# METALLURGY AND MATERIALS SCIENCE
## CURRICULUM STRUCTURE OF IV B. TECH. REGULAR
**Effective from 2010-11**

### VII -Semester

<table>
<thead>
<tr>
<th>Sr. No</th>
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<th>Subject Title</th>
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<tr>
<td></td>
<td>MT401</td>
<td>Design and Selection of Materials</td>
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<td>02</td>
<td>MT402</td>
<td>Corrosion and Surface Protection</td>
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<td>03</td>
<td>MT403</td>
<td>Electronic and Magnetic Materials</td>
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<td>04</td>
<td>MT404*</td>
<td>Elective I</td>
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<td>05</td>
<td>MT406</td>
<td>Corrosion &amp; Surface Protection Laboratory</td>
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<td>06</td>
<td>MT408</td>
<td>Project-I</td>
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### VIII Semester

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<tbody>
<tr>
<td>01</td>
<td>MT409</td>
<td>Materials Joining</td>
<td>3 L - - -</td>
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<tr>
<td>02</td>
<td>MT410</td>
<td>Fracture and Failures</td>
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<tr>
<td>03</td>
<td>MT411</td>
<td>Ceramic Engineering</td>
<td>3 L - - -</td>
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<td>04</td>
<td>MT412</td>
<td>Elective II</td>
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<td>05</td>
<td>MT413</td>
<td>Materials Joining Laboratory</td>
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<td>07</td>
<td>MT415</td>
<td>Project -II</td>
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19 Hrs

18 Hrs
Elective I (MT404)

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<td>MT404-1</td>
<td>Secondary Steel Making</td>
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<td>02</td>
<td>MT5106</td>
<td>Nano-materails &amp; Nanotechnology</td>
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<td>03</td>
<td>MT5105</td>
<td>Powder Metallurgy</td>
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<td>04</td>
<td>MT5112</td>
<td>Advanced Composites</td>
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Elective II (MT412)

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<td>01</td>
<td>MT412-1</td>
<td>Surface Modification</td>
<td>3 2</td>
<td>4</td>
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<tr>
<td>02</td>
<td>MT412-2</td>
<td>Wire Technology</td>
<td>3 2</td>
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Final Year B.Tech. Seventh Semester

MT401  Design and Selection of Materials

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

Examination Scheme
Test I–20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVES:
• To understand the role of the Materials Engineer in design process
• To introduce different methods of material selection and apply them for different engineering components

Unit 1
Materials in Design, Evolution of Engineering Materials, Design process, Types of design, Design flow chart- tools and material data, Interaction between Function, Material, Shape and Process,

Unit 2
Revision of engineering materials and properties, Material properties interrelationship charts such as Young’s modulus-density, Strength-density, Young’s modulus-Strength, wear rate-hardness, Young’s modulus – relative cost, strength-relative cost and others

Unit 3
Materials selection, selection strategy: material attributes, translation of design requirements, screening attribute limits, ranking by indices, search supporting information, Local conditions, method of finding indices, Weighted-Properties Method, computer aided selection, structural index; Case studies: table legs, flywheel, springs, elastic hinges, seals, pressure vessels, kiln wall, passive solar heating, precision devices, bearings, heat exchangers, airframes, ship structures, engines and power generation, automobile structures

Unit 4
Materials Substitution, Pugh Method, Cost–Benefit Analysis, Cost basis for selection, causes of failure in service, Specifications and quality control, Selection for static strength, toughness, stiffness, fatigue, creep, corrosion resistance, wear resistance, material databases

Unit 5
Process selection, ranking processes, cost, computer based process selection, Case studies: fan, pressure vessel, optical table, cast tables, manifold jacket, spark plug insulator

Unit 6
Selection under multiple constraints, conflicting objectives, penalty-functions, exchange constants, Case studies: connecting rods, windings of high field magnets, casing of minidisk player, disk-brake caliper
TEXT BOOKS:


REFERENCE BOOKS:

MT402  Corrosion and Surface Protection

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Test I–20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVES:
• To acquaint the student about the fundamentals of corrosion and its application in various industrial practices.

