Course structure and revised syllabus

For

M.Tech Program in Materials Science

2020-2021
Course Structure and Revised Syllabus:

M.Tech. Program in Materials Science - 2013

<table>
<thead>
<tr>
<th>Admission Eligibility Qualification</th>
<th>Degree after the Program</th>
<th>Hard Core credits (including project)</th>
<th>Soft core credits</th>
<th>Total credits</th>
<th>No. of Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.Sc (Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science)</td>
<td>M.Tech.</td>
<td>60</td>
<td>46-50</td>
<td>110</td>
<td>3 years</td>
</tr>
<tr>
<td>B.Sc (Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science) (optional exit)</td>
<td>M.Sc.</td>
<td>50</td>
<td>22-26</td>
<td>76</td>
<td>2 years</td>
</tr>
<tr>
<td>B.E/ MBBS/ B.Tech/ B.Pharma/ BDS/ BSc(Ag)(any branch)</td>
<td>M.Tech.</td>
<td>52</td>
<td>12</td>
<td>64</td>
<td>2 years</td>
</tr>
<tr>
<td>M.Sc (Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science, Nanotechnology)</td>
<td>M.Tech.</td>
<td>52</td>
<td>12</td>
<td>64</td>
<td>2 years</td>
</tr>
</tbody>
</table>
Terms and Conditions:

Total number of seats : 30
Admission is purely based on all India basis.
Admission is purely based on the marks obtained in the entrance exam.
(Syllabus will be specified by the board of studies. The question paper for entrance examination contains four parts each containing Physics, chemistry, Mathematics and Biology. Out of which the candidate can opt for any two parts.)
Other admission regulations are as per the CBCS regulations of University of Mysore 2010.
Project internship can be pursued in any reputed lab or industry or institution in India or abroad.
Odd semester will be during August/September to December/Jan
Even semester will be during Feb/March to June/July. Valuation process is continuous and internal.
This course is essentially an M.Tech Program like any other M.Tech Programs and provision for open electives is not created explicitly. However, if any candidate is interested, he/she can avail the benefit of registration for extra credits to take up open electives.
As and when the new soft core papers are approved by the BOS, the advantage is extended to the students in the higher semester as well along with the incoming students.

Scheme of Evaluation
Each student shall be evaluated continuously by means of tests and/or assignments. There will be two tests: C1 in the sixth week, C2 in the twelfth week and C3 in sixteenth week of the semester. A final examination C4 will be held around eighteenth week.

The C1, C2 and C3 tests will be for 20 marks each and C4 will be for 40 marks. If marks scored in C1+C2+C3 is less than 30%, the student is not allowed to take C4. If the attendance is less than 75% the student is not allowed to take C4.

C1 C2 and C3 tests will be for 1 hour duration. C3 examination will be for 2 hrs duration. Practical tests/examinations will be for 4 hours respectively.

Make up Examination and Re-Appearances for C3 Examination

If a student scores less than 30% in C4, he can take the make-up examination before one month after the announcement of the results with prior information to the department.

If he/she again fails to clear the examination, such students can Re-register for that paper/papers in the department and attend the classes with the regular students of odd and even semesters respectively. This is allowed up to VIII semesters minus the IV semesters of the course (double the duration of the course)

Note: While Re-registering, make sure that per semester with re registration shall not exceed a total of 24 credits for the odd and even semesters.
Hard core courses for M.Tech. Materials Science program.

<table>
<thead>
<tr>
<th>CODE</th>
<th>Paper title</th>
<th>Core</th>
<th>Credits</th>
<th>Lecture</th>
<th>Tutorial</th>
<th>Practical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSH-1</td>
<td>Introduction to Materials (I-Sem)</td>
<td>Hard</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-2</td>
<td>Thermodynamics and Statistical Mechanics (I-Sem)</td>
<td>Hard</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-3</td>
<td>Materials Preparation Techniques (II-Sem)</td>
<td>Hard</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-4</td>
<td>Methods of Materials Characterization (II-Sem)</td>
<td>Hard</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-5</td>
<td>Physics and Chemistry of Materials (III-Sem)</td>
<td>Hard</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-6</td>
<td>Materials and Environmental Effects (III-Sem)</td>
<td>Hard</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-7</td>
<td>Characterisation lab-1</td>
<td>Hard</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-8</td>
<td>Characterisation lab-2</td>
<td>Hard</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-9</td>
<td>Characterisation lab-3</td>
<td>Hard</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td></td>
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<tr>
<td>MSH-10</td>
<td>Characterisation lab-4</td>
<td>Hard</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td></td>
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<tr>
<td>MSH-11</td>
<td>Characterisation lab-5</td>
<td>Hard</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MSH-12</td>
<td>Minor Project</td>
<td>Hard</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>MSH-13</td>
<td>Major Project (Only for M.Tech. exit)</td>
<td>Hard</td>
<td>0</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

|               | Total: (M.Tech-exit) (For B.E. background) | 52   |
|               | For B.Sc., background                      | 60   |
### Soft core courses for M.Tech. Materials Science program

<table>
<thead>
<tr>
<th>Code</th>
<th>Paper title</th>
<th>Core</th>
<th>Lecture</th>
<th>Tutorial</th>
<th>Practical</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSS-1</td>
<td>Structure, Property and Functions of Materials</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-2</td>
<td>Basics of Chemistry</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-3</td>
<td>Spectroscopic Techniques for Materials</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-4</td>
<td>Nanoscale Devices</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-5</td>
<td>Nanochemistry</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-6</td>
<td>Carbon Nanotubes</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-7</td>
<td>Materials for Aerospace Applications</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-8</td>
<td>Composite Materials</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-9</td>
<td>Polymer Science and Cell Biology</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-10</td>
<td>Metals and Alloys</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-11</td>
<td>Nano-biotechnology in Health Care</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-12</td>
<td>Nano-photonics</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
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<td>4</td>
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<tr>
<td>MSS-13</td>
<td>Thermodynamic Modelling of Systems</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>MSS-14</td>
<td>Basics of Engineering Drawing and Graphics</td>
<td>Soft</td>
<td>2</td>
<td>2</td>
<td>0</td>
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</tr>
<tr>
<td>MSS-15</td>
<td>Ceramics Science and Technology</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
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<tr>
<td>MSS-16</td>
<td>Materials for Renewable Energy and Storage</td>
<td>Soft</td>
<td>3</td>
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<tr>
<td>MSS-17</td>
<td>Basics of Nanotechnology</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
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<tr>
<td>MSS-18</td>
<td>Enterprise Architecture</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
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<tr>
<td>MSS-19</td>
<td>Chemical Engineering</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
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<tr>
<td>MSS-20</td>
<td>Advanced X-ray Diffraction Studies</td>
<td>Soft</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>
MSH-1:  Introduction to Materials: 4 Credits (Hard core)  Total: 48 hrs

