INSTITUTE OF CHEMICAL TECHNOLOGY
Department of Physics

Rules and Regulations of Syllabi relating to the Degree of Master of Science in Physics (Materials Science)

Preamble

Physics is a fundamental science close to nature and involves study of matter and its motion in space- time, energy and force. Physics is both important and influential because advances in its understanding have often translated into newer technologies, which are of interdisciplinary consequences. Any newer area of research is characterized by a statement of different enforcing conditions; success lies in how correctly the basic physical phenomena are interpreted in these conditions.

In tune with the aforesaid, to make research and development meaningful and effective, we intend to start a post-graduate (PG) course. This course is designed to educate students-

- In basic physics – Physics at atomic and molecular level.
- In various statistical, computational and numerical methods.
- In physical and analytical characterization methods.
- In newer research areas, by way of introducing electives and assigning result oriented research projects.
- The new research areas can include polymer science, colour science and application, nanoscience, renewable energy sources, surface and interfacial science etc.

This course will equip students with basic understanding of relevant Physics and with various analytical tools. Students, hence, can effectively contribute to various industries and/or emerging branches of research.

This entire approach resonates with the national initiative taken by MHRD, MNRE and Govt. of India to have healthy educational and research culture.

Regulations Related to the M. Sc. Physics (Materials Science) Course

1) **Intake**

   20 candidates shall be admitted every year. The distribution of seats shall be as per the Institute's norms.

2) **Admission**

   The candidate who have taken the post-H.S.C. 3-year degree course of Bachelor of Science with 6 units of Physics at the third year of the course and any two of chemistry, mathematics or statistics as the two other subjects at the first and second years of University of Mumbai or of any other recognized University; and passed the qualifying examination with at least 60% of the marks in aggregate or equivalent grade average. (55% for the backward class candidates only from Maharashtra State are eligible to apply).

   The candidates who have cleared the qualifying examination in one sitting will be preferred. The admissions will be done strictly on the basis of merit, based on the marks obtained in the qualifying examination

Course structure

The course is a credit-based 4-semester (2-year) course.

There will be two semesters in a year: July to December - semester I, and December to May - semester II. Each semester will consist of 15-16 weeks of instructions including seminars / projects/assignments.

At the end of each semester the candidates will be assessed as per the norms of the Institute.

Various activities associated with the semesters will be carried out as per the academic calendar of the Institute.

The requirement of attendance of the students shall be as per the norms of the Institute.

All the relevant academic regulations of the Institute shall be applicable to the course.

Assessment of the students will be done as per the norms of the Institute.

In case of any difficulty regarding any assessment component of the course, the Departmental Committee shall take appropriate decision, which will be final.

Electives: The electives to be offered during a given academic year will be decided by the Departmental Committee before the beginning of the year and will be announced by the Head. The students have to take electives from this list only.

Project: At the end of the Second semester, the Head of Department in consultation with the Departmental Committee will assign topics for the projects to the students and assign the supervisors. The students will do the work related to the project in semester IV on the topics assigned. The students shall submit the project report before the prescribed date which will be a date before the last date of the semester IV. The report shall be submitted with soft binding. The project report will be examined by the supervisor along with one other internal/external referee to be appointed by the Departmental committee. The referees shall give marks to the report as per the norms. The students will make presentation on the work in front of the Project Evaluation Committee (PEC) appointed by the Departmental Committee, in open defence form. The PEC will give marks to the presentation. The comments received from the referees as well as given by the PEC need to be incorporated in the thesis in consultation with the supervisor before doing the hard binding. The thesis in the hard copy form will be maintained in Department office. Final copy of the thesis will be submitted to the Institute in hard-bound form

Semester wise pattern of the M.Sc. (Physics) course

SEMESTER I

SUBJECT CODE	SUBJECT	L	T	P	C
PYT 2101	Classical Mechanics	2	1	--	3
PYT 2102	Mathematical Physics	2	1	--	3
PYT 2103	Quantum Mechanics I	2	1	--	3
PYT 2104	Electronics I	2	1	--	3
PYT 2105	Materials Science	2	1	--	3
PYT 2106	Solid State Physics	2	1	--	3
PYP 2107	General Physics Laboratory	--	1	6	4
	Total	12	7	6	22