Unit 1 (06)

Unit 2 (06)

Unit 3 (06)

Unit 4 (06)
Principles of Protection, Inhibition, Coating Application Methods Including Electrophoretic Coating for Corrosion Control.

Unit 5 (06)
Corrosion Testing by Physical and Electrochemical Methods such as ASTM standard methods likeG-8, G-5, G-1 etc. and their equivalents, Surface Preparation, Exposure Technique, Corrosion Rate Measurements.

Unit 6 (06)

TEXT BOOKS:

REFERENCE BOOKS:
MT403 Electronic and Magnetic Materials

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Test I–20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVES:
- To get acquainted with the field of electronics applications of materials.

Unit 1 (06)

Unit 2 (06)
Semiconductors, Extrinsic, Intrinsic, Semiconductor Devices, Compound Semiconductor, Microelectronic Devices Such as LED, CMOS, MOSFETS, BPT etc, Manufacturing Methods and Applications.

Unit 3 (06)

Unit 4 (06)

Unit 5 (06)

Unit 6 (06)

TEXT BOOKS:

REFERENCE BOOKS:
Elective I    MT404-1    Secondary Steel Making

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

Examination Scheme
Test I– 20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVE:
- To study various steel making processes in its current level of technology, along with applicable physical and chemical principle.

Unit 1 (06)

Unit 2 (06)

Unit 3 (06)
Phenomena During Tapping and Teeming of Molten Steel: Teeming Speed, Temperature Change from Furnace to Mould, Gas Absorption During Tapping and Teeming from Surrounding Atmosphere, Refractory Selection.

Unit 4 (06)
Theory of Segregation and Crystallization During Solidification in Killed Steel Ingots, Morphology and Microstructure of Killed Steel Ingots, Blowhole Formation and Ramming Segregation and Structure of Ramming Steel Ingots.

Unit 5 (06)

Unit 6 (06)
Ingot Casting and Continuous Casting: Heat Transfer And Solidification Rate in Ingot Casting and Continuous Casting, Distinguishing Metallurgical Aspects of Continuous Casting of Steel.

TEXT BOOKS:
- Kudrin V. –Steel Making; Mir Publisher.

REFERENCE BOOKS:
- Darken and Gurry- Physical Chemistry of Metals.
Elective I  MT5106  Nano-materials & Nanotechnology

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

Examination Scheme
Test I–20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVES:
- To introduce students to nanoscience and nanotechnology
- To understand basics of synthesis, properties and applications of nanomaterials.

Unit 1 (06)
Definition, Length scales, Importance of Nanoscale and Technology, Top down and bottom up approaches, Properties of selected nanomaterials including carbon nanotubes (CNT), metal nanoparticles, nanoclays, nanowires, colloidal semiconductors and concept of quantum dots.

Unit 2 (06)
Fabrication of Nanomaterials: Synthesis and purification of CNT, synthesis of expanded graphite (EG), clay, electro-ceramics, semi-conducting and magnetic nanoparticles, Fabrication of nano-composites : Clay-rubber, Clay-polymer, CNT-metal, CNT-polymer and EG-polymer,

Unit 3 (06)

Unit 4 (06)
Thin Films: Production of thin films by PVD, CVD, Film formation mechanisms, Epitaxial films, their growth, structure and their relevance in semiconductors, electrical properties of thin films, magnetic thin films for memory applications and protective coatings,

Unit 5 (06)
Biomaterials: Introduction, Property requirements of biomaterials, Classes of biomaterials used including metals, polymers and nanocomposites, hydrogels, thin films and coatings. Degradation of materials in biological environment,

Unit 6 (06)
Applications in medicine, dentistry and artificial organs and implants. Applications: Applications in structural, electronics, optical, magnetic and bio-medical fields, solar cells, LED, LCD, electrically conducting polymers, batteries, fuel cells, Nano-composites, Nano-SMART materials.

REFERENCE BOOKS:
- Nanomaterials: An introduction to synthesis, properties and applications, Editor-Dieter Vollath, Wiley-CVH
- Encyclopedia of Nanotechnology- Hari Singh Nalwa.
- Springer Handbook of Nanotechnology - Bharat Bhusan, Springer-Verlag Publ media.
- Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong.
Elective I    MT5105    Powder Metallurgy

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Test I – 20 marks
Test II – 20 marks
End Sem exam – 60 marks

OBJECTIVES:
• To understand the basic principles of powder metallurgy and its applications.

