Syllabus of M. Sc. (Physics) Semester – I to Semester – IV as per NEP-2020 implemented from 2023-24

Program Outcomes for M.Sc. Physics (CBCS) Program

The M.Sc. Physics program offered by Rashtrasant Tukadoji Maharaj Nagpur University at the PGTD Physics as per NEP 2020 has been granted AUTONOMY under Direction 14/2022 and 15/2023, is a 2 Years-4 Sem. PG Degree (88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (44 credits) after Four Year UG Degree aiming at students becoming career oriented and capable of nurturing their scientific temperaments. Students will get exposure to the depth and core understanding of various dimensions of Physics during these two years of the study. The training provided will give students the breadth and depth of scientific knowledge in the important fields of Physics. The M.Sc. in Physics at RTM Nagpur University allows specialization in the areas of Materials Science, X Rays, Nanoscience and Nanotechnology, Quantum Computing, Digital Electronics and Microprocessors, Experimental Techniques and Electroacoustic etc. Research activities of the Department are mostly focused on materials science research and have grown steadfastly since its inception, expanding into areas of functional materials for Luminescence, Solar Cells, Fuel Cell, Batteries, Sensors and Energy Harvesting materials, Acoustics, and Nanostructure Polymers as well as Theoretical Physics. Department is actively involved in R & D as well as consultancy project and has also collaborations with several R & D organization in the India e.g. IUC-DAE-CSR (Indore), RRCAT (Indore), NEERI (Nagpur), IISER (Pune), IISc (Bangalore) etc as well as outside the India with Penn State University, State College (USA), Institute of Energy and Climate change, Forchunszentrum Julich GMBH, (Germany) & ICTP Italy.

The students of M. Sc. Physics (CBCS) Program will upon completion of the course have

Programme specific Outcome

- Understanding basic principles of Physics which are underlying a wide selection of physical phenomenon.
- Explore with current state-of-art in the selected area of Physics.
- Inculcate the habit to plan, design and execute new experiment. Analyse, interpret experimental result and write report on it.
- Assess the errors involved in an experiment work; searching out and adopting new way of learning to reduce errors. Presents the experimental outcome in effective manner.
- After completing PG degree from this programme, they will be eligible to continue research at the higher degree Ph.D. level. They will be trained by experimental, computer programming and data interpretation programming skill and exposed to improve their employability in research and development, in scientific and engineering industries.

- Additionally, they will have necessary numerical and transferable skills to select general career choice such as accounting and computing
- Better understanding of major thrust areas of the discipline
- Know how on current developments in the Materials Science research
- Capacity to identify, analyze and design safe experimental process, to provide efficient solutions by fair interpretation of data
- Gain perfect insight into Materials Science research ethics for production of quality research and publication.
- An ability to engage themselves in lifelong learning to foster their growth as a successful researcher and establish themselves as an entrepreneur in the field of Physics.
- Critical understanding of scientific fundamentals and their application for professional success through focused tests and should demonstrate signs of improvement.
- Communicate their thoughts unmistakably to individuals from all foundations in composed and spoken arrangement.
- Serve society for its progression through productive research and moral practices.
- Be employment prepared to work in any segment.

M.Sc. Physics (CBCS) Program: AUTONOMOUS

M.Sc. Semester I consists of two DSC papers, four DSE, One RM and two practicals' all theory papers). M.Sc. Semester II consist of two DSC papers, four DSE, one OJT and two practicals on all theory papers.Third semester has a three DSC, Three DSE, one DSE based practical Lab. & one Mini Research Project Work. Fourth semester has three DSC, four DSE & one Major research project.

1. The Practical shall be evaluated by both the External and Internal Examiner in the respective Department as per guidelines appended with the direction no.14/2022 & 15/2023.

2. The student will have to carry out the project work (based on guidelines appended to the Direction in lieu of practical in the third & fourth semester in the department or depending on the availability of placement; he/she will be attached to any of the national/regional/private research institute /organization.

3. Internal Assessment Marks will be as per direction no. 15/2023.

4. The number of students are distributed among each teachers for On Job Training(OJT). Students will be evaluated by each teacher.

Project Work Scheme / Guidelines for the Students, Supervisors and Examiners

Every student is required to carry out a project work in semester III & IV in lieu of Practical. The project can be of following types.

A) Experimental Project Work; OR B) Field Based Project Work; OR C) Review writing based Project Work.

Experimental Project Work OR Field Based Project Work :

Student can carry out Experimental / Field based Project Work on a related research topic of the subject /course. It must be an original work and must indicate some degree of experimental work / Field work. On the basis of this work, student must submit the Project Report (typed and properly bound) in two copies at least one month prior to commencement of the final Practical / lab Examination of Semester III & IV. The project report shall comprise of Introduction, Review of literature, Material and Methods, Results, Discussion, Summary, Conclusion and References along with the declaration by the candidate that the work is original and not submitted to any University or Organization for award of the degree and certificate by the supervisor and forwarded through Head / Course-coordinator.

Review writing based Project Work .

Student can carry out review writing based Project Work on a related topic of the subject / course. It must be a review of topic based on research publications. Student shall refer peer reviewed original research publications and based on findings, write a summary of the same.

The pattern of review writing shall be based on reputed reviews published in a standard, peer reviewed journals. On the basis of this work, student must submit the Project Report (typed and properly bound) in two copies at least one month prior to commencement of the final Practical / lab Examination of Semester III & IV. The project report shall comprise of Abstract, Introduction, detailed review, Discussion, Summary, Conclusion and References along with the declaration by the candidate that the work is original and not submitted to any University or Organization for award of the degree and certificate by the supervisor and forwarded through Head / Course-coordinator.