SEMESTER II

SUBJECT CODE	SUBJECT	L	T	P	C
PYT 2201	Quantum Mechanics II	2	1	--	3
PYT 2202	Polymer Physics I	2	1	--	3
PYT 2203	Electronics II	2	1	--	3
PYT 2204	Classical Electrodynamics	2	1	--	3
PYT 2205	Materials Synthesis	2	1	--	3
PYT 2302	Analytical Techniques I	2	1	--	3
PYP 2207	Electronics Laboratory	--	1	6	4
	Total	12	7	6	22

SEMESTER III

SUBJECT CODE	SUBJECT	L	T	P	C
PYT 2301	Polymer Physics II	2	1	--	3
PYT 2206	Statistical Mechanics	2	1	--	3
PYT 2303	Analytical Techniques II	2	1	--	3
PYT 2304	Computational Physics	2	1	--	3
PYT 2305	Introduction to Ceramics	2	1	--	3
PYT 2306	Molecular Quantum Mechanics	2	1	--	3
PYP 2307	Chemical Physics Laboratory	--	1	6	4
	Total	12	7	6	22

SEMESTER IV

SUBJECT CODE	SUBJECT	L	T	P	C
PYT 2401	Introduction to Nanoscience	2	1	--	3
PYT 2402	Introduction to phase transformations	2	1	--	3
PYT 2403	Elective Paper	2	1	--	3
PYT 2404	Elective Paper	2	1	--	3
PYP 2405	Project	--	6	8	10
	Total	12	7	6	22

SEMESTER I

PYT 2101 Classical Mechanics

Lagrangian formulation of classical mechanics [10+5T]

Degrees of freedom, constraints, Hamilton's principle, derivation of Lagrange's equations from Hamilton's principle, ignorable coordinates and constants of motion, applications

Hamiltonian formulation of classical mechanics [10+5T]

Legendre transformations, Hamilton's equations of motion, derivation of Hamilton's equations form extended Hamilton's principle, ignorable coordinates and constants of motion, applications

Small oscillations [10 + 5]

Formulation of the problem, the eigenvalue equation and the principal axis transformation, normal coordinates, free vibrations in a linear triatomic molecule and its eigenfrequencies.

References

1) Classical Mechanics – H. Goldstein
2) Classical Mechanics – N. C. Rana and P. S. Joag
3) Mechanics – K. R. Symon
4) Mechanics – L. D. Landau and E. M. Lifshitz

PYT 2102 Mathematical Physics

Differential equations [10+5T]

First and second order ordinary differential equations, Frobenius method of series solutions, Legendre, Laguerre, Hermite, Bessel and Chebyshev equations and their solutions by Frobenius method, applications

Partial differential equations, Green's function, applications

Fourier series and integral transforms [10+5T]

Fourier series, Fourier integrals and Fourier transforms, properties, inverse Fourier transforms, applications

Laplace transform, properties, inverse Laplace transforms, applications

Complex analysis [10+5T]

Functions of a complex variable, Cauchy-Riemann conditions, contour integrals, Cauchy-Goursat theorem and applications, Cauchy integral formula, Liouville's theorem, Taylor and Laurent series, residues and poles, residue theorem, applications

References

1) Mathematical Physics – A. K. Ghatak, I. C. Goyal and S. J. Chua
2) Mathematical Methods in the Physical Sciences – M. Boas
3) Advanced Engineering Mathematics – E. Kreyszig
4) Complex Variables and Applications – R. V. Churchill

PYT 2103 Quantum Mechanics I

Review of concepts [6+3T]
Operators, postulates of quantum mechanics, expectation values, Ehrenfest's theorem, commutators, Heisenberg's uncertainty principle, wave packet formalism, Schrodinger equation.
Formalism [12+6T]
Dirac notation, Hilbert space, Hermitian operators and their properties, matrix mechanics, basis and representations, unitary and similarity transformations, Schrodinger, Heisenberg and Dirac pictures of quantum mechanics
Applications of Schrodinger equation [12+6T]
Schrodinger's wave equation, properties of the wavefunction, applications of the time-independent Schrodinger equation: particle in a box, finite well, finite barrier, step potential, delta-function potential, harmonic oscillator, etc.

