



**D.Y. PATIL EDUCATION SOCIETY**  
**[Deemed to be University], Kolhapur**  
Re-accredited by NAAC with 'A' Grade



# **Centre for Interdisciplinary Research (CIR)**

**Department of Physics**

**Syllabus For**

**M.Sc. PHYSICS**

**Choice Based Credit System**

**D. Y. PATIL EDUCATION SOCIETY, KOLHAPUR**  
(DEEMED TO BE UNIVERSITY)



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**Department of Physics**

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**M. Sc. Physics**  
*(Choice Based Credit System)*

Year of Implementation : 2023-24

### **PHY-01- About the course**

In recent years, application of physics in technical and biomedical field are recognized as important and forefront fields. The branch holds the promise of many breakthroughs that may possibly change the course of future medical advances and our insight. It has been observed that properties such as electronic structure, reactivity, conductivity, melting temperature, optical properties and mechanical properties change as the particles become smaller than a critical size. This dependence of property on size allows for the engineering of nanostructures with varied properties with applications in producing stronger and lighter materials for advanced applications in energy (Supercapacitors, batteries), environment (Photocatalysts, dye degradation, water purification, green hydrogen production, HER/OER) and healthcare (biosensors, diagnosis and treatment of diseases).

Masters Program in Physics (Solid state Physics) will provide students to understand the current concepts and prospect of world of nanoscience with hands-on experience. The course structure and the syllabi has been tailor made with the aim to enable the student acquire a holistic and inter-disciplinary view of the subjects and their inter-relationship along with the application of the knowledge gained in one course on another. This Program would prepare the students for research in application of Physics in technological and biomedical field by opening more job opportunities.

### **PHY-02- Vision Mission and Goal**

**Vision:** To be a world-class centre of academics and research in physics specifically in by pursuing interdisciplinary ties for the benefit of nation and masses at large.

**Mission:** To promote academic growth by offering state-of-the-art postgraduate program in the field of Physics

#### **Goals:**

- To develop overall excellence in student that meet international standard.
- To enable the interdisciplinary research through the Physical sciences, Medical Sciences, Chemical sciences and Engineering discipline.
- To develop state-of-art resource centre in Physics and education hub.
- To provide solutions for industry through technology transfer and contribute to social as well as country economic growth.

### PHY-03- Outcome of the program

- Students will be well versed with the concept of Physics
- Students will learn different characterization technique involved in physics
- Culture of Interdisciplinary research will be seeded through collaborations with Medical Sciences and Life sciences
- Students will get the job opportunities below:
  - Academics such as Assistant Professor (in Graduate college/University after SET/NET/Ph.D.), Lecturer in Engineering College, Polytechnic college etc.
  - They are eligible for giving the SET/NET/GATE examination based on which they can apply for Ph.D. position as well as after qualifying SET/NET examination, they will be eligible for getting Assistant Professor position in Graduate college/University.
  - Students will be eligible for getting Junior Research Fellowships (JRF) on different research projects.
  - There are various permanent positions in Research and Development (R&D) sections of the Central government.
  - There are various positions in Central government jobs after M.Sc. Physics.
  - After completion of M.Sc. Physics, students will be eligible for doing further Diploma in Radiation Physics (conducted by Atomic Energy Regulatory Board). After completion of which, they are eligible to work as Medical Physicist (as well as Radiological Safety Officer) in Cancer Hospitals.
  - Students have career opportunities in electronics and manufacturing companies
  - Students are eligible to pursue Higher Degree in the field of Physics.

### PHY-04- Syllabus

#### Course Structure & Distribution of Credits.

M.Sc. Physics Program is Choice Based Credit System (CBCS) based and consists of total 16 theory courses and total four practical lab courses spread over 4 semesters and one research project. For first two semesters, eight theory courses and two practical lab courses will be common and compulsory to all the students. For third and fourth semesters, three theory papers and one practical lab course are compulsory to all the students. For remaining one theory paper, student can select one theory paper from groups of elective papers of these semesters. Each theory course will be of four credits, a practical lab course will be of four credits and a project will be of four credits. A student earns 24 (twenty four) credits per semester and total 96 (ninety six) credits in 4 semesters.



**Eligibility:** Graduation from Physics The course structure is as follows,

### Theory Courses

	<b>Paper I</b>	<b>Paper-II</b>	<b>Paper-III</b>	<b>Paper-IV</b>
<b>Semester-I</b>	Mathematical Physics (PHY 101) (Compulsory)	Solid State Physics-I (PHY 102) (Compulsory)	Semiconductor Devices (PHY 103) (Compulsory)	Classical And Quantum Mechanics I (PHY 104) (Compulsory)
	<b>Paper-V</b>	<b>Paper-VI</b>	<b>Paper-VII</b>	<b>Paper-VIII</b>
<b>Semester-II</b>	Electrodynamics (PHY 201) (Compulsory)	Nuclear Physics (PHY 202) (Compulsory)	Radiation Physics (PHY 203) (Compulsory)	Statistical Mechanics (PHY 204) (Compulsory)
	<b>Paper-IX</b>	<b>Paper-X</b>	<b>Paper-XI</b>	<b>Paper-XII</b>
<b>Semester-III</b>	Classical And Quantum Mechanics II (PHY 301) (Compulsory)	Experimental Techniques (PHY 302) (Compulsory)	Solid State Physics- II (PHY 303) (Compulsory)	Physics of Semiconductors/ Science & Properties of Nanomaterials/ Nanomaterials Synthesis (PHY 304) (Elective)
	<b>Paper-XIII</b>	<b>Paper-XI V</b>	<b>Paper-XV</b>	<b>Paper-XVI</b>
<b>Semster-IV</b>	Atomic and Molecular Physics (PHY 401) (Compulsory)	Properties of Materials (PHY 402) (Compulsory)	Thin Solid Films: Deposition and properties (PHY 403) (Compulsory)	Heterostructures and quantum devices/ Characterization of Nanomaterials / Application of nanomaterials (PHY 404) (Elective)

### Practical Lab courses

Semester-I	Lab course 1	Group A	Group B
Semester-II	Lab course 2	Group A	Group B
Semester-III	Lab course 3	Group A	Research Project
Semester-IV	Lab course 4	Group A	Research Project

## PROGRAM OUTCOMES

After completion of the program, the student shall:

Program outcome (PO)	
PO1	Knowledge and Skills
PO2	Planning and Problem-solving abilities
PO3	Communication
PO4	Research Aptitude
PO5	Professionalism and Ethics
PO6	Leadership
PO7	Societal Responsibilities
PO8	Environment and Sustainability
PO9	Lifelong Learner

- PO1.** Possess knowledge of Basics Nuclear & Radiation Physics, Mathematical Physics, Solid State Physics, Semiconductor Devices and Electrodynamics.
- PO2.** Demonstrate an ability to apply the knowledge acquired through the state-of-the art, students get skilled with logical thinking in steps, formulating model systems and solving problems
- PO3.** With satisfactory number of presentations and group discussions the students become good communicators, which develop communication skills to communicate effectively in interviews, colleagues, industries, academia for collaborative research by explaining their ideas with good interpersonal and workplace-based skills.
- PO4.** Students will get the lessons of research and development during their project work, assignments. During project work, group discussion and laboratory class pupils get nurtured to become a team member and to stand beside the others with fellow feeling in need.
- PO5.** Develop understanding and implementation of ethics in profession, research, society, workplace.
- PO6.** Develop leadership skills, to work effectively and efficiently, logical reasoning, time management, values required for self- directed and lifelong learning, soft skills for professional development and execute their professional roles in society.
- PO7.** Develop character with good moral values, human values, good social behavior, gratitude, honesty, ethics, safety, hygiene, responsibility, confidence, tolerance and critical thinking.
- PO8.** Able to contribute in environment and sustainable development to achieve the national sustainable development goals.
- PO9.** This course is helpful for lifelong learning in Physics Stream.

## Semester I

M.Sc. Physics Program for Semester-I consists of four theory courses (compulsory). The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one hour duration)

Theory Paper	Subject	Lectures (Hours.)	Credits
(Paper I) PHY 101	Mathematical Physics (Compulsory)	60	04
(Paper II) PHY 102	Solid State Physics-I (Compulsory)	60	04
(Paper III) PHY 103	Semiconductor Devices (Compulsory)	60	04
(Paper IV) PHY104	Classical And Quantum Mechanics(Compulsory)	60	04
<b>Total</b>		<b>240</b>	<b>16</b>

One practical laboratory course ( Lab Course 1) consisting two groups of practicals (group A and group B) : 16 hours per week

Practical Lab Course 1	Practical Lab (Hours)	Credits
PHYP101 (Group A)	60	04
PHYP102 (Group B)	60	04
<b>Total</b>	<b>120</b>	<b>08</b>

The practical lab course will contain experiments performing, seminars, tutorials, design of new experiments, demonstrative experiments, computer learning etc.

### Course Outcome

#### Paper I: PHY 101: Mathematical Physics

At the end of the course student should,

- CO1** Comprehend the knowledge of matrices, differential equations, integral transforms and its special functions to enable problem analysis and solving.
- CO2.** To understand the various special functions of differential equations and Fourier integral transform.
- CO3.** Understand the probability and statistical distributions, Central tendency, computational programming to collect, analyse, interpret data, and apply relevant statistical tests to make a scientific report.
- CO4.** To understand the deviation and distribution for various physical data
- CO5.** To provide the correlation and regression analysis to find the relation between two sets of data.
- CO6.** To teach various types of statistical distribution and uses for small to very large sampling sizes.

## **Paper II: PHY 102: Solid State Physics-I**

**At the end of the course student should,**

- CO1.** Understand the basics of crystal structure and its various types of bonding.
- CO2.** Know about the band structure in conductor, direct and indirect semiconductor and insulator.
- CO3.** Understand the basic physics of solids such as thermal behaviour and magnetic characteristics in view of its usage in medical instrumentation.
- CO4.** Learn the Einstein's, Debye's theories and lattice vibrations
- CO5.** Learn phenomenon of superconductivity, fluorescence and phosphorescence, thermo luminescence, Electroluminescence and to identify, analyse and solve the problem associated with it.
- CO6.** Understand the superconductivity and various types of luminescence, Fluorescence and Phosphorescence and LASER etc.,

## **Paper III: PHY 103: Semiconductor devices**

**At the end of the course student should,**

- CO1.** Know the concepts various junction like p-n, BJT, JFET, MOSFET, UJT and SCR.
- CO2.** To understand the various diode construction and its circuits.
- CO3.** Understand the principles of various Oscillators for constructing electronic circuits.
- CO4.** To know functioning of transducers and thermocouple-based thermometers
- CO5.** Capable of how the logic and integrated circuits digital data is generated
- CO6.** Explain the concepts of amplifier AC-DC converter, various dose rate meters and radiation detectors circuits.

