of Welding', Chapman and Hall, 1985.
3. Jackson M. D., 'Welding Methods and Metallurgy', Griffin, London, 1967.
4. Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM, 2007.
5. Welding Metallurgy – Sindo Kour, 2nd edition, published by Wiley.

Course Outcomes:

At the end of the course, student will be able to gain:

1. Basic theoretical & practical knowledge of welding of ferrous metals and alloys.
2. Basic theoretical & practical knowledge of welding of non ferrous metals and alloys.
3. Conduct quality control tests on welded joints.
4. Knowledge of heat affected zone and its analysis.
5. Knowledge about different welding processes.

CORROSION ENGINEERING
(Program Core – IV)

M.Tech, ET. II-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:

1. Electrometallurgy principles in deposition, winning and the efficiency of the bath to be discussed.
2. Testing methods are to be studied. Various ways in which corrosion takes place in metals/alloys together with corrosion protection methods and tests conducted are to be studied.
3. Design corrosion resistant structures and materials.

UNIT-I

Introduction, electro chemistry principles, electrochemical reactions, Polarization, passivity, environmental effects (oxygen, oxidizers, velocity, temperature, corrosive concentration, galvanic coupling).

UNIT-II

Corrosion, introduction, definition, classification, forms of corrosion, uniform corrosion.
Two metal corrosion: sacrificial anode, EMF and galvanic Series, environmental effects.
Pitting corrosion: pit shape and growth, autocatalytic nature of pitting, crevice corrosion.

UNIT-III

Intergranular corrosion: sensitization, weld decay, Knife-line attack.
Stress corrosion cracking: crack morphology, stress effects, environmental factors, metallurgical factors, Erosion corrosion: cavitation damage, fretting corrosion, corrosion fatigue.

UNIT-IV

Corrosion prevention methods: alteration of environment (inhibitors), design, coatings, cathodic and anodic protection. Materials selection, metallurgical aspects, hydrogen damage (hydrogen blistering, hydrogen embrittlement, prevention).

UNIT-V

Modern theory and applications of corrosion: introduction, free energy, cell potentials, emf series, applications of thermodynamics to corrosion, corrosion rate expressions and measurements, corrosion testing.

Text Books:

1. Corrosion Engineering, M. G. Fontana, 3rd edition, McGraw-Hill, 1985.
2. Theory of Corrosion and Protection of Metals, N. D. Tomashov, Macmillan, 1967.

Reference Books:

1. Corrosion and Corrosion Control, H. H. Uhlig, Wiley, 1985.
2. Introduction to Electrometallurgy & Corrosion by Sharan – Narayan.
3. Corrosion Engineering 1st Edition Principles and Solved Problems by Branko Popov.
4. Handbook of Corrosion Engineering, Second Edition by: Pierre R. Roberge, Ph.D.

Course Outcomes:

1. Able to interpret electro chemical phenomenon.
2. Can explain different types of corrosion and their causes and effect.
3. Able to identify the different remedial measures to be taken.
4. Able to design corrosion resistant structures and materials.
5. Determine the thermodynamic causes of corrosion.
6. Conduct corrosion tests and able to quantify the corrosion processes.

ADVANCES IN NON DESTRUCTIVE TESTING METHODS
(Program Elective – III)

M.Tech, ET. II-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:

1. Provide an opportunity to learn visual methods, electrical methods and magnetic methods.
2. To develop a fundamental understanding of ultrasonic testing of material and radiographic methods.
3. To be able to select the suitable NDT methods for particular environments.

UNIT-I

Introduction. Visual methods**:** Optical aids, In-situ metallography, Optical holographic methods, Dynamic inspection.

UNIT-II

Penetrant flaw detection**:** Principles, Process, and Penetrant systems. Liquid penetrant materials, Emulsifiers, cleaners, developers, sensitivity. Advantages, limitations and applications.
Magnetic methods**:** Methods of generating fields, magnetic particles and suspending liquids. Magnetography, field sensitive probes, advantages, limitations and applications of magnetic methods.

UNIT-III

Electrical methods: Eddy current methods, potential-drop methods, applications.
Electromagnetic testing: Magnetism, Magnetic domains, Magnetization curves, Magnetic Hysteresis. Hysteresis-loop tests, comparator - bridge tests Absolute single-coil system, applications.