References
1) Introductory Quantum Mechanics – R. Liboff
2) Quantum Mechanics – A. Ghatak and S. Lokanathan
3) Introduction to Quantum Mechanics – D. J. Griffiths
4) Principles of Quantum Mechanics – R. Shankar

PYT 2104 Electronics I
Transducers [6+3T]
Strain gauge, capacitive transducer, load cell, piezo-electrical transducer, photoelectric transducer, photo-voltaic cell, semiconductor photodiode, phototransistor, thermocouple, semiconductor diode temperature sensor, IC-type sensor, pyrometer, total radiation pyrometer, infrared pyrometer, optical pyrometer, ultrasonic temperature transducer.
Arithmetic Circuits [6+3T]
Unsigned binary numbers: limits, overflow, sign-magnitude numbers: range of sign-magnitude numbers, 2's complement representation: 1's complement, 2's complement, positive and negative numbers, converting to and from 2's complement representation, 2's complement arithmetic: addition, subtraction, overflow, what to do with arithmetic building blocks: half adder, full adder, controlled inverter.
Combinational Logic Design using circuits [6+3T]
Multiplexers: 4-to-1 Multiplexer, 16-to-1 Multiplexer, the 74150, Multiplexer Logic, Bubbles on Signal Lines, Universal Logic circuit, Nibble Multiplexers
De-Multiplexers: 1-to-2 De-multiplexer, 1-to-16 De-multiplexer, the 74154
Decoders: 1-of-16 Decoder, BCD-to-Decimal Decoders, the 7445
Encoders: Decimal-to-BCD Encoder, the 74147
Introduction to Microcontrollers [12+6T]
Introduction, Microcontrollers and Microprocessors, History of Microcontrollers and Microprocessors, Embedded Versus External Memory Devices, 8-bit & 16-bit Microcontrollers, CISC and RISC Processors, Harvard and Von Neumann Architectures, Commercial Microcontrollers.
Introduction, MCS-Architecture, Registers in MCS-51,8051 Pin Description, 8051 Connections, 8051 Parallel I/O Ports, Memory Organization. 8051 Instruction Set and Programming: MCS-51 Addressing Modes and Instructions: 8051 Addressing modes, MCS-51 Instruction Set, 8051 Instructions and Simple programs

References
1) Electronic Instrumentation – H. S. Kalsi
2) Digital Principles and Applications – D. P. Leach, A. P. Malvino and G. Saha
3) Modern Digital Electronics – R. P. Jain
4) Microcontrollers (Theory and Applications) – A. V. Deshmukh
5) The 8051 Microcontroller and Embedded Systems – R. Kapadia
6) 8051 Micro-controller – K. J. Ayala
7) Programming and customizing the 8051 microcontroller – M. Predko

8) The 8051 Microcontroller and Embedded Systems – M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay

PYT 2105 Materials Science

Introduction to Materials Science [18+9T]

Types of materials, properties of materials, levels of structure, short review of basic structure, crystal structure of metals, metallic alloys, ceramics, polymers, silicates, composites, etc. and its correlation with the properties of the material.

Adhesion science [12+6T]

Adhesion and cohesion, electrostatic theory of adhesion, mechanical and diffusion theories of adhesion, various theories of adhesion between solid/solid and solid/liquid interfaces.

References

1) Handbook of adhesion – D. E. Packham
2) The science and engineering of materials – D. R. Askeland
3) Handbook of adhesive technology – A. Pizzi and K. L. Mittal

PYT 2106 Solid State Physics

Crystal structure [10+5T]

Crystal structure, reciprocal lattice, x-ray diffraction amplitude: structure factor and atomic form factor, Bragg relations, applications of x-ray, electron and neutron diffraction.

Band theory of solids, lattice vibrations and thermal physics [10+5T]

Kronig-Penney model, Brillouin zones, Fermi surfaces, normal and Umklappe processes

Vibrations of monoatomic and diatomic lattices, normal mode frequencies and dispersion relations, quantisation of lattice vibrations, concept of phonon

Thermal conductivity, lattice thermal resistivity

Magnetism [10+5T]

Dia-, para- and ferromagnetism, quantum theories of dia- and paramagnetism, paramagnetism of conduction electrons, quantum theory of ferromagnetism, Curie temperature and susceptibility, antiferro- and ferrimagnetism, domain structure, magnetic bubble domains

Brief introduction to superconductivity

References

1) Introduction to Solid State Physics – C. Kittel
2) Elementary Solid State Physics – M. A. Omar
3) Solid State Physics – A. J. Dekker

SEMESTER II

PYT 2201 Quantum Mechanics II

Quantum theory of the hydrogen atom [6+3T]

Schrodinger equation for hydrogen atom, separation of variables, angular equations: spherical harmonics, radial equation: eigenvalues and eigenfunctions, probability distribution

Angular momentum [8+4T]

Angular momentum operators, eigenvalues and eigenfunctions of L^2 and L_Z, commutator relations, matrix representation of angular momentum, Clebsch-Gordan coefficients, Pauli spin matrices

Approximation methods [16+8T]

Time-independent perturbation theory, non-degenerate and degenerate cases, applications

Ritz variational method, applications

Time-dependent perturbation theory, applications

Brief introduction to scattering theory, differential and total cross sections, method of partial waves. Simple examples.