## **Paper IV: PHY 104: Classical and Quantum Mechanics**

**At the end of the course student should,**

- CO1.** Learn the basic mathematical tools like variation calculus to mechanical systems and able to compute Lagrangian and Hamiltonian equation of motion.
- CO2.** Understand about the central force problem, phase space, canonical transformation and Hamilton Jacobi technique.
- CO3.** Solve the hydrogen atom problem to calculate energy levels by quantum mechanics
- CO4.** Learn the Schrodinger equations to solvable simple problems.
- CO5.** Understand the quantum mechanical angular momentum algebra and spin.
- CO6.** Compute corrections in energy and wave functions by approximation technique.

## Semester II

M.Sc. Physics Program for Semester-II consists of four theory courses (compulsory). The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one hour duration)

Theory Paper	Subject	Lectures (Hours)	Credits
(Paper V) PHY 201	Electrodynamics (Compulsory)	60	04
(Paper VI) PHY 202	Nuclear Physics (Compulsory)	60	04
(Paper VII) PHY 203	Radiation Physics (Compulsory)	60	04
(Paper VIII) PHY 204	Statistical Mechanics (Compulsory)	60	04
Total		240	16

One practical laboratory course (Lab Course 2) consisting two groups of practicals (group A and group B) . Practical lab courses: 16 hours per week

Practical Lab Course 2	Practical Lab (Hour)	Credits
PHYP201 (Group A)	60	04
PHYP202 (Group B)	60	04
Total	120	08

The practical lab course will contain experiments performing, seminars, tutorials, design of new experiments, demonstrative experiments, computer learning etc.

### Paper V: PHY 201: Electrodynamics

At the end of the course student should,

- CO1.** Interpret the deeper meaning of the Maxwellian field equations and account for their symmetry and transformation properties. Define and derive expressions for the energy both for the electrostatic and magneto statics fields.
- CO2.** Learn the basics of analog electronics such as ICs, CCDs, RC and LC.
- CO3.** Calculate the electromagnetic radiation from localised charges which move arbitrarily in time and space, taking into account retardation effects. Formulate and solve electrodynamic problems in relativistically covariant form in four-dimensional space time
- CO4.** Learn the transmission of electromagnetic waves through wave guide.
- CO5.** Understand the basics of electromagnetic radiations, particle accelerators and radiation reactions.
- CO6.** Know the electric, magnetic fields, electric potential and vector potentials for point charge and radiation emitted by moving charges.

#### **Paper VI: PHY 202: Nuclear Physics**

**At the end of the course student should,**

- CO1.** Familiarize with the properties of an atom and nucleus to know various interesting branches such as radioactivity, fission and fusion reactions, nuclear reactors, nuclear power plants, particle physics etc. that has huge applications for the benefits of society.
- CO2.** Gain knowledge how ionizing radiation interacts with matter, how it affects living organisms and how it is used as a therapeutic technique and radiation safety practices.
- CO3.** Understand the nuclear models and various decay process like Alpha, Beta, and Gamma
- CO4.** Familiarize with the electromagnetic spectrum, radiation sources, types and its properties
- CO5.** Learn the various nuclear reactions by examples and experiments
- CO6.** Familiarize with the four basics of in nature, its relative strength and various classification of elementary particles.

#### **Paper VII: PHY 203: Radiation Physics.**

**At the end of the course student should,**

- CO1.** Understand the basic of radioactivity, Natural radioactive series, Artificial production of radioactivity and various decay modes.
- CO2.** Gain functional knowledge regarding need for radiological protection and the sources and approximate level of radiation exposure for treatment purposes.
- CO3.** To learn the construction and working of different types of particle accelerators.
- CO4.** Learn the construction of X-ray generator used in Diagnostic radiology.
- CO5.** Learn the various ionizing radiation interaction with matter (Electron, Photon, Neutron).
- CO6.** To learn the penetration and linear energy stopping powers of various radiations.

#### **Paper VIII: PHY 204: Statistical Mechanics**

**At the end of the course student should,**

- CO1.** Learn about relevant quantities used to describe macroscopic systems, thermodynamic potentials and ensembles.
- CO2.** Understand the macroscopic and microscopic descriptions of temperature, entropy and free energy and their description in terms of probabilities.
- CO3.** To study theory of statistical mechanics and the approximations making a statistical description possible
- CO4.** Understand the strength and limitations of the models used and be able to compare different microscopic models.
- CO5.** Describe transport phenomena and show an understanding on how diffusion coefficients are computed.
- CO6.** Show an analytic ability to solve problems relevant to statistical mechanics.

### Semester III

Theory Paper	Subject	Lectures(Hours.)	Credits
(Paper IX) PHY 301	Classical And Quantum Mechanics II	60	04
(Paper X) PHY 302	Experimental Techniques	60	04
(PaperXI) PHY 303	Solid State Physics-II	60	04
(Paper XII) PHY304	Physics of Semiconductors/ Science & Properties of Nanomaterials/ Nanomaterials Synthesis	60	04
<b>Total</b>		<b>240</b>	<b>16</b>

#### Paper IX: PHY 301 Classical and Quantum Mechanics II

After completion of the course students will be able to

- Understand various Perturbation theories for time evolution problem
- Understand various scattering theories and its importance in quantum physics
- Know eigen functions, symmetric and asymmetric wave functions for many electron systems
- Apply knowledge of semiclassical theory of radiation to explain interaction of radiation with matter

#### Paper X: PHY 302: Experimental techniques

- Acquire the knowledge of production of low pressures by means of various techniques such as rotary and diffusion pump and identify the vacuum leaks using detectors
- Learn how to produce low temperatures using different techniques and also learn microscopic techniques to know the properties of materials
- Apply the acquired knowledge on atomic absorption spectrometry and x- ray diffraction to determine the elements and their concentrations in the sample with their structural properties
- Explain x-ray fluorescence spectrometry and Mossbauer spectroscopy



**Paper XI: PHY 303: Solid State Physics**

- Explain the different theories and models of the metals.
- Elucidate the transport properties of metals in terms of electrical conductivity, thermal scattering, and dielectric properties.
- Differentiate phonons, plasmons, polaritons, and polarons and obtain the dispersion relations for electromagnetic waves.
- Explain various defects in the solids, mechanism of photoluminescence, thermoluminescence, electroluminescence etc.

**Paper XII: PHY 304: Physics of Semiconductors (Elective-I)**

- Explain energy bands in solids, types of semiconductors, and temperature dependence of conductivity of the solids.
- Differentiate between direct and indirect recombination, trapping of electrons, diffusion and drift of the charge carriers in semiconductors.
- Explain behaviour of electron in periodic potential and related properties.
- Explain nucleation and growth processes of semiconductor formation using different techniques of crystal growth formation.

**Paper XII: PHY 304: Science and properties of nanomaterials (Elective-II)**

- Apply the acquired knowledge of quantum structures to understand the quantum tunnelling
- Learn the thermal, electrical, and magnetic properties of materials at nanoscale
- Identify the structures of nanomaterials of metals, alloys, ceramics and semiconductors
- Explain the size and shape dependent optical, electrical, magnetic and mechanical properties of the nanomaterials

**Paper XII: PHY 304: Nanomaterials Synthesis (Elective-III)**

- Understand top-down and bottom-up approaches for the synthesis of nanomaterials
- Understand mechanism of nucleation and growth during the formation of nanomaterials in chemical synthesis
- Understand and apply the synthetic route to prepare 2 dimensional nanomaterials
- Understand and apply the synthetic route to prepare 3 dimensional nanomaterials.

## Semester IV

Theory Paper	Subject	Lectures(Hours.)	Credits
(Paper XIII) PHY 401)	Atomic and Molecular Physics	60	04
(Paper XIV) PHY 402	Properties of Materials	60	04
(Paper XV) PHY 403	Thin Solid Films: Deposition and properties	60	04
(Paper XVI) PHY404	Heterostructures and Quantum Devices/ Characterization of nanomaterials/ Application of nanomaterials	60	04
Total		240	16

### Paper XIII: PHY 401: Atomic and Molecular Physics

- Acquire the knowledge of different electronic coupling schemes to explain the atom model for two valence electrons
- Explain the Zeeman, Paschen-back, and Stark effect and the origin of hyperfine structure
- Apply the knowledge on microwave spectroscopy to analyze chemical nature of the materials
- Apply the acquired knowledge on the energy of a diatomic molecule to analyze chemical properties of materials using infra-red spectroscopy

### Paper XIV: PHY 402: Properties of Materials

- Explain various types of point defects in solids.
- Differentiate the dislocations in solids and elucidate interaction of dislocations with points defects.
- Elucidate techniques for identifying the defects in solids.
- Classify the techniques for material testing and explain various tests used for solid materials testing.

### Paper XV: PHY 403: Thin Solid Films: Deposition and properties

- Explain various physical methods of thin film depositions.
- Elucidate the process of nucleation, growth of thin film deposition and factors affecting quality of the films.
- Explain various properties of thin films.