UNIT-IV

Ultrasonic testing of materials: Advantages, disadvantages, Applications, Generation of Ultrasonic waves, general characteristics of ultrasonic waves; methods and instruments for ultrasonic materials testing; special techniques. Principles, test procedures of composites by Ultrasonic flaw inspection.
Acoustic emission methods: Basic Principles and practice, computerized tomography, composite health monitoring.

UNIT-V

Radiographic methods: Limitations, Principles of radiography, sources of radiation, Ionizing radiation - X-rays sources, gamma-rays sources. Recording of radiation. Radiographic sensitivity, principles and practice as applied to composites. Fluoroscopic methods, Special techniques, Radiation safety.

Text Books:

1. Non-Destructive Testing by R. Halmshaw, 2nd edition, by The British Institute of NDT.
2. Ultrasonic Testing of Metals; J Krantkramer and H. Krantkramer, Spinger Vekg, 1987.

Reference Books:

1. Testing of Materials by A. V. K. Suryanarayana, 2nd edition, BS publications, 2007.
2. Metals Handbook Vol. II, Nondestructive inspection and quality control.
3. R. C. Mc Master Ed., Non-destructive Testing Hand Book Vol. I & II, Ronald Press Company.
4. J. F. Himsley, Non-destructive Testing, Macdonald and Evans, London, 1959.

Course Outcomes:

The end of the student gain will be:

1. Complete knowledge on microscopic evaluation and dynamic inspection.
2. Knowledge about application of NDT methods like visual observation, penetrant detection, electrical methods etc.
3. Ability to use ultrasonic testing and radiographic methods for checking various types of defects.
4. Selection of suitable NDT methods for various environments.
5. Documentation of testing and evaluation of results for further analysis.

ADVANCES IN NON-FERROUS METALS PRODUCTION
(Program Elective – III)

M.Tech, ET. II-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:
1. To explain the fundamentals of extraction of non ferrous metals.
2. Gain knowledge in extraction of copper, zinc, aluminium and titanium in modern techniques.
3. Gain knowledge in extraction of uranium, thorium, zirconium and their refining techniques.

UNIT-I
Introduction, Unit operations for pyrometallurgy, Hydrometallurgy, Electrometallurgy. Advantages and disadvantages.

UNIT-II
Advanced extraction and refining techniques for the production of Cu, Zn, Al and Ti.

UNIT-III
Processing techniques for the extraction of Nuclear reactor materials.
Uranium: Acid and alkali processes for digestion of uranium ores, purification of crude salt, production of reactor grade UO_2 and uranium.

UNIT-IV
Thorium: Flow sheets, Acid and alkali processes for digestion of thorium ores, purification and production.

UNIT-V
Zirconium: Flow sheets, Acid and alkali processes for digestion of zirconium ores, purification and production.

Text Books:
1. Nuclear Reactor General Metallurgy – N. Sevryukov, B. Kuzmin and Y.Chelishchevr.
2. Extraction of Non- Ferrous Metals – HS Ray, KP Abraham and R. Sridhar, Affiliated East-West press pvt, ltd, New Delhi,1985.

Reference Books:
1. S. Glasstone and A. Sesonke, Nuclear Reactor Engineering, CBS Publishers and Distributors, Delhi,2003.
2. C. B. Gill, Non- Ferrous Extractive Metallurgy, John Wiley and Sons, 1980.
3. Fathi Habashi, Hand Book of Extractive Metallurgy, Vols. II and III, Wiley- VCH, 1997.

Course Outcomes:

At the end of the course, student would be able to apply:

1. The fundamental understanding of principles of extraction.
2. Awareness about modern extraction and refining techniques in production of copper, zinc, aluminium, titanium, uranium, thorium and zirconium.
3. Know the advantages and disadvantages in different extraction processes.
4. Able to understand different types of solution and their properties used in extraction process.
5. Gain knowledge about different purification techniques for different materials.
6. Comparison between traditional and modern techniques of extraction.

