ACADEMIC REGULATIONS
COURSE STRUCTURE AND
DETAILED SYLLABUS

METALLURGICAL ENGINEERING

For

M. Tech. (Metallurgy)

(Two Year **Full Time** Programme)

JNTUH COLLEGE OF ENGINEERING HYDERABAD
(Autonomous)
Kukatpally, Hyderabad – 500 085, Telangana, India.

2015

JNTUH COLLEGE OF ENGINEERING HYDERABAD
M.Tech. (Metallurgy) – Full Time w.e.f. 2015-16

I – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Advanced Physical and Mechanical Metallurgy	4	0	0	4
2	Advanced Ferrous Metal Production	4	0	0	4
3	Elective -1	4	0	0	4
4	Elective -2	4	0	0	4
5	Elective -3	4	0	0	4
6	Elective -4	4	0	0	4
7	Materials Testing Lab	0	0	4	2
8	Soft Skills Lab	0	0	4	2
	Total Credits				**28**

II – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Welding Metallurgy	4	0	0	4
2	Advanced Non-Ferrous Metal Production	4	0	0	4
3	Elective - 5	4	0	0	4
4	Elective - 6	4	0	0	4
5	Elective - 7	4	0	0	4
6	Elective - 8	4	0	0	4
7	Welding Technology Lab	0	0	4	2
8	Seminar	0	0	4	2
	Total Credits				**28**

III – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Comprehensive Viva Voce				4
2	Project Phase – I				12
	Total Credits				**16**

IV – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Project Phase – II & Dissertation				18
	Total Credits				**18**

JNTUH COLLEGE OF ENGINEERING HYDERABAD

M.TECH. (Metallurgy) – FULL TIME W.E.F. 2015-16

Elective - 1:
1. Corrosion Engineering
2. Advanced Thermodynamics and Kinetics
3. Furnace Technology and Pyrometry

Elective - 2:
1. Particulate Material Technology
2. X-Ray Diffraction and Electron Microscopy
3. Materials Characterization Techniques

Elective - 3:
1. Metal Casting Technology
2. Phase Transformations in Metals and Alloys
3. High Temperature Materials

Elective - 4:
1. Advanced Engineering Materials
2. Nano Materials
3. Light Metals and Alloys

Elective - 5:
1. Alloy Steels
2. Semiconductors and Magnetic Materials
3. Ferro Alloy Technology

Elective - 6:
1. Non-Destructive Testing of Materials
2. Transport Phenomena in Metallurgy
3. Testing of Materials

Elective - 7:
1. Composite Materials
2. Strengthening Mechanisms
3. Process Modeling and Simulation

Elective - 8:
1. Fracture Mechanics and Failure Analysis
2. Surface Engineering
3. Nuclear Metallurgy

JNTUH COLLEGE OF ENGINEERING HYDERABAD

M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

ADVANCED PHYSICAL AND MECHANICAL METALLURGY

Pre-requisites: None

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.

Course outcomes:
At the end of the course the student will be able to:
1. Identify the solidification structures, stress-strain behaviour and fracture mechanisms under various conditions.
2. Awareness of cold worked and annealed properties of given alloys.
3. Gain knowledge about phase transformations, 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, recrystallization 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.

References:
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.
3. R. E. Smallman and A. H. W. Ngan, Physical Metallurgy & Advanced Materials, 7th Ed., Elsevier, 2007.
4. J. W. Martin, R. D. Doherty and B. Cantor, Stability of Microstructures in Metallic Systems, 2nd Ed.Cambridge University Press, UK, 1997.

5. D. A. Porter, and K. E. Easterling, Phase Transformations in Metals and Alloys, Van Nostrand Reinhold, UK, 1986.
6. C. R. Calladine, Plasticity for Engineers – Theory and Applications, Horwood, Chichester, England, 2000.
7. B. Verlinden, J. Driver, I. Samajdar, R.D. Doherty, Thermo-Mechanical Processing of Metallic Materials, Pergamon Materials Series, Series Ed. R.W. Cahn, Elsevier, Amsterdam, 2007.

JNTUH COLLEGE OF ENGINEERING HYDERABAD

M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

ADVANCED FERROUS METAL PRODUCTION

Pre-requisites: None

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.

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. Knowledge about smelt reduction processes.
3. Knowledge about the importance of secondary steel making processes and types of 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 SM 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 process.

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

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

CORROSION ENGINEERING
(Elective – 1)

Pre-requisites: None

Course Objective:
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.

Course outcome:
1. The student gains knowledge on various types of electrolytic cells and the processes taking place in them.
2. The student obtains knowledge about the importance of controlling corrosion and its preventive measures.
3. The course is useful for higher studies, R&D, and also for getting into jobs in industries.

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 / Reference 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.
3. Corrosion and Corrosion Control, H. H. Uhlig, Wiley, 1985.

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

ADVANCED THERMODYNAMICS AND KINETICS
(Elective – 1)

Pre-requisites: None

Course Objectives:
1. The prime aim of this course is to apply thermodynamics and kinetics to various metallurgical aspects like solutions and phase diagrams.
2. The course is also intended to gain knowledge on microstates and macrostates.

Course outcomes:
At the end of the course the student would be able to:
1. Know the laws of thermodynamics with reference to metallurgical processes and materials.
2. Awareness about microstates and macrostates and interpretation and calculation of various data/properties obtained.
3. Identify the feasibility / non-feasibility of metallurgical processes and reactions.
4. Design alloy systems by applying the concepts of thermodynamics.

UNIT-1
Review of laws of thermodynamics, Maxwell equations, Joule-Thompson experiment and Joule – Thomson coefficient, Reversible work, availability, irreversibility and second law, efficiency for a closed system and steady state, control volume. Generalized relations, Clausius - Clayperon equation, Bridgeman tables for thermodynamic relations.