Unit-I:  Materials through ages

12 hours

Unit-II:  Crystal Structure

12 hours

Unit-III:  Crystal Diffraction and Reciprocal Lattice (Qualitative)

12 hours

Unit-IV:  Chemical Bonding in crystals and Imperfection

12 hours

References


MSH-2: Thermodynamics and Phase Equilibria  4 Credits (Hard core)  Total: 48 hrs

Unit-I: Kinetic Theory and Gas Laws
Kinetic Theory of Matter, Different States of Matter, Concept of Ideal or Perfect Gas, Kinetic Theory of Gases, Expression for the Pressure of a Gas, Kinetic interpretation of Temperature.

12 hours

Unit-II: Equation of State

12 hours

Unit-III: Phase equilibrium
Basic concepts of phase, components, Degrees of freedom. Concept of equilibrium and equilibrium constant, Phase rule and its application to One, two and three component systems. Phase diagram and phase equilibrium studies.

12 hours

Unit-IV: Laws of Thermodynamics
Basic concepts and conventions, system and surrounding, Macroscopic physical properties, Time dependent and time independent processes, First law of thermodynamics – expressions for heat and work, Enthalpy, Heat capacity, heats of formations and heats of reactions. Second law of thermodynamics, types of disorders and concept of Entropy and derivation of expressions of entropy. Gibbs free energy, derivation of expression of free energy as function of P and T, Clapyeron equation, partial molar quantities, chemical potential, fugacity and activity. Application of thermodynamics for phase equilibrium studies.

12 hours

References

MSH-3: Materials Preparation Techniques 4 credits (Hard core) Total 48 hours

Unit-I
Solid state routes; Nucleation; Role of impurities; Mechanical mixing; Grinding; Solid solution techniques. Top-Down reactions. Rate of crystallization. High temperature processes – heating, annealing, sintering treatment; Sputtering, Spin Coating.

12 hours

Unit -II
Evaporation; precipitation; Solution growth; Nucleation; Rate of crystallization; Supersturation; Top seeded solution growth; sol-gel techniques; high temperature solution; Hydrothermal; Solvothermal methods; Ammonothermal method; Glycothermal; Melt methods- super cooling, Czechorliskii methods; Skull melting.

12 hours

Unit -III
Vapour phase methods - Thin films, epitaxial growth, substrates selection, career gases, metastable growth of materials. Chemical Vapour Deposition - Principles, apparatus, examples of CVD growth of thin films, advantages and disadvantages; Chemical Vapour Transportation; Molecular Beam Epitaxy, Liquid Phase Epitaxy, Vapour growth of Nitrides. Metal-organic Vapour phase epitaxy. Plasma Energetics; Laser ablation.

12 hours

Unit -IV
Biological synthesis, Biomimetic method, bacterial synthesis of nanoparticles; Electrochemistry - solvent selection, apparatus, deposition, growth of thin films, coatings, examples; Multi-energy processing - Mechanochemical; Sonochemical; Photochemical; Biochemical, Microbial, Organic synthesis. Growth of organic crystals.

12 hours

References:

MSH-4: Methods of Materials Characterization 4 credits (Hard core) Total: 48 hrs

Unit-I
Thermal analysis; TGA; DTA; DSC; Basic principle. Differences between DTA and DSC. Instrumentation-power compensated DSC, heat flux measurement in DSC. Applications testing the purity and characterizations of various materials (Polymeric, Pharmaceutical, Agricultural materials) Thermo mechanical analysis, Dynamic mechanical analysis, dilatometry; (Thermal expansion) Principles and applications.

12 hours
Unit-II
Microscopic techniques, Phase Contrast Microscopy – Principles, types, hot stage microscopy, Electron imaging techniques; Scanning Electron Microscopy; principle, instrumentation, measurement and analysis; Tunnelling Electron Microscopy; principle, instrumentation, measurement and analysis, Field Emission SEM; Scanning Tunnelling Microscopy; Atomic Force Microscopy; principle, instrumentation, measurement and analysis; Scanning Probe Microscopy; High Resolution TEM; principle, instrumentation, measurement and analysis, High Resolution SEM; principle, instrumentation, measurement and analysis

12 hours

Unit-III
Particle size measurement; Basic principle of particle analysis, equivalent sphere model, \(D_{[1,0]}, \ D_{[3,2]} \) and \(D_{[4,3]} \) representations, conversion between length and volume/mass means, mean, median and mode statistics; Methods of measurement of particle size, XRD, optical and laser scattering techniques; surface area and porosity; definition and meaning, measurement using BET method, adsorption isotherms, DC polarization, AC impedance measurements.

12 hours

Unit-IV
Photoluminescence, principle of working, instrumentation and measurement; demonstration of band gap measurement using PL spectrometer; Positron Annihilation Lifetime Spectroscopy; Basics of positron annihilation, the sources of positrons, three methods of positron annihilation techniques; lifetime, Doppler broadening and angular correlation methods, Application of lifetime spectroscopy for the free volume determination in polymers and polymer nanocomposites. Non-linear electro-optical properties of materials, mechanical properties, tensile strength, micro hardness; zeta potential.

