UNIVERSITY OF MYSORE
MANASAGANGOTRI, MYSORE 570006

Course structure and Revised syllabus

for

M.Tech Program in Materials Science

2013

M.Tech. Program in Materials Science

Course Structure and Revised Syllabus:

M.Tech. Program in Materials Science - 2013

Admission Eligibility Qualification	Degree after the Program	Hard Core credits (including project)	Soft core credits	Open elective credits	Total credits	No. of Years
B.Sc (Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science)	M.Tech.	52	46-50	8-12	110	3 years
B.Sc(Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science)	M.Sc. (optional exit)	42	22-26	8-12	76	2 years
B.E/ MBBS/ B.Tech/ B.Pharma/ BDS/ BSc(Ag)(any branch)	M.Tech.	52	12	-	64	2 years
M.Sc(Physics, chemistry, Geology, Polymer, Biochemistry, Biotechnology, Microbiology, Botany, Zoology, Environmental science, Sericulture, Computer science, Food Science, Mathematics, Statistics, Forensic Science, Nanotechnology)	M.Tech.	52	12	-	64	2 years

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 in concurrence with the Department of Computer Science, University of Mysore.

Scheme of Evaluation

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

The C1 and C2 tests will be for 25 marks each and C3 will be for 50 marks. If marks scored in C1+C2 is less than 30%, the student is not allowed to take C3. If the attendance is less than 75% the student is not allowed to take C3.

C1 and C2 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 C3, 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. in Materials Science program.

CODE	Paper title	Core	Credits			
			Lecture	Tutorial	Practical	Total
MSH-1	Introduction to Materials	Hard	3	1	0	4
MSH-2	Thermodynamics and Statistical Mechanics	Hard	3	1	0	4
MSH-3	Materials Preparation Techniques	Hard	3	1	0	4
MSH-4	Methods of Materials Characterization	Hard	3	1	0	4
MSH-5	Physics and Chemistry of Materials	Hard	3	1	0	4
MSH-6	Materials and Environmental Effects	Hard	3	1	0	4
MSH-7	Characterisation lab-1	Hard	0	1	3	4
MSH-8	Characterisation lab-2	Hard	0	1	3	4
MSH-9	Characterisation lab-3	Hard	0	1	3	4
MSH-10	Characterisation lab-4	Hard	0	1	3	4
MSH-11	Characterisation lab-5	Hard	0	1	3	4
MSH-12	Minor Project	Hard	0	1	5	6
MSH-13	Major Project (Only for M.Tech. exit)	Hard	0	2	8	10
		Total : (MSc-exit)				42
		Total : (M.Tech-exit)				52

Soft core courses for M.Tech. in Materials Science program

Code	Paper title	Core	Credits			
			Lecture	Tutorial	Practical	Total
MSS-1	Structure, Property and Functions of Materials	Soft	3	1	0	4
MSS-2	Spectroscopic Techniques for Materials	Soft	3	1	0	4
MSS-3	Physics of Nanoscience and Nanotechnology	Soft	3	1	0	4
MSS-4	Nanoscale Devices	Soft	3	1	0	4
MSS-5	Nanochemistry	Soft	3	1	0	4
MSS-6	Carbon Nanotubes	Soft	3	1	0	4
MSS-7	Materials for Aerospace Applications	Soft	3	1	0	4
MSS-8	Composite Materials	Soft	3	1	0	4
MSS-9	Polymer Science and Cell Biology	Soft	3	1	0	4
MSS-10	Physics and Chemistry of Polymers	Soft	3	1	0	4
MSS-11	Nano-biotechnology in Health Care	Soft	3	1	0	4
MSS-12	Nano-photonics	Soft	3	1	0	4
MSS-13	Thermodynamic Modelling of Systems	Soft	3	1	0	4
MSS-14	Basics of Engineering Drawing and Graphics	Soft	2	2	0	4
MSS-15	Ceramics Science and Technology	Soft	3	1	0	4
MSS-16	Materials for Renewable Energy and Storage	Soft	3	1	0	4
MSS-17	Basics of Nanotechnology	Soft	3	1	0	4
MSS-18	Enterprise Architecture	Soft	3	1	0	4
MSS-19	Chemical Engineering	Soft	3	1	0	4
MSS-20	Advanced X-ray Diffraction Studies	Soft	3	1	0	4
MSS-21	Analytical and Inorganic Chemistry	Soft	3	1	0	4
MSS-22	Semiconductor Optoelectronics	Soft	3	1	0	4
		Total soft credits available to choose				62

MSH-1: Introduction to Materials: 4 Credits (Hard core) *Total: 48 hrs*

Unit-I: Materials through ages

Materials - Synthetic and Natural materials. Materials through ages - Palaeolithic to Modern period. Bulk, fine and Nanomaterials, Classification, Crystalline - Functional materials, Smart Materials, Centrosymmetric and Non-centrosymmetric materials, Amorphous, Glasses, Metals, Alloys, Semiconductors - types of semiconductors, Opto-electronic, Polymers, Ceramics, Bio-materials Polymer, Blends, Composites.

12 hours

Unit-II: Crystal Structure

Periodic Array of Atoms Crystal Lattice-Lattice Translation Vectors - United-Basis-Symmetry Consideration- Bravis Lattice - Crystal Planes and Millers Indices-Simple Crystal Structure (HCP, FCC, BCC, SC, Diamond).

12 hours

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

Bragg's Law, Laue Equations, Reciprocal Lattice, Braggs Condition, Brillouin Zones, Atomic Scattering, Geometrical Structure Factor, Experimental X-Ray Diffraction, Methods of Crystal Structure, Laue Method, Rotary Crystal Method, Powder Method or Debye-Scherrer Method, Weber-Feckner Method.