References

1) Introductory Quantum Mechanics – R. Liboff
2) Quantum Mechanics – A. Ghatak and S. Lokanathan
3) Introduction to Quantum Mechanics – D. J. Griffiths
4) Principles of Quantum Mechanics – R. Shankar

PYT 2202 Polymer Physics I

Introduction [6+3T]

General introduction to macromolecules, classification of polymers, structure of crystalline and amorphous polymers, lamellar, fibrillar, globular and spherulitic structures, domain structure of amorphous polymers

Chain conformation in polymers [8+4T]

Chains and preferred conformations, dimensions of random coil polymers, experimental determination of dimensions of chain molecules, models for calculating the average end-to-end distance for polymer chains, molecular weight and size and its effects on properties of polymers

Synthesis of polymers [4+2T]

Radical chain polymerisation, ionic and coordination chain polymerisation, co-polymerisation

Thermal properties [6+3T]

Glass transition temperature, melting temperature, heat distortion temperature, factors affecting T_g and its relation with various properties

Molecular weight of polymers [6+3T]

Average molecular weight, different approaches to defining molecular weight, degree of polymerisation, polydispersity and molecular weight distribution in polymers, size of polymer molecules

References

1) Textbook of Polymer Science – F. W. Billmeyer
2) Polymer Physics – U. W. Gedde
3) Macromolecular Physics: Part II and Part III – B. Wunderlich
4) Liquid Crystals: Fundamentals – S Singh and D. A. Dunmur
5) Principles of Polymer Morphology – D. C. Bassett
6) Principles of Polymer Chemistry – P. J. Flory
7) Viscoelastic Properties of polymers – J. D. Ferry
8) Thermal Analysis – B. Wunderlich
9) The physics of liquid crystals – P. G. de Gennes and J. Prost

PYT 2203 Electronics II

Power Supplies [8+4T]

Monolithic IC regulators (3-terminal regulators): basic types of IC regulators, on-card regulation versus single point regulation, load and line regulation redefined, the LM78XX series, fixed regulator, the LM79XX series, regulated dual supplies, adjustable regulators, ripple rejection

Switching regulators: the pass transistor, switching the pass transistor on and off, topologies, buck regulator, boost regulator, buck-boost regulator, monolithic buck regulators, monolithic boost regulators, monolithic buck-boost regulator

Oscilloscope [8+4T]

Introduction, basic principle, CRT features, block diagram of oscilloscope, simple CRO, typical CRT connections, dual trace oscilloscope, storage oscilloscope, digital storage oscilloscope.

8051 microcontroller: timer/counters, serial communication, interrupts [6+3T]

Programming 8051 timers, counter programming, basics of serial communication, 8051 connection to RS232, 8051 serial port programming in assembly, 8051 interrupts, programming timer interrupts, programming external hardware interrupts

Interfacing with 8051 [8+4T]

LCD and keyboard interfacing: LCD interfacing, keyboard interfacing, ADC, DAC and sensor interfacing: interfacing ADC to 8051(only interfacing ADC0804 and ADC0808 to 8051), DAC 1408, sensor interfacing and signal conditioning

Motor control: relay, optoisolators, dc and stepper motors, relays and optoisolators, stepper motor interfacing, dc motor interfacing and PWM

References

1) Electronics Principles – A. Malvino and D. J. Bates
2) Electronic Instrumentation – H. S. Kalsi
3) The 8051 Microcontroller and Embedded Systems – M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay
4) The 8051 Microcontroller and Embedded Systems – R. Kapadia
5) 8051 Micro-controller – K. J. Ayala
6) Programming and customizing the 8051 microcontroller – M. Predko

PYT 2204 Classical Electrodynamics

Review of classical electrodynamics [6+3T]

Maxwell's equations, Poynting vector and Maxwell's stress tensor, conservation laws