12 hours

References


MSH-5: Physics and Chemistry of Materials 4 credits (Soft core) Total: 48 hrs

Unit-I
Electromagnetic spectrum, accelerator beams, synchrotron radiation, Fermi energy in metals and semiconductors, Specific heat of solids, Conductivity and susceptibility of solids, Energy gap of semiconductors, Hall effect in metals and semiconductors, Quantum theory of metals, Quantized Hall effect.

12 hours
Unit-II

12 hours

Unit-III

12 hours

Unit-IV
Introduction, MX (NaCl, CsCl, ZnS) and MX2 (fluorite, rutile-crystobalite and cadmium iodide) types. The perovskite and spinel structures. Thermodynamics of ionic crystal formation. Lattice energy, Born-Haber cycle, Born-Lande equation. Applications of lattice energetics. Ionic radii, factors, affecting the ionic radii, radius ratio rules. Electron deficient compounds: Diborane and its reactions, higher boranes, ployhedral boranes (preparations, properties, structure and bonding). Wade’s rules, carboranes and metallocarboranes.

References

MSH-6: Materials and Environmental effects 4 Credit (Hard core) Total: 48 hrs

Unit-I

12 hours

Unit-II
Electrochemical methods to Measure Corrosion: DC Polarization, linear polarization method, AC Impedance; Experimental measurement of corrosion Quantification of corrosion Environmentally Induced Cracking, Corrosion Fatigue, Hydrogen Induced Cracking, Application of Fracture mechanics.

12 hours
**Unit-III**

12 hours

**Unit-IV**
Environmental effects from the chemical processes industry (like Pulp mill operations, bleach plants, boilers, paper machine, water treatment plants in the pulp and paper industry and others), infrastructure, and transportation industry.

12 hours

**References**


**MSS-1: Structure, Property and Functions of Materials** 4 credits (Soft core)

Total: 48 hrs

**Unit-I: Materials**

12 hours

**Unit-II: Polymers**

12 hours

**Unit-III Earths Materials**

12 hours
**Unit-IV: Biomaterials**

**References**
5. Ferry : Viscoelasticity properties of polymers
6. Aklonies,et al., An introduction of Viscoelasticity in polymers
8. From Bioimaging to Biosensors – Noble Metal Nanoparticles in Biodetection, by Lai-kwan Chau (National Chung Cheng University, Taiwan), Huan-Tsung Chang (National Taiwan University, Taiwan)

**MSS-2 : Basics of Chemistry**

**Unit I:**
**Elements of quantum mechanics:** Wave mechanical concept of the atom, dual nature of electron, derivation of de-Broglie’s equation. Heisenberg’s uncertainty principle and its significance. Schrodinger wave equation-explanation of the terms therein (no derivation) Eigen values and functions, significance of $\psi$ and $\psi^2$. Quantum numbers and their significance. Shapes of s, p and d orbitals. Effective nuclear charge, screening effect-based on Slater’s rules (problems to be worked out). General energy level diagram of multi electron atom (up to n=4). Pauli’s exclusion principle, Hund’s rule, (n+1) rule, Aufbau principle.
**Periodic Table and Periodicity:** Classification of elements into s, p, d, and f-blocks, cause of periodicity. Detailed discussion of the following periodic properties of elements with examples: Atomic radius, Ionization enthalpy, Electron gain enthalpy and Electronegativity.
**Chemical bonding:** Ionic bond, Covalent bond, Coordinate bond, metallic bonding and hydrogen bonding.

**Unit II:**
**Hybridization:** Tetravalency of carbon, sp$^3$, sp$^2$ and sp – hybridization (in brief). Bond length, bond angle, bond energy, localized and delocalized chemical bonds – resonance and hyperconjugation effects.
**Types of organic reactions:** Definition with examples of addition, substitution, elimination, isomerisation, oxidation, reduction, condensation and rearrangement reactions.

Geometrical isomerism: Definition with example, designation of cis-trans and E-Z notations with examples. Geometrical isomerization of aldoximes and ketoximes, 12 hours

Unit III
Colligative Properties: Concept of vapour pressure, variation of vapour pressure with temperature. Definition of boiling point and freezing point, effect of dissolution of solute on the vapour pressure of the solvent. Lowering of vapour pressure. Raoult’s law – relation between relative lowering of vapour pressure and molar mass (to be derived). Determination of relative molar mass of solute by dynamic method. Elevation of boiling point and its relation to lowering of vapour pressure and molar mass (to be derived). Ebulloscopic constant of the solvent and its relation to the boiling point (only equation). Determination of molar mass of the solute by Walker-Lumsden method. Depression in freezing point and its relation to lowering of vapour pressure and molar mass (to be derived). Cryoscopic constant and its relation to the melting point (equation). Determination of molar mass of a non-volatile solute by Beckmann’s method (problems to be worked out).

Semi permeable membrane – natural and artificial, preparation of copper ferrocyanide membrane by Morse-Frazer method. Definition of osmosis, osmotic pressure (mention application), determination of osmotic pressure by Berkley-Hartley’s method, laws of osmotic pressure analogy with gas laws, determination of molar mass from osmotic pressure measurements (relation to be derived), isotonic solutions, plasmolysis. 12 hours

Unit IV
Indicator – Definitions, types (acid-base, redox, adsorption indicators), examples for each type. Theory of indicators – Oswald’s theory and Quinonoid theory – indicator constant – action of phenolphthalein and methyl orange in acid-base solutions – pH titration curves for strong acid vs strong base, weak acid vs strong base, weak base vs strong acid, choice of indicators in these types of titrations – color change and pH range. Universal indicator – definition.


Reference:
11. Elements of Physical Chemistry by Lewis and Glasstone.

MSS-3: Spectroscopic Techniques for Materials  4 credits (Soft core)  Total: 48 hours

Unit I
UV-Visible spectroscopy: Modes of electronic excitations, simple chromophoric groups—systems of extended conjugation, aromatic systems. Types of auxochromes—functions of auxochromes, absorption and intensity shift. Types of transition probability, types of absorption bonds, solvent effects and choice of solvent. Effect of polarity on various type of bonds, Woodwards empirical rules for predicting the wavelength of maximum absorption: - Olefins, conjugated dienes, cyclic trienes and polyenes, $\alpha,\beta$-unsaturated aldehydes and ketones, benzene and substituted benzene rings.  