12 hours

Unit-IV: Chemical Bonding in crystals and Imperfection

Ionic Crystals, Covalent Crystals, Metallic Crystals Molecular Crystals and Vander Waals Attraction, Hydrogen Bonded Crystals, Mixed or Multiple Bond Crystals. Classification of Imperfections, Concentration of Vacancies (Schottky Defects), Frenkel Defects, Extrinsic vacancies, Color Centers, Dislocations, Dislocation Energies, Dislocation and Shear Strength of Single Crystal, Defects, Grain Boundaries, Staining Faults.

12 hours

References

1. Murugesan R, Modern Physics, S. Chand & Company, 9/e.Rev. Edn. 2003, EN8305SC011.
2. Arthur Beiser, Modern Physics, Addison Wesley Longman Publishing Co (January 1968) ISBN-10: 0201005158
3. Leonid Azaroff, An Introduction to Solids, McGraw-Hill Companies; New edition (1984)
4. Charles Kittel, Introduction to Solid State Physics, John Wiley & Sons, UK 7th Edition (1995)
5. Donald E. Sands, Introduction to Crystallography, Dover Publications, (1994).
6. Darrell Irvine and Nicola Marzari, Fundamentals of Materials Science, MIT Open Course Ware Publications (2005).

MSH-2: Thermodynamics and Statistical Mechanics 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

Derivation of Gas Equation, Derivation of Gas Laws, Avogadro's Hypothesis, Graham's Law of Diffusion of Gases, Degree of Freedom & Maxwell's Law of Equipartition of Energy, Mean Free Path, Van-der Waals Equation of State, Critical Constants, Corresponding States, Critical Coefficient.

12 hours

Unit-III: Laws of Thermodynamics

Thermal Equilibrium Concept of Temperature (Zeroth Law of Thermodynamics), Concept of Heat-Heat: A Path Function, Work: A Path Function, Comparison of Heat and Work - First Law of Thermodynamics, Isothermal Process, Adiabatic Process, Isobaric Process, Isochoric Process, Second Law of Thermodynamics, Entropy, Third Law of Thermodynamics.

12 hours

Unit-IV: Statistical Thermodynamics

Statistical Mechanics- Systems, ensembles, time average, ensemble average, Phase space and micro space: -Statistical definition of entropy- Statistical Equilibrium – Thermal, mechanical and particle (chemical) equilibriums: Gibbs 'Paradox -Maxwell-Boltzmann Distribution law for an Ideal Gas; Quantum Statistics-Formulation of quantum statistics, Distribution laws: Fermi-Dirac and Bose-Einstein Distribution Laws (Qualitative only), Electron Fermi gas-Boson (Photon) gas- Bose-Einstein Condensation; Comparison of Three Statistics (MB, FD and BE).

12 hours

References

1. Richard E. Sonntag and Claus Borgnakke, Introduction to Engineering Thermodynamics, Wiley; 2 edition (March 3, 2006), ISBN-10: 0471737593.
2. Ken A. Dill and Sarina Bromberg, Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology Garland Science. (Taylor & Francis Group), 2003.
3. Statistical Mechanics by SL Gupta and V Kumar (2011) Pragati Prakashan, India

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; Superstaturation; Top seeded solution growth; sol-gel techniques; high temperature solution; Hydrothermal; Solvothermal methods; Ammonothermal method; Glycothermal; Melt methods-super cooling, Czechorlskii 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:

1. Springer Handbook of Crystal Growth; Eds: G. Dhanraj, K. Byrappa, V. Prasad, M. Dudley, Springer Verlag (2010)
2. Springer Handbook of Nanotechnology; Eds: Bharath Bhushan, Springer Verlag, 2nd Edition (2009).
3. Handbook of Crystal Growth, K. Byrappa and T. Ohachi, Springer-Verlag (2003).
4. Growth of Single Crystals, R.A. Laudise, Prentice-Hall (1973).
5. Growth and Characterization of Technologically Important Crystals, By: K. Byrappa, R. Fornari, T. Ohachi, H. Klapper, Allied Sciences, New Delhi (2003).

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 fee 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

1. Sam Zhang, Lin Li and Ashok Kumar, Materials Characterization Techniques, CRC Press, (2008)
2. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley & Sons (2008)
3. Elton N. Kaufmann, Characterization of Materials, Vol.1, Wiley & Sons (2003)
4. R.A. Laudise, Growth of Single Crystals, Prentice Hall, (1973)
5. G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley (Eds.), Springer Handbook of Crystal Growth, Springer-Verlag (2010)
6. Peter E.J. Flewitt and R.K. Wild, Physical Methods of Materials Characterization, 2nd Edition, Taylor & Francis (2003)

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

Physical properties of materials Conductivity, density, refractive index, tensile strength, microstructure of bulk, small and nanoscale materials. Optical, Magnetic, Electronic, Semiconducting, Superconducting, Thermal, Electro-optic, Thermo-optic, Superionic, insulator properties of materials.

12 hours

Unit-III

Statistical Treatment of Analytical Data. Limitations of analytical methods. Classification of errors. distributions: Student's t-test, F-test, Chi-square test; Linear correlation; Nonparametric or Rank correlation; Smoothing of data. Fundamentals of chromatography. Phase rule studies. Energetic of cell reactions.

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

1. Pillai, Solid State Physics, Narosa Publication999999999s, India (2007)
2. J.I. Gersten and F.W. Smith, The Physics and Chemistry of Materials, Wiley & Sons (2001)
3. A. Navrotsky, Physics and Chemistry of Earth Materials, 6th Edition, (1995) Cambridge Series.

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

Unit-I

Basics of Corrosion, Different forms of Corrosion, electrochemical corrosion, thermodynamic principles of electrochemical reactions, Electromotive Force Series, Pourbaix Diagrams, Evans Diagrams, Mixed Potential Theory, Passivity,

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

Atmospheric Corrosion, Oxidation in Gaseous Environments, Ellingham Diagrams, Role of Protective Scale, Molten Salt Corrosion, Environmental degradation of ceramics, Degradation of Polymeric Materials, Microbial corrosion, Corrosion of Bio-Implants, Corrosion Prevention methods.

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.