**Paper XVI: PHY 404: Hetero structures and Quantum Devices (Elective-I)**

- Determine the properties of semiconductor abrupt junctions at the equilibrium conditions
- Analyze the electrical and optical characteristics of LEDs and transistors using the properties of semiconductor heterojunctions
- Identify the characteristics of LASERs using 2D electron gas model and quantum wells
- Learn the electric and optical properties along with magneto conductivity of different nanostructures

**Paper XVI: PHY 404: Characterization of nanomaterials (Elective-II)**

- Understand various characterization techniques utilized for structure determination of synthesized nanomaterials
- Know different microscopy techniques to visualize the surface, shape and microstructure of nanomaterials as well as thin films
- Understand principle and working of magnetic properties measurement systems for magnetic nanomaterial characterizations
- Understand application oriented thin film characterization techniques

**Paper XVI: PHY 404: Application of nanomaterials (Elective-III)**

- To understand the importance of nanomaterials in energy storage applications such as batteries, supercapacitors and fuel cells
- To explain the applications of nanomaterials in sensing such as humidity sensors, gas sensors, glucose sensors
- To know few important biomedical applications of nanomaterials with special interest in cancer nanotechnology
- To describe the environmental impact of nanomaterials and understand the applications

## Semester –I

### PHY 101: Mathematical Physics

(60 hours, 4 credits)

#### UNIT I: MATRICES AND DIFFERENTIAL EQUATIONS

(10 h)

Matrices, inverse, orthogonal and unitary matrices, independent elements of a matrix, eigenvalues and eigenvectors, diagonalization, complete orthonormal sets of functions second order linear ODEs with variable coefficients, solution by series expansion, Cayley-Hamilton theorem and applications, similar matrices and diagonalizable matrices, eigen values of some special complex matrices, quadratic forms, problems

#### UNIT II: SPECIAL FUNCTIONS OF DIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORMS

(10 h)

Legendre, Bessel, Hermite and Laguerre equations, physical applications, generating functions, recursion relations, Laplace transform, first and second shifting theorems, inverse LT by partial fractions, LT of derivative and integral of function, Fourier series, FS of arbitrary period, half wave expansions, partial sums, Fourier integral and transforms, FT of delta function

#### UNIT III: PROBABILITY, STATISTICS AND ERRORS

(20 h)

Probability: addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data. basic ideas of statistical distributions, frequency distributions, averages or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis, application to radiation detection: uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit. binomial distribution, Poisson distribution, Gaussian distribution, exponential distribution, additive property of normal variates, confidence limits, bivariate distribution, correlation and regression, chi-Square distribution, t- distribution, F-distribution. Statistics of nuclear counting: Application of Poisson's statistics - goodness-of-fit tests -Lexie's divergence coefficients, Pearson's chi-square test and its extension, random fluctuations, evaluation of equipment performance, Signal-to- noise ratio, selection of operating voltage, preset of rate meters and recorders, efficiency and sensitivity of radiation detectors, statistical aspects of gamma ray and beta ray counting, special considerations in gas counting and counting with proportional counters, statistical accuracy in double isotope technique, sampling and sampling distributions, confidence intervals, clinical study designs and clinical trials, hypothesis testing and errors, regression analysis.

**UNIT IV: NUMERICAL METHODS, COMPUTATIONAL TOOLS & TECHNIQUES****(20 h)**

Need for numerical methods, accuracy and errors on calculations - round-off error, evaluation of formulae, iteration for Solving  $x = g(x)$ , initial approximation and convergence criteria, Newton-Raphson Method. Taylor series, approximating the derivation, numeric differentiation formulas, introduction to numerical quadrature, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Boole rule, Weddle rule, initial value problems, Picard's method, Taylor's method, Euler's method, the modified Euler's method, Runge-Kutta method, Monte Carlo: Random variables, discrete random variables, continuous random variables, probability density function, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, law of large number, central limit theorem, random numbers and their generation, tests for randomness, inversion random sampling technique including worked examples, integration of simple 1-D integrals including worked examples.

**BOOKS FOR STUDY AND REFERENCE:**

1. Pipes L.A. & L.R. Harvil, Applied Mathematics for Engineers and Physicists (3<sup>rd</sup> Edition), Mc Graw-Hill Book Co., New York, 1970.
2. Mary.L.Boas, Mathematical methods in the Physical Sciences (2nd edition), John Wiley & Sons., New York, 1983.
3. E. Butkov, Mathematical Physics, Addison Wesley, New York, 1973.
4. E. Walpole, R.M. Myers, S.L. Myers, K. Ye, "Probability & Statistics for Engineers and Scientists (9<sup>th</sup> edition)", Pearson Education, 2012.
5. SathyaPrakash, Mathematical Physics, Sultan Chand & Co., New Delhi, 2004.
6. M.K. Venkatraman, Advanced Mathematics for Engineers & Scientists, National Publishing co., Madras, 1994.
7. G. Arfken and H.H. Weber, Mathematical Methods for Physicists (4th edition), Prism Books, Bangalore, 1995.

**PHY 102: Solid State Physics-I****(60 hours, 4 credits)****UNIT I: CRYSTAL STRUCTURE and BONDING****(15 h)**

Crystalline and amorphous solids, translational symmetry. Elementary ideas about crystal structure, lattice and basis, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, fcc. and bcc, lattices, Laue and Bragg equations. determination of crystal structure with X-rays.

Different types of bonding- ionic, covalent, metallic, van-der Waals and hydrogen. band theory of solids, periodic potential and Bloch theorem, energy band structure.

## **UNIT II: BAND STRUCTURE, DIELECTRIC AND MAGNETIC PROPERTIES OF SOLIDS (20 h)**

Band structure in conductors, direct and indirect semiconductors and insulators (qualitative discussions); free electron theory of metals, effective mass, drift current, mobility and conductivity, Wiedemann-Franz law. Hall effect in metals: Phenomenology and implication. Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization, molecular field in a dielectric; Clausius-Mosotti relation, dia, para and ferro-magnetic properties of solids, Langevin's theory of diamagnetism and paramagnetism, quantum theory of paramagnetism, Curie's law, ferromagnetism: spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis.

## **UNIT III: LATTICE VIBRATIONS (15 h)**

Elastic and atomic force constants; dynamics of a chain of similar atoms and chain of two types of atoms; optical and acoustic modes; interaction of light with ionic crystals. Einstein's and Debye's theories of specific heats of solids.

Lattice vacancies, diffusion, colour centres: F centres, other centres in alkali halides.

## **UNIT IV: SUPERCONDUCTIVITY (10 h)**

Introduction (Kamerlingh - Onnes experiment), effect of magnetic field, type-I and type-II superconductors, Isotope effect, Meissner effect, BCS pairing mechanisms, Ideas about High-T<sub>c</sub> superconductors

### **BOOKS FOR STUDY AND REFERENCE:**

1. C. Kittel, Introduction to Solid State Physics (8th edition), John Wiley and Sons, New York, 2004.
2. M. A. Omar, Elementary Solid State Physics: Principles and Applications, Addison- Wesley Publishing Company, Inc, USA, 1975.
3. J. Dekker, Solid State Physics, Macmillan India, 2000
4. S. O. Pillai, Solid State Physics, New Age International, India, 2006.
5. J. P. Srivastava, Elements of Solid State Physics, Prentice Hall India Pvt., Limited, India, 2004.
6. R.J. Elliot and A.F. Gibson, An Introduction to Solid State Physics and Applications, McMillan, London, 1928.
7. D.W. Snoke, Solid State Physics: Essential Concepts, Person Education, 2009.

**PHY 103: SEMICONDUCTOR DEVICES****(60 hours, 4 credits)****UNIT I: Basics of SEMICONDUCTOR DEVICES****(15 h)**

Characteristic curves and physics of p-n junction; Schottky, tunnel and MOS diodes; bipolar junction transistors (BJT), junction field effect transistor (JFET), metal oxide semiconductor field effect transistor (MOSFET), uni-junction transistor (UJT) and silicon-controlled rectifier (SCR), optoelectronic devices (photo-diode, solar cell, LED, LCD and photo transistors) diffusion of impurities in Si, growth of oxide.

Op-amp: introduction, input modes and op-amps with negative feedback, open-loop response - mathematical operations, analog simulation, OTAs, CFOAs, active filters,

**UNIT II: ANALOG DEVICES****(15 h)**

Oscillators- principles, types, frequency stability, response, the phase shift oscillator, Wein bridge oscillator, oscillator with RC feedback circuits (RC and LC) , relaxation oscillators, linear and nonlinear oscillators, 555 timer as an oscillator, IC voltage regulators, evolution of ICs, CCDs, multi-vibrators, classification, selection of a transducer, strain gauge, displacement transducer (capacitive, inductive, differential transformer, photo electric and piezoelectric transducers), strain flow measurements, thermistor and thermo couple based thermometers for measuring temperature.

**UNIT III: DIGITAL DEVICES****(15 h)**

Introductory digital concepts, overview of logic functions, fixed function integrated circuits, programmable logic devices, digital integrated circuits, NAND and NOR gates building block, X-OR gate, simple combinational circuits, half and full address, functions of combinational logic, flip flops and related devices, counters, shift registers, memory and storage (ROM, RAM and EPROM), microprocessor and microcontroller basics (Intel 8085).

**UNIT IV: EL NUCLEAR DEVICES****(15 h)**

Preamplifier, AC-DC converter, Pulse shaper, Isolator, High range gamma survey meter circuit, scintillation dose rate meter, scintillator photodiode X-ray detector, pocket monitor, general purpose contamination monitor, discriminator single channel analyzer, linear gate, time to amplitude converter.

**BOOKS FOR STUDY AND REFERENCE:**

1. S. M. Sze, K.K. Ng, Physics of semiconductor devices (3rd edition), Wiley-Interscience, New York, 1969.
2. P. Horowitz and W. Hill, "The art of electronics", (2nd edition), Cambridge university press, Cambridge, 1995.
3. A.P. Malvino, "Electronic principles", (6th edition), Tata McGraw Hill Publ. Co. Ltd., New Delhi, 1999.



4. T.L. Floyd, Electronic devices', (6th edition), Pearson Education Inc., New Delhi, 2003
5. R.F. Coughlin and F.F. Driscoll, 'Operational amplifiers and linear integrated circuits', (6<sup>th</sup> edition), Pearson Education Inc., New Delhi, 2001.
6. M. Lakshmanan and K. Murali, Chaos, 'Chaos in nonlinear Oscillators', World Scientific, Singapore, 1996.
7. T. L. Floyd, Digital Fundamentals, (8<sup>th</sup> edition), pearson education Inc., New Delhi, 2003.
8. S. Brown and Z. Vranesic, 'Fundamentals of digital logic with Verilog design', Tata McGraw Hill Publ Co. Ltd., New Delhi, 2003.
9. H. Skalsi, "Electronic instrumentation (2<sup>nd</sup> edition), Tata McGraw Hill Publ. Co. Ltd., New Delhi, 2004.