IR spectroscopy: Principles, Hook’s law, characteristic group frequencies and skeletal frequencies. Finger print region. Identification of functional groups: Alkenes, alkynes, aromatics, carbonyl compounds (aldehydes and ketones, esters and lactones), halogen compounds, sulphur and phosphorous compounds, amides, lactams, amino acids, and imines. Factors affecting group frequencies and band shapes, conjugation, resonance and inductance, hydrogen bonding and ring strain, tautomerism, cis-trans isomerism. Applications of IR spectra to co-ordinatation compounds, organotransition metal complexes (N,N-dimethyl acetamides, urea, DMSO, NO$_3^-$, SO$_4^{2-}$, NO$_2^-$)  

12 hours

Unit II
Nuclear magnetic resonance spectroscopy: General introduction and definition, magnetic properties of nuclei (magnetic moment, g factor) and theory of nuclear resonance. Larmor precession frequency, resonance condition and relaxation processes.

Chemical shift: Standards employed in NMR, factors affecting chemical shift, electronegativity, shielding and deshielding mechanism, Vander waals deshielding, H-bonding, diamagnetic and paramagnetic anisotropies. Spin-spin coupling, chemical shift values and correlation for protons bonded to carbon and other nuclei. Instrumentation and sample handling.

Equivalence and magnetic equivalence proton exchange reactions, effects of chiral center, complex spin-spin interaction, stereochemistry, hindered rotation, Karplus curve-variation of coupling constants with dihedral angles. Simplification of complex spectra: isotopic substitution, increasing magnetic field strength, double resonance, spin decoupling, constant shift reagents, solvent effect, Fourier-transfer technique, variable temperature profile, nuclear overhauser effect (NOE).  

12 hours
Unit III
LC-MS, LC-MS/MS, GC-MS: Principles and applications
Composite problems involving the applications of UV, IR, and 1H -NMR and mass spectroscopic techniques. 12 hours

UNIT – IV

Electron Spin Resonance Spectroscopy: Basic principles, hyperfine couplings, the ‘g’ values, factors affecting ‘g’ values, isotropic and anisotropic hyperfine coupling constants, Zero Field splitting and Kramer’s degeneracy. Measurement techniques and Applications to simple inorganic and organic free radicals and to inorganic complexes.

Mössbauer spectroscopy: The Mössbauer effect, chemical isomer shifts, quadrupole interactions, measurement techniques and spectrum display, application to the study of Fe2+ and Fe3+ compounds, Sn2+ and Sn4+ compounds( nature of M-L bond, coordination number and structure), detection of oxidation states and inequivalent Mössbauer atoms.

Photoelectron spectroscopy (PES): Brief theory, principle of working, instrumentation and data acquisition analysis. 12 hours

REFERENCES:

11. NMR spectroscopy-Powai.
MSS-4: Nanoscale Devices  
4 credits (Soft core)  
Total: 48 hrs

Unit - I  Processing
Silicon Processing methods- Cleaning / Etching- Oxidation- Gettering- Doping-Epitaxy-Sputtering-Chemical Vapor Deposition (CVD), Plasm Enhanced CVD- Reactive Ion Etching (RIE)- Moore's law-Design rules for 45nm, 32nm, and beyond- Semiconductor device roadmap- Silicon -insulator technology- Gate of high -K dielectrics  
12 hours

Unit -II  Fabrication
12 hours

Unit -III  Lithographic techniques
Top down approach to nanolithography-Immersion lithography- Optical lithography, UV photolithography- Phase lithography- Including Plasma X-ray sources- E-Beam Lithography- Focused Ion beams- Photoresist. Soft lithography for nanofilms and nanoscale patterning. Lithographic techniques and surface chemistry for the fabrication of PEG-passivated protein microarrays.  
12 hours

Unit -IV  Fabrication of nanostructures
12 hours

References:
**MSS-5: Nanochemistry**  
4 Credits (Soft core)  
*Total: 48 hrs*

**Unit-I Fundamentals of molecular self-assembly**
The nanoscale and colloidal systems-Fundamentals of Surface and interfacial chemistry-Surface tension and Wettability-Insoluble monolayers-Surface Chemistry and monolayers-Electrostatic interactions in self assembling systems-Self-Assembly of amphiphiles-Monolayers-Micelles and microemulsions-the Structure and properties of Micelles.  

12 hours

**Unit-II Nanomaterials**

12 hours

**Unit-III Dendrimersand their applications**
PPI and PAMAM dendrimers, Synthesis-Generation 1 and Generation 2, Application in Drug tergetting

12 hours

**Unit-IV Functionalization and applications of Nanomaterials**

12 hours

**References**


**MSS-6: Carbon Nanotubes**  
4 Credits (Soft core)  
*Total: 48 hrs*

**Unit-I Introduction and Morphology**
Carbon allotropes, Fullerenes, Discovery of carbon nanotubes, Single and double walled carbon nanotubes, Bundled Nanotubes. The structure of carbon nanotubes: From a Graphene Sheet to a Nanotube - Archiral and Chiral Nanotubes, theoretical discussion, experimental studies, ZigZag and Armchair Nanotubes - Eulers Theorem in Cylindrical and Defective Nanotubes.

12 Hours
**Unit-II Production Techniques of Nanotubes**
Carbon nanotube production: Arc discharge, Laser ablation, Chemical vapour deposition, Hydrothermal, Miscellaneous synthesis methods. Growth mechanism of Multi/Singlewalled nanotubes by arc discharge and Chemical vapour deposition method. Role of Metal Catalyst, High-Pressure CO Conversion (HIPCO), Experimental Puzzles of MWNT - Aspect Ratio-Perfection-chemical inertness. Purification and processing of MWCNTs and SWCNTs, separation of metallic and semiconducting SWCNTs.  