References

1. D. A. Jones: Principles and Prevention of Corrosion, Macmillan Publ. Co. (1996).
2. C. Scully: The Fundamental of Corrosion, 2nd ed., Pergamon Press: E. E.Stansbury and R. A. Buchanan, Fundamentals of Electrochemical Corrosion, ASM International (2000)
3. M.G. Fontana: Corrosion Engineering, 3rd. Ed., McGraw Hill. (1986)
4. J. M. West: Electrodeposition and Corrosion Control, J. Wiley W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons (2000).
5. W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons, 2000: Metals Handbook, Vol. 13: Corrosion, ASM International

MSS-1: Structure, Property and Functions of Materials **4 credits (Soft core)** ***Total: 48 hrs***

Unit-I Materials

Solid Solutions and Alloys: Phase Transitions: Overview of Crystal Structures: Structure - Property Relations: Neumann's Law: Thermal Properties: Optical Properties: Electrical Properties: Dielectric Properties: Magnetic Properties: Mechanical Properties.

12 hours

Unit-II Polymers

Importance of polymers. Fundamentals of polymers-Monomers the repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization-condensation, addition, free radical, ionic, co-ordination polymerization and ring opening polymerization. Molecular weight and Polydispersion. Average molecular weight concepts-number weight and viscosity average molecular weight. Practical significance of molecular weight. Size of polymer molecules

12 hours

Unit-III Viscoelasticity

Aspects relating process and morphology : Kinetics and thermodynamics of melting nucleation ,and crystal growth : phase separations and transitions in solution and bulk polymers : Anisotropy in polymers : Influence of Structure on mechanical property ; Basics of diffusion : diffusion process in polymers

12 hours

Unit-IV Biomaterials

Protein, antibodies, Enzymes, Nucleotides, immobilization, functionalization methods for biomaterials (Antibody/enzyme/protein), encapsulation methods, biocompatible materials, Biodegradable polymers Bio-compatibility criteria, Toxicity evaluation (Inflammation, hypersensitivity, carcinogenesis). Application of biomaterials in orthopedics (artificial ligaments and tendons), cardiovascular tissues engineering (pacemakers). Biosensors, targeted drug delivery and affordable diagnostics.

12 hours

References

1. Re.E.Newnham, Properties of Materials: Anisotropy, Symmetry, Structure, Oxford University Press.
2. Buddy Ratner. Biomaterials Science. Second edition. Orlando, Academic Press, 2000;
3. Jonathan Black. Biological performance of materials: fundamentals of biocompatibility New York, Marcel Dekker, 1999
4. Joon Park and Joseph Bronzino. Biomaterials: Principles and Applications. Fort Lauderadale FL, CRC Press, 2003.
5. Ferry : Viscoelasticity properties of polymers
6. Aklonies,et al., An introduction of Viscoelasticity in polymers
7. Research and Development on Biosensors for food Analysis in India In: Advances in Biosensors M.S. Thakur and N.G. Karanth, 2003, Oxford University, Press, 2003.
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)
9. Advances in Biosensors, Volume 1, Reinhard Rennerberg and A.P.F. Turner, 1991.
10. Nanoparticles and Biophotonics as Efficient Tools in Resonance Energy Transfer-Based Biosensing for Monitoring Food Toxins and Pesticides, M. S. Thakur, Rajeev Ranjan, Aaydha C. Vinayak, Kunhitlu S. Abhijith, and Richa Sharma. Advances in Applied Nanotechnology for Agriculture, Chapter 4, 2013, pp 55-84, ACS Symposium Series, Volume 1143.

MSS-2: Spectroscopic Techniques for Materials 4 credits (Soft core) *Total: 48 hrs*

Unit-I UV-Visible & Raman Spectroscopy

Spectrum of Electromagnetic Radiation -UV-Visible Spectroscopy of Materials; Principle of working, instrumentation, experimentation, analysis of the UV-Vis spectrum, FITR Spectroscopy- Principle of working, instrumentation, experimentation, analysis of the FTIR spectrum, Brief Theory of Raman Spectroscopy-Instrumentation-Sample Handling and spectrum recording, Diagnostic Structural Analysis-Polarization Measurements-Quantitative Analysis

12 hours

Unit-II Nuclear Magnetic Resonance Spectroscopy

Basic Principles of NMRS - Continuous Wave NMR Spectrometers - Principle of working, instrumentation, experimentation, analysis of the NMR spectrum, Pulsed Fourier Transform NMR Spectrometer - Principle of working, instrumentation, experimentation, analysis of the NMR spectrum ; Molecular Structure - Quantitative Analysis from the NMR spectroscopy.

12 hours

Unit-III Electron Spin Resonance Spectroscopy

Electron the probe; its behaviour in materials- ESR Spectrometer - Principle of working, instrumentation, experimentation, analysis of the ESR Spectra - Interpretation of ESR Spectra for the determination of properties of the materials- Quantitative Analysis.

12 hours

Unit-IV Mass Spectrometry

Ion Scattering Spectrometry: Brief theory, Principle of working Instrumentation and data acquisition and analysis; Secondary Ion Mass Spectrometry (SIMS) - Brief theory, Principle of working, Instrumentation and data acquisition and analysis, Auger Emission Spectroscopy (AES) - Brief theory, Principle of working, Instrumentation and data acquisition and analysis, Electron Spectroscopy for Chemical Analysis (ESCA)- Brief theory, Principle of working, Instrumentation and data acquisition and analysis ,Low Energy Electron Diffraction (LEED) - Brief theory, working Principle, Instrumentation and data acquisition and analysis, Photoelectron Spectroscopy (PES) Brief theory, Principle of working, Instrumentation and data acquisition and analysis.