**PHY 104 Classical and Quantum Mechanics-I (60 hours, 4 credits)**

**UNIT I: Variational principle, Hamiltonian and Canonical transformations (15 h)**

Hamilton's principle, Hamiltonian, generalized momentum, constant of motion, Hamilton's canonical equations of motion, deduction of canonical equations from Variational principle, principle of least action, proof of principle of least action, Applications of Hamilton's equations of motion, examples of Hamilton equation of motion, generating functions, illustrations of canonical transformations, condition for transformation to be canonical

**UNIT II: Special Relativity in classical Mechanics (15 h)**

Special theory of relativity, Lorentz transformation and its consequences, Lorentz Tensor, Elastic Scattering, Mass energy relation, Lagrangian formulation for relativistic mechanics, Particle accelerating under constant force, Hamiltonian formulations, Particle in Electro-magnetic field

**UNIT III: Formalism of Quantum Mechanics (15 h)**

Need for Quantum mechanics, Wave particle duality, relation between group velocity and phase velocity, Heisenberg's Uncertainty principle, Schrödinger time dependent and time independent wave equations, Application of Schrödinger time independent wave equation to particle in one dimensional rigid box, Step potential, reflection and transmission coefficients, Solution of radial Schrödinger equation to obtain energy values, Scanning tunnelling microscope, problems

**Unit IV: Quantum dynamics and Theory of Radiation (15 h)**

Rotations and angular momentum commutation relations, spin  $\frac{1}{2}$  system and finite rotations, SO(3), SU(2) and Euler rotations, eigenvalues and eigenstates of angular momentum, orbital angular momentum, addition of angular momentum, Semiclassical theory of radiation, transition probability for absorption and induced emission, electric dipole and forbidden transitions, selection rules.

**BOOKS FOR STUDY AND REFERENCE:**

1. H. Goldstein, C. Poole, J. Safko, Classical Mechanics (3<sup>rd</sup> edition), Addison Wesley, Cambridge, 1980.
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1991.
3. R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill Education, New Delhi, 1999.
4. S. L. Gupta, V. Kumar and R. C. Sharma, Classical Mechanics, Pragati Prakashan Meerut, 2000 .
5. Ghatak, S. Lokanathan, Quantum Mechanics: Theory and Applications, Kluwer Academic Publishers, London, 2004.
6. J. J. Sakurai, Modern Quantum Mechanics, Addison Wesley Publication Company Inc.USA, 1933.
7. L. I. Schiff, Quantum Mechanics, Tata McGraw Hill Education, New Delhi, 1949.
8. M. Mathews, K. Venkatesan, Quantum Mechanics, Tata McGraw Hill Education, New Delhi, 1978.

## Semester –II

### PHY 201: Electrodynamics

(60 hours, 4 credits)

#### UNIT I: MAXWELL'S EQUATIONS AND E.M. WAVES

(15 h)

Review of four-vector and Lorentz transformation in four-dimensional space, electromagnetic field tensor in four dimensions and Maxwell's equations: microscopic and macroscopic forms (revision), conservation of the bound charge and current densities, E.M. wave equations in waveguide of the arbitrary cross section: TE and TM modes; Rectangular and circular waveguides, hybrid modes, concept of LP modes.

#### UNIT II: TIME –DEPENDENT POTENTIALS AND FIELDS

(15 h)

Scalar and vector potentials: coupled differential equations, Gauge transformations: Lorentz and Coulomb Gauges, Retarded Potentials, Lienard –Weichert Potentials, Fields due to a charge in the arbitrary motion.

#### UNIT III: RADIATION FROM ACCELERATED CHARGES AND RADIATION REACTION

(15 h)

Fields of charge in uniform motion, applications to linear and circular motions: cyclotron and synchrotron radiations, Power radiated by point charge: Larmor's formula, angular distribution of radiated power, Cerenkov radiation and Bremsstrahlung (qualitative treatments), radiation reaction: criteria for validity, Abraham–Lorentz formula, physical basis of radiation reaction, self force.

#### UNIT IV: FORMULATION OF COVARIANT ELECTRODYNAMICS

(15 h)

Contravariant and co-variant four-vectors and their products, tensors of rank two and their differentiation, co-variant form of Maxwell's equations: four-potential and four current, E.M. field tensor: its curl and divergence.

#### BOOKS FOR STUDY AND REFERENCE:

1. D.J. Griffiths, Introduction to Electrodynamics (3rd edition), Prentice Hall, New Jersey, 1999.
2. J.R. Reitz, F.J. Milford & R.W. Christy, Foundation of E.M. Theory (3rd edition), Addison Wesley, New Jersey, 1979.
3. J.D. Jackson, Classical Electrodynamics (3rd edition), Wiley Eastern, New York, 1975.
4. S.P. Puri, Classical Electrodynamics, Tata McGraw Hill Education, New Delhi, 1990.

**PHY 202: Nuclear Physics****(60 hours, 4 credits)****UNIT I: BULK PROPERTIES OF NUCLEI****(15 h)**

Nuclear mass, charge, size, binding energy, spin and magnetic moment, Isobars, isotopes and isotones; mass spectrometer (Bainbridge), Spin and parity.

Nature of forces between nucleons, nuclear stability and nuclear binding.

**UNIT II: NUCLEAR STRUCTURE AND UNSTABLE NUCLEI****(15 h)**

The liquid drop model (descriptive) and the Bethe-Weizsacker mass formula, application to stability considerations, extreme single particle shell model (qualitative discussion with emphasis on phenomenology with examples).

(a) Alpha decay : alpha particle spectra – velocity and energy of alpha particles. Geiger- Nuttal law. (b) Beta decay : nature of beta ray spectra, the neutrino, energy levels and decay schemes, positron emission and electron capture, selection rules, beta absorption and range of beta particles, Kurie plot. (c) Gamma decay : gamma ray spectra and nuclear energy levels, isomeric states. Gamma absorption in matter – photoelectric process, Compton scattering, pair production (qualitative).

**UNIT III: NUCLEAR REACTIONS****(15 h)**

Conservation principles in nuclear reactions. Q-values and thresholds, nuclear reaction cross-sections, examples of different types of reactions and their characteristics. Bohr's postulate of compound nuclear reaction, Ghoshal's experiment.

Discovery and characteristics, explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements. Chain reaction and basic principle of nuclear reactors. Nuclear fusion: energetics in terms of liquid drop model.

**UNIT IV: ELEMENTARY PARTICLES****(15 h)**

(a) Four basic interactions in nature and their relative strengths, examples of different types of interactions. Quantum numbers – mass, charge, spin, isotopic spin, intrinsic parity, hypercharge. Charge conjugation. Conservation laws. (b) Classifications of elementary particles – hadrons and leptons, baryons and mesons, elementary ideas about quark structure of hadrons – octet and decuplet families.

### BOOKS FOR STUDY AND REFERENCE:

1. W.N. Cottingham and D. A. Greenwood, An Introduction to Nuclear Physics, Cambridge University Press, 1986.
2. B. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill Education, New Delhi, 1971.
3. S. N. Ghoshal, Atomic and Nuclear Physics, S. Chand, New Delhi, 1997.
4. S. B. Patel, Nuclear Physics: An Introduction, New Age International, New Delhi, 1991.
5. E. Segre, Nuclei and Particles (2<sup>nd</sup> edition), W.A. Benjamin Inc., 1977.
6. J.S. Lilley, Nuclear Physics: Principles and applications (1<sup>st</sup> edition), John Wiley and Sons (Asia) Pvt. Ltd., 2001.
7. J. Basdevant, J. Rich and M. Spiro, Fundamentals in Nuclear Physics: from Nuclear Structure to Cosmology, Springer-Verlag New York, 2005.
8. Seiden, Particle Physics: A Comprehensive Introduction, Persian Education, 2004.

### PHY203: Radiation Physics

(60 hours, 4 credits)

#### UNIT I: RADIOACTIVITY

(15 h)

Radioactivity, general properties of alpha, beta and gamma rays, laws of radioactivity, laws of successive transformations, natural radioactive series, radioactive equilibrium, alpha ray spectra, beta ray spectra, theory of beta decay, gamma emission, electron capture, internal conversion, nuclear isomerism, artificial radioactivity, nuclear cross sections, elementary ideas of fission and reactors, fusion.

#### UNIT II: PARTICLE ACCELERATORS

(15 h)

Particle accelerators for industrial, medical and research applications: the resonant transformer, Cascade generator, Van De Graff Generator, Pelletron, Cyclotron, Betatron, Synchro-Cyclotron linear accelerator, Klystron and magnetron, travelling and standing wave acceleration, Microtron, electron synchrotron, proton synchrotron, details of accelerator facilities in India.

#### UNIT III: X-RAY GENERATORS

(15 h)

Discovery, production, properties of X-rays, characteristics and continuous spectra, design of hot cathode X-ray tube, basic requirements of medical diagnostic, therapeutic and industrial radiographic tubes, rotating anode tubes, hooded anode tubes, industrial X-ray tubes, X-ray tubes for crystallography, rating of tubes, safety devices in X-ray tubes, ray proof and shockproof tubes, insulation and cooling of X-ray tubes, mobile and dental units, faults in X-ray tubes, limitations on loading, electric accessories for X-ray tubes, filament and high voltage transformers, high voltage circuits, half-wave and full-wave rectifiers, condenser discharge apparatus, three phase apparatus, voltage doubling circuits, current and voltage stabilizers, automatic exposure control, automatic brightness control, measuring instruments:

Measurement of kV and mA, timers, control panels, complete X-ray circuit, image intensifiers and closed circuit TV systems, modern trends.

#### **UNIT IV: INTERACTION OF RADIATION WITH MATTER**

**(15 h)**

Interaction of electromagnetic radiation with matter, exponential attenuation, Thomson scattering, photoelectric and Compton process and energy absorption, pair production, attenuation and mass energy absorption coefficients, relative importance of various processes. interaction of charged particles with matter, classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, dependence of collision energy losses on the physical and chemical state of the absorber, Cerenkov radiation, electron absorption process, scattering excitation and ionization, radiative collision, Bremsstrahlung: range energy relation, continuous slowing down approximation (CSDA), straight ahead approximation and detour factors, transmission and depth dependence methods for determination of particle penetration, empirical relations between range and energy, back scattering, passage of heavy charged particles through matter, energy loss by collision, range energy relation, Bragg curve, specific ionization, stopping power, Bethe Bloch Formula, interaction of neutrons with matter, scattering, capture, neutron induced nuclear reactions.