UNIT-2
Quasichemical approach to solutions, alternate standard states, fugacity, activity and equilibrium constant, activities in multi-component systems, solubility of one component in another phase, Thomson – Freundlich equations, solubility of metastable phase, retrograde solubility.

UNIT-3
Free energy versus composition for cases when A and B have same and different crystal structure, solid and liquidus lines for ideal solutions, reaction between phase diagrams of different types, equilibrium and temperature diagrams, applications of phase diagrams, composition fluctuation in solutions, ionic theory and reaction in slags.

UNIT-4
Microstates and macrostates, thermodynamic probability, degeneracy of energy levels, Maxwell – Boltzman, Fermi – Diarc, and Bose – Einstein statistics. Microscopic interpretation, calculation of the macroscopic properties from partition functions.

UNIT-5
Reaction kinetics: homogeneous and heterogeneous reactions, diffusion in gases, reaction of sphere and broken solids, nucleation and bubble formation, metastable products and partial equilibrium.

REFERENCES:

1. Kenneth Wark Jt.m, Advanced Thermodynamics for Engineers, McGrew – Hill Inc., 1995.
2. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
3. Holman, J.P., Thermodynamics, Fourth Edition, McGraw – Hill Inc., 1988.
4. D.R Gaskell, Introduction to Thermodynamics of Materials, Taylor and Francis, 2003.
5. Hillert, M. Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic Basis, Cambridge University Press, 1998.
6. Sonntag, R.E., and Van Wylen.G, Introduction to Thermodynamics, Classical and Statistical Thermodynamics, Third Edition, John Wiley and Sons, 1991.
7. Physical chemistry of metals, L.S Darken, Gurry McGraw-Hill Inc., US 1953.

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

FURNACE TECHNOLOGY AND PYROMETRY
(Elective – 1)

Pre-requisites: None

Course Objective:
1. To explain the phenomenon of heat transfer by conduction, convection, radiation and to study the working of various types of furnaces.
2. To study the principles of temperature measurement by various methods.

Course Outcomes:
At the end of the course students will be able to:
1. Apply the various methods of heat transfer and solve problems.
2. Can apply /select a suitable pyrometer for high temperature measurements under various conditions.
3. Will be able to select / have knowledge about a particular furnace details and applications.

Unit-I
Steady State Heat Transfer: Importance of heat transfer, conduction through plane, cylindrical, spherical and compound walls, shape factor and effect of variable thermal conductivity.
Unsteady state conduction: Thermal diffusivity equation for uni-directional heat flow. Sudden change of surface temperature of a thick plane wall, cylinder and sphere. Graphical Solutions.

Unit-II
Dimensional groups. Free and Forced convection. Heat Transfer by combined effect of conduction and convection between two fluids separated by a plane wall and cylindrical wall. Types of Heat exchangers on mode of travel. Log mean temperature difference for both parallel and counter flow exchangers.
Radiation - emissivity-luminous and non-luminous flames. Radiant exchange between parallel surfaces enclosed body and enclosure. Combined effect of conduction ,convection and radiation. Thermal efficiency of insulation.

Unit-III
Furnaces: Characteristic features of vertical shaft furnaces, reverberatory furnaces, Electric Arc and Induction furnaces. Tube and muffle type resistance furnaces, continuous furnaces. Sources of heat losses in furnaces and heat balance.

UNIT-IV
Pyrometry: Thermo electric pyrometer- Peltier and Thomas e.m.f's. Thermo-electric power of thermocouples. Required properties of thermocouples. Noble and base metal thermocouples. Thermo-pile. Measurement of e.m.f by Milli-voltmeters and potentiometers. Cold junction correction. Resistance thermometers – Calendars correction. Principle, construction of resistance thermometers. Measurement of resistance compensation for connection wires.

Unit- V

Optical pyrometers-principle involved in optical pyrometers, Black body conditions. Wiens and Plancks laws of monochromatic radiation. Principle and construction of disappearing filament optical pyrometer (morse type). F and F optical pyrometer (Wedge type) and Pyro-optical pyrometer. The effect of the distance between pyrometer and source, Emmissivity of materials. Absorbing media and reflection of optical pyrometer readings.

Total radiation pyrometer: Principles, construction of ferry radiation pyrometer, ferry metal spiral radiation pyrometer, fixed focus radiation pyrometer (foster Pyrometer) and pyro-pyrometer.

Text Books:

1. Elements of heat transfer- Jakob & Hawikns.
2. Pyrometry - W.P. wood & J. M. Corck

References:

1. Furnaces-J. D. Gilchrist, First edition, Published by Pergamon press.
2. Elements of thermodynamics& heat transfer- Obert & Young.
3. Control systems & Instrumentation – S. Bhasker.

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

PARTICULATE MATERIAL TECHNOLOGY
(Elective – 2)

Pre-requisites: None

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.

Course outcomes:
At the end of the course the student will be able to:
1. Classify powder preparation techniques.
2. List out the characterization techniques of powders.
3. Describe hot, cold and pressure-less powder compaction and sintering techniques of powder compacts.
4. List applications of powder metallurgy.

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: porous metals, cermets, cemented carbides, electrical and magnetic materials; dispersion strengthened materials.

Text / Reference Books:

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

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L	T	P	C
4	0	0	4

X-RAY DIFFRACTION AND ELECTRON MICROSCOPY
(Elective – 2)

Pre-requisites: None

Course Objectives:
1. To familiarize with X-rays and bragg's law and diffraction methods.
2. To develop a fundamental understanding of structure determination and particle size determination.
3. To gain knowledge in SEM and TEM etc.,

Course outcomes:
1. Able to apply the knowledge of X-ray, Bragg's law to evaluate the structures.
2. Able to work with SEM and TEM.

UNIT - I
Introduction to X-rays, properties, absorption, filters, production, detection.