12 hours

References

1. Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, CBS publishers & Distributors, Delhi, Sixth Edition, 1986.
2. Colin N. Barnwell and Elaine M. McCash, Molecular Spectroscopy, McGraw-Hill College; 4 Sub edition (June 1, 1994), ISBN-10: 0077079760

MSS-3: Physics of Nanoscience and Nanotechnology 4 credits (Soft core) *Total: 48 hrs*

Unit-I Crystal Structure

Periodic array of atoms- Crystal lattice- Lattice translation vectors- Basis -Symmetry consideration-Basis Lattice-Crystal planes and Miller Indices- Simple crystal structure (HCP, SC,BCC,FCC, Diamond)

12 hours

Unit -II Crystal Diffraction and reciprocal lattice

Bragg's Law-Laue equations- Reciprocal lattice- Bragg's Condition- Brillouin Zones- Atomic Scattering-Geometrical structure factor-Experimental X-ray diffraction- Methods of crystal structure- Laue method- Rotary crystal method- Powder method or Debye -Scherrer method-Weber-Feckner Method.

12 hours

Unit-III Crystal Bonding

Ionic crystals- Covalent crystals- Metallic crystals- Molecular crystals and Van der Waals attraction- Hydrogen bonded crystals- Mixed or multiple bond crystals

12 hours

Unit -IV Imperfection in Crystals

Classification of imperfections-Concentration of vacancies (Schottky defects) -Frenkel defects- Extrinsics vacancies- Color centers-Dislocations - Dislocation energies- Dislocation and shear strength of single crystal-Defects-Grain boundaries-Staining faults.

12 hours

References

1. Murugesan R, Modern Physics, S Chand and Company, 9/e Rev. Edn 2003 EN8305SC011 2)
2. Arthur Beiser, Modern Physics, Addison Wesley , Longman Publishing Co (1968) ISBN-10:0201005158

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 -insultaor technology- Gate of high -K dielectrics

12 hours

Unit -*II* *Fabrication*

Thermal manufacturing - Rapid Thermal Processing and beyond: Applications in Semiconductor Processing of Complimentary Metal Oxide Semiconductor. Memory devices – Volatile and Non-volatile memory. The material challenge of Ultra thin body (UTB) - metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) for technology. Insulated-gate field-effect transistor (IGFET). 3D inter-connect technology.

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*

Si-Ge-Si-C , Diamond,-Synthesis- Defects and properties on the nanoscale-Bottom up approach- Chemical self assembly- Properties of nanoparticles, Nanoclusters, Nanotubes, Nanowires, Nanoflowers, and Nanodots. Invention jet prints nanostructures with self-assembling material. Surfaces, Interfaces and Thin films. Fabrication of nanostructures using polymer brushes. Top down fabrication of nanostructures. Template assisted nanostructure growth. Nanostructured Films on Silicon Surfaces, Deposition, Characterization and Application of Nanocrystalline Diamond Films, Boron Nitride films,

12 hours

References:

1) Mark J Jackson, *Micro and Nanomanufacturing ,* Springer; First Edition, (2006) ISBN-10:038725744
2) Dieter K, Schroder, *Semiconductor Material and Device Characterization,* Wiley-IEEE Press, 3rd Edition, (2006) ISBN-10:0471739065
3) L. B. Freund and S Suresh, *Thin film materials: Stress, Defect formation and surface Evolution,* Cambridge University Press, (2004) ISBN-10:0521822815
4) Zheng Cui, *Micro-nanofabrication: Technologies and Applications,* Springer First Edition (2006), ISBN-10:3540289224
5) R. Kassing, P. Petkov, W. Kulish, C. Popov., Functional Properties of Nanostructured Materials. Springer (ISBN: 978-1-4020-4595-0 (Print) 978-1-4020-4594-3 (Online)

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-Suraface tension and Wettability-Insoluble monolayers-Surface Chemistry and monolayers-Electrostatic interactions in self assembling systems-Self-Assemble of amphiphiles-Monolayers-Micelles and microemulsions-the Structure and properties of Micelles.

12 hours

Unit-II Nanomaterials

Defining nanodimensional materials-Sice effects in Nanomaterials-Application and technology development-Supramolecular machines-Fundamentals of energy transfer and photon motion manipulation-Solar energy harvesting-Fundamentals of electron motion manipulation-Electron pumping and molecular wires-General methos available for the synthesis of nanomaterials-Manipulation o Nanopartices-Nanofabrication-Methods- Bottom up methods- Photolithography-Scanning probe methods-Soft lithography

12 hours

Unit-III Polymers

The interaction of polymers with surfaces-Polyelectrolyte multilayer assemblies-The application of electrostatic self-assembly to construct multilayers in a layer -Bilayer fashion- Fabrication methos-including self assembly

12 hours

Unit-IV Functionalization and applications of Nanomaterials

Chemical functionalization - Recent advances in Thiol-Au and Silane Chemistry- Layer-by-Layer synthesis of multilayer assemblies Applications - Quantum dots - nanocores and applications. Detailed description of the fabrication of functinalised Gold Nanocores and their application in cancer therapy.

12 hours

References

1. The chemistry of nanomaterials Volume 1, Synthesis, Properties and Applications: Edited by CNR Rao, A Muller, A K Cheetham; (2005) John-Wiley and Sons, Inc, ISBN:3-527- 30686-2
2. The chemistry of nanomaterials Volume 2, Synthesis, Properties and Applications: Edited by CNR Rao, A Muller, A K Cheetham; (2005) John-Wiley and Sons, Inc, ISBN:3-527- 30686-2

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

Unit-I Morphology

From a Graphene Sheet to a Nanotube - Archiral and Chiral Nanotubes - Singlewall, Multiwall and Bundled Nanotubes - ZigZag and Armchair Nanotubes - Eulers Theorem in Cylindrical and Defective Nanotubes

12 hours

Unit-II Production Techniques of Nanotubes

Carbon Arc Bulk Synthesis in Presence and Absence of Catalysts - High - Purity Material (Bucky Paper) Production Using Pulsed Laser Vaporization (PLV) of Pure and Doped Graphite - High- Pressure CO Conversion (HIPCO) - Nanotube Synthesis Based on Boudoir Reaction-Chemical Vapor Deposition (CVD) - Synthesis of Aligned Nanotube Films.