**Unit-III Electrochemical properties and functionalization of Nanotubes**

**Unit-IV Applications of Nanotubes**
Catalytic: Macroscopic shaping of CNTs, specific metal support interaction, dispersion of the active phase, electrically and thermally conductive supports. Biomedicine: cell penetration, drug delivery, gene delivery, anticancer approaches, antioxidants properties, toxicity. Probes and Sensors: nanotube tips for atomic force microscopy, gas sensors, biosensors, physical sensors. Containers: mechanisms of nanotube filling, fullerene C$_{60}$, higher fullerenes, endohedral fullerenes, functionalized fullerenes, molecules without metal atoms, organometallic and coordination compounds, oxides and hydroxides, inorganic materials. Effect of Doping on conductivity - Harnessing Field Enhancement - Flat Panel Displays  

**References**
1. Dirk M. Guldi and Nazario Martin, Carbon nanotubes and related structures  
2. Peter J. F. Harris, Carbon nanotube science.  

**MSS-7: Materials for Aerospace Applications** 4 credits (soft core) 48 hours

**Unit I: Introduction to aerospace materials**
The importance of aerospace materials, understanding aerospace materials, the main types of polymer based aerospace materials, advantages of polymer based materials, High performance like light weight and other important properties of materials for aerospace applications including modified structures on nano-scale materials  

12 hours
Unit II: Polymers for aerospace structures
Aerospace applications of polymers, advantages and disadvantages of polymers for aerospace applications, Polymerization routes, Thermoset, Thermoplastics and elastomers, Structural adhesives, Mechanical properties, Polymer additives, Polymers for radar absorbing materials, Fracture toughness properties, Ductile/brittle fracture transition for polymers, Improving the fracture toughness of aerospace materials

12 hours

Unit III: Manufacturing of fibre-polymer composite materials
Fibre reinforcements for composites, Production of prepeg and fabrics, Core materials for sandwich composites, Composites manufacturing using prepeg, Composites manufacturing by resin infusion, Machining of composites, Damage mechanics of composites. Fracture processes, Stress concentration effects in materials, Fracture mechanics, Application of fracture mechanics to aerospace materials

12 hours

Unit IV: Fibre-polymer composites for aerospace structures and engines

12 hours

References:
6. ASTM standards.

MSS-8: Composite Materials 4 Credits (Soft core) Total: 48 hrs

**Unit-II:** Reinforcements; Types, Properties, Uses of silica, Titanium dioxide, Talc, Mica, etc., Flake, Fibres -Structure, property and applications of natural and synthetic fibres, organic and inorganic fibres. Example: Glass, Carbon, Aramid, Nylon, Boron, Aluminium carbide, Silk, Jute, Sisal, Cotton, etc, Coupling agents.  

12 hours

**Unit-III:** Processing : Thermoplastic, Thermosets, etc., Types of methods, Processing conditions advantages and disadvantages, Film forming, Lamination, Sandwich, etc., Hand Layup methods, compression and Transfer molding, Pressure and Vacuum bag process, Filament winding, Spin coating, Pultrusion, Reinforced RIM, Injection molding of Thermosets, SMC and DMC, Factors affecting the performance of Composites. Testing of Composites; Destructive and non-destructive tests, Tensile, Compression, Flexural, ILSS, Impact strength, HDT, Basic Concepts of fracture mechanism.  

12 hours

**Unit-IV:** Composite product design, Fundamentals, Definitions, Structure -Material -Design relationships, Design methodologies, Material Considerations, Application of Composites- Aerospace, Transport, marine, Structural, Chemical and Corrosion resistant products, sports, electrical, Electronic, Communication, Biomedical Applications, Repairs and maintenance, etc., Nanocomposites: -Types, preparation, characterization and applications.  

12 hours

**References**

2. Polymers and Polymer Composites in Construction L.C. Holleway, 1990
9. Polymer Layered Silicate and silica nano Composites, Y.C.Ke,P.stroeve and F.s.Wang, Elesvier, 2005

**MSS-9: Polymer Science and Cell Biology**  
4 Credits (Soft core) Total: 48 hrs

**Unit-I: Basic Polymer Science**

Basic concepts: Classification of Polymers, Nomenclature of Polymers, Polymer synthesis and structure-chain structure and configuration - Amorphous polymer state-Conformation of polymer chain - Macromolecular dynamics - structure of crystalline polymers-polymer in the liquid crystalline state - Glass, Rubber - Transition behaviour, condensation including co-ordination, cationic, anionic, Ring opening Redox polymerization, Living Radical polymerization-Atom transfer radical polymerization.  

12 hours
Unit-II: Properties of polymers
Methods of measuring transitions in polymers - Cross linked polymers and rubber elasticity - Polymer Visco elasticity and Rheology, Mechanical Behaviour of polymers - Polymer surfaces and interface, Bulk, solution, precipitation polymerization, Suspensions, emulsion, melt polycondensation, Criteria of polymer solubility, solubility parameter, thermodynamics and phase equalibria of polymer solution, Fractionation of polymers by solubility.

12 hours

Unit-III: Cell Structure
Origin and overview of cells, prokaryotic and lukaryotic cells, subcellular organels, cells as experimental models, Chemistry of cells, molecular composition. Enzymes as biological catalysts. Metabolic energy, Biosynthesis of cell constituents.
Bio energetics and metabolism, cytoskeleton and cell movement, Cell signalling, Cell cycle, Cancer cells.

12 hours


12 hours

References

MSS-10: Metals and Alloys 4 Credits (Soft core) Total: 48 hrs

Unit- I Crystal defects in metals: Vacancy, interstitial, substitutional, free energy of mixing, dislocation (elementary concepts only), edge / screw dislocation, partial dislocation, stacking fault, dislocation lock, dislocation pile up, Hall Petch relation, grain boundary structure.
Diffusion: Elementary concepts of phenomenological& atomistic approaches.