UNIT - II
Diffraction, Bragg's law, diffraction directions, diffraction methods, scattering by an electron, by an atom, by a unit cell, structure-factor calculations, factors effecting the intensity of the diffraction lines, Intensity calculations.

UNIT - III
Reciprocal lattice, Ewald spehre construction, techniques for structure determination, point groups, plane groups, space groups, systematic absences due to symmetry elements, Wyckoff notation, Fourier series methods, phase problem, patterson function, heavy atom methods, anamolous scattering. Finite size effects. intensity distribution in reciprocal space, particle size determination for polycrystalline samples.

UNIT - IV
Introduction to electron microscopy, electrons and their interactions with the specimen, electron diffraction, reciprocal lattice and its use.

UNIT - V
TEM-construction, contrast mechanisms and some applications, SEM – its working principle, optics of SEM, image acquisition, processing and storage in SEM, specimen preparation for SEM.

Text / Reference Books:

1. Elements of Diffraction, B. D. Cullity, and S. R. Stock, Third Edition, Prentice Hall, 2001.
2. Elements of X-ray Crystallography, L. C. Azaroff, McGraw-Hill, New York, 1968.
3. Crystallography and Crystal Chemistry, F. D. Bloss, Holt, Rinehart and Winston, New York, 1971.
4. Transmission Electron Microscopy of Materials, G. Thomas and M. T. Goringe, John Wiley & Sons, New York, 1979.
5. Electron Microscopy of Materials - An Introduction, M. V. Heimendahl, Academic Press, 1980.

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

MATERIALS CHARACTERIZATION TECHNIQUES
(Elective – 2)

Pre-requisites: None

Course objectives:
1. To explain and describe the various working techniques of optical microscope, scanning and transmission, electron microscopes.
2. To explain and describe the various working techniques of XRD, SPM, AFM.

Course outcomes:
At the end of the course, student will gain hands on experience on utilization of
1. Optical, scanning and transmission electron microscopes.
2. XRD, SPM and AFM.

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, 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) and atomic force microscopy (AFM) - 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 / REFERENCE BOOKS:

1. ASM Hand book: Materials Characterization, ASM International, 2008.
2. Robert F. Speyer: Thermal Analysis of Materials, Marcel Dekker Inc., NewYork, 1994
3. V.T. Cherapin and A.K. Mallik: Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
4. S.J.B. Reed: Electron Microprobe analysis, Cambridge University Press, London, 1975.

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

METAL CASTING TECHNOLOGY
(Elective – 3)

Pre-requisites: None

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.

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.

Unit-1
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-2
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-3
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-4
Additive manufacturing: Principles and technology of 3D printing, Advantages, limitations.

Unit-5
Melting and quality control of cast iron, steel and aluminium. Defects arising with various casting processes, their identification and preventing methods.

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

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

PHASE TRANSFORMATIONS IN METALS AND ALLOYS
(Elective – 3)

Pre-requisites: None

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, at transformation and diffusionless transformations.

Course Outcomes:
At the end of the course the student will be able to:
1. Get familiarize with single and binary components and various crystal interfaces.
2. Understand the theory of nucleation and growth kinetics of solidification.
3. Apply the fundamentals of phase transformation to steels and other engineering materials.

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; Interphase. 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; ordering Transformations.

UNIT – V
Diffusionless Transformations: Characteristics; Martensite crystallography; Theories of Martensite Nucleation; Martensite growth, Tempering of Ferrous martensites.

TEXT / REFERENCE BOOKS:
1. Phase Transformations in metal and Alloys: D.A. Porter and K.E.Easterling, Second edition, Reprint 2001.

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

HIGH TEMPERATURE MATERIALS
(Elective – 3)

Pre-requisites: None

Course objectives:
1. To learn and design material's microstructure for high temperature application.
2. To learn scientific issues related to high temperature such as creep, oxidation and material degradation.

Course Outcomes:
1. Comprehensive, exposure and understanding of processing, characterization and properties of high temperature materials.
2. Exposure to advanced high temperature materials such as super alloys, inter metallic and ceramics.

UNIT-I
Creep, creep resistant steels,

UNIT-II
Fatigue, thermal fatigue, ageing, structural changes, material damage, crack propagation, damage mechanics, life time analysis

UNIT-III
Oxidation, high temperature corrosion, erosion, Super alloys

UNIT-IV
Ceramics and polymers for high temperature applications,

UNIT-V
Intermetallics, usage of, spring steels, evaluation of property data extrapolation.

TEXT / REFERENCE BOOKS:
1. Evans, R.W and Wilshire, B. Creep of metals and alloys, Institute of metals, 1985, London.
2. J.R. Davis, ASM Specialty Handbook: Heat- resistant materials, ASM, 1997.

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

ADVANCED ENGINEERING MATERIALS
(Elective – 4)

Pre-requisites: None

Course objective:
1. To gain knowledge in applications properties strengthening mechanisms in Structural steels and super alloys and stainless steels
2. To develop a fundamental understanding of various electrical and electronic materials
3. To highlight the importance of bio materials.

Course Outcomes:
At the end of the course, student will be able,
1. To select and design components based on their properties and requirements.
2. Awareness about the electrical and electronic materials
3. Knowledge about bio materials like, titanium and stainless steel based.

UNIT - I
Structural Steels: Introduction, Classification: HSLA steels, Dual phase steels, TRIP steels, Maraging steels, HSS steels.

UNIT - II
Superalloys: Introduction, Classification, Applications and properties of Ni, Fe, Co based superalloys and their thermo-mechanical treatments.

UNIT - III
Electrical and Electronic Materials: Introduction, Classification, Applications and properties of Pyro, Piezo, Ferro-electrics, Extrinsic and Intrinsic semiconductors; super conducting materials.

UNIT – IV
Stainless steels: Ferritic, Martensitic, Austenitic stainless steels.