Unit 1 (06)

Unit 2 (06)
Characterization and Testing of Metal Powders: Sampling, Particle Size and Distribution-Sieve Analysis, Light Scattering, Sedimentation, Microscopy and Image Analyzer, Chemical Analysis of Metal Powders, Surface Area, Density and Porosity of Metal Powder, Apparent and Tap Density of Metal Powder, Flow Rate, Compressibility and Green Strength.

Unit 3 (06)

Unit 4 (06)
Sintering: Different Stages of Sintering and Development of Microstructures During Sintering, Different Mechanisms of Sintering, Liquid Phase Sintering and Activated Sintering, Sintering Furnaces and Furnace Atmospheres.

Unit 5 (06)
Application:
Detailed Study on Processing of any 03 Components used in following applications: Bearing Materials, Tool Materials, Ferrites, Cermets, Friction Materials, Medical and Dental Applications, Nuclear Applications, Automotive Applications.

Unit 6 (06)

TEXT BOOKS:
• Sands & Shakespeare - Powder Metallurgy.
• Thumler - Powder Metallurgy.
• Barsaum - Fundamentals of Ceramics.
REFERENCE BOOKS:

- W.D.Kingery, Introduction to Ceramic Material.
- Powder Metallurgy, ASM Handbook, Vol-VII.
- Rehamann, Processing of Ceramics and Sintering

**Powder Metallurgy Laboratory**

A set of 08 number of Experiments based on the theory syllabus will be conducted.
OBJECTIVES:

- To understand advanced concepts in production, characterization of composites.

Unit 1: (06)
Introduction to Advanced Composites, Type of Reinforcements; carbon fiber, glass fiber, aramid fiber and particulates (Al₂O₃, SiC, Silicates, ZrO₂ etc.), Classification of Composites, Role of Interfaces, Type of Bonding at the Interfaces, Composite’s Property Maps (modulus Vs density), Benefits of Composites compared to Matrices, Interface Reactions.

Unit 2: (06)
Processing of Metal Matrix Composites (MMCs): Solid State, Liquid State, Deposition, In-situ; Interface Reactions, Thermal, Mechanical and Electrical Properties of MMCs, Applications of MMCs and Limitations.

Unit 3: (06)
Polymer Matrix Composites (PMCs): High Performance Polymer Matrices (PEEK, PPS, PEI, PES etc), Processing of PMCs: Hand Methods, Moulding Methods, Filament Winding; Thermal, Mechanical and Electrical Properties of PMCs, Limitations and Applications of PMCs.

Unit 4: (06)
Ceramic Matrix Composites (CMCs): Cold Pressing and Sintering, Hot Pressing, Reaction Bonding Processes, Infiltration, Directed Oxidation or Lanxide Process, In-situ Chemical Reaction Techniques, Sol-gel Processing, Self-Propagating High-Temperature Synthesis (SHS); Interfaces in CMCs, Applications and Properties of CMCs.

Unit 5 (06)

Unit 6 (06)

TEXT BOOKS:

- Composite Materials-Functional Materials for Modern Technology, DDL Chung,
REFERENCE BOOKS:

Following experiments will be conducted:

1. Preparation of different types of composite materials.
2. Microscopic examination of above composite materials.
3. Study of physical properties of composite materials.
4. Determination of mechanical properties such as tensile strength, % elongation and compressive strength.
5. Determination of impact strength of composites.
6. Determination of thermal and electrical properties of composites.
7. Problems on design of composite materials.
# MT406  
**CORROSION AND SURFACE PROTECTION LABORATORY**

<table>
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<td>Practical: 2 hrs/week</td>
<td>Practical / Oral: 50 Marks</td>
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<td>Term Work: 50 Marks</td>
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A Set of 08 Number of Experiments Based on the Theory Syllabus.