12 hours

Unit-II Solidification of binary alloys: Limits of solubility, isomorphous system, lever rule, constitutional super cooling, effect of non equilibrium cooling, eutectic, peritectic, eutectoid& peritectoid system, complex phase diagram, ternary diagram, composition triangle, ternary eutectic, vertical& horizontal sections, structure of cast metal, segregation& porosity, iron-carbon diagram, steel& cast iron. Binary phase diagrams of common commercial alloys: Cu-Ni, Au-Cu, Ni-Cr, Al-Si, Al-Zn, Al-Ag, Pb-Sn, Cu-Zn, Cu-Sn, Cu-Al, Ti-Al, Ti-V: interpretation of microstructure & properties.

12 hours


12 hours
**Unit–IV Application of physical metallurgy:** Strengthening mechanism, strength vs. toughness (ductility), thermo mechanical processing, micro alloyed steel, ultra high strength steel, superalloy, control of texture.  

**References:**

**MSS-11: Nano-biotechnology in Health Care 4 Credits (Soft core) Total: 48 hrs**

**Unit-I**

**12 hours**

**Unit-II**
Techniques involved in Nanoparticles application in diagnostics and characterization: Fluorescence resonance energy transfer (FRET), Surface energy transfer (SET), Raman light scattering, Surface Plasmon Resonance (SPR), Transmission electron microscopy, Scanning electron microscopy Atomic force microscopy, confocal microscopy, scanning tunneling microscopy, fluorescence spectroscopy.  

**12 hours**

**Unit-III**
Micro-array (DNA and Protein array)-concepts and advantages of Microfluidic devices, Materials for manufacture of microfluidic devices, (Silicon and PDMS). Nanoparticles for Optical Imaging of Cancer, Nanogold in Cancer Therapy and Diagnosis, Nanotubes, Nanowires, Nanocantilevers and Nanorods in Cancer Treatment and Diagnosis. Carbon Nanotubes in Cancer Therapy and Diagnosis.  

**12 hours**

**Unit-IV**

**12 hours**

**References:**
1. From Bioimaging to Bisensors – Noble Metal Nanoparticles in Biodetection, by Lai-kwan Chau (National Chung Cheng University, Taiwan), Huan-Tsung Chang (National Taiwan University, Taiwan)
3. Nanoparticles and Biophotonics as Efficient Tools in Resonance Energy Transfer-


6. Nanoparticulates as Drug Carriers edited by Vladimir P Torchilin (Northeastern University, USA), 2006, Imperial college press.

MSS-12: Nano-photronics 4 Credits (Soft core) Total: 48 hrs

**Unit-I: Quantum confined materials**
Quantum dots - Optial transitions absorption - interband transitins - quantum confinement - intraband transitions fluorescence/luminescence - photoluminescence/fluorescence optically excited emission electroluminescence emission.

12 hours

**Unit-II: Plasmonics**
Internal reflection and evanescent waves - plasmons and surface plasmon resonance - Attenuated Total reflection - Grating SPR coupling - Optical waveguide SPR coupling - SPR dependencies and materials - plasmonics and nanoparticles.

12 hours

**Unit-III: New Approaches in Nanophotonics**
Near filed optics - Aperture less near field optics - near field scanning optical microscopy (NSOM or SNOM) - SNOM based detection of plasmonic energy transport - SNOM based visualization of waveguide structures - SNOM in nanolithography - SNOM based optical data storage and recovery.

12 hours

**Unit-IV: Biophotonics**
Interaction of light with cells-tissues - nonlinear optical processes with intense laser beams - photo induced effects in biological systems - generation of optical forces - optical trapping and manipulation of single molecules and cells in optical confinement - laser trapping and dissection for biological systems-single molecules biophysics - DNA protein interaction.

12 hours

**References**

3. M Ohtsu, K Kobayashi, T Kawazoe and T Yatsui, Principals of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan (2003).
MSS-13: Thermodynamic Modelling 4 Credits (Soft core) Total: 48 hrs

Unit-I

12 hours

Unit-II
Crystallization kinetics. Basic concepts. Different methods Models for determining the crystallization kinetics for simple systems. In situ studies on crystallization kinetics.

12 hours

Unit-III

12 hours

Unit-IV

12 hours

References
MSS-14: Basics of Engineering Drawing and Graphics  4 Credits  (Soft Course)

Total: 48 hrs

Unit I: Principles of Graphics
Two dimensional geometrical construction Concept of section planes - Conic sections, involutes and cycloids - Representation of three dimensional objects - Principles of projections - standard codes of principles.

12 hours

Unit II: Orthographic Projections
Projections of points, straight line and planes - 'Auxiliary projections' - Projection and sectioning of solids - Intersection of surfaces - Development of surfaces.

12 hours

Unit III: Pictorial Projections
Isometric projections - 'Perspectives' - Free hand sketching. Conversion of pictorial views of simple machine parts into orthographic views, conversion of orthographic views of simple machine parts into isometric views.

12 hours

Unit IV: Computer Graphics
Hardware - Display technology - Software - Introduction to drafting software

12 hours

References


Note:
1. Further details on Basics of engineering drawing and graphics are illustrated below since this is a new course introduced to enhance the industrial acceptability of the M.Tech Program.

MSS-15: Ceramics Science and Technology  4 Credits (Soft core)  Total: 48 hrs

Unit I
Ceramics: Definition, scope, bonding and structure, crystal structure, defects, polymorphism, ceramics as a class of material, variations within ceramics; defect structures; chronological developments, structure of silicates; polymorphic transformations, raw materials.
Unit II

Unit-III
Elementary ideas about the raw materials used in pottery, Heavy clayweres, Refractorier, Glass, Cement, Industries. Raw materials clays and their classification, Quartz, Polymorphism of quartz, Feldspar and its classification, Talc, Steatite and Mica. Fabrication methods: Packing of Powders, Classification and scope of various fabrication methods. Dry and semi dry pressing, extrusion, Jiggering & jollying, Slip casting HP & HIP. Drying & Firing of ceramics: Biscuit firing and glost firing, fast firing technology, action of heat on triaxial body, Elementary ideas of various furnaces used in ceramic industries. 12 hours

Unit-IV
Advanced ceramics: Bio-ceramics, Space ceramics, Automotive ceramics, Electronic ceramics, Superconducting ceramics, Elementary ideas of their preparation and applications. 12 hours