12 hours

Unit- III Growth of Single-Wall / Multiwall Nanotubes

Experimental Puzzles of SWNT - High Yield - Universality of Diameter - Role of Metal Catalyst - Key Question - Shape of Baby Tube - Application of Continuum Elasticity Theory to Nanotubes - Tube Diameter Optimization in a Finite System-Continuous Growth By Addition of Carbon at The Open Edge- Role of Metal Catalyst - Termination of Growth. Experimental Puzzles of MWNT - Aspect Ratio-Perfection-chemical inertness - Key Quwestion - Independent or Concerted Growth Equilibrium Structure of Double - Wall Nanotubes-Structure Stability at The Growing Edge-Termination By a Multi - Walled Dome.

12 hours

Unit-IV Structural, Electronic Properties & Applications of Nanotubes

Structural Changes in Free - Standing and Interacting Nanotubes Librations, Rotations - Effect of Inter tube interactions on the Electronic Structure Electronic Structure of Graphite as Building Block of Nanotubes. Effect of Chirality and Discrete Atoms-Conducting versus Insulating Nanotubes - Band Structure of Metallic Carbon Nanotubes - Effect of Doping on conductivity - Harnessing Field Enhancement - Flat Panel Displays - Carbon nanotubes & Drug Delivery.

12 hours

References

1. M.Endo, S.Iijima, M.S. Dresselhaus, Carbon Nanotubes, Pergamon; Ist Ed Edition (December 1st 1996), ISBN-10: 0080426824
2. Ado Jorio, Mildred S. Dresselhaus, and Gene Dresselhaus Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Springer; 1 edition (April 20,2001) ISBN-10: 3540410864

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 prepregs and fabrics ,Core materials for sandwich composites, Composites manufacturing using prepregs, 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

Types of composite materials, Aerospace applications of fibre-polymer composites, Advantages and problems with using fibre-polymer composites, Mechanics of continuous fibre composites, Sandwich composites, Environmental durability of composites Fatigue stress, Fatigue life (S-N) curves, Fatigue crack growth curves, Fatigue of fibre-polymer composites, Creep behaviour of materials, Creep of polymers and polymer composites, Designing Creep resistant materials

12 hours

References:

1. Mechanics of Fibrous Composites, C.T. Herakovich, John Wiley & Sons, Inc., New York, 1998
2. Analysis and Performance of Fibre Composites, B.D. Agarwal and L.J. Broutman, John Wiley & Sons, Inc. New York.
3. Fundamentals of Modern Manufacturing, Materials, Processing, and Systems, 2nd edition, Mikell P. Grover, John Wiley & Sons, inc
4. Structure and properties of engineering materials, fifth edition, Henkel and Pense, McGraw Hill, 2002
5. Mechanical Testing of Advanced Fibre Composites, J.M. Hodgkinson, Woodhead Publishing Limited, Cambridge, 2000.
6. ASTM standards.

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

Unit-I

Introduction: Definition, Reason for composites, classification of composites, Raw materials, classification, Chemistry, Properties and applications. Matrix: Thermoplastics-Raw materials, Physical and chemical properties, Thermal behaviour and mechanical properties, Thermosets-Epoxy; Curing reactions, Hardener, Gel time Viscosity Modifications, Prepreg making, Unsaturated polyester resin; catalyst, curing reaction, Viscosity modifier, Alkyd Resin, Vinly ester, polyimides, Physical and chemical properties, Thermal behaviour, Mechanical Properties and uses, Elastomeric composites.

12 hours

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

1. Handbook of Composites by G. Lubin, Van Nostrand, New York, 1982.
2. Polymers and Polymer Composites in Construction L.C. Holleway,1990
3. Engineering plastics and Composites by John C.Bittence,1990
4. Handbook of Plastics, Elastomers and Composites by Charles A Harper,1975
5. Designing with Reinforced Composites - Technology Performance, Economics Rosato, 2nd ED.1997
6. Delwane Composite design Encyclopedia (Vol 3 Processing and Fabrication / Technology_ Ed. Leif A. Carlssen. and Joahn W. Hillispie, Technomic Publishing Ah. Lancaster U.S.A.
7. Fibre Glass Reinforced Plastics Nicholas P.Cheremisinoff and Composites Paul N.Cheremmisinoff., Noyes publications,N.J. U.S.A (1995)
8. Composite applications The Future is now, Thomas J. Drozdr, (Eds), Published by Society of Manufacturing Engineers, Michigan,1989.
9. Polymer Layered Silicate and silica nano Composites, Y.C.Ke,P.stroeve and F.s.Wang, Elesvier,2005
10. Hand Book of Plastics Testing Technology Vishu Shah, John Wiley & Sons, Inc NY. (1998)

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

Unit-I: Basic Polymer Science

Polymer synthesis and structure-chain structure and configuration - Amorphous polymer state-Conformation of polymer chain - Macromolecular dynamics - structure of crystalline polymers-polymers in the liquid crystalline state - Glass, Rubber - Transition behaviour

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.

12 hours

Unit-III: Cell Structure

Overview of cells- Origin and overview of cells- Cells as experimental model - Chemistry of cells -Molecular composition- Enzymes as biological catalysis- Metabolic energy- Biosynthesis of cell consitutents- Cell membranes - Fundamentals of molecular biology- Hereditary genes and DNA-Expression of Genetic DNA -Recombinant DNA- Detection of nucleic acid and proteins.

12 hours

Unit-IV: Central Dogma of life

Flow of genetic information-Organisation and sequence of cellular genomes, Replicating-Maintenance of genomic DNA- RNA synthesis and processing- Protein synthesis and regulation. Cell structure and function- the nucleus- Protein sorting and transport, Bioenergetics and metabolism-Cytoskeleton and cell movement- the cell structure -cell regulation-Cell signalling -Cell Cycle- Cancerous cells.