Electrodynamics of continuous media [12+6T]

Electromagnetic waves in free space and in material media, polarisation and refractive index, skin depth in conductors, waveguides, and classification of fields in waveguides

Electromagnetic radiation [12+6T]

Gauge freedom and gauge transformations, wave equations in terms of the potentials, moving charges in free space, Lienard-Wiechert potentials and fields, radiation from a charged particle, multipole expansions for a charge distribution in free space, radiation from antennae and arrays

References

1) Foundations of Electromagentic Theory – J. R. Reitz, E. J. Milford and R. W. Christy
2) Introduction to Electrodynamics – D. J. Griffiths
3) Classical Electricity and Magnetism – W. K. H. Panofsky and M. Phillips
4) Classical Electromagnetic Radiation – J. B. Marion and M. A. Heald

PYT 2205 Materials Synthesis

Introduction [6+3T]

Concept of equilibrium and non-equilibrium processing and their importance in materials science

Synthesis of bulk materials [12+6T]

Metallic and non-metallic, ceramics and other materials, basic elements of powder technologies, compaction, sintering calcination, vitrification reactions, phenomenon of particle coalescence, porosity, concept of quenching, glass formation, splat quenching.

Thin films techniques [12+6T]

Ion-beam processing, features of ion-induced phenomena in materials

Laser-based techniques, CW and pulsed laser processing, laser annealing, alloying, cladding, metallurgy, reactive processing, laser deposition

Basic concepts of sputtering, chemical vapour deposition and other techniques

References

1) Materials Science and Engineering – V. Raghavan
2) Physical metallurgy: Vol. I and II – R. W. Cahn and P. Hassen

PYT 2206 Statistical Mechanics

Review of statistical thermodynamics [6+3T]

Thermodynamics and kinetic theory, introduction to probability, binomial, Poisson and Gaussian distributions, specification of the state of a system, concept of statistical ensemble, phase space, Liouville's theorem, equilibrium and fluctuations

Ensemble theory [14+7T]

Microcanonical ensemble, statistical concept of temperature, canonical ensemble, partition function, calculation of thermodynamic variables from the partition function, ideal monoatomic gas in a canonical ensemble, Gibbs' paradox, equipartition theorem, Maxwell-Boltzmann velocity distribution, grand canonical ensemble, chemical potential and fugacity, grand partition function, applications

Quantum statistical mechanics [10+5T]

Quantum distribution functions, partition function for ideal quantum gases, thermodynamic quantities and equations of state for ideal Fermi and Bose gases

References

1) Statistical Mechanics: An Introduction – S. Lokanathan and R. S. Gambhir
2) Statistical Mechnics – R. K. Pathria
3) Fundamentals of Statistical and Thermal Physics – F. Reif

SEMESTER III

PYT 2301 Polymer Physics II

Mechanical behaviour [12+6T]

Fundamental concepts of rheology, elastic, viscoelastic and flow behavior, theory of linear viscoelasticity, concept of relaxation, stress-strain behaviour, its dependence on internal and external factors, fatigue and lifetime of polymers

Thermal behaviour [8+4T]

Thermal transitions, melting of crystalline polymers, thermal degradation, thermal expansion in polymers, thermogravimetry, differential scanning calorimetry

Electrical behaviour [10+5T]

Electrical/conducting properties of polymers, diffusion of fluids through polymeric surfaces, barrier properties

References

1) Textbook of Polymer Science – F. W. Billmeyer
2) Polymer Physics – U. W. Gedde
3) Macromolecular Physics: Part II and Part III – B. Wunderlich
4) Liquid Crystals: Fundamentals – S Singh and D. A. Dunmur
5) Principles of Polymer Morphology – D. C. Bassett
6) Principles of Polymer Chemistry – P. J. Flory
7) Viscoelastic Properties of polymers – J. D. Ferry
8) Thermal Analysis – B. Wunderlich
9) The physics of liquid crystals – P. G. de Gennes and J. Prost

PYT 2302 Analytical Techniques I

Molecular Absorption and Emission Spectroscopy [12+6T]

Review of molecular spectra, electronic, vibrational and rotational energy levels, theory of molecular absorption, Beer-Lambert's law.
UV-visible spectroscopy and electronic energy levels, molecular structure using IR/FTIR and Raman spectroscopy, photoluminescence, fluorimetry.