#### **BOOKS FOR STUDY AND REFERENCE:**

1. E.B. Podgorsak, Radiation Oncology Physics, IAEA Publication, Austria, 2005.
2. F. M. Khan, The Physics of Radiation Therapy (3<sup>rd</sup> edition), LIPPINCOTT WILLIAMS & WILKINS, USA, 2003.
3. H. E. Jones, J. R. Cunnighum, Physics of Radiology (4<sup>th</sup> edition), Charles C Thomas, USA, 1983.
4. W. J. Meredith & J. B. Massey, Fundamental Physics of Radiology (3<sup>rd</sup> edition), John Wright & Sons Ltd. 1977 .
5. W. R. Handee, Medical Radiation Physics, Year Book Medical Publishers Inc., London, 2003

#### **PHY 204: Statistical Mechanics**

**(60 hours, 4 credits)**

##### **Unit I: Statistical Mechanics and Thermodynamics:**

**(15 h)**

Basic concepts – Phase space, ensemble, a priori probability, Liouville's theorem (Revision). Fluctuations of physical quantities, Statistical Equilibrium, Thermodynamics – Thermodynamic Laws and Functions – Entropy, Free energy, Internal Energy, Enthalpy (definitions), Contact between statistics and thermodynamics – Entropy in terms of microstates, change in entropy with volume and temperature.

**Unit II: Statistical Ensembles Theory: (15 h)**

Micro canonical Ensemble– Micro canonical distribution, Entropy and specific heat of a perfect gas, Entropy and probability distribution.

Canonical Ensemble– Canonical Distribution, partition function, Calculation of free energy of an ideal gas, Thermodynamic Functions, Energy fluctuations.

Grand Canonical Ensemble– Grand Canonical distribution, Thermodynamic Functions, Number and Energy fluctuations.

**Unit III: Formulation of Quantum Statistics: (15 h)**

Distinction between MB, BE and FD distributions, Quantum distribution functions – Boson and Fermion gas and their Boltzmann limit, Partition function. Ideal Bose gas, Bose Einstein Condensation, Phonon gas, Liquid He4: Second Sound. Ideal Fermi gas: Weakly and strongly degenerate, Electron gas: Free electron theory of metals, Pauli paramagnetism.

**Unit IV: Phase Transitions and Critical Phenomenon: (15 h)**

The Phenomenology of Phase Transitions, Phase Transitions, Phase Diagrams, The general structure of phase diagrams Conditions for phase equilibrium, Landau-Ginsberg theory and mean field theory,

First order Phase Transition: Clausius - Clayperon equation, Second order phase transition, The critical indices, Calculation of the Critical Index, Scaling theory

**Text and Reference books:**

1. Statistical Mechanics Theory and Applications, S K Sinha, Tata McGraw-Hill, (1990).
2. Introduction to Statistical mechanics, B B Laud, Macmillan, N Delhi, (1981).
3. Statistical Mechanics by R K Pathria, Pergamon press (1972).
4. Statistical and thermal Physics F Reif, McGraw-Hill (1965).
5. Statistical Physics, L D Landau and E M Lifshitz, Pergamon press (1958).



## Semester –III

### PHY 301: Classical and Quantum Mechanics- II

(60 hours, 4 credits)

#### Unit 1: Variational Methods; Perturbation theory for time evolution problem (15)

Variational methods, Time-dependent potentials: the Interaction picture, Time dependent Perturbation theory, Applications to Interactions with classical radiation field

#### Unit 2: Scattering Theory (15)

The Lippmann-Schwinger Equation, the Born Approximation, Optical Theorem, Method of Partial Waves, Low-Energy Scattering and Bound States, Resonance Scattering, Scattering by Hard sphere, Coulomb Scattering,

#### Unit 3: Theory of Spin Angular Momentum (15)

Eigen values and eigen functions of  $L^2$  and  $L_z$  operators, ladder operators  $L_+$  and  $L_-$ , Pauli theory of spins (Pauli's matrices), matrix representation of  $J$  in  $|j m\rangle$  basis. Addition of angular momenta, Computation of Clebsch-Gordon coefficients in simple cases ( $J_1=1/2$ ,  $J_2=1/2$ ) Identical particles; Symmetric and antisymmetric wave functions; Collision of identical particles; Spin angular momentum; Spin functions for a many-electron system.

#### Unit 4: Theory of Radiation (15)

Semi classical theory of radiation; Transition probability for absorption and induced emission; Electric dipole and forbidden transitions; Selection rules.

#### Text and Reference Books

1. Goldstein, C. Poole, J. Safko, Classical Mechanics (3<sup>rd</sup> edition), Addison Wesley, Cambridge, 1980.
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1991.
3. R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill Education, New Delhi, 1999.
4. S. L. Gupta, V. Kumar and R. C. Sharma, Classical Mechanics, Pragati Prakashan Meerut, 2000
5. Ghatak, S. Lokanathan, Quantum Mechanics: Theory and Applications, Kluwer Academic Publishers, London, 2004.
6. J. J. Sakurai, Modern Quantum Mechanics, Addison Wesley Publication Company Inc.USA, 1933.
7. L. I. Schiff, Quantum Mechanics, Tata McGraw Hill Education, New Delhi, 1949.
8. M. Mathews, K. Venkatesan, Quantum Mechanics, Tata McGraw Hill Education, New Delhi, 1978.

**PHY302: Experimental Techniques****(60 hours, 4 credits)****UNIT I: VACUUM TECHNIQUES****(15 h)**

Production of low pressures: rotary, diffusion, and sputter ion pumps; measurement of low pressure: McLeod, Pirani, thermocouple & Penning gauges; leak detection: simple methods of LD, palladium barrier and halogen leak detectors.

**UNIT II: LOW TEMPERATURE AND MICROSCOPY TECHNIQUES****(15 h)**

Production of low temperatures: adiabatic cooling, the Joule-Kelvin expansion, adiabatic demagnetization, 3 He cryostat, the dilution refrigerator, principle of Pomeranchuk cooling, principle of nuclear demagnetization; measurement of low temperatures, Optical microscopy, scanning electron microscopy, electron microprobe analysis, low energy electron diffraction.

**UNIT III: ATOMIC ABSORPTION SPECTROMETRY AND X- RAY DIFFRACTION****(15 h)**

Fundamentals: principle, basic equipment, operation, monochromator action, modulation; apparatus: double beam instrument, radiation sources, aspiration and atomization; interferences, control of AAS parameters, reciprocal sensitivity and detection limit; techniques of measurement routine procedure, matrix matching method, and method of additions.

X-ray diffractometer (XRD)- principle and working, types of XRD, Powder XRD, single Crystal XRD, Small angle X-ray scattering, High and low temperature XRD, analysis of crystal structure from XRD graph, evaluation various parameter from XRD graph such as lattice parameter, Miller indices, density, crystallite size.

**UNIT IV: X-RAY FLUORESCENCE SPECTROMETRY AND MÖSSBAUER SPECTROSCOPY (15 h)**

Introduction to wavelength-dispersive X-ray fluorescence spectrometry (WDXRF) and energy-dispersive X-ray fluorescence spectrometry (EDXRF), dispersive systems, detectors, instruments, matrix effects, XRF with synchrotron radiation. Elementary theory of recoil free emission and resonant absorption of gamma rays, Mössbauer experiment, hyperfine interactions: chemical isomer shift, magnetic dipole hf splitting, and electric quadrupole hf splitting; line broadening.

**BOOKS FOR STUDY AND REFERENCE:**

1. J.Yarwood, High vacuum techniques, Chapman & Hall, 1967.
2. A.Roth, Vacuum technology, North-Holland Publishing Company, Amsterdam, 1982.
3. G.K.White, Experimental techniques in low temperature physics, Oxford, 1968.
4. L.C. Jackson, Low temperature physics, Methuen & Co. Ltd., 1962
5. O.V.Lounasmaa, Experimental principles & methods below 1K, Academic press, New York, 1974
6. D.K.Bowen , C.R.Hall, Microscopy of materials, the MacMillan press Ltd., London,1975.

**Paper XI: PHY 303: Solid State Physics-II****(60 hours, 4 credits)****Unit 1 : The Drude Theory of metals**

Basic assumptions of Model, Collision or relaxation times, DC electrical conductivity, Failures of the free electron model, the tight-binding method Linear combinations of atomic orbitals, Application to bands from s-Levels, General features of Tight-binding levels, Wannier functions. Other methods for calculating band structure independent electron approximation, general features of valence band wave functions, Cellular method, Muffin-Tin potentials, Augmented plane wave (APW) method, Pseudopotentials

**Unit 2: Transport Properties of Metals**

Drift velocity and relaxation time, The Boltzmann transport relation, The Sommerfeld theory of metals of electrical conductivity, The mean free path in metals, Thermal scattering, The electrical conductivity at low temperature, The thermal conductivity of metals, Dielectric Properties of insulators Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossotti relation, Long- wavelength optical modes in Ionic crystals.

**Unit 3: Phonons, Plasmons, Polaritons, and Polarons**

Vibrations of monatomic lattices: first Brillouin zone, group velocity, Long wavelength limit, Lattice with two atoms per primitive cell. Quantization of lattice vibrations, Phonon momentum Dielectric function of the electron gas, Plasma optics, Dispersion relation for Electromagnetic waves, Transverse optical modes in a plasma, Longitudinal Plasma oscillations, Plasmons, Polaritons, LST relations, Electron- electron interaction, Electron- phonon interaction: Polarons,

**Unit 4: Point defects and Luminescence**

Lattice vacancies, diffusion, colour centres: F centres, other centres in alkali halides. Types of luminescence, The Frank–Condon principle, mechanism of Photoluminescence, Thermoluminescence, Electroluminescence, chemo luminescence, triboluminescence, applications of luminescence in different fields

**Reference Books :**

1. Solid State Physics by N W Ashcroft and N D Mermin, HRW, International editions (1996) ( Units 1 and 2)
2. Introduction to Solid State Physics by C Kittel (4th edition ) John Wiley Publication (1979) ( Units 3 and 4)
3. Solid State Physics by A J Dekker Macmillan India Ltd, (1986)

**PHY 304 Elective I- Physics of Semiconductor****(60 hours, 4 credits)****Unit I Energy bands and charge carriers in semiconductors****(15 h)**

Bonding forces and energy bands, direct and indirect band gap semiconductors, variation of energy bands with alloy composition, effective mass, electrons and holes in quantum wells, the Fermi level, electron and hole concentrations at equilibrium, temperature dependence of carrier concentrations, electrical conductivity and mobility, high field effects.

**Unit II Excess carriers in semiconductors****(15 h)**

Optical absorption, direct recombination of electrons and holes, indirect recombination, trapping, steady state carrier generation, quasi Fermi levels, diffusion process of carriers, diffusion and drift of carriers, diffusion and recombination: the continuity equation, steady state carrier injection, diffusion length, the Haynes-Shockley experiment.