UNIT - V
Bio materials: Introduction, Property requirements for biomaterials, concept of biocompatibility, important bio metallic alloys**.**

Text / Reference Books:

1. An Introduction to Materials Science and Engineering, W. D. Callister, John Wiley & Sons (2007)
2. Superalloys-II edited by C.T. SIMS, N.S. Stoloff and W.C.Hagel A Wiley-Interscience publication John wiley and sons, Newyork, 1972.
3. Materials Science and Engineering, V. Raghavan, PHI, 2004.

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M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

NANO MATERIALS
(Elective – 4)

Pre-requisites: None

Course objective:
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.

Course Outcomes:
The student will be able to design a component/material that would provide us a 'better tomorrow' via nanotechnology.

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 Depostion(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 fullerence and nano tubes: carbon fullerness, formation, properties and applications. Carbon nano tubes: formation and applications.

Text books:
1. Nano structures and Nano materials: Synthesis, properties and applications - Guozhong Cao- Imperial College press in 2004, 2nd edition.

JNTUH COLLEGE OF ENGINEERING HYDERABAD

M.Tech. I Year I-Sem (Metallurgy)

L	T	P	C
4	0	0	4

LIGHT METALS AND ALLOYS
(Elective – 4)

Pre-requisites: None

Course Objective:
This course is mainly intended to deal with
1. The physical metallurgy, of Aluminum Magnesium and Zinc alloys in detail.
2. The physical metallurgy, of Titanium, Beryllium and Zirconium alloys in detail.

Course Outcome:
At the end of the course the student will be able:
1. To attain sound knowledge on microstructures, properties, and applications of several nonferrous alloys such as Al, Be, Mg, Ti, and Zn alloys.
2. To design light alloys for specific metallurgical applications.

UNIT - I
Aluminium alloys, Classification, Properties and physical metallurgy of Al-Cu alloys, Al-Mg alloys, Al-Zn alloys, Al-Mn alloys and Al-Si alloys Aluminium alloys: Ternary phase diagrams, Al-Cu-Mg alloys, Al-Si-Mg alloys and Al-Zn-Mg alloys.

UNIT - II
Magnesium Alloys: Precipitation hardening in Magnesium Base alloys, Mg-Al-Zn alloys, Corrosion resistance of Mg-alloys.
Zinc-base alloys: Classification, properties and applications.

UNIT - III
Commercially Pure Titanium and its properties, applications, Interstitial solid solutions of Titanium, Strengthening mechanisms of Titanium alloys.

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.

UNIT - V
Beryllium alloys: Classification properties and applications Zirconium alloys: Classification, properties and applications.

TEXT BOOK / REFERENCE BOOKS:
1. Heat treatment, structure and properties of Nonferrous alloys- Charlie Brooks, ASM Metals Park, Ohio, USA, 1982.
2. Light alloys: Metallurgy of the light metals by I. J. Polmear, published by London: E.Arnold, metal park, ohio American society for metals 1982.
3. Introduction to Physical Metallurgy – S.H. Avner, published by Tata Mc Graw Hill, 1997.
4. Engineering Physical Metallurgy – Y. Lakhtin, by CBS Publishers and Distributors.
5. ASM Metals Handbook Vol-1 & 2
6. Metallurgical abstracts on light metals and alloys Keikinzoku Shōgakukai, Light Metal Educational Foundation., 1999

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L	T	P	C
0	0	4	2

MATERIALS TESTING LAB

Pre-requisites: Advanced Physical Metallurgy and Mechanical Metallurgy

Course Objective:

1. This laboratory course is primarily designed to introduce various testing methods for evaluation of mechanical properties of metals.
2. To study the fracture mechanics of different materials.

Course Outcomes: At the end of the lab course the student will be able to:

1. Demonstrate and conduct experiment for characterization of tensile properties and analyze the data obtained and its applications.
2. Conduct compression test and three point test and analyze the results obtained and its applications.
3. Conduct and analyze the fatigue properties of materials and its applications.
4. Conduct creep test and analyze the creep properties and its applications.
5. Investigate K_{1C}, J_{1C} and Fatigue Crack Growth rate (FCG) at room temperature for different materials.

1. **Tensile Testing** (Room Temperature and High Temperature)
   To determine the
   - Elastic modulus
   - Yield and Ultimate tensile strength
   - Breaking stress
   - Percentage Elongation
   - 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.

8. **Fatigue Crack Growth rate** (FCG) at room temperature

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L	T	P	C
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SOFT SKILLS LAB
(Activity-based)

Course Objectives

- To improve the fluency of students in English
- To facilitate learning through interaction
- To illustrate the role of skills in real-life situations with case studies, role plays etc.
- To train students in group dynamics, body language and various other activities which boost their confidence levels and help in their overall personality development
- To encourage students develop behavioral skills and personal management skills
- To impart training for empowerment, thereby preparing students to become successful professionals

Learning Outcomes

- Developed critical acumen and creative ability besides making them industry- ready.
- Appropriate use of English language while clearly articulating ideas.
- Developing insights into Language and enrich the professional competence of the students.
- Enable students to meet challenges in job and career advancement.

INTRODUCTION

Definition and Introduction to Soft Skills – Hard Skills vs Soft Skills – Significance of Soft/Life/Self Skills – Self and SWOT Analysis ***and***

1. **Exercises on Productivity Development**
    - Effective/ Assertive Communication Skills (Activity based)
    - Time Management (Case Study)
    - Creativity & Critical Thinking (Case Study)
    - Decision Making and Problem Solving (Case Study)
    - Stress Management (Case Study)
2. **Exercises on Personality Development Skills**
    - Self-esteem (Case Study)
    - Positive Thinking (Case Study)
    - Emotional Intelligence (Case Study)
    - Team building and Leadership Skills (Case Study)
    - Conflict Management (Case Study)
3. **Exercises on Presentation Skills**
    - Netiquette
    - Importance of Oral Presentation – Defining Purpose- Analyzing the audience- Planning Outline and Preparing the Presentation- Individual & Group Presentation- Graphical Organizers- Tools and Multi-media Visuals
    - One Minute Presentations (Warming up)
    - PPT on Project Work- Understanding the Nuances of Delivery- Body Language – Closing and Handling Questions – Rubrics for Individual Evaluation (Practice Sessions)
4. **Exercises on Professional Etiquette and Communication**
    - Role-Play and Simulation- Introducing oneself and others, Greetings, Apologies, Requests, Agreement & Disagreement….etc.