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# MT 408  
**PROJECT I**

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<tr>
<td>Interaction: 2 hrs/week</td>
<td>Oral: 100 Marks</td>
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<td>Term Work: 100 Marks</td>
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The B. Tech. Project is aimed at training the students to analyze independently any problem in the field of Metallurgical Engineering and Material Science. The project may be analytical, computational, experimental or a combination of the three in a few cases. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature and analytical, computational, experimental aptitude of the student. The progress will be reviewed in two stages - in the middle of the two semesters (Project I) and at the end of second semester (Project II). In the final stage, it will be externally evaluated on the basis of oral/seminar talk.
Final Year B.Tech. Eighth Semester

MT409 Materials Joining

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Test I–20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVES:
- To understand basic principles of joining materials.
- To be able to analyze metallurgical phenomena occurring in joining processes.

Unit 1 (06)

Unit 2 (06)

Unit 3 (06)

Unit 4 (06)

Unit 5 (06)
Fusion Zone, Solidification, Effect of Cooling Rate, Partially Melted Zone, Liquation, Heat Affected Zone, Defects in Welded Joints, Micro-Segregation, Macro-Segregation, Banding, Gas Porosity, Inclusions, Weld Metal Cracking, Liquation Cracking, Hydrogen Cracking.

Unit 6 (06)

TEXT BOOKS:
MT410  Fracture and Failures

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Test I–20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVES:
- To make the students familiar with the low and high temperature failure mechanisms involved in engineering components.

Unit 1  (06)
Fatigue: Cyclic Loading, Cyclic stress and cyclic strain controlled fatigue, Fatigue life estimation of notched components, Fatigue Initiation Mechanism, Factors affecting Fatigue Life,

Unit 2  (06)
Crack Growth, Fatigue Failure, Second Order Terms, Predicting Direction of Crack Growth, Crack Closure, and Corrosion Fatigue.

Unit 3  (06)

Unit 4  (06)
Crack Tip Plasticity, Plastic Zone Size and Shape, Elastic Plastic Failure, Plane Strain Fracture Toughness, Design for Fracture Mechanics, Test Procedures for Kc, Kic, CTOD& J.

Unit 5  (06)

Unit 6  (06)
Wear: Types: Abrasive Adhesive, Oxidative, Corrosion, Erosion, Fatigue, Mechanism of Wear Particle Formation and Wear tests, Failure analysis

TEXT BOOKS:
MT411  Ceramic Engineering

Teaching Scheme  Examination Scheme
Lectures: 3 hrs/week  Test I–20 marks

OBJECTIVES:
• To make the students familiar with the ceramics as engineering materials

Unit 1 (06)
Introduction to bonding, important ceramics structures, point defects, defect reactions, diffusion and defects.

Unit 2 (06)
Ceramic powder processing and forming – Solid state and viscous sintering, Herrings-Scaling law, stress in densification and sintering stress; Grain growth and Ostwald ripening, grain growth kinetics, pore-grain boundary interactions.

Unit 3 (06)
Novel techniques like spray pyrolysis, solgel process etc., near net shape forming, gel casting, slip, gel casting, plastic forming, thick films and thin films, Multilayer ceramic technology –processing and sintering of multilayer structure. Low temperature co-fired glass ceramics.

Unit 4 (06)
Structural ceramics, deformation behaviour and toughening of ceramics, toughening mechanism, crack deflection, bridging, shielding, pullout, Zirconia Ceramics: Crystal structure and polymorphic modifications, transformation toughening; effect of microstructure, different system in zirconia (PSZ, TZP, ZTA, ZTC), Weibull parameters

Unit 5 (06)
Ceramics in tribological and thermal applications: scope, material requirements, fabrication and applications, wear components, ceramic cutting tools, ceramic coatings, Surface melting and Thermo chemical treatments, Thermal properties, high strength and high temperature strength, thermal stresses and fracture, applications.

Unit 6 (06)
Glass and glass-ceramics: Structural models, theory of glass formation, Homogeneous and heterogeneous nucleation and crystal growth, TTT diagram, toughening of glass, optical properties, Glass ceramics- fabrication, advantages of glass ceramic formation, properties and applications.

TEXT BOOKS:
Elective II  MT412-1  Surface Modification

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Test I– 20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVES:
• To expose the students to the various techniques involved in Surface Engineering.