STRENGTHENING MECHANISMS
(Program Elective – III)

M.Tech, ET. II-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:
1. To explain and describe various strengthening mechanisms involved in the development of existing alloys and new alloys.
2. To understand the role of solutes, precipitates, fibers in the strengthening mechanisms.
3. To understand recovery, recrystallization and grain growth.

UNIT-I
Strengthening from grain boundaries, Hall-Petch relation, ASTM grain size measurement, yield-point phenomenon, strain aging.

UNIT-II
Solid solution strengthening: Elastic interaction, modulus interaction, stacking fault interaction, electrical interaction, short range order interaction, long range order interaction.

UNIT-III
Cold working: working: Strain hardening of single crystals, annealing of cold worked metal, recovery, recrystallization and grain growth.

UNIT-IV
Strengthening from fine particle Principle, mechanisms and examples of Precipitation hardening (age hardening), Dispersion hardening.

UNIT-V
Fiber strengthening, strength and moduli of composites (Iso-strain and Iso-stress condition), influence of fiber length, orientation and concentration. Martensitic strengthening.

Text Books:
1. Mechanical Metallurgy - G. E. Dieter, Third edition, published by Newyork Mc Graw Hill,1986.
2. Mechanical Behaviour of Materials - Thomas H Courtney, published by Wave land Pr. Inc, 2nd edition,2005.

Reference Books:
1. Materials Science and Engineering an Introduction - William D Callister Jr, David G. Rethwisch,
published by John Wiley and Sons, Inc eighth edition.
2. Materials Science and Engineering - V Raghavan fifth edition published by PHI learnings

Course Outcomes:
At the end of the course, student would be able:
1. Able to explain the process of strengthening by grain / grain boundary in materials.
2. Explain and illustrate how alloying can improve strength in metals.
3. Choose cold working and annealing cycles for improving strength and ductility in materials for suitable applications.
4. Gain knowledge about strengthening by the secondary phase particles.
5. Analyze the composite strengthening by various methods of orientation of fibers in materials.
6. Can develop particular strengthening mechanisms for design of high strength metals and alloys.

PARTICULATE MATERIAL TECHNOLOGY
(Program Elective – IV)

M.Tech, ET. II-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:

1. To build the necessary background of emergence and importance of powder metallurgy, scope and limitations.
2. Obtain a necessary knowledge about various powder production techniques and characteristics.
3. Obtain a working knowledge of compaction and sintering techniques.
4. Gain an effective knowledge of applications of powder metallurgy products.

UNIT-I

Introduction: emergence and importance of particulate materials and their processing, comparison of powder metallurgy with other manufacturing techniques, its scope and limitations; Metal powder production methods: physical Methods, chemical methods and mechanical methods; selection of metal powder production method.

UNIT-II

Characterization and testing of particulate materials: chemical composition and structure, particle size and shape, Particle surface topography, Surface area, apparent and tap density, flow rate, compressibility, green strength, pyrophorosity and toxicity and Porosity measurements.

UNIT-III

Treatment of metal powders: annealing, powder mixing, mechanical milling, shape forming: die compaction: types of presses, tooling and design; behavior of powder during compaction, modern methods of powder consolidation:isostatic pressing, roll compaction, powder extrusion, and forging, slip casting, hot pressing and hot isostatic pressing.

UNIT-IV

Sintering: solid state sintering: stages of sintering, driving forces for sintering, mechanism of sintering; liquid phase and activated sintering; sintering furnaces: batch type furnaces, continuous sintering furnaces and vacuum furnaces; Sintering zones: entrance zone, high temperature zone and cooling zone; sintering atmosphere: hydrogen, reformed hydro carbon gases, nitrogen, dissociated ammonia, argon and helium and vacuum.

UNIT-V

Powder metallurgy applications: Production of self lubricating bearings, porous metals and filters, cermets, cemented carbides, electrical and magnetic materials; dispersion strengthened alloys by powder metallurgy route.

Text Books:

1. Powder Metallurgy - PC Angelo, PSG College.
2. Powder Metallurgy Technology by G S Upadhyaya.

Reference Books:

1. Powder Metallurgy Science – RM German, MPIF, NJ, USA, 1994.
2. Powder Metallurgy Principles – FV Lenel.
3. Introduction to Powder metallurgy – JS Hirschhorn.
4. ASM Handbook on Powder Metallurgy, Metals Park, Ohio, USA.