- Telephone Etiquette
- Active Listening
- Group Discussions (Case study)- Group Discussion as a part of Selection Procedure- Checklist of GDs
- Analysis of Selected Interviews (Objectives of Interview)
- Mock-Interviews (Practice Sessions)
- Job Application and Preparing Resume
- Process Writing (Technical Vocabulary) – Writing a Project Report-Assignments

5. Exercises on Ethics and Values

Introduction — Types of Values - Personal, Social and Cultural Values - Importance of Values in Various Contexts

- Significance of Modern and Professional Etiquette – Etiquette (Formal and Informal Situations with Examples)
- Attitude, Good Manners and Work Culture (Live Examples)
- Social Skills - Dealing with the Challenged (Live Examples)
- Professional Responsibility – Adaptability (Live Examples)
- Corporate Expectations

☞ Note: Hand-outs are to be prepared and given to students.

☞ Training plan will be integrated in the syllabus.

☞ Topics mentioned in the syllabus are activity-based.

SUGGESTED SOFTWARE:

☞ The following software from **'train2success.com'**

- Preparing for being Interviewed
- Positive Thinking
- Interviewing Skills
- Telephone Skills
- Time Management
- Team Building
- Decision making

SUGGESTED READING:

1. Alex, K. 2012. *Soft Skills.* S. Chand Publishers
2. *Management Shapers*. 2011. Collection of 28 Books by different Authors. Universities Press.
3. Sherfield, Robert M. *2005. et al Cornerstone: Developing Soft Skills*. Pearson
4. Suresh Kumar,E; Sreehari, P. & Savithri, J. 2011. *Communication Skills and Soft Skills- An Integrated Approach.* New Delhi: Pearson
5. The ACE of Soft Skills by Gopalaswamy Ramesh & Mahadevan Ramesh. 2013. Pearson Publishers. New Delhi.
6. Patnaik, P. 2011. *Group Discussion and Interview Skills.* New Delhi: Foundation
7. Sudhir Andrews. 2009. *How to Succeed at Interviews.* New Delhi: Tata McGraw Hill
8. **Sasikumar, V & Dhamija, P.V. 1993. *Spoken English - A Self-Learning Guide to Conversation Practice.* New Delhi: Tata McGraw-Hill**
9. *Dixson, Richard J. Everyday Dialogues in English. Prentice Hall India Pvt Ltd*
10. Mukhopadhyay. L *et al. 2012. Polyskills. New Delhi: CUP India Pvt Ltd*
11. Rizvi, M. A. 2005. *Effective Technical Communication.* New Delhi: Tata McGraw Hill
12. *The Hindu Speaks on Education* by the Hindu Newspaper
13. Naterop, B. Jean and Revell, Rod. 2004. *Telephoning in English*. Cambridge: CUP

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M.Tech. I Year II-Sem (Metallurgy)

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4	0	0	4

WELDING METALLURGY

Pre-requisites: None

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

Course out comes:
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.

Unit – I
Heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry, plate thickness, preheat, significance of thermal severity number

Unit – II
Weld metal solidification - columnar structures and growth morphology- effect of welding parameters - absorption of gases - gas/metal and slag/metal reactions

Unit – III
Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating- weldability of low alloy steels, welding of stainless steels use of Schaffler and Delong diagrams, welding of cast irons

Unit – IV
Welding of Cu, Al, Ti and Ni alloys – processes, difficulties, microstructures, defects and remedial measures

Unit – V
Origin and types of process induced defects, - significance - remedial measures, hot cracking - cold cracking -lamellar tearing - reheat cracking - 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
3. Kenneth Easterling, ‘Introduction to Physical Metallurgy of Welding’, 2nd Edition, Butterworth Heinmann, 1992
4. Saferian D., ‘The Metallurgy of Welding’, Chapman and Hall, 1985
5. Jackson M. D., ‘Welding Methods and Metallurgy’, Griffin, London, 1967
6. Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM, 2007
7. Welding Metallurgy – Sindo Kour, 2nd edition, published by Wiley.

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L	T	P	C
4	0	0	4

ADVANCED NON-FERROUS METAL PRODUCTION

Pre-requisites: None

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.

Course Outcome:
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.

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

References:

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. .
3. S. Glasstone and A. Sesonke, Nuclear Reactor Engineering, CBS Publishers and Distributors, Delhi,2003.
4. C. B. Gill, Non- Ferrous Extractive Metallurgy, John Wiley and Sons, 1980.
5. Fathi Habashi, Hand Book of Extractive Metallurgy, Vols. II and III, Wiley- VCH, 1997.
6. W. G. L. Davenport, M. King, M. Schelesinger and A. K. Biswas, Extractive Metallurgy of Copper, Elsevier Science, 2002.

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M.Tech. I Year II-Sem (Metallurgy)

L	T	P	C
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ALLOY STEELS
(Elective –5)

Pre-requisites: None

Course objectives:
This course deals with
1. Low carbon, Medium carbon and High carbon steels with respect to structure property correlations and strengthening mechanisms with alloy additions
2. Ultra high strength steels, Stainless steels and Tool steels with respect to heat treatment, properties and applications.

Course Outcomes:
1. Ability to understand different types of alloys used in alloy steels.
2. Ability to solve different metallurgical problems in alloy steels.
3. It has a lot of scope in R&D and in automobile engineering.