12 hours

References

1. Leslie Howar Sperling, Introduction of physical polymer science, Wiley-Interscience; 4th Edition (2005) ISBN-10: 047170606X.
2. Geoffrey M Cooper, The cell- A molecular approach, Sinauer Associates Inc; 4 the Edition, (2006) ISBN-10: 0878932194

MSS-10: Physics and Chemistry of Polymers **4 Credits (Soft core)** ***Total: 48 hrs***

Unit- I Basic concepts: Classification of polymers, Nomenclature of Polymers concepts such as monomer,polymer,oligomer,dendrimer ; functionality and physical state (amorphous and crystalline) Stereo- regular polymers, co- polymers, block and graft co-polymers, molecular forces and chemical bonding in polymers. Polymerization mechanism, addition and condensation including co-ordination, cationic, anionic, Ring opening Redox polymerization, Living Radical polymerization-Atom transfer radical polymerization.

12 hours

Unit-II Methods of Polymerization – Bulk, solution, precipitation polymerization, Suspensions,emulsion, melt polycondensation, interfacial polymerization, solution . polycondensation, solid phase, gas phase and (formulation, mechanism, properties of the polymer produced advantages and disadvantages of each technique).Criteria of polymer solubility, solubility parameter, thermodynamics and phase equalibria of polymer solution, Fractionation of polymers by solubility.

12 hours

Unit - III Structure property relationship in polymers, configuration of polymer chains, crystallinity in polymers, crystallisation and melting, strain induced morphology, crystalline melting point, glass transition temperature, factors influencing Tg and Tm. Polymer rheology: Viscous flow, Kinetic theory of rubber elasticity, Visco-elasticity.

12 hours

Unit – IV Molecular weight and size: Importance of molecular weight, Molecular weight distribution, concept of Average molecular weights, measurement of molecular weight by end group analysis, colligative property, Light scattering, Ultracentrifugation, dilute solution viscosity, Gel permeating chromatography.

12 hours

References:

1.Text book of Polymer Science – Fred W. Billmeyer, J.R. John Wiley & Son, New York.(1990)
2.Polymer Science – V.R. Gowarikar, N.V. Vishwanathan, Jayadev Shreedhar Wiley Eastern Ltd. New Dehli, India(1986)
3.Analysis of polymers – an introduction – T.R. Crompton. Smithers Rapra Technology Pvt Ltd., SY4 4NR, UK, 2008
4.Experimental methods in polymer chemistry – J.F. Rabek. John Wiley and Sons NY(1980)
5.Polymer Science, P.L. Nayak, Kalyani publishers, New Dehli.(2005)
6.Analysis and Characerisation of Polymers – Sukumar Maiti, Ansandhan Prakashan, Midnapur, India.(1978)

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

Unit-I

Introduction on biocompatible nano-particles (Gold, silver, zinc, carbon, graphene and quantum dots), synthesis and applications. Nano-biosensors and Lab-on-chip devices for ultrasensitive diagnostics: Amperometric, potentiometric and potentiometric and flurometric biosensors (glucose biosensors, enzyme biosensors, screen printed electrodes). Affordables diagnostics.

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

Introduction, Liposomes, dendrimers, Layer by layer deposition, self-assembled monolayers, In-vivo imaging. Nanobiotechnology for food health and environment.

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)
2. Advances in Biosensors, Volume 1, Volume 1, Reinhard Renneberg and A.P.F. Tuner, 1991.
3. Nanoparticles and Biophotonics as Efficient Tools in Resonance Energy Transfer-Based Biosensing for Monitoring Food Toxins and Pesticides, M. S. Thakur, Rajeev Ranjan, Aaydha C. Vinayaka, Kunhitlu S. Abhijith, and Richa Sharma. Advanes in Applied Nanotechnology for Agriculture, Chapter 4, 2013, pp 55-84, ACS Symposium Series, Volume 1143.
4. Nanomaterials for Cancer Diagnosis, Challa S. S. R. Kumar (Editor), ISBN: 978-3-527-31387-7,448 pages, January 2007.
5. Microarray Technology and Its Applications, Uwe R. Muller, Dan V. Nicolau, Springer, 30-Mar-2006- Technology and Engineering.
6. Nanoparticulates as Drug Carriers edited by Vladimir P Torchilin (Northeastern University, USA), 2006, Imperial college press.

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

Unit-I: Quantum confined materials

Quantum dots - Optial transitions absorption - interband transitins - quantum confinement - intraband transitions flurescence/luminescence - photoluminescence/flurescence 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 soupling - Optical wavegide 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 miroscopy (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

1. H Masuhara, S Kawata and F Tokunga, Nanobiophotonics, Elsevier Science 2007.
2. BEA Sale and A C Teich, Fundamentals of photonics, John Wiley and Sons, NewYork 1993.
3. M Ohtsu, K Kobayashi, T Kawazoe and T Yatsui, Principals of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan (2003).
4. P N Prasad, Introduction to Biophotonics, JohnWiley and Sons (2003).

MSS-13: Thermodynamic Modelling **4 Credits (Soft core)** ***Total: 48 hrs***

Unit-I

Application of a Phase Rule to two and three component systems. Concepts of Thermodynamics. Partial molar volume and its determination by density measurements. Order of reaction and its determination. Energy of activation and its determination. Assumption of activated complex theory. Fast reactions with examples, polymers and their classification.

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

Thermodynamic equilibrium for simple to complex systems. Equilibrium reactions. Equilibrium and non-equilibrium phases. Estimation of solubility and stability. Dissociation constant. Activation coefficient. Speciation constant. Isoelectric points. Thermal stability and Chemical stability.

12 hours

Unit-IV

Thermodynamic modeling basic concept. Thermodynamic variables. Equation of state for predicting partial molal standard state properties of the system species. Helgeson equation of state. Calculation of excess properties of ions. Simple models. Pitzer model, Setschenow model. Bromley Zemaitis model. Helgeson Kirkham Flowers (HKF) model. Theoretical Phase diagrams with examples. Yield diagrams. Commercial softwares - CALPHAD, ChemApp, SimuSage, OLI Systems - FactSage Interface, etc.