Course Outcomes:

At the end of the course the student will be able to:

1. Classify powder preparation techniques.
2. Explain the characterization techniques of powders.
3. Describe hot, cold and pressure-less powder compaction and sintering techniques of powder compacts.
4. To understand sintering zones and gain knowledge about sintering atmospheres.
5. List out the applications of powder metallurgy.

NUCLEAR METALLURGY
(Program Elective – IV)

M.Tech, ET. II-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:
1. To explain and describe the basics of Nuclear technology and relevance of metallurgy to nuclear reactors.
2. To gain a working knowledge of extraction of nuclear metals like Uranium, Thorium, and Beryllium.
3. To understand principles of nucleation reactors and its safety.

UNIT–I
Elementary nuclear physics and chemistry: Structures of nucleus, radioactivity, bending energy: nuclear interaction; fission and fusion: nuclear reaction; energy, release and chain reactions; neutron cross-section; multiplication and criticality concepts and factors.

UNIT-II
Mechanisms of moderation, radiation detection, radiation effects on fissile and non-fissile materials; radiation damage and radiation growth; thermal cycling; protection against radiations.

UNIT–III
Types of reactors and classification.
Considerations in selection and properties of common materials used as fuels, their physical and chemical properties; canning materials; coolants; control rods; reflectors and shielding materials.

UNIT–IV
Occurrence and general characteristics of nuclear minerals.Flow sheets of processing of nuclear minerals for the production of nuclear grade uranium, thorium, beryllium and zirconium with emphasis on basic scientific principles involved.

UNIT–V
Production and enrichment of uranium, Fabrication fuel elements. Irradiated fuel processing for recovery of Plutonium.
Nuclear power production in India and its economics.

Text Books:
1. Metallurgy in Nuclear Power Technology: Wright JC, Iliffe Book Ltd., 1962
2. Nuclear Reactor Metallurgy: Wilkinson WD and Murphy WF, Van Nostrand, 1958.

Reference Books:
1. Symposium on Rare Materials: Indian Institute of Metals 1957.
2. Nuclear Chemical Engineering - Manstion Bendict and Thomas H. Pigfort.
3. Nuclear Reactor General Metallurgy - N. Sevryukov, B. Kuzmin and Y. Chelishchevr.

Course Outcomes:

At the end of the course, student would be able:

1. Use fundamental concepts of physics and chemistry to know the basics of nuclear energy. Understand the use of nuclear energy as a major source of energy.
2. Recognize the predominant mechanisms for materials failure in radiation environments, and understand the fundamentals of radiation damage events and gain knowledge about the safety measures and control.
3. Understand the guiding principles of reactor safety and report findings including recommendations for improvement.
4. Understand materials design issues in various reactor configurations and recognize the materials used in different types of reactor applications.
5. Understand the manufacturing processes and fabrications methods used for various materials used in reactors.
6. Work and communicate effectively in diverse and multi-disciplinary teams and be aware of modern professional, ethical, and societal issues as well as recognize the need for lifelong learning.

FERRO ALLOY TECHNOLOGY
(Program Elective – IV)

M.Tech. I Year II-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil

Course Objectives:
The prime objective of the course is to
1. Make the student aware of various ferroalloys properties and their uses.
2. To expose the students in various production methods of ferro alloys.
3. Describe the layout of plant production economics.

UNIT-I
Introduction: Types of Ferro alloys and their uses.
Principles: Physicochemical aspects of ferroalloys. Production by various methods.

UNIT-II
Types of furnaces, its design and refractories. Mechanical euipment, auxiliaries, electric power in to heat. Furnace power supply. Working voltage, power factor and efficiency.

UNIT-III
Production: Production of ferro-silicon, ferro -manganese (high and low carbon). Ferro-chrome (high and low carbon),

UNIT-IV
Production: Ferro-molybdenum, Ferro-tungsten, ferro-titanium are ferro-vanadium.

UNIT-V
Lay out: Lay out of a ferro alloy plant and its production economics. Present status of ferroalloy industry in India. Future plans and developments.