Unit 1
Introduction to surface engineering, Scope of surface engineering in metals, ceramics, polymers and composites, Surface Preparation methods such as Chemical, Electrochemical, Mechanical- Sand Blasting, Shot peening, Shot blasting, Hydroblasting, Vapor Phase Degreasing etc., Properties of Various Coating, Coating Methods.

Unit 2
Chemical Conversion Coating: Chromating, Phosphating, Anodizing, thermochemical processes, industrial practice, economy and energy considerations.

Unit 3
Metallic coating: Surface pretreatments, Hot Dipping, galvanizing, Electrolytic and Electroless plating of important metals and alloys, testing/evaluation of surface properties.

Unit 4
Coating from Vapour Phase: PVD, CVD, Various Methods used, mechanisms, important reactions involved and applications.

Unit 5
Plasma Coating: Sputtering, Plasma Spray & Ion Implantation Methods, mechanisms & applications.
Surface modification by directed energy beams like ion, electron and laser beams, novelty of composition and microstructures.

Unit 6
Diffusion Coating: Various Techniques For Single And Multiple Element Coating, High Temperature Coating- Carburising, Carbonitriding, Siliconizing, Chromizing, Aluminizing, Boronizing, Boronitriding.

Text Books
• J. R. Davis-Surface Engineering for Corrosion and Wear Resistance.
• James A. Murphy- Surface Preparation and Finishes for Metal, McGraw-Hill, New York 1971

Reference Books
Surface Modification Laboratory

A set of 08 number of Experiments based on the theory syllabus will be conducted.
Elective II  MT412-2  Wire Technology

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

Examination Scheme
Test I–20 marks
Test II– 20 marks
End Sem exam – 60 marks

OBJECTIVES:
• To introduce students to wire technology
• To understand fundamentals of wire manufacturing process and applications

Unit 1  (06)
Brief revision of hot rolling, mechanical working, cold work and work hardening, solid solution strengthening, effect of alloying elements on work hardening of steel. The Stelmor cooling process, TTT & CCT Diagrams.

Unit 2  (06)

Unit 3  (06)
Effect of processing parameters on mechanical properties of wire – effect of carbon and other alloying elements on work hardening, effect of microstructure, drawing strain – total and stepwise, strain rate, lubrication and cooling efficiency.

Unit 4  (06)
Heat Treatments and their effects on microstructures and mechanical properties – patenting, annealing, stress relieving, quenching and tempering.

Unit 5  (06)

Unit 6  (06)
Applications of wires and their basic principles – electrical conductor wire, tire cord, mechanical springs, wire ropes. Brief introduction to other metallic wires – copper, aluminium, and tungsten.

TEXT BOOKS:
• Ferrous Wire – Volume 1 and 2, The Wire Association International
• Electrical Wire Handbook – Part 1 and 2, The Wire Association International
• Physical Metallurgy Principles, Reed-Hill, 2nd ed, East West Press, New Delhi, 1973
• Research Articles from Technical Publications and Conferences.

Wire Technology Laboratory
A set of 08 number of Experiments based on the theory syllabus will be conducted.
MT413  MATERIALS JOINING LABORATORY

Teaching Scheme
Practical: 2 hrs/week

Examination Scheme
Practical / Oral: 50 Marks
Term Work: 50 Marks

Minimum 8 assignments from the following areas are required to be completed.

1. Working on welding machines for different welding processes such as manual arc welding, MIG welding, TIG welding, Spot welding,
2. Diffusion welding of two dissimilar metals,
3. Case studies of welding defects, application of NDT and remedies
4. Soldering and brazing practice
5. Measurement of hydrogen in weld metal of welded steels
The B. Tech. Project is aimed at training the students to analyze independently any problem in the field of Metallurgical Engineering and Material Science. The project may be analytical, computational, experimental or a combination of the three in a few cases. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature and analytical, computational, experimental aptitude of the student. The progress will be reviewed in two stages - in the middle of the two semesters (Project I) and at the end of second semester (Project II). In the final stage, it will be externally evaluated on the basis of oral/seminar talk.