Structural, Micro-structural and Composition Analysis of Solids [18+9T]

X-ray diffraction (XRD), electron and neutron diffraction, scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning tunneling microscopy (STM), atomic force microscopy (AFM), Auger electron spectroscopy (AES) and X-ray photoelectron spectroscopy (XPS), secondary ion mass spectroscopy (SIMS), Mossbauer spectroscopy.

References

1) Fundamentals of Molecular Spectroscopy – C. Banwell and E. McCash
2) Instrumental Methods of Analysis – H. H. Willard, I. I. Merritt and J. A. Dean
3) Dye Lasers – F. P. Schafer
4) Infrared Spectra of Complex Molecules – L. J. Bellamy
5) Fundamentals of Surface and Thin Film Analysis – L. C. Feldman and J. W. Mayer
6) X-ray Structure Determination – G. H. Stout and I. H. Jensen

PYT 2303 Analytical Techniques II

Chromatography [10+5T]

Introduction to chromatographic methods, gas chromatography, liquid chromatography, behaviour of solutes, column efficiency and resolution, band broadening, gas chromatographs, stationary phases and column selection, GC detectors, high performance liquid chromatography, HPLC instrumentation, sample introduction, separation columns, detectors.

Resonance Spectroscopy [10+5T]

Nuclear magnetic resonance (NMR), explanation using quantum mechanics, chemical shift, instrumentation for NMR, factors affecting NMR spectra, electron spin resonance (ESR).

Other Techniques [10+5T]

Mass Spectroscopy (MS, GC/MS), Light scattering / particle size analysis, Atomic Absorption Spectroscopy (AAS), C-H-N analysis.

References

1) High Resolution NMR Spectroscopy – E. D. Becker
2) Nuclear Magnetic Resonance Spectroscopy – R. K. Harris
3) Physical Methods – R. S. Drago
4) Advances in Electrochemical Science and Engineering – I. I. Gerischer and C. W. Tobnia

PYT 2304 Computational Physics

Introduction to Linux,C++ and Fortran [12+6T]

Basic linux commands, editing files in Linux, compiling and executing C++ programmes in Linux, flow charts, algorithms, integer and floating point arithmetic, operators, input-output, pointers, program organizations, control structures, functions, vectors, arrays. Flow charts, algorithms, integer and floating point arithmetic, precision, variable types, arithmetic statements, input and output statements, control statements, executable and non executable statements, arrays, repetitive and logical structures, subroutines and functions, operation with files, operating systems, creation of executable programs.

Numerical Methods [18+9T]

Solution of algebraic and transcendental equations: Iterative, bisection and Newton-Raphson methods, solution of simultaneous linear equations: matrix inversion method, Interpolation: Newton and Lagrange formulae, numerical integration, trapezoidal, Simpson and Gaussian quadrature methods, least-square curve fitting, straight line and polynomial fits, numerical solution of ordinary differential equation: Euler and Runge-Kutta methods. Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation.

References

1) Computational physics – S. E. Koonin and D. C. Meredith
2) Computational methods in physics and engineering – S. S. M. Wong
3) Computer programming in FORTRAN 77 – V. Rajaraman
4) Fortran 90/95 for scientists and engineers – S. J. Chapman
5) Computer oriented numerical methods – V. Rajaraman
6) Starting out with C++ - T. Gaddis
7) C++ Language Tutorial, http://www.cplusplus.com/doc/tutorial/
8) Numerical Recipes in C++ - W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery

PYT 2305 Introduction to Ceramics

Introduction

Bonding and crystal structure, point defects, effects of partial pressure of oxygen and temperature on defect concentration, effect of microstructure on the properties of ceramics

Synthesis

Synthesis of ceramic powders and nanoparticles, sintering and grain growth mechanisms

Mechanical properties

Theoretical fracture strength, Griffith's theory of brittle fracture, fracture toughness, factors affecting mechanical properties of ceramic materials, toughening mechanisms, R-curve behaviour and designing with ceramics, Weybull modulus, creep and fatigue in ceramic materials

Thermal properties

Thermal expansion, thermal conductivity, thermal stress and thermal shock resistance, spontaneous microcracking, thermal tempering

Introduction to glassy materials

Ceramic composites, glass ceramics, measurement of ceramic properties

References

1) Fundamentals of ceramics – M. W. Barsoum
2) Ceramic science and technology – W. D. Kingery, H. K. Bowen and D. R. Ulman