**Unit III Dynamics of charge carriers and lattice, and Semiconductor Interfaces****(15 h)**

Electrons in a periodic potential, group velocity of electrons, inverse effective mass tensor, force equation, dynamics of electrons and holes, effective mass theory of impurities, the vibrational specific heat, thermal expansion, thermal conductivity. Schottky barriers, rectifying contacts, ohmic contacts, surface and interface states and their effects on barrier height, acceptor and donor surface states, Fermi level pinning.

**Unit IV Semiconductor crystal growth process****(15 h)**

Nucleation and growth theory, atomic bonding, formation energy of clusters, supersaturation, supercooling and volume energy, stability of small nuclei, the formation energies of liquid nuclei and crystalline nuclei, nucleation rates, the growth of crystal surfaces, growth of bulk semiconductors by zone melting and zone refining, Czochralski and liquid encapsulation techniques, growth of epitaxial layers by LPE, VPE and MBE techniques.

**Reference Books**

1. Physics of Semiconductor Devices by Dilip K. Roy, Univ. Press (India) Pvt. Ltd., 1992.
2. Physics of Semiconductor Devices by S.M. Sze
3. Solid state electronic devices by B. G. Streetman.
4. Semiconductors by R. A. Smith, Cambridge Univ. Press.
5. Solid state electronics by Wang, Mc. Graw Hill.
6. Crystal Growth by B. R. Pamplin (ed.)
7. Growth of Single Crystal by R. A. Laudise.
8. Growth of crystals from solutions by J. C. Brices
9. Solid State and Semiconductor Physics by M.C. Kelvey.
10. Modern techniques in metallography – D.G. Brandon, Butterworths (1966).

**PHY 304 Elective II- Science and Properties of Nanomaterials**

(60 hours, 4 credits)

**Unit-I Scales In Nanophysics, Quantum Structure****(15 h)**

3D-Potential Wells (Spherical & Rectangular Parallelepiped), 2D (Circular & Square, Quantum Corrals), 1D (Quantum Wires), 0D (Quantum Dots). Barrier Penetration: Step Potential; Rectangular Barrier Penetration; Tunneling; WKB. Applications of Barrier Penetration: TEM, AFM, STM.

**Unit-II INTRODUCTION TO SOLID STATE PHENOMENA AT NANOSCALE****(15 h)**

Solid state phenomena - intro, phonons, heat capacity: thermal energy of a harmonic oscillator, specific heat capacity: Debye and Einstein models, anharmonicity and thermal expansion, heat conduction by phonons. Magnetism, dielectrics and super conductivity. Finite solids and nanostructures, Phonons in nanomaterials, surface plasmons in metal nanostructures, nanosized magnetic domains, magnetic tunnel junctions and magneto-resistance

**Unit-III: Classification and Nomenclature of Nanomaterials:****(15 h)**

Nanosized metals and alloys, semiconductors, ceramics – a comparison with respective bulk materials; Organic semiconductors, carbon materials; Zero-, one, two and three dimensional nanostructures – quantum dots, quantum wells, quantum rods, quantum wires, quantum rings; bulk nano structured, nano composites, Nano machines and Devices.

**Unit-IV Size and shape dependent properties of nanomaterials****(15 h)**

Optical, emission, electronic, transport, photonic, refractive index, dielectric, mechanical, magnetic, non-linear optical properties; Transition metal sols, origin of plasmon band, Mie theory, influence of various factors on the plasmon absorption. quantum confinement in semiconductors – particle in a box like model for quantum dots; origin of charge on colloidal sols, zeta potential, catalytic and photocatalytic properties, Mechanical properties

**References:**

1. P. Hofmann, Solid state Physics – An Introduction, Wiley VCH (2008).
2. David Pines, Elementary Excitations in Solids, CRC Press(1999)
3. Nanoscale Physics for Materials Science, By Takaaki Tsurumi, Hiroyuki Hirayama, Martin Vacha, Tomoyasu Taniyama, CRC Press, 2009
4. Leonid V. Azaroff, "Introduction to Solids", Second Edition, Tata McGraw- Hill Publishing Company Limited, 2006

**PHY 304 Elective III- Nanomaterial Synthesis**

(60 hours, 4 credits)

**Unit-I Synthesis Methods of Nanomaterials:****(15 h)**

Top down approach, solid state reaction, ball Milling; Bottom up approaches – Synthesis of zero dimensional metal, metal oxides, semiconductor nanoparticles by different routes – co-precipitation, Colloidal method, micro-emulsion, Sol-gel, combustion etc

**Unit II Kinetically Confined Synthesis of Nanoparticles****(15 h)**

Nucleation and Growth of nanomaterials, Factors affecting the growth of nanoparticles, various theories of formation of nanoparticles: LaMer theory, Ostwald Ripening etc. Aerosol synthesis, Micellar growth, Spray pyrolysis, Template-based synthesis; Electrospinning

**Unit-III Synthesis of two dimensional nanosystems****(15 h)**

Fundamentals of Film Growth; Vapor phase deposition methods - Physical and chemical methods; Superlattices; Self Assembly; LangmuirBlodgett Films; Electrochemical Deposition; Core/shell structures, Carbon-based Nanomaterials, Micro and Mesoporous Materials, Organic-Inorganic Hybrids

**Unit IV: Synthesis of 3D nano structured materials****(15 h)**

Synthesis of 3D nano structured materials using high-energy mechanical attrition by devitrification of an amorphous precursor, etc. Introduction to nanolithography and self-assembly routes. Preparation of quantum dots, nano wires and films, preparation of single-walled and multi-walled nanotubes. Brute force methods vs. soft Chemistry routes, Microwave and ultrasound assisted synthesis, CFC(controlled flow cavitations), SCF's(super critical fluids). Surfactant behavior, micelles, self assembled mono layers (SAM's),Langmuir-Blodgett(LB)films

**Reference:**

1. Nanomaterials Chemistry by Rao C. N., A. Muller, A. K. Cheetham,, WileyVCH , 2007.
2. Nanomaterials and Nanochemistry by Brechignac C., P. Houdy, M. Lahmani, Springer publication, 2007.
3. Nanoscale materials in chemistry by Kenneth J. Klabunde, Wiley Interscience Publications,2001
4. Nanochemistry by Sergeev G.B., Elsevier publication,2006.
5. Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao, Imperial College Press, 2004.
6. Nanomaterials – Handbook by Yuri Gogotsi, CRC Press, Taylor & Francis group, 2006.

## Semester –IV

### PHY 401: Atomic and Molecular Physics

(60 hours, 4 credits)

#### UNIT I: THE ATOM MODEL FOR TWO VALENCE ELECTRONS

(15 h)

Coupling Schemes: l-l coupling, s-s coupling, LS or Russell, Saunder's coupling, the Pauli exclusion principle, Coupling schemes for two electrons, Tau-factors for LS coupling, Lande interval rule, jj-coupling, branching rules, selection rules.

#### UNIT II: ZEEMAN EFFECT, PASCHEN-BACK EFFECT AND STARK EFFECT

(15 h)

The magnetic moment of the atom, Zeeman effect for two-electrons, intensity rules for Zeeman effect, Paschen-Back effect for two electrons, Stark effect of hydrogen, weak field Stark effect in hydrogen, strong field Stark effect in hydrogen, origin of hyperfine structure.

#### UNIT III: MICROWAVE SPECTROSCOPY

(15 h)

Classification of molecules: linear, symmetric tops, spherical tops, asymmetric tops; rotational spectra: the rigid diatomic molecule, the non-rigid rotator, spectrum of a nonrigid rotator, chemical analysis by microwave spectroscopy, techniques and instrumentation of microwave spectroscopy.

#### UNIT IV: INFRA-RED SPECTROSCOPY

(15 h)

The energy of a diatomic molecule, the simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating-rotator, analysis by infra-red spectroscopy, techniques and instrumentation of infra-red spectroscopy

#### BOOKS FOR STUDY AND REFERENCE:

1. H.E. White, Introduction to Atomic Spectra, Tata McGraw Hill Education, New Delhi, 1934.
2. C.N. Banwell, Fundamentals of Molecular Spectroscopy (3<sup>rd</sup> edition), Tata MacGraw Hill Education, New Delhi, 1983.
3. G. Herzberg, Spectra of Diatomic Molecules, Vol. I, N.J.D. van Nostrand, 1950.
4. B.P. Straughan and S. Walker, Spectroscopy, Vol. I, II and III, Chapman and Hall, 1976.
5. G.M. Barrow, Introduction to Molecular Spectroscopy, Tata MacGraw Hill Education, 1962.
6. J.M. Brown, Molecular Spectroscopy, Oxford University Press, 1998.



**PHY 402: Properties of materials****(60 hours, 4 credits)****Unit I Point defects**

Classification of defects, fundamental properties of point defects, lattice distortion, migration energy, point defects in thermal equilibrium, point defects in ionic crystals, equilibrium concentration of Frenkel and Schottky defects, ionic conductivity, determination of physical quantities associated with point defects, point defects in non-thermal equilibrium

**Unit II Dislocations****(15 h)**

Strength of an ideal crystal, concept of dislocation, geometrical aspects of dislocations, movement of dislocations, dislocations in periodic crystal structures, interaction of dislocations with point defects, Cottrell atmosphere, imperfect or partial dislocations, stacking faults, Lomer Cottrell locks, Thomson tetrahedron, partial dislocations in other crystal structures, multiplication of dislocations, Jogs and their formation, motion of a vacancy jog, measurement of stacking fault energy, origin of dislocations.

**Unit III Techniques for observation of defects****(15 h)**

Techniques for observation of point defects and dislocations, electron microscopy, field ion microscopy, surface methods, x-ray topography, moiré technique such as destructive and non-destructive testing methods, liquid penetrant test, Magnetic particle test, thermography test, acoustic test, ultrasonic test, current test, radiographic test

**Unit IV Testing of materials**

Introduction to material testing, Classification of materials testing, Purpose of testing, selection of material, development of testing, Mechanical testing of materials, Hardness test(Vicker, Brinell, Rockwell), tensile testing, impact testing (Izod, Charpy)-Principles, techniques, methods, advantages and limitations, Bend Test, Shear Test, Creep and fatigue testing-principles, techniques, methods, advantages and limitations

**Reference Books :**

1. Physical metallurgy - R.W. Cahn, II Edition, North Holland, Amsterdam (1970)
2. Introduction to dislocations - D. Hull, ELBS (1971)
3. Dislocations and plastic flow in crystals - A.H. Cottrell, Oxford Univ. Press (1965)
4. Imperfections in crystals - Van Burren, North Holland (1960)
5. Theory of crystal dislocations - F.R.N. Nabarro, Clarendon Press (1968)
6. Dislocations in crystals - W.T. Read, McGraw Hill (1953)
7. Modern physical metallurgy - R.E. Smallman, Butterworths (1970)
8. Techniques of metal research - R.F. Bunshaw, Interscience (1968)
9. Experimental methods in materials research - Herbert Herman, Interscience (1967)
10. Modern techniques in metallography - D.G. Brandon, Butterworths (1966)
11. Introduction to properties of engineering materials - K.J. Pascoe, Blackie and Sons, London (1968).