UNIT – I
Low-carbon Mild steels: Introduction; cold forming steels, High strength packing steels; HSLA steels; Low-carbon Ferrite pearlite steels – structure property relation-ships, 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: Introduction, steels tempered at low temperatures, secondary hardening, thermo- mechanical treatments, rapid austenitizing treatments, structure-property relationships in tempered mantensite, cold-drawn pearlite steels, maraging steels.

UNIT – IV
Stainless steels: Classification, Composition, Microstructures, Heat treatment an application.

UNIT- V
Tool steels and Heat resistant steels: Classification, Composition, Micro structure an Heat treatment and application.

TEXT / REFERENCE 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.
3. Alloys Steels – Wilson.
4. Heat Treatment of steels – Rajan & Sharma

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L	T	P	C
4	0	0	4

SEMI CONDUCTORS AND MAGNETIC MATERIALS
(Elective –5)

Pre-requisites: None

Course objective:
This course specifically deals with a class of materials, semiconductors and magnetic materials which have wide application in electronic and memory storage devices.

Course outcomes:
1. This course would benefit the student through giving the inputs on semiconductor and magnetic materials technology.
2. This will allow them choose the stream of electronic materials as their subject of interest.

UNIT - I
Review of electron theory of metals; Electrical and thermal conductivity – Classical approach and quantum mechanical considerations; Resistivity of pure metals and alloys, and ordered alloys; Thermoelectric phenomena.

UNIT - II
Semiconductors: Band structures, Intrinsic semiconductors, Extrinsic semiconductors; Hall effect; Elemental and compound Semiconductors and their application; Super conductivity; super conducting materials; Structure and application.

UNIT-III
Ferromagnetism: Ferromagnetic domains; Hysteresis loops, magnetostriction and magnetoelectricity, origin of Hysteresis due to domain wall movement; soft magnetic alloys.
Ferri magnetic material; Spiral structure; Theory of ferrimagnetisms; magnetic structures of ferrites; permeability of ferrites; stress-induced anisotropy in ferrites; Applications of soft ferrites.

UNT-IV
Factors determining the permeability of metals and alloys; Effect of fundamental properties on permeability, Ni-Fe alloys, Fe-Co alloys, high permeability of iron and ferritic iron, Si – Fe alloys and Cu – Ni alloys.
Amorphous ferromagnetic alloys and Ferro fluids: Preparation and structure of amorphous ferromagnetic and its application; Ferro fluids.

UNIT-V
Permanent magnetic materials: Energy product of a permanent magnet material; Behaviour of permanent magnets under dynamic or recoil conditions; Alnicos; Fe- Cr-Co alloys.
Cu-Ni-Fe and Cu-Ni-Co alloys; Fe-Co-Mo alloys, Pt-Co alloys; Permagnent, magnets based on the Intermetallic compound Sm_2 Ca_{l2} Coercivity mechanisms; Applications of permanent magnetic; Temperature dependence of magnetic properties of permanent magnets.

TEXT / REFERENCE BOOKS:

1. R.E. Hummel: Electronic Properties of materials by Springer, fourth edition.
2. R.A. Macurie: Ferromagnetic Materials structure and properties, publisher academic press Inc 1994.
3. An Introduction to Materials science- H. L. Mancin by Princeton University Press, 2004.
4. Magnetic materials- Fundamental and devices- Nicola Spaldin by Cambridge University Press, 2003.
5. Fundamentals of Semiconductors- physical and materials properties - Peter Y. Yu Manuer Cardona.
6. Semi Conductors - Halbleiter. Ed. Annuelle.

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L	T	P	C
4	0	0	4

FERRO ALLOY TECHNOLOGY
(Elective – 5)

Pre-requisites: None

Course Objective:
1. The prime objective of the course is to make the students understand various ferroalloys used in Industries.
2. To expose the students in various production methods of ferro alloys.

Course Outcome:
At the end of the course, student would be able to
1. Acquire sufficient knowledge on the course, the student would be able to select the required ferroalloy for a specific application.
2. Have knowledge in layout ferroalloy plans, its economics and status.

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 / REFERENCE BOOKS:

1. Riss M. And Khodorovsky V - Production ferroalloys, Mir Publishers, Moscow 1967.
2. Symposium on ferro alloys: NML Technical Jl. Feb 1962.
3. Ferro Alloys- F.P.Edneral , Mir Publishers 1979

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M.Tech. I Year II-Sem (Metallurgy)

L	T	P	C
4	0	0	4

NON DESTRUCTIVE TESTING OF MATERIALS
(Elective –6)

Pre-requisites: None

Course Objective:
1. Provide an opportunity to learn visual methods, electrical methods and magnetic methods and non destructive testing.
2. To develop a fundamental understanding of ultrasonic testing of material and radiographic methods.

Course Outcome:
The end of the student gain will be
1. Knowledge about application of NDT methods like visual observation, electrical methods, penetrant detection etc.,
2. Ability to use ultrasonic testing and radiographic methods for checking various types of defects.

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, applications.
MAGNETIC METHODS**:** Advantages, Limitations, Methods of generating fields; magnetic particles and suspending liquids Magnetography, field sensitive probes; applications. Measurement of metal properties.

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. Acoustic emission methods: Basic Principles, methods and applications.

Unit V
RADIOGRAPHIC METHODS: Limitations; Principles of radiography; sources of radiation, Ionising radiation - X-rays sources, gamma-rays sources Recording of radiation; Radiographic sensitivity; Fluoroscopic methods; special techniques; Radiation safety.

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

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M.Tech. I Year II-Sem (Metallurgy)

L	T	P	C
4	0	0	4

TRANSPORT PHENOMENA IN METALLURGY
(Elective- 6)

Pre-requisites: None

Course Objective:
1. Gain knowledge in the importance of diffusion and concepts of fluid mechanics in extractive metallurgy.
2. Applied the concept of heat transfer in various fluids
3. To highlight the importance of various macroscopic balances and applications of Newtons's law of Viscosity.