12 hours

References

1. J. Thoma and B.O. Bouamama, Modelling and Simulation in Thermal and Chemical Engineering: A Bond Graph Approach, Springer (2000)
2. H. L. Lukas, Suzana G. Fries, Bo Sundman, Computational thermodynamics: the CALPHAD method, Cambridge University Press, UK (2007)
3. Jrgen Gmehling, Brbel Kolbe, Michael Kleiber, Jrgen Rarey, Chemical Thermodynamics: For Process Simulation, John Wiley & Sons (2012).
4. Advanced Course on Thermodynamic Models: Fundamentals & Computational Aspects, www.cere.dtu.dk, Department of Chemical and Biochemical Engineering - Sltofts Plads - Building 229 - DK2800 Kgs. Lyngby..

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

1. Narayanan, K.L., and Kannaiah, P., " Engineering Graphics ", Tata McGraw-Hill Publishers Co., Ltd., 1992.
2. William M. Neumann and Robert F.Sproul, " Principles of Computer Graphics ",McGraw Hill, 1989.
3. Warren J. Luzzadder and John M. Duff, " Fundamentals of Engineering Drawing ",Prentice-Hall of India Private Ltd., Eastern Economy Edition, 1995.
4. Natarajan K.V., " A Text Book of Engineering Drawing ", Private Publication, Madras, 1990.
5. Mathur, M.L. and Vaishwanar, R.S., " Engineering Drawing and Graphics ", Jain Brothers,New Delhi, 1993.

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

Definition & scope of ceramics and ceramic materials. Examples of ceramic crystals, short-range and long-range order, imperfections, polymorphism. Ceramic Binary and ternary systems, ceramic microstructures. Crystallization of glass and glass-ceramics. Thermal, electrical, magnetic and optical properties of ceramics and application. Classification of ceramic materials conventional and advanced, Areas of applications.

12 hours

Unit-II

Conventional Ceramics: b) Refractories : Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application. c) Whitewares : Classification and type of Whitewares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas. d) Ceramic Coatings : Types of glazes and enamels, Elementary ideas on compositions, Process of enameling & glazing and their properties. e) Glass : Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses.Application of glasses. f) Cement & Concrete : Concept of hydraulic materials, Basic raw materials, Manufacturing process, Basic compositions of OPC. Compound formation,setting and hardening.Tests of cement and concrete.

12 hours

Unit-III

Elementary ideas about the raw materials used in pottery, Heavy claywere s, Refractoriers, 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 is 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

1. F.H Norton, Elements of Ceramics, Addison-Wesley Press (1974)
2. M.W. Barsoum, Fundamentals of Ceramics, McGraw-Hill (2003)
3. W.D Kingery, Introduction to Ceramics, Wiley & Sons (1976).
4. Lawrence H. Van Vlack, Physical Ceramics for Engineers, Addison-Wesley Publishing (1964).
5. F. Singer and S.J. Singer, Industrial Ceramics, Chapman & Hall, UK (1963)

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

1. Vielstich, W., et al. (eds.) (2009). Handbook of fuel cells: advances in electrocatalysis, materials, diagnostics and durability. 6 vol. Hoboken: Wiley, 2009
2. Francis de Winter, Solar Collectors, Energy Storage, and Materials (Solar Heat Technologies), MIT Press, USA (1991)
3. David S. Ginley, David Cahen, Fundamentals of Materials for Energy and Environmental Sustainability, Cambridge University Press (2011)
4. Materials, Electronics, and Renewable Energy Part III Physics, Small lecture theatre, Cavendish Laboratory lecturers: David MacKay and Neil Greenham
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

Nanomaterials synthesis techniques nanoengineering of materials. Bottom up and Top down routes. Solution, Melt and Gas Processing of nanomaterials. Nature inspired processes.

12 hours

Unit-IV

Nanomaterials characterization X-rays, Spectroscopic - infrared, UV-Vis, Laser Raman, Photoluminescence, Electron Microscopic techniques, Thermal analysis, surface characteristics, light scattering methods, gas adsorption, magnetic susceptibility, conductivity, band gap calculations. Nanotechnology in modern technology in relation to electronic, biological, consumer and domestic applications. Applied nanobiotechnology and nanobiomedical science drug delivery, drug targeting, biosensors, bioimaging, neutron capture therapy.

12 hours

References

1. Bharath Bhusan, Springer Handbook of Nanotechnology, 3rd edition, Springer-Verlag (2009)
2. CNR Rao and T. Cheetham, Chemistry of Nanomaterials : Synthesis, Properties and Applications, Wiley & Sons (2005)
3. Hari Singh Nalwa, Encyclopedia of Nanotechnology, American Scientific Publishers (2004)
4. K. Byrappa and M. Yoshimura, Handbook of Hydrothermal Technology, 2nd edition, Elsevier (2012)
5. K. Byrappa and T. Adschiri, Hydrothermal Technology for Nanotechnology, Progress in Crystal Growth and Characteriation of Materials, Volume 53 (2007) pp.117-166.
6. K. Byrappa and M. Yoshimura (Editors): Special Edition of Journal of Materials Science, Volume 41, No.6 (2006).
7. K. Byrappa and T. Adschiri (Editors), Special Edition of Journal of Materials Science, Volume 43, No.7 (2008).
8. Charles P. Poole Jr. and Franks J. Qwens, Introduction to Nanotechnology, Wiley & sons (2003)

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 study1 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:

Mass Transfer: Molecular and convective mass transfer, mass transfer equations. Heat Transfer: Heat transfer by conduction, convection and radiation, heat transfer equations, Heat exchangers. Momentum Transfer: Fluid flow, pipes and tubes, fittings, valves and pumps, measurement of pressure and flow.

12 hours

Unit III:

Size reduction, size separation, sedimentation, centrifugation, filtration, crystallization, Extraction, drying, evaporation, distillation.