**PHY 403: Thin Solid Films: Deposition and properties**

(60 hours, 4 credits)

**Unit 1: Physical methods: Vacuum evaporation and sputtering****(15)**

Vacuum system, experimental technique, Thermal evaporation methods: Resistive heating, Flash evaporation, Laser evaporation, Electron bombardment heating, Arc evaporation, Radio frequency heating, Sputtering process, Glow discharge DC sputtering, Triode sputtering, Getter Sputtering, Radio frequency sputtering, Magnetron sputtering, Ion beam sputtering.

**Unit 2: Chemical Methods****(15)**

**Chemical vapor deposition:** Common CVD reactions, Methods of film preparation, laser CVD, Photochemical CVD, Plasma enhanced CVD, Chemical bath deposition: ionic and solubility products, preparation of binary semiconductors, **Electrodeposition**,: Deposition mechanism and preparation of compound thin film **Spray pyrolysis** :Deposition mechanism and preparation of compound thin films.

**Unit 3: Nucleation, growth and structure of films****(15)**

Nucleation: Condensation process, Langmuir- Frenkel theory, other theories of condensation and experimental results. Growth: Liquid like coalescence, influence of deposition parameters, physical structure of films. Crystallographic structure of films: lattice constant, Size effect, Disordered and amorphous structures, Abnormal metastable crystalline structures, two-dimensional superstructures. Epitaxial growth of thin films: Influence of substrate and deposition conditions, theories of Epitaxy

**Unit 4: Properties of thin films****(15)**

Mechanical properties: Stresses in thin films, Mechanical constants of thin films, Electrical and magnetic properties: Electrical conduction in thin metallic discontinuous films, Electrical conduction in thin metallic films, Optical properties: Optical constants of thin films, experimental methods as Reflection, Interferometric, and Critical angle method.

**Reference books**

1. Thin Film Phenomena by K L Chopra McGraw -Hill Book Company, NY 1969
2. Thin Film Technology by O S Heavens (1970)
3. Properties of Thin Films by Joy George, Marcel and Decker, (1992) ( Units 1-3)
4. Physics of Thin Films L Eckertova, Plenum Press NY (1980) ( Unit 4)

**PHY 404: Elective- I- Heterostructures and Quntum devices****(60 hours, 4 credits)****Unit I Semiconductor abrupt junctions****(15)**

Equilibrium conditions, the contact potential, space charge at a semiconductor junction, qualitative description of current flow at a junction, minority and majority carrier currents, carrier injection, minority carrier distributions, variation of the quasi Fermi levels with the position, junction current from excess minority carriers, junction breakdown mechanisms, capacitance of p-n junctions.

**Unit II Semiconductor heterojunctions****(15)**

Types of heterojunctions, energy band diagrams of heterostructures, current-voltage and capacitance-voltage characteristics of anisotype heterojunctions, heterojunction bipolar transistors, electrical and optical characteristics of LEDs, laser gain semiconductor band system, high electron mobility transistor, hot electron heterojunction transistor.

**Unit III 2D electron gas and Quantum wells****(15)**

2D electron gas in Si and GaAs MOS structures, effect of applied bias on energy bands of the MOS capacitors, bias dependence of capacitance, free charge carrier transfer, triangular quantum wells (both finite and infinite), coupled quantum wells and super lattices, doubleheterostructure lasers, single quantum well lasers, multiple quantum well lasers. Optical absorption due to electronic transistions in quantum wells

**Unit IV Transport properties of heterostructures and quantum devices****(15)**

Effect of electric field parallel and perpendicular to the interfaces, effects of constant magnetic field, Landau levels, magneto conductivity in a 2D heterostructure. One-D and Zero-D quantum structures, density of states in 3D, 2D, 1D and 0D structures, 1D and 0D optical phenomena and optical devices, quantum confined stark effect, quantum well modulators, self-electro-optic effect devices, resonant tunneling devices, the coulomb blockade, single electron transistor

**Reference Books**

1. Semiconductor heterojunctions by B. L. Sharma and R. K. Purohit, Pergamon press.
2. Heterojunction and metal-semiconductor junctions by A. R. Milnes and D. L. Hench, Academic press.
3. Solar cells by H. J. Hovel.
4. Solid-state electronic devices by B. G. Streetman.
5. Luminescence and LED by E. W. Williams and R. Hall.
6. Semiconductor physics and applications by M. Balkanski, R. F. Wallis, Oxford Uni. Press.
7. Physics of semiconductor devices by D. K. Roy, Univ. Press, 2000.
8. Introduction to mesoscopic physics-second edi. by Yoseph Imry, Oxford Univ. Press, 2002.

**PHY 404: Elective- II- Characterization of Nanomaterials****(60 hours, 4 credits)****Unit-I Structural characterizations****(15 h)**

X-ray-based techniques, X-ray absorption spectroscopy (XAS) includes both extended X-ray absorption fine structure (EXAFS) and X-ray absorption near edge structure (XANES, also known as NEXAFS), X-ray photoelectron spectroscopy (XPS), Differential electrochemical mass spectroscopy (DEMS), quadrupole mass spectrometry (QMS), Nuclear magnetic resonance (NMR) spectroscopy, Low-energy ion scattering (LEIS), Dynamic light scattering (DLS), Secondary ion mass spectrometry (SIMS) and Time of flight secondary ion mass spectrometry (ToF-SIMS)

**Unit-II Advanced Microscopy techniques for NP characterization****(15 h)**

High-resolution TEM (HRTEM), Cryo-electron microscopy (cryo-TEM), selected area electron diffraction (SAED), scanning transmission electron microscopy (STEM), High-angle annular dark-field imaging (HAADF-STEM), Aberration-corrected electron microscopy, Electron energy loss spectroscopy (EELS)

Electron backscatter diffraction (EBSD), Magnetic force microscopy (MFM)

**Unit-III Characterization methods for magnetic nanostructures****(15 h)**

Superconducting quantum interference device magnetometry (SQUID), Vibrating sample magnetometry (VSM), Mössbauer spectroscopy, Ferromagnetic resonance (FMR), X-ray magnetic circular dichroism (XMCD), Magnetic susceptibility, Superparamagnetic relaxometry (SPMR),

**Unit-IV Characterization of thin films****(15 h)**

Limitations and Considerations in Thin Film Characterization Cyclic voltammetry (CV) and Linear sweep techniques (LSV), Potential Step: Chronoamperometry (CA), Electrochemical impedance spectroscopy,

**References:**

Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao, Imperial College Press, 2004.

Nanomaterials – Handbook by Yury Gogotsi, CRC Press, Taylor & Francis group, 2006.

**PHY 404: Elective- III- Applications of nanomaterials****(60 hours, 4 credits)****1. Unit-I- Nanomaterials in Energy Technology****(15 h)**

Introduction Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion-Materials for light emitting diodes, batteries, catalytic reactors, capacitors fuel cells, Nanomaterials in Energy Storage Nanomaterials for fuel cells, carbon material for energy storage, hydrogen storage in carbon nanotubes, use of nanoscale catalysts to save energy and increase the productivity in industry, Rechargeable batteries based on nanomaterials, Nano-electrochemical systems and novel microfluidic devices. Electrochemical Energy Storage Systems Batteries: Primary, Secondary, Lithium, solid-state and molten solvent batteries; Lead Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes.

**2. Unit-II-Nanodevices and sensors****(15 h)**

Carbon Nanotechnology: Introduction to carbon nanotubes and their applications in various industries, supercapacitors, hydrogen storage, photovoltaic applications, OLED displays, handling of CNTs. Precision Engineering in VLSI technology: Electron beam lithography (EBL), focused ion beam (FIB), reactive ion etching (RIE) and femtosecond pulsed laser ablation, Multilayers structures for device applications. Application of nanotechnology in food and Agriculture industry: fisheries and livestock sectors, toxicological effect of Nanoparticles. Nanotechnology for environmental safety: Pollution control, gas sensing, waste water treatment. Impact of nanotechnology on the environment: Health, safety and environmental risks/hazards; Social and ethical impacts

**3. Unit-III : Nanomaterials in Biomedical applications****(15 h)**

Introduction about drug delivery systems: Basics of drug delivery, Types polymer, lipid, metal based drug delivery system and miscellaneous. Drug targeting strategies for site specific drug delivery-passive and active targeting, time and rate controlled drug delivery. Polymer based drug nanocarriers: Classification and types of polymeric nanocarriers, Different methods of polymeric nanocarrier preparation: Precipitation, Emulsion diffusion/Solvent evaporation, Salting out etc. Various applications of polymeric nanocarriers: Theranostic, Imaging etc. Dendritic nanostructures for drug delivery: Introduction of different dendritic nanostructures, chemical structures, types of dendrimers, methods of preparation convergent and divergent, physicochemical properties of dendrimers, interaction between drug molecules and dendrimers, applications of dendrimers Nanocarriers for gene delivery: Challenges in gene delivery, basic concept, design of nanotechnology-based systems for gene delivery,

#### 4. Unit- IV Environmental nanotechnology (15 h)

I Introduction: Overview of physical, chemical and biological processes concerning the environment; types, transport and transformation processes of contaminants in air, water and soil; effects of contaminants on environment. Environmental impacts of nanomaterials - Exposure and risk assessment, Dose-response, mechanisms of toxicity; ecotoxicological impacts of nanomaterials, Environmental applications of nanomaterials: Mechanism for remediation of aqueous contaminants, photocatalyst; membranes incorporating nanomaterials, transport processes in membrane technology; nanomaterial based adsorbents for water and wastewater treatment – adsorption at metal oxide surfaces, hybrid adsorbents; case studies. Hierarchical self-assembled nano-structures and nanomaterials for adsorption of heavy metals.