3) Ceramic fabrication processes – F. F. Y. Wang
4) Better ceramics through chemistry – C. J. Brinker, D. E. Clark and D. R. Ullrich

PYT 2306 Molecular Quantum Mechanics
Group Theory in Molecular Quantum Mechanics [12+6T]
Molecular symmetries and point groups, introduction to group theory, irreducible representations of molecular point group, wavefunctions according to molecular symmetry, applications to spectroscopy of some simple molecules.
Quantum Chemistry [18+9T]
Molecular Schrodinger equation, Born-Oppenheimer approximation, molecular orbital and valence bond theory of molecule formation, spin singlet and triplet states in molecules and their separation, transitions between singlet and triplet states.
Hybridisation of orbitals and molecular structure, molecular orbitals in conjugated chains, Huckel approximation, Hellman-Feynman theorem and applications.

References
1) Chemical Applications of Group Theory – F. A. Cotton
2) Introductory Quantum Mechanics – A. K. Chandra
3) Molecular Quantum Mechanics – Atkins and Friedman
4) Quantum Chemistry – I. Levine
5) Introduction to Group Theory – A. W. Joshi

SEMESTER IV

PYT 2401 Introduction to Nanoscience
Introduction [8+4T]
Metal Nanoclusters, magic Numbers, modeling of nanoparticles, bulk to nano transitions, effect of size reduction on the physical and chemical properties of materials, properties of nanomaterials
Synthesis and characterisation techniques [6+3T]
High energy mechanical milling, melt mixing, ionized cluster beam deposition, sputter deposition, PVD, CVD, pulse laser methods, microemulsion, sol-gel method, etc.
Structural and chemical characterization, XRD, UV-visible, near-infrared, SEM, TEM, photoluminesence, XPS, EXAFS.
Special Nanomaterials [8+4T]
Carbon nanostructures, fullerenes, carbon nanotubes
Bulk nanostructured materials, solid disordered nanostructures, nanostructured multilayers, metal nanoclusters, composite glasses, porous silicon
Application of Nanomaterials [8+4T]
Nanoelectronics, quantum dots and quantum well devices, plasmon waveguides (optical devices), automobiles, space, defense, sports and cosmetics

References
1) Introduction to Nanotechnology – C. P. Poole, Jr. and F.J. Owens
2) Nanotechnology: Principles and Practices – S. K. Kulkarni
3) Nanostructures and Nanomaterials – G. Cao
4) Nanomaterials – A. S. Edelstein, R. C. Cammaratra
5) Nanostructures: Theory and Modeling – C. J. Delerue and M. Lannoo
6) Carbon nanotubes – S. Fiorito

PYT 2402 Introduction to Phase Transformations

Formalism [18+9T]

Gibbs free energy composition diagrams, analysis and synthesis of phase diagrams, solid-solid nucleation theory, interface and diffusion-controlled growth, thermodynamics and kinetics of phase separation, order-disorder transformations

Applications [12+6T]

Crystallography of martensitic transformation, transformations in rapidly solidified alloys and glasses, phase stability in advanced ceramics, high pressure phase transformation, phase transformations in steels

References

1) Theory of transformations in metals and alloys – J. W. Christian
2) Phase transformations in materials – J. Haasen
3) Theory of structural transformations in solids – A. G. Khachaturyan
4) Phase diagrams: Materials science and technology, vol. 6 – A. M. Alper

PYT 2403/2404 Advanced Polymer Physics (Elective)

Polymer composites [8+4T]

Importance of polymer blends/composites, concept of polymer miscibility, interchange forces in polymer blends, phase equilibria and transitions, phase separation, behaviour of polymer mixtures: upper and lower critical solution temperatures, polymer-polymer compatibility, role of additives

Polymer nanocomposites [8+4T]

Dispersion of nanomaterials (layered silicates, carbon nanotubes) in host materials, preparation of nanocomposites: intercalation, exfoliation, common solvent, polymer melt intercalation methods, in-situ polymerisation method, crystallization of nanocomposites, various properties of nanocomposites

Polymer rheology [8+4T]

Concept of stress and strain tensors, constitutional equations of rheology, shear and extensional viscosities, dependence of viscosity on temperature, pressure and molecular weight, flow curve, flow of Newtonian and non-Newtonian liquids, rheology of extrusion and calendaring

Polymer mixing [6+3T]