Text Books:
1. Riss M. And Khodorovsky V - Production ferroalloys, Mir Publishers, Moscow 1967.
2. Symposium on ferro alloys: NML Technical Jl. Feb 1962.

Reference Book:
1. Ferro Alloys- F.P.Edneral , Mir Publishers 1979.
2. Handbook of Ferroalloys 1st Edition Theory and Technology by Michael Gasik.

Course Outcomes:
At the end of the course, student would be able to:
1. Can list out the various Ferro alloys and their applications.
2. Knowledge of metallurgical phenomena taking place in the production of Ferro alloys.
3. Illustrate and design of furnaces.
4. Appreciate the need for recover, reuse, and recycle of by-products.
5. Describe the process details and steps to be taken for production economics.
6. Judge and predict the future of Ferro alloy technology.

AUDIT COURSE – II

M.Tech, ET. II-Sem

L	T	P	C
2	0	0	0

Pre-Requisites: Nil.

Course Objectives:

Course Outcomes:

METAL JOINING LAB
(LABORATORY - III)

M.Tech, ET. II-Sem

L	T	P	C
0	0	4	2

Pre-Requisites: Advances in Metal Joining.

Course Objectives:

1. To expose students to different weld joining techniques.
2. To study the properties of weld.
3. To inspect the quality of welded joints.

List of Experiments:

1. Fabrication of weld joints using Arc welding.
2. Fabrication of weld joints using Gas welding.
3. Fabrication of weld joints using TIG welding.
4. Fabrication of weld joints using MIG welding.
5. Microstructural study of welded joints.
6. Hardness survey of welded joints.
7. Tensile Testing of Welded joints.
8. Quality Inspection of welded joints by Dye penetrant testing method.
9. Quality Inspection of welded joints by Magnetic particle testing method.
10. Quality Inspection of welded joints by Ultrasonic testing method.

Course Outcomes:

At the end of the course, student would be able to:

1. Fabricate weld joints using Arc, Gas, TIG and MIG welding techniques.
2. Study the microstructure, hardness and tensile strength of welded joints.
3. To inspect the quality of weld joint on surface and subsurface by using dye penetrant method.
4. To inspect the quality of weld joint at greater depths by using ultrasonic testing method.

CORROSION ENGINEERING LAB
(LABORATORY - IV)

M.Tech, ET. II-Sem

L	T	P	C
0	0	4	2

Pre-Requisites: Corrosion Engineering.

Course Objectives:

1. Give knowledge about Corrosion & its Classification.
2. Learn different corrosion protection techniques.

List of Experiments:

1. To conduct the Uniform Corrosion.
2. To understand the principles involved in galvanic cell corrosion.
3. To study the pitting corrosion of Aluminium, Stainless steel in suitable environment.
4. To anodize the given Aluminium sample and to colour with a dye and measure the thickness of an oxide film.
5. Corrosion Prevention method by using electroplating of Copper.
6. Corrosion Prevention method by using electroplating of Nickel.
7. Corrosion Prevention method by using electroplating of zinc.
8. Corrosion rate measurement.
9. Corrosion Prevention of mild steel.
10. Galvanic coupling.

Course Outcomes:

1. Gain knowledge about corrosion and its types.
2. Learn about different corrosion protection methods.
3. Understand the principles of different types of corrosion.
4. Able to determine the formed layer on material surface protective or not.

MINI PROJECT WITH SEMINAR

M.Tech, ET. II-Sem

L	T	P	C
0	0	4	2

Pre-Requisites: Nil.

Course Objectives:

1. This course is mainly intended to make the students acquire real time practical experience on the industry oriented processes, technologies, and applications once again.
2. Students will be exposed to sophisticated equipments and modern technologies.

Course Outcomes:

At the end of the course the student will be able to:

1. Identify a research problem after thorough literature review in metallurgical engineering, plan and execute experimental work to obtain results.
2. Further analyze the results, prepare a technical report and make a presentation.

SURFACE ENGINEERING
(Program Elective – V)

M.Tech, ET. III-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:
1. To provide a state- of- the art knowledge to the students and various surface engineering techniques.
2. To explain the importance, need of surface engineering and past, present and future status of surface engineering.
3. To comprehend the laser processing, electrons and ion beam processing of surfaces, to characterize and evaluate coatings.
4. To understand the combat techniques to protect surfaces from wear, corrosion and other failure causing environments.