Course Outcome:
At the end of the course the student will be able to:
1. Understand the concepts of fluid mechanics in extractive metallurgy.
2. Apply the concepts of heat and mass transfer in various conditions.
3. Determine the various macroscopic balances.

UNIT – I
Fick's law of Diffusion, Diffusion Coefficients for gases, Gas diffusion - Equimolar counter diffusion of two gas components. Diffusion of one ideal gaseous component through a second stagnant ideal gas composed of ideal gas, liquid diffusion, diffusion in solids.

UNIT – II
Diffusion in turbulent flow, similarity between heat and mass transfer for several engineering systems; fluids flowing in turbulent motion through pipes.

UNIT – III
Gases flowing at right angles to cylinders, gases flowing parallel to flat plates, heat and mass transfer in free convention, humidification.

UNIT – IV
Newton's law of viscosity. Non-Newtonian fluids. Theory of viscosity of gases at low density. Theory of viscosity of liquids. Velocity distributions in laminar flow; shell momentum balances, flow of a falling film, flow through a circular tube.

UNIT – V
The equations of change for isothermal systems; continuity equation of motion, velocity distributions in turbulent flow, fluctuations and time-smoothed quantities, time-smoothing of the equations for change of an incompressible fluid. Macroscopic balances for isothermal systems-Macroscopic mass balance, Macroscopic momentum balance.

TEXT / REFERENCE BOOKS:
1. G.H Gieger & D.R Porier, "Transport Phenomenan in metallurgy by Addision Wesley Publication Company,1973.
2. Elements of Heat Transfer: M. Jacob and G. A. Hawkins by John Wiley & Sons, Newyork, 1957.
3. Transport Phenomena: R. B. Bird, W. E. Stewart and E. N. Lightfoot by john Wiley and sons,Inc., Newyork,1960.

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M.Tech. I Year II-Sem (Metallurgy)

L	T	P	C
4	0	0	4

TESTING OF MATERIALS
(Elective- 6)

Pre-requisites: None

Course Objectives:
1. To gain and understanding of the response of various metals under the application of stress and/or temperature.
2. To build necessary theoretical back ground of the role of lattice defects in governing both elastic and plastic properties of metals will be discussed.
3. Obtain a working knowledge of various hardness testing machines BHN, VHN, RHN
4. Obtain a working knowledge of creep and fatigue and analysis of data.

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. Recognize the importance of crystal defects including dislocations in plastic deformation.
3. Identify the testing methods for obtaining strength and hardness.
4. Examine the mechanisms of materials failure through fatigue and creep

UNIT – I
Introduction, Importance of testing
Hardness Test: Methods of hardness testing – Brinell, Vickers, Rockwell hardness tests.
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 / REFERENCE BOOKS:
1. Mechanical Metallurgy – G. E. Dieter, Third edition, published by Newyork Mc Graw Hill,1986.
2. Mechanical behavior - Ed. Wulf.
3. Mechanical Metallurgy – White & Lemay.
4. Testing of Metallic Materials - A.V.K. Suryanarayana

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4	0	0	4

COMPOSITE MATERIALS
(Elective-7)

Pre-requisites: None

Course Objectives:
1. Develop understanding of the structure of ceramic materials on multiple length scales.
2. Develop knowledge of point defect generation in ceramic materials, and their impact on transport properties.
3. To describe key processing techniques for producing metal, ceramic-, and polymer-matrix composites.
4. To demonstrate the relationship among synthesis, processing, and properties in composite materials.

Course Outcomes:
1. Knowledge of the crystal structures of a wide range of ceramic materials and glasses.
2. Able to explain how common fibers are produced and how the properties of the fibers are related to the internal structure.
3. Able to select matrices for composite materials in different applications.
4. Able to describe key processing methods for fabricating composites.

UNIT - I

Introduction: Definition, Classification of Composite materials based on structure, based on matrix, Advantages of composites, Applications of composites, Functional requirements of reinforcement and matrix.

UNIT - II

Types of reinforcements and their properties: Fibers: Carbon, Boron, Glass, Aramid, Al_2O_3, SiC, 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.

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

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STRENGTHENING MECHANISMS
(Elective – 7)

Pre-requisites: None

Course Objectives:
1. To explain and describe various strengthening mechanisms involved in the development of existing alloys and new alloys.

Course Outcomes:
At the end of the course, student would be able
1. To understand and develop design of alloys as per the actual service condition of engineering applications

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

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PROCESS MODELING AND SIMULATION
(Elective – 7)

Pre-requisites: None

Course Objectives:
1. Gains Knowledge about fundamentals of Modeling techniques
2. Gains Knowledge about Simulation methods.
3. Apply the knowledge of modeling and simulation to various structural materials.

Course out comes:
1. Gains knowledge about modeling and simulation.
2. Can apply statistical, Monte Carlo methods to structural materials etc.
3. Can apply computational micro-mechanics multiscale coupling to structural materials etc.

Unit I
Introduction and Fundamentals: All numerical techniques and their basics; Control volume method; finite difference method; least squares method.

Unit II
Multiscales Modeling and Simulation in Materials & Science Ab Initio Methods,

Unit III
Statistical Machanics, Monte Carlo Simulations, Molecular Dynamics, continuum modeling. Computational micro- mechanics Multiscale coupling.

Unit IV
Application of Multiscale Modeling: Modeling dislocation behavior, Phase field modeling, Modeling of grain growth and microstructure in polycrystalline materials,

Unit V
Modeling of structural materials.