Theory of mixing, macro- and micro-mixing, distributive and dispersive mixing, polymer-polymer mixing, melt mixing, solution blending, mixing by reaction

References

1) Structure and properties of oriented polymers – I. M. Ward
2) Polymer-clay nanocomposites – T. J. Pinnavaia and G. W. Beall
3) Principles of polymer morphology – D. C. Bassett
4) Polymer alloys and blends – L.A. Utracki
5) Thermal characterization of polymeric materials – E. A. Turi
6) Polymer Characterisation: Physical Techniques – D. Cambell and J. R. White
7) Introduction to Polymer Spectroscopy – W. Klopffer

PYT 2403/2404 Colour Science (Elective)

Introduction [8+4T]

Concept of colour appearance, illumination, sources/illuminants, lamp efficacy and colour rendering properties of source, interaction of electromagnetic radiation with matter, specular and diffused reflectance, absorption, Beer-Lambert's Law, Kubelka-Munk theory

Colour specification and communication [12+6T]

Additive and subtractive mixing, basic primaries, quantification of colour, various CIE colour spaces, Munsell colour order system, colour measuring instruments, booths and spectrophotometers, visual and instrumental quality control, evaluation of colour difference in colour quality control, tolerances & pass-fail analysis, colourant simulation and recipe match predictions

Colour perception [10+5T]

Perception of colour by a human observer, colour vision and colour theories, effect of surface texture, viewing geometry, surround, etc. on colour perception, colour contrast and colour harmony

References

1) Colour Physics for Industry – R.Mcdonald
2) Color: A Multidisciplinary Approach – H. Zollinger
3) The Colour Science of Dyes and Pigments – K. Mclaren
4) Color in Business, Science and Industry – D.B.Judd
5) The Elements of Colour – J. Itten

PYT 2403/2404 Solar Energy and Non-Conventional Energy Sources (Elective)

Review of conventional energy resources [10+5T]

Conventional energy sources, energy conservation and efficiency in production transfer and utilization (potential and limitations), climate changes and environmental pollution, measurement of pollution, pollution management

Renewable energy resources [20+10T]

Renewable energy sources, advantages of renewable energy utilisation

Solar energy: solar radiation, availability, measurement and estimation, solar thermal conversion device and storage application

Solar photovoltaics: fundamentals of photo voltaic energy, conversion physics and material properties, basics to photovoltaic conversions, different types of solar cells

Tidal energy, wind energy, bioenergy as renewable energy sources

Harnessing energy for utilisation, product design and development of newer ways, their management

References

1) Fundamentals of Solar Cells – A. L. Fahrenbruch and R. H. Bube
2) Solar Cell Device Physics – S. Fonash
3) Solar energy: principles of thermal collection and storage – S. P. Sukhatame
4) Solar engineering of thermal process – J. A. Duffie and W. A. Beckman
5) Renewable energy resources – T. Twidell and A. D. Weir
6) Principles of Solar energy – D. Y. Goswami, F. Kreith and J.F Kreider

LABORATORY COURSES

PYP 2107 General Physics Laboratory

Any 8 of the following list of experiments have to be completed.

1) Michelson Interferometer
2) Susceptibility by Gouy's / Quincke's Method
3) Analysis of Sodium Spectrum
4) LASER Diffraction
5) h/e using Vacuum Photocell
6) Hall Effect and van der Pauw's method
7) Ultrasonic Interferometer
8) Carrier lifetime by reverse pulse method
9) Resistivity by Four-Probe Method
10) Electron spin resonance
11) Zeeman Effect

PYP 2207 Electronics Laboratory

Any 8 of the following list of experiments have to be completed.

1) Constant Current Source
2) Constant Voltage Source
3) Waveform generation using Op-Amp
4) Active Filters using Op-Amp
5) Linear Sweep Generator using 555 timer
6) 8-bit DAC
7) Adder / Subtractor
8) Presettable Counters
9) Shift Register
10) Multiplexer / Demultiplexer
11) 8051 Microcontroller Programming
12) Port Programming using 8051 Microcontroller

PYP 2307 Chemical Physics Laboratory

1) Differential Scanning Calorimeter
2) Universal Testing Machine
3) UV-Visible Spectrophotometer
4) FTIR Spectrophotometer
5) Fluorimeter
6) Two-Component Mixture Analysis
7) Lovibond Tintometer
8) Colour Measurement Spectrophotometer
9) LCR Meter