References

MSS-16: Materials for Renewable Energy and Storage 4 Credits (Soft Core)
Total: 48 hrs

Unit-I
Introduction to new generation of materials and nano-engineering of their structures for sustainable energy economy. Contribution to high performance renewable energy production, storage, conversion and usage. Solar grade glass; (a) properties-transparency, emissivity and reflectivity, (b) manufacturing- Flat glass for PV & CSP, tube glass for Evacuated Tube Receiver (ETR) and Collector (ETC). 12 hours
Unit-II
Solar Photo Voltaic (PV) cells: Single and multi-crystalline silicon solar cells, amorphous silicon, thin film; Cd-Te, CIGS, CZTS, nano-, micro-, poly-Si. Transparent conducting coating, Multi-junction, solar PV concentrator, flexible solar cells. Emerging PV: dye sensitized, other organic, and quantum dot cells. Nano-engineered materials. 12 hours

Unit-III
Materials for Concentrated Solar Power (CSP): Reflector materials; glass, metal, polymer and film. Receiver and collectors; absorptive coating and anti-reflective coating. Materials and shapes for thermal storage, Lithium ion Batteries. 12 hours

Unit-IV
Fuel cells; materials and construction; PEM Fuel Cell(FC), AFC, PAFC, MCFC, SOFC. Catalysts for electro catalysis, fuel reformer and water splitting. 12 hours

References
5. Fuel Cell Handbook,
6. Introduction to Fuel Cell Technology

MSS-17: Basics of Nanotechnology 4 Credits (Soft core) Total: 48 hrs

Unit-I
Introduction to nanotechnology basics, definition. History of nanotechnology. Nanotechnology in relation to other branches of science. Structure of solids crystalline and non-crystalline. Types of common materials and advanced materials inorganic, organic, biologic. Types of nanomaterials depending upon their properties electronic, semiconductors, superconductors, super ionic, magnetic, optic, opto-electronic, spintronics, lasers, photonics, ceramics, bio ceramics, biomedical, biosensors, bio imagers, photocatalysts, quantum dots. 12 hours

Unit-II
Basic properties of materials and the instrumentation used to study these properties. Size effect of materials on properties. Quantization effect on the properties of materials with examples. Nanocomposites and their applications in modern technology. Nanotubes carbon nanotubes and other nanotubes. Nanomaterials natural and synthetic. Nanocomposites and Nanohybrid materials. 12 hours
**Unit-III**

12 hours

**Unit-IV**

12 hours

**References**

**MSS-18 Enterprise Architecture** 4 Credits (Soft core)  
Total: 48 hrs

**Unit I:**
1. What is Enterprise Architecture?
2. History of Architecture in the context of engineering discipline
3. History of Enterprise Architecture
4. Why Enterprise Architecture?
5. What are the various Enterprise Architecture Frameworks?
6. Why Zachman Framework an Ontology?

**Unit II:**
1. Growing enterprise opportunities
2. Enterprise Disorders & limitations of current approach
3. Zachman Framework & Primitive Models
4. Sample – Strategy Primitive model
5. Sample – Business process primitive models
6. Busting biggest myth about Enterprise Architecture
7. Summary
Unit III:
1. Case study 1 Sample Problem– Application Rationalization arising out of Acquisition & Merger
2. Identify the cells responsible for the problem
3. Identify the primitives for each cell
4. Creating the composite models – 11 departments
5. Sample – Finance Department models, composites, relationship matrix, performance indicators
6. Composite Models & Traceability
7. Relationship Matrix, GAP Analysis & Application Maturity Index
8. Current status of Baseline Architecture v1.0
9. Timeline, Effort, Cost Estimations & Benefits

Unit IV:
1. Sample case 2: Which cells are key to define the Disaster Recovery Plan
2. Sample case 3 - HR: Resource Request Process
3. Visual diagnosis for effective enterprise treatment
4. Use of Enterprise Architecture by Governments and Government Departments
5. Use of Enterprise Architecture in Telecom Industry
6. Use of Enterprise Architecture in Healthcare
7. Use of Enterprise Architecture in Banking & Finance
8. Use of Enterprise Architecture in Manufacturing

How to use Enterprise Architecture in managing Universities & Colleges

MSS 19: Chemical Engineering 4 credits (Soft core) Total: 48 hours

Unit I:
Introduction, concepts of Unit operation and Unit Processes, Units and Dimensions, Dimensional Analysis.

12 hours

Unit II:

12 hours

Unit III:

12 hours
Unit IV:

12 hours


MSS-20: Advanced X-ray Diffraction Studies 4 Credits (Hard core) Total: 48 hrs

Unit-I

12 hours

Unit-II

12 hours

UNIT-III
Debyes function: Application to amorphous structures, nano-composites: (20 lectures) : Particle size and strain analysis line profile and Fourier techniques : Texture, Micro-texture and Residual stress "Pole figure in x-ray (single crystal and area detector). 

12 hours

Unit-IV

12 hours

References


MSS -21: Analytical and Inorganic Chemistry  4 credits (soft core)  Total: 48 hours

Unit I: Statistical Treatment of Analytical Data:

Unit II: Physical Chemistry
Application of physical chemistry

Unit III:
Photodegradation of materials, Photocatalyst- ZnO, TiO₂, principle of photocatalyst, application of ZnO, TiO₂ in the photo degradation of various types, pesticides and in industrial effluents. Effect of photodegradation on chemical oxygen demand in drinking water and in industrial waste water. Photophysical properties of materials; Theory, instrumentation, and applications of fluorescence, characteristic of fluorescence, resonance fluorescence, sensitized fluorescence, quenching of fluorescence. Theory, principle, and applications of phosphorescence.

Unit IV: Organic Chemistry
Importance of natural products and synthetic products of organic origin materials in industry, pharmaceutical, petroleum refinery and agricultural fields. Uses of Dyes, polymers (plastics) soaps and detergents in industry, drugs and cosmetics in pharmaceutical industries, waxes,
coal tar from petroleum industry and pesticides, (insecticides, pesticides, herbicides, fumigacide etc.)