Text / Reference Books:
1. DierkRaabe, Computational Materials Science, Wiley VCH Verlag GmbH, 1998
2. Z. Xiao Guo (Ed), Multiscale Materials Modelling: Fundamental and Applications. Woodhead Publishing Limited, Cambridge, 2007
3. Zoe H. Barber, Introduction of Materials Modelling, Maney Publishing, 2005

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FRACTURE MECHANICS AND FAILURE ANALYSIS
(Elective – 8)

Pre-requisites: None

Course Objective:
1. Gain an understanding of fundamentals of fracture mechanics, Griffith crack theory.
2. Analyze the crack behavior in various conditions.
3. Obtain a working knowledge of failure analysis.

Course Outcomes:
At the end of the course the student will be able to:
1. Apply the knowledge of fracture mechanics under various conditions.
2. Awareness about crack formation and crack growth in materials under various conditions.
3. Able to analyze and take remedial steps in case of failure by fracture.

UNIT - I
Introduction to fracture mechanics: Fracture criteria, theoretical strength, stress-concentration factor, Griffith crack theory, strain-energy release rate.

UNIT - II
Mechanism of fracture: introduction, cleavage fracture, ductile fracture, fatigue cracking, environment assisted cracking, evaluation of fracture toughness. Introduction to LEFM: Concept, analysis of simple crack problems, nucleation and propagation of cracks, correlation between microstructure and fracture behavior in different materials.

UNIT - III
Crack behavior in elastic-plastic materials, effect of strain rate, environment, temperature, and irradiation on fracture behavior of materials. Application of fracture mechanics to material selections, alloy design, and design of structures.

UNIT - IV
Conventional approach to fatigue crack growth in reactive environment, static and cyclic loading.

UNIT - V
Failure analysis: failure analysis methodology, failure types and characteristics, and concept of failure mechanism. Tools and techniques of failure analysis, case studies: in-process failure and service failure conditions.

Text / Reference Books:
1. Fracture Mechanics: Fundamentals and Applications, T. L. Anderson, CRC Press, Inc., 1995.
2. Fracture and Fatigue Control in Structures, S.T. Rolfe and J.M. Barsom, Prentice-Hall, 1972.
3. ASM Handbook: Fatigue and Fracture, S. R. Lampman, (Rechnical Ed.) ASM International, 1996.
4. Elementary Engineering Fracture Mechanics, David Broek, Scjtoff & Noordhoff, 1978.
5. Case Histories in Failure analysis, ASM, Ohio, 1979.
6. Failure analysis- R W Hertzberg, Deformation of Fracture Mechanics of Engineering Materials- John Wiley& Sons publications (1995).

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SURFACE ENGINEERING
(Elective – 8)

Pre-requisites: None

Course Objectives:
1. To provide a state- of- the art knowledge to the students and various surface engineering techniques.

Course Outcomes:
1. This course provides an opportunity to the students to engineer the microstructure for an enhanced performance based on the need in actual practice.

Unit- I
Introduction to surface modification, need for surface modification, surface properties, surface property modification, history of surface modification

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, carbonitriding, nitro carburizing, Boronising, Plasma nitriding, thermal spraying, Plasma spraying.

Unit-IV
Thermal Processes: hardening, tempering, 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.

Text books/ References:

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.
3. Advanced techniques for surface engineering, W.Gissler, Herman A.Jehn, published by Kluwer Academy Publishers in 1992.
4. Laser material processing, William M.Steen, fourth edition, Springer

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NUCLEAR METALLURGY
(Elective – 8)

Pre requisites: None

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.

Course outcomes:
At the end of the course, student would be able:
1. To get idea about the working of nuclear reactors and application in nuclear reactor.
2. Justify the extraction techniques adopted for Uranium, Beryllium, Thorium and Zirconium.

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 / REFERENCE 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
3. Symposium on Rare Materials: Indian Institute of Metals 1957.

4. Principles of Nuclear Reactor Engineering: Glasstone S and Snesonske A Macmillan, London.
5. Uranium and Thorium: Grainger L; George Newnes Ltd., London.
6. Nulcears Fuels: Gurinsky DH and Dienes JL; Macmillan.
7. Reactor Hand book Material; US Atomic Energy Commission, McGraw Hill Book Co. 1955
8. Proceedings of the symposium on Nuclear Science and Engineering – Bhabha Atomic Research Centre, Bombay.

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WELDING TECHNOLOGY LAB

Pre-requisites: METAL JOINING THEORY

Course Objectives:

1. To provide with the knowledge on joining of different materials and associated processes.
2. To characterize the welded materials hardness and micro structure etc.,

Course Outcomes:

1. Demonstrate and conduct experiments on Arc, Gas welding processes.
2. Demonstrate and conduct experiment on TIG & MIG welding processes.
3. Conduct Tensile and hardness test and interpret the results obtained.
4. Appreciate the importance of Microstructural characterization of welded joints.
5. Demonstrate, conduct and analyze the quality of welds by NDT methods.

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.

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SEMINAR

Pre-requisites: None

Course Objectives:

1. The prime objective of this course is to make students become effective communicators
2. Enhance their presentational and creative abilities.
3. Enhance their technical knowledge and skills.

Course Outcomes:

1. The student will be able to communicate and present the work carried out by him effectively
2. Also be able to clarify the questions raised.
3. Apply the knowledge gained in carrying out R&D works, consultancy services etc.

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Comprehensive Viva Voce

Pre-requisites: Course Work

Course Objectives: To test the knowledge, analyses, skills and applications of the topics studied during the course work.

Course Outcomes: At the end of the course the student will be able to:
1. Demonstrate an understanding of advanced topics
2. Explain the principles and phenomena, and their applications

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PROJECT PHASE-I

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

Course Objective:
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 and materials engineering, plan and execute experimental work to obtain results.
2. Further analyze the results, prepare a technical report and make an oral presentation.

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PROJECT PHASE-II & DISSERTATION

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

Course Objective:
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 and materials engineering, plan and execute experimental work to obtain results.
2. Further analyze the results, prepare a technical report and make an oral presentation.