UNIT-I
Introduction to surface modification, need for surface modification, surface properties, surface property modification, history of surface modification techniques.

UNIT-II
Plating and coating process: concept of coating, types of coatings, properties of coatings, hard facing, anodizing, PVD, CVD, Electro deposition, Electro less deposition, hot deposition, hot dipping.

UNIT-III
Thermo-chemical Processes: carburizing, nitriding, carbo-nitriding, nitro carburizing, Boronising, Plasma nitriding, thermal spraying, Plasma spraying, Alumnizing.

UNIT-IV
Thermal Processes: Flame hardening, induction hardening, laser hardening, laser surface alloying, laser cladding, electro-beam hardening.

UNIT-V
General design principles related to surface engineering, design guidelines for surface preparation, surface engineering solution to specific problems. Case studies related to Engineering Components, Shafts, Bearings, Turbine blades.

Text Books:
1. Advanced thermal assisted surface engineering processes, Ramnarayan Chattopadhyay, published by Kluwer Academy Publishers 2004.
2. Surface engineering of metals: principles, Equipment and techniques, Tadeusz Burokowski, Tadeusz Wierzchon, CRC Press 1998.

Reference Books:
1. Advanced techniques for surface engineering, W.Gissler, Herman A.Jehn, published by Kluwe Academy Publishers in 1992.
2. Laser material processing, William M.Steen, fourth edition, Springer.

Course Outcomes:

1. Gain knowledge of different surface properties, appreciate the need for surface modification and past practices.
2. Knowledge of plating and coatings techniques.
3. Knowledge of modification by chemical process.
4. Knowledge of modification by thermal process.
5. Design various surface modifications according to the needs, compatibility and efficiency of the processes.
6. This course provides an opportunity to the students to engineer the microstructure for an enhanced performance based on the need in actual practice.

MATERIALS CHARACTERIZATION TECHNIQUES
(Program Elective – V)

M.Tech, ET. III-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:
1. To explain and describe the various working techniques of optical microscope, Scanning and Transmission Microscopes used for evaluating material properties.
2. To explain and describe the various working techniques of XRD, SPM, AFM for evaluating material properties.
3. To differentiate and compare between various characterization techniques.
4. Obtain knowledge on the various thermal analyses techniques.

UNIT – I
Optical Microscopy–Introduction, optical principles, Instrumentation, specimen preparation-metallographic principles, Imaging Modes, Applications, Limitations.

UNIT – II
(a) Scanning Electron Microscopy (SEM)-Introduction, instrumentation, Contrast formation, Operational variables, Specimen Preparation, Imaging Modes, Applications, and Limitations.
(b) Transmission Electron Microscopy(TEM)-Introduction, instrumentation, Specimen preparation –pre thinning, final thinning, Image modes-mass density contrast, diffraction contrast, Phase contrast, Applications, Limitations.

UNIT – III
X-Ray Diffraction (XRD) - Introduction, Basic principles of diffraction, X-ray generation, Instrumentation, Types of analysis, Data collection for analysis, Applications, Limitations.

UNIT – IV
Thermal Analysis: Introduction , Basic thermodynamics and heat transfer, common characteristics- Instrumentation, experimental parameters, Different types used for analysis ,Differential thermal analysis, Differential Scanning Calorimetry, Thermogravimetry, Dilatometry, Dynamic Mechanical analysis- Basic Principles, Instrumentation, working principles, Applications ,Limitations.

UNIT – V
Scanning Probe Microscopy (SPM) Introduction, Instrumentation, Scanning Tunneling Microscopy-Basics, Probe Tips Working environment, operational modes, Applications, Limitations.
Atomic Force Microscopy (AFM) –Basic Principles, instrumentation, operational modes, Applications, Limitations.

Text Books:
1. V.T. Cherapin and A.K. Mallik: Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
2. Robert F. Speyer: Thermal Analysis of Materials, Marcel Dekker Inc., New York, 1994.

Reference Books:

1. S.J.B. Reed: Electron Microprobe analysis, Cambridge University Press, London, 1975.
2. ASM Hand book: Materials Characterization, ASM International, 2008.