References:
4) Chemical kinetics. KJ. Laidler
5) Chemical kinetics. Moore and pearson
6) Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J.C. Kuriacose.
7) Advances in Photochemistry - Rohatgi Mukherjee
9) Elements of physical chemistry – Glass stone and lewis
10) Encyclopedia of chemical technology – Kirck-othmer series
11) Inorganic chemistry – JE Huheey

MSS-22 Semiconductor optoelectronics 4 credits (Soft Core) Total 48 hours

Unit-I: Review of Semiconductor Device Physics:
Energy bands on solids, the E-k diagram, Density of states, Occupation probability, Fermi level and quasi Fermi levels, p-n junctions, Schottky junction and Ohmic contacts. Semiconductor optoelectronic materials, Bandgap modification, Heterostructures and Quantum Wells.

12 hours

Unit –II: Interaction of photons with electrons and holes in a semiconductor:
Rates of emission and absorption, Condition for amplification by stimulated emission, the laser amplifier. Semiconductor Optical Amplifiers & Modulators: Semiconductor optical amplifiers (SOA), SOA characteristics and some applications, Quantum-confined Stark Effect and Electro-Absorption Modulators.

12 hours

Unit –III: Semiconductor Photon Sources:
Electroluminescence. The LED: Device structure, materials and characteristics. The Semiconductor Laser: Basic structure, theory and device characteristics; direct modulation. Quantum-well laser; DFB-, DBR- and vertical-cavity surface-emitting lasers (VCSEL); Laser diode arrays. Device packages and handling.

12 hours

Unit-IV: Semiconductor Photodetectors:
Types of photodetectors, Photoconductors, Single junction under illumination: photon and carrier-loss mechanisms, Nosie in photodetection; Photodiodes, PIN diodes and APDs: structure, materials, characteristics, and device performance. Photo-transistors, solar cells, and CCDs. Optoelectronic integrated circuits – OEICs.

12 hours

Reference

List of experiments for Practical classes

I – Semester

MSH-7: Characterisation Lab-1 4 credits (Hard core) 48 hours

Experiments:
1) Crystal Models-Crystal symmetry-Basic forms, 7 crystal systems, Holhedral forms, axial ratio, axial angles, crystal faces indexing.
   Important hemihedral and hemimorphic forms.
2) X-ray powder pattern method
3) UV-Visible spectrometer recording of a material and interpretation
4) (a) Microscopic identification of cells in fixed slides: plant cells, bacterial cells, fungal hypha and animal tissues. (b) Observing stages
   of cell cycle – onion root ti (c) Microbial cell culture techniques – bacterial and fungal
   (d) Gram staining
5) (a) Spread plate technique
   (b) Streaking method
   (c) Serial dilution of bacterial cultures (Ex:- isolation of bacteria from mud)
   (d) Size determination of biomolecules using microscopic techniques.
6) Particle size determination by optical diffraction method.
7) Particle size determination by X-ray diffraction technique.
8) Thermistor-temperature variation.

II – Semester

MSH-8: Characterisation Lab-2 4 credits (Hard core) 48 hours

Experiments:
1) FTIR and $^1$H NMR recording of a materials/organic/inorganic compounds and interpretation
2) Determination of the birefringence of the given sample using the Abbe Refractometer/Prism coupler.
3) Measurement of the band gap energy of the given semiconductor by the method of four probes
4) Determine the refractive index and thickness of polymer films using Metricon prism coupler.
5) Free volume estimation of a polymer by positron annihilation lifetime spectroscopy
6) Measure the AC impedance of the given composite and construct the Bode-Bode plot
8) Isolation of plasmid DNA from *E.coli*
9) Isolation of genomic DNA from *E.coli*
10) Transformation of cell – heat shock technique
11) Isolation of DNA and spectrophotometric analysis

**III – Semester**

**MSH-9: Characterisation Lab-3**

4 credits (*Hard core*)

48 hours

**Experiments:**

1. Paramagnetic susceptibility of the given salts.
2. Hall effect in metals/semi conduction.
3. Crystallization
4. Distillation.
5. Fractional crystallization.
6. Synthesis of aspirin, antipyrine
7. Synthesis of liquid crystals.
8. Thin layer chromatography and column chromatography
9. Isolation of DNA from animal tissues
10. Isolation of DNA from plant tissues
11. Isolation of mRNA from animal tissues
12. Restriction enzyme digestion
13. DNA ligation
14. Agarose gel electrophoresis (AGE)
15. SDS PAGE electrophoresis
16. Biological materials characterization by X-ray diffraction studies.

**IV- Semester**

**MSH-10 Characterisation Lab.-4**

4 credits (*Hard core*)

48 hours

**Experiments (for B.Sc., students)**

1. Preparation of simple materials: Crystals, glasses, polymers, and composites by hydrothermal, solvothermal, Flux, gel, melt and sol-gel techniques.
2. Synthesis of Au, Ag, Cu NPs by Chemical/Biological methods.
3. Preparation of materials exposed to microwave radiations.
4. Preparation of pellets of materials.
5. Fermi energy estimation of conductors/Semi conductors using Bridge.
7. Morphological changes in materials due to irradiation.
8. Animal cell culture techniques – primary cell culture, sub-culturing.

**V-Semester**

**MSH-11 Characterisation Lab.-5** 4 credits *(Hard core)* 48 hours

**Characterization Lab-5 is For B.Sc, Students**
1) Preparation of carbon nanoparticles and X-ray investigation
2) FTIR and UV-Visible studies of polymers (both natural and man-made)
3) Preparation of polymer film and x-ray investigation
4) X-ray studies of natural polymers like silk, cotton, hemp and jute
5) AFM Study of a polymer film/composite material/Nanomaterials
6) SEM study of a polymer film/composite material/Nanomaterials
7) Conductivity of a polymer film

**PROJECT WORK**

**MSH-12: Minor project during III Semester for non B.Sc. students and in V semester for B.Sc. students. : 6 credits**

**MSH-13 Major project during IV semester for non-B.Sc. students and in VI Semester for B.Sc. students. : 10 credits**

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