#### References

1. Linden, Hand book of Batteries and fuel cells, Mc Graw Hill, (1984).
2. Hoogers, Fuel cell technology handbook. CRC Press, (2003).
3. Vielstich, Handbook of fuel cells: Fuel cell technology and applications, Wiley, CRC Press, (2003).
4. Applications of Nanoscience in Photomedicine, Eds:Michael R. Hamblin and Pinar Avci, 2015, Elsevier
5. Nanotechnology in Catalysis 3, Eds: Zhou, B., Han, S., Raja, R., Somorjai, G.A., 2007 Springer
6. Nanopharmaceutics-The Potential Application of Nanomaterials, Ed: Xing-Jie Liang, 2012, World Scientific
7. Understanding Nanomedicine: An Introductory Textbook by Rob Burgess. 2012 CRC Press
4. Nanomedicine for Drug Delivery and Therapeutics, Editor(s): Ajay Kumar Mishra, 2013, Wiley
8. Lead J., and Smith, E. "Environmental and Human Health Impacts of Nanotechnology" John Wiley & Sons. 2009
9. Skoog, D.A., Holler, F.J., and Crouch S.R. "Instrumental Analysis" Clenage Learning India Private Limited, New Delhi. 2007
10. Masters, G.M. and Ela, W.P. "Introduction to Environmental Engineering and Science" Prentice Hall. 2007

## **PRACTICAL LAB. COURSE 1 SEM-I**

### **(Lab-I : Group A)**

1. Write a C program to find the roots of quadratic equations.
2. C program for addition, subtraction and multiplication, division of two numbers.
3. Present your data by using MS-Office excel.
  - a. Pie chart
  - b. Polygon
  - c. Histogram
  - d. Scatter diagram
4. Present your data using Origin software.
  - a. Pie diagram
  - b. Scatter diagram
  - c. Polygon
  - d. Histogram
5. To verify Simpsons and trapezoidal rule.
6. Determination of crystal structure by X-ray diffraction (XRD) technique.
7. Simple measurement of the band gap in Silicon and Germanium.
8. To study the seven-crystal structure (Bravais lattices).
9. To determine the resistivity of semiconductors by Four probe Method.
10. Determination of the size of lycopodium particles using XRD pattern.
11. To determine crystal structure of the material of thin film from given XRD pattern
  - a. FCC
  - b. BCC
  - c. HCP

**SEM-I**  
**(Lab-I; Group-B)**

1. To study the stair case ramp generator.
2. To find the Ripple factor and regulation of a Full-wave Rectifier with and without filter.
3. To obtain the load regulation and ripple factor of a half- wave rectifier.
  - a. with Filter
  - b. without Filter
4. To study astable multivibrator with variable duty cycle using IC-555.
5. To construct a Zener diode voltage regulator and measure its line and load regulation.
6. To observe the characteristics of UJT and calculate the intrinsic stand off ratio ( $\eta$ ).
7. Laboratory Experiments Manual for 8085 Microprocessor
  - a. Write 8085 assembly language program for addition of two 8-bit numbers and sum is 8 bit.
  - b. Write 8085 assembly language program for addition of two 16-bit numbers and sum is 16 bit.
8. To verify De-Morgan's theorem using logic gates.
9. To verify the characteristic tables of D-type, R-S (Reset -Set) type T type and J-K type Flip-Flops.
10. To plot B-H curve in ferromagnetic material.
11. To study photoelectric effect and calculate Planck's constant using five different colored LEDs and photoelectric cell.
12. Measure the ratio of the electron charge-to-mass ( $e/m$ ) by studying the electron trajectories in a uniform magnetic field.



## PRACTICAL LAB COURSE 2 SEM II

### (Lab-II; Group-A)

1. Construction and study of mode properties of planer wave guides.
2. To study the phenomena of magnetic hysteresis and calculate the retentivity, coercivity and saturation magnetization of a material using a hysteresis loop tracer.
3. Measurement of inductance using impedance at different frequency.
4. To study the Hall effect and to find out Hall coefficient and determine carrier concentration.
5. To determine the absolute activity of an alpha source.
6. To determine the absolute activity of americium source using Radlab software.
7. To determine the Decay ratio of 230-Th alpha source.
8. To measure the Percentage Energy resolution of NaI (TL) detector for C-60 source and 137-Cs.
9. To study Gamma spectroscopy and linear attenuation coefficient of the (Al) using gammaradiation having energy (661.65 KeV).
10. To determine the thermal neutron flux distribution for Am-Be source and source strength for same source with BF<sub>3</sub> counter.

### (Lab-II; Group-B)

1. To study the operating plateau of the Geiger Muller tube.
2. To study natural radioactivity series and its application in medical field.
3. Study of absorption of alpha and beta rays.
4. Study of statistics in radioactive measurement.
5. Range of beta particles.
6. Study the voltage-current characteristics of GM Tube.
7. To study the absorption of beta radiation.
8. To study the absorption of gamma radiation.
9. Verification of inverse square law.

The candidate shall be awarded the degree of **Master of Science in Physics** after completing the course and meeting all the evaluation criteria.

#### A. Scheme of Examination and Passing

1. This course will have 20 % Term Work (TW)/ Internal Assessment (IA) and 80% external (University written examination of 3 h duration for each course paper and practical examination of 3 h duration for each practical). All external examinations will be held at the end of each semester and conducted by the University as per the existing norms.
2. For all the theory courses, term work/ Internal assessment- (IA) (20 marks) and University examination (80 marks) - shall have separate heads of passing (i.e. 8 Marks for passing in IA and 32 Marks for passing in University examination).
3. To pass, a student has to obtain minimum grade point E, separately in the IA and external examination. The candidate will be declared 'Fail' if total of IA and University exam marks are less than 40. The candidate has to re-appear for exam and clear the respective head for passing condition.
4. The University (external) examination for Theory and Practical shall be conducted at the end of each Semester.
5. The candidates shall appear for the external examination of 4 Theory courses each carrying 80 marks of 3 hours duration and 2 practical courses each carrying 100 marks at the end of each semester.
6. The candidate shall prepare and submit for the practical examination a certified journal based on the practical course carried out under the guidance of a faculty member with minimum number of experiments as specified in the syllabus for each group.
7. In order to appear for the theory and practical examination, 75% attendance in theory and 80% attendance in practical is mandatory.
8. The candidate shall prepare the dissertation based on the Research Project for the fulfillment of Master's Degree.

#### b. Standard of Passing for University Examinations:

As per ordinances and regulations prescribed by the University for semester-based credit and grading system.

#### c. Standard point scale for grading:

Grade	Out of 100 Marks ( including IA and University Exam)	Out of 80	Out of 20	Grade Points
O	70 & above			7
A	60-69.99			6
B	55-59.99			5
C	50-54.99			4
D	45-49.99			3
E	40-44.99			2
F(Fail)	39.99 & below			1

3

### Grade Point Average (GPA) calculation:

1. GPA is calculated at the end of each semester after grades have been processed and after any grade have been updated or changed. Individual assignments/quizzes/surprise tests/unit tests/tutorials/project/seminars etc. as prescribed by University are all based on the same criteria as given above. The teacher should convert his marking into the Quality-Points and Letter-Grade.
2. Performance of a student in a semester is indicated by a number called Semester Grade Point Average (SGPA). It is the weighted average of the grade points obtained in all the subjects registered by the students during the semester.
3. The Final remark will be decided on the basis of Cumulative Grade Point Average (CGPA) which is weighted average of the grade point obtained in all the semesters registered by the 1 earner.

$CGPA = \frac{\sum_{j=1} C_j p_j}{\sum_{j=1} C_j}$	<p><math>C_j</math> = The number of credits earned in the <math>j^{th}</math> course upto the semester for which the CGPA is calculated</p> <p><math>p_j</math> = Grade point earned in the <math>j^{th}</math> course*</p> <p><math>j = 1, 2, \dots, n</math> represents number of courses for which the student is registered upto the semester for which the CGPA is calculated.</p> <p>* : A letter Grade lower than E in a subject shall not be taken into consideration for the calculation of CGPA</p> <p>The CGPA is rounded upto the two decimal places.</p>
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$SGPA = \frac{\sum_{i=1} C_i p_i}{\sum_{i=1} C_i}$	<p><math>C_i</math> = The number of credits earned in the <math>i^{th}</math> course of a semester.</p> <p><math>p_i</math> = Grade point earned in the <math>i^{th}</math> course</p> <p><math>i = 1, 2, \dots, n</math> represents number of courses for which the student is registered.</p>
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Centre for Interdisciplinary Research

M.Sc. Part I and II Examination, Month .....Year .....

Semester: I, II

(Name of PHY -101, ....104)

(Name of PHY – 201, ...204)

The question paper is divided in to two sections- Section A and B

The Total Duration is of 3 Hrs.

(Section A+B=Hrs)

**SECTION-A (MCQs)** is for 30 minutes duration, carrying 16 Marks.

Q.1 Multiple choice questions.

**Instructions :**

- 1) Attempt all questions.
- 2) **Darken** the appropriate circle against the question number once only.  
Use **blue/Black** ball point pen only.
- 3) **Each** question carries **one mark**.
- 4) **A Student will not be allotted any marks if he/she overwrites, strikes out or puts white ink on the circle once marked.**
- 5) Do not write anything on the **blank portion of the question paper**.  
If written anything, such type of act will be considered as an attempt to resort to unfair means.

**SECTION – B** is for 2.30 Hrs duration, carrying 64 Marks.

**Instructions :** 1) **Q. No.2** is compulsory.

- 2) Attempt **any three** from Q. No. 3 to Q. No.7.
- 3) The number to the **right side** indicates full marks.
- 4) Draw diagrams wherever necessary.

**Q. No.2 Attempt any four (Short answer questions)**

**(4x4=16) Marks**

- 1.
- 2.
- 3.
- 4.
- 5.

**Attempt any three from Q. No.3 to Q. No. 7**

**Q.No.3**

**(16 Marks)**

- a. Long answer Question for 12 Marks.
- b. Short answer Question for 4 Marks.

**Q.No.4**

**(16 Marks)**

- a. Long answer Question for 12 Marks.
- b. Short answer Question for 4 Marks.

**Q.No.5**

**(16 Marks)**

- a. Long answer Question for 12 Marks.
- b. Short answer Questions for 4 Marks.

**Q.No.6**

**(16 Marks)**

- a. Long answer Question for 12 Marks.
- b. Short answer Question for 4 Marks.

**Q.No.7**

**(16 Marks)**

- a. Long answer Question for 12 Marks.
- b. Short answer Question for 4 Marks.



**D.Y. PATIL EDUCATION SOCIETY**  
**[Deemed to be University], Kolhapur**  
Re-accredited by NAAC with 'A' Grade