Course Outcomes:

At the end of the course, student will gain hands on experience on utilization of:

1. Will be able to use metallurgical microscopes to analyze the experimental results.
2. Understand the various specimen preparation techniques for SEM, TEM and analyze the experimental results.
3. Describe the construction of XRD machine and understand its principle and analyze / interpret the experimental results.
4. Conduct characterization measurement by thermal analysis and solve problem using the thermo dynamic principles.
5. Analyze, evaluate and interpret data and solve practical characterization problems using modern tools like SPM, AFM etc.
6. Knowledge on thermal analyses methods such as DSC, calorimetry, dilatometry and etc.

NANO MATERIALS
(Program Elective – V)

M.Tech. II Year I-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:

1. This course is primarily intended to expose the students to a highly interdisciplinary subject.
2. This would emphasize on the classification, synthesis and applications of Nano materials.
3. To enhance the various nano synthesis techniques and to identify and solve problems.
4. To describe methods for production of nano materials and their characterization techniques for application of nano materials.

UNIT-I

Introduction, Importance of Nano-technology, Emergence of Nano-Technology, Bottom-up and Top-down approaches, challenges in Nano Technology.

UNIT-II

Zero Dimensional Nano-structures, Nano particles through homogenous nucleation; Growth of nuclei, synthesis of metallic Nano particles, Nano particles through heterogeneous nucleation; Fundamentals of heterogeneous nucleation and synthesis of nano particles using micro emulsions and Aerosol.

UNIT-III

One Dimensional Nano-structures, Nano wires and nano rods, Spontaneous growth: Evaporation and condensation growth, vapor-liquid-solid growth, stress induced recrystallization.

Template based synthesis: Electrochemical deposition, Electro-phoretic deposition. Electro-spinning and Lithography.

UNIT-IV

Two dimensional Nano-Structures, Fundamentals of film growth. Physical vapour Deposition(PVD): Evaporation molecular beam epitaxy (MBE), Sputtering, Comparison of Evaporation and sputtering.

Chemical Vapour Deposition (CVD): Typical chemical reactions, Reaction kinetics, transportant phenomena, CVD methods, diamond films by CVD.

UNIT-V

Thin films, Atomic layer deposition (ALD), Electrochemical deposition (ECD), Sol-Gel films.

Special Nano Materials, Carbon fullerene and nano tubes: carbon fullerenes, formation, properties and applications. Carbon nano tubes: formation and applications.

Text Books:

1. Nano Materials: A. K. Bandyopadyay, New age Publications.
2. Nano Essentials: T. Pradeep, TMH.

Reference Books:

1. Springer Handbook of Nanotechnology.
2. The Guest for new materials Auther S. T. Lakshmi Kumar, Published by Vigyan Prasar.
3. Nano – The Essentials: C – Pradeep (IIcue Professor), McGraw Hill.
4. Nano Materials Synthesis, Properties and applications, 1996, Edlstein and Cammarate.

Course Outcomes:

1. Understand and describe the importance and impact of nanoscale science which has to the engineering of materials and processes for the 21st century. Use fundamental knowledge in materials science to solve problems associated with nanomaterials and nanotechnology.
2. Understand and describe the latest development of the nanomaterials in commercial and industrial applications. Apply the basic principle of nanomaterials science and engineering, that microstructure controls properties and processing controls microstructure.
3. Identify the scientific issues that underpin the nanoscale properties of materials, nanotechnology in nature and nanoscale measurement and analysis. Describe the different chemical and physical behaviours of nanomaterials.
4. Evaluate the role of standards with respect to nanomaterial performance. Use technical terms relating to nanomaterials science and engineering. Solve simple nanomaterials selection problems and critically assess nanomaterials selection procedures.
5. Understand and apply methodologies and techniques of synthesis, processing and characterization of major classes of nanomaterials. Recognize major application areas of nanomaterials and nanotechnologies in contemporary world and be able to generate creative solutions for different applications.
6. Demonstrate the capacity for self-directed learning on topics related to nanoscience and nanotechnology.

COMPOSITE MATERIALS
(Open Elective)

M.Tech, ET. III-Sem

L	T	P	C
3	0	0	3

Pre-Requisites: Nil.