12 hours

Unit IV:
Reaction Engineering: Reaction kinetics, order of reaction, Batch, fed batch and continuous reactors, reactor design. Process Control: Proportional, integral, derivative and PID controllers, stability of controllers. Basics of Flow sheet, material balance, materials economics, safety analysis

12 hours

1. Badger Walter, L. and Banchero Julis, T., Introduction to Chemical Engineering, Tata McGraw Hill Pub. 1997.
2. McCabe, W.L., Smith, J.C. and Harriot, H.P., Unit Operations in Chemical Engineering, Mc Graw Hill, 2009
3. Jonson, C.D., Process Control and Instrumentation Technology, Prentic Hall India, 2003
4. Peters, Max S., and Timmerhaus, Klauss D., Plant Design and Economics for Chemical Engineers, Mc Graw Hill, 1991

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

Unit-I
Powder Diffraction Methods and calibration techniques: The modern Automated diffractometer: Applications of the Powder Method: Qualitative phase analysis: Crystallography and space group analysis: Indexing and lattice parameter determination, refinement and identification: Powder pattern calculation :Crystal structure determination - The Rietveld method.:

12 hours

Unit-II
Single Crystal Methods : Quantitative X-ray Diffraction: Interaction of X-rays with matter: absorption and EXAFS (time?): X-ray reflectometry analysis: Small Angle Scattering (5 lectures): Patterson Function: Pair correlation functions and linkage to structure function: Application to spherical, elliptical and needle shape inclusions":

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
Electron Diffraction (Orientation Imaging Microscopy): Fourier Analysis of Distributions: Euler angle definition of orientation space: Orientation Distribution Function: Fourier analysis of Orientation Distribution Function and quantification of texture: Stress (residual stress analysis)

12 hours

References

1. R. Jenkins and R. L. Snyder, Introduction to X-ray Analysis Diffractometry, John Wiley and Sons (1996):
2. Jens Als-Nielsen and Des Mc Morrow, Elements of Modern X-ray Physics, 2nd Edition Wiley & Sons (2011)
3. D. L. Bish and J. E. Post ed., Modern Powder, Diffraction Reviews in Mineralogy Vol. 20, Mineralogical Society of America, (1989).:
4. John Mc. Cowley Diffraction Physics, Klug and Alexander, X-ray Diffraction Procedures, J. Wiley and Son, New York (1972)
5. B. D. Cullity, Elements of X-ray Diffraction, Addison Wesley Publishing Company, Reading, Mass. (1956)

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

Unit I: Statistical Treatment of Analytical Data:
Limitations of analytical methods. Classification of errors:- Systematic errors- Sources, effects and their reduction. Random errors - Sources and distribution. Accuracy and precision.Fundamentals of chromatography**:** General description- Definition, terms and parameters used in chromatography (RF- value, retention volume and time). Ion-exchange chromatography (ICH), The synthesis of novel cation (Amberlite TR-1204) and anion exchange resin materials and its application in ion exchange chromatographic separation of the components from the reaction mixture. Potentiometry and conductometry: Theory, principle of working and few applications. Ionic bond and covalent bond: Properties of ionic substances, structure of ionic crystals, Hybridization, VSEPR concept to explaining the structure of simple molecules of materials.

12 hours

Unit II: Physical Chemistry
Application of physical chemistry
Application of phase rule to two and three component systems. Concepts of entropy and free energy. Partial molar volume and its determination by density measurements. Symmetry elements and symmetry operations with examples of simple molecule materials. X-ray diffraction, Bragg equation and Miller indices. Order of a reaction and its determination. Energy of activation and its determination. Assumption of activated complex theory. Fast reactions with examples, polymers and their classification. Arrhenius theory of strong and weak electrolytes. Corrosion and its prevention. Law of photochemistry. Quantum yield and its determination.

12 hours

Unit III:
Photodegradation of materials, Photocatalyst- ZnO, TiO_2, principle of photocatalyst, application of ZnO, TiO_2 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.

12 hours

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.)

12 hours

References:

1) Quantitative analysis. R.A.DAY and A.L. underwood 6th edition prentice hall, Inc1999
2) Principle of Instrumental analysis, D.A.skoog, F.J.Holler and T.A.Nieman, 5thedition. Thomson Asia pvt.Ltd. Singapore 1998
3) Analytical chemistry. G.D. christian 5th edition 2001, John-wiley and sons Inc. India
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
8) Principle and applications of Photochemistry – R.P. Wayne, Elsevier, New York, (1970).
9) Elements of physical chemistry – Glass stone and lewis
10) Encyclopedia of chemical technology – Kirck-othmer series
11) Inorganic chemistry – JE Huheey
12) Chemical Kinetics –L.K. Jain.
13) Physical chemistry by PW. Atkins, ELBS, 4th edition, Oxford University press (1990).

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

1. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007), Ch.16, 17, and 18.
2. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
3. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995)
4. G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3rd Ed. (2000), Ch.4,6.
5. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, Oxford University Press, New York (2007), 6th Ed. Ch.15-17.
6. J. M. Senior, Optical Fiber Communication: Principles and Practice, Prentice Hall of India, 2nd Ed.(1994), Ch.6-8.

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 recording of a materials and interpretation
Measure the stretching frequency of the carbonyl (C=O) and nitrile (CN) groups in a given sample and compare with literature values using FTIR Spectroscopy
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
7) Well diffusion method ,Disk diffusion method, Antimicrobial activity of nanoparticles using.
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. Paramognetic susceptibility of the given salts.
2. Hall effect in metals/semi conduction.
3. Crystallization
4. Distillation.
5. Fractional crystallization.
6. Synthesis of aspiriy, 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

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 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.
6. Morphological studies of prepared materials.
7. Morphological changes in materials due to irradiation.
8. Animal cell culture techniques – primary cell culture, sub-culturing.
9. Size determination of bio-materials using microscope and Zeta potential.
10. Protein adsorption in bio-materials.
11. Cell bio-material interpretation.

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.
6) SEM study of a polymer film
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

****