Course Objectives:

1. Describe the importance of composite materials and its constituents.
2. Familiarize the students with various types of fibers, their properties and processing techniques.
3. Introduce the various process techniques for composite materials.
4. To demonstrate the relationship among synthesis, processing and properties in composite materials.

UNIT-I

Introduction, Classification of Composite materials based on structure and matrix and reniforcements, Advantages and applications of composites, Functional requirements of reinforcement and matrix materials.

UNIT-II

Types of reinforcements and their properties: Carbon, Boron, Glass, Aramid, Al_2O_3 and SiC fibers. Nature and manufacture of glass, carbon and aramid fibres, Comparison of fibres. Role of interfaces: Wettability and Bonding, The interface in Composites, Interactions and Types of bonding at the Interface, Tests for measuring Interfacial strength.

UNIT-III

Fabrication of Polymeric Matrix Composites, Structure and properties of Polymeric Matrix Composites, Interface in Polymeric Matrix Composites, Applications. Fabrication of Ceramic Matrix Composites, Properties of Ceramic Matrix Composites, Interface in Ceramic Matrix Composites, Toughness of Ceramic Matrix Composites, Applications of Ceramic Matrix Composites.

UNIT-IV

Fabrication of Metal Matrix Composites: Solid state fabrication, Liquid state fabrication and In-situ fabrication techniques. Interface in Metal Matrix Composites. Mechanical bonding, Chemical bonding and Interfaces in In-situ Composites. Discontinuously reinforced Metal Matrix Composites: Properties and Applications. Fabrication of Carbon fiber composites, properties, interface and applications.

UNIT -V

Micromechanics of Composites: Density, Mechanical Properties: Prediction of Elastic constants, Micro mechanical approach, Halpin-Tsai equations, Transverse stresses. Thermal properties: Hydrothermal stresses and Mechanics of Load transfer from matrix to fiber.

Text Books:

1. Composite Materials – Science & Engineering, K.K. Chawla, Springer-Verlag, New York, 1987.
2. An Introduction to Composite Materials, Hull, Cambridge, 2nd Edt. 1997.

Reference Books:

1. Composites, Engineered Materials Handbook, Vol.1, ASM International, Ohio, 1988.
2. Structure and Properties of Composites, Materials Science and Technology, Vol. 13, VCH, Weinheim, Germany, 1993
3. Composite Materials: Engineering and Science, F.L. Matthews and R.D. Rawlings, Chapman & Hall, London, 1994.

Course Outcomes:

1. Can classify the composites, know the required properties, reinforcements and matrix materials and uses of composites.
2. Able to explain how common fibers are produced and how the properties of the fibers are related to the internal structure and the interfaces obtained.
3. Knowledge of processing techniques for polymer matrix and ceramic matrix composites and their properties and uses.
4. Knowledge of processing techniques for metal matrix composite and their properties and uses.
5. Ability to arrive at different deformation and failure mechanisms of composite materials under different loading conditions in engineering applications.
6. Able to explain the microscopy elastic properties and strengths of the composite.

DISSERTATION - I / INDUSTRIAL PROJECT

M.Tech, ET. III-Sem

L	T	P	C
0	0	20	10

Pre-Requisites: Course work relevant to the topic of the project.

Course Objectives:

1. This course is mainly intended to make the students acquire real time practical experience on the industry oriented processes, technologies, and applications once again.
2. Students will be exposed to sophisticated equipments and modern technologies.

Course Outcomes:

At the end of the course the student will be able to:

1. Identify a research problem after thorough literature review in metallurgical engineering, plan and execute experimental work to obtain results.

DISSERTATION – II

M.Tech, ET. IV-Sem

L	T	P	C
0	0	32	16

Pre-Requisites: Course work relevant to the topic of the project.

Course Objectives:

1. This course is mainly intended to make the students acquire real time practical experience on the industry oriented processes, technologies, and applications once again.
2. Students will be exposed to sophisticated equipments and modern technologies.

Course Outcomes:

At the end of the course the student will be able to:

1. Identify a research problem after thorough literature review in metallurgical engineering, plan and execute experimental work to obtain results.
2. Further analyze the results, prepare a technical report and make a presentation.