The supervisor shall be able to guide not more than 11 (Eleven) students in the given examination. The supervisor shall declare in the project of every student which he / she guiding stating that he / she has not guided more than 11 students in the given examination.

The supervisors for the Project Work shall be from the following.

A person shall be full time university PG recognized faculty member in the relevant subject.

OR

A person appointed in PG on contractual / contributory basis, having NET / SET and approved by the University in the relevant subject and having 3 years teaching experience as contractual / contributory at PG level.

OR

University approved Ex-Faculty members in the relevant subject

The Project Work will carry total 100 marks and will be evaluated by both external and internal examiners in the respective Department.

The examiners will evaluate the Experimental Project Work taking into account the Coverage of subject matter, Arrangement and presentation, References, etc.

For written Project work its Presentation: 40 Marks - Evaluated jointly by External & Internal

For Viva-Voce: 10 Marks - Evaluated by External examiner

Internal Assessment: 50 Marks - Evaluated by Internal examiner

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Total: 100 Marks

Internal Assessment:

1. The internal assessment marks shall be awarded by the concerned teacher.

2. The internal assessment shall be completed by the University department at least 15 days prior to the final examination of each semester. The Marks shall be sent to the University immediately after the Assessment in the prescribed format.

3. For the purpose of internal assessment the University Department shall conduct one to two assignments described below. Best two scores of a student in these assignments shall be considered to obtain the internal assessment score of that student.

4. General guidelines for Internal Assessment are:

a) The internal assessment marks assigned to each theory paper as mentioned shall be awarded on the basis of attendance and assignments like class test, home assignments, study tour, industrial visits, visit to educational institutions and research organizations, field work, group discussions or any other innovative practice / activity.

b) There shall be one to two assignments (as described above) per Theory paper.

c) There shall be no separate / extra allotment of work load to the teacher concerned. He/She shall conduct the Internal assessment activity during the regular teaching days / periods as a part of regular teaching activity.

d) The concerned teacher / Department shall have to keep the record of all the above activities until six months after the declaration of the results of that semester.

e) At the beginning of each semester, every teacher / Department shall inform his / her students unambiguously the method he / she propose to adopt and the scheme of marking for internal assessment.

f) Teacher shall announce the schedule of activity for internal assessment in advance in consultation with HOD.

g) Final submission of internal marks to the University shall be before the commencement of the University Theory / Practical examinations.

Practical Examination

1. Each practical carries 100 marks. For the examination, the distribution of the marks shall be as follows:

a. Record / Journal / Internal assessment: 50 marks – Evaluated by Internal

b. Practical Performance: 40 marks – Evaluated jointly by External & Internal

c. Viva-voce: 10 marks – Evaluated by External

NOTE: Practical performance shall be jointly evaluated by the External and Internal Examiner. In case of discrepancy, the External Examiner's decision shall be final.

2. Practical exam shall be of 2 to 6 hours' duration for one or two days, depending on subject and number of students.

3. The Practical Record of every student shall carry a certificate as shown below, duly signed by the teacher-in-charge and the Head of the Department.

4. If the student fails to submit his / her certified Practical Record duly signed by the Teacher-In- Charge and the Head of the Department, he / she shall not be allowed to appear for the Practical Examination and no Marks shall be allotted to the student.

Semester I

Paper 1 (DSC 1) Mathematical Physics (MPH1T01)

Course Outcomes
CO 1: Students will able to understand how to solve the ploblems related to the periodic functions and non-periodic functions by using the Fourier transform.
CO 2: To learn Application of Laplace transforms are applicable to find out typical Integrals and derivatives.
CO3: In the world of vectors and scalers vector space is use to verify different properties of vectors and scalers.
CO 4: Again should understand how to solve problems in row and column forms. How to solve the equations of multirank?
CO 5: Differential equations which cannot be solve by ordinary methods can be solved by using the special functions.

Unit I
Fourier Series: Definition, Dirichlet′s condition, Functions defined in two are more subranges, Half Range Series, Change of interval and functions having Arbitrary Period.
Fourier transform, Convolution theorem, Parseval′s identity, Applications to the solution of differential equations,

Unit II
Laplace transform of elementary functions – Unit step functions, Shifting Theorems, Impulse function, Periodic functions, Convolution Therem, Evaluation of integrals.
Inverse Laplace transforms – Methods of finding Inverse Laplace transforms, Shifting Properties, Inverse Laplace transform of Derivatives, Integrals– Heaviside expansion formula – Solutions of simple, differential equations

Unit III
Linear vector spaces – linear independent bases, Dimensionality, inner product, matrices, linear transformation,
Matrices– Inverse, Orthogonal and Unitary matrices, Cayley Hamilton theorem, eigen vectors and eigen value problem, Diagonalization, Complete orthonormal sets of function.
Unit-IV
Special Function– Hermite, Legendre, Laguerre polynomials, Generating Function and recursion relations, differential and integral form.

1. Matrices and Tensor in Physics: A.W.Joshi
2. Mathematical Physics: H.K.Dass
3. Vector analysis – Newell
4. Rajput B S, Mathematical Physics, Pragati Prakashan (Meerat) 1999

Paper 2 (DSC 2) Electronics (MPH1T02)

Course Outcomes

Students will be able to

CO 1: Understand the construction and properties of different Electronics Semiconductor devices like PN junction diodes, JFET, MOSFET etc.

CO 2: Understand the applications of semiconductor devices in linear and digital circuits.

CO 3: Study the characteristics and applications of different transistors and different biasing operations with their applications.

CO 4: Study the coupling of amplifier stages, characteristics and applications of operational amplifiers and oscillators.

CO 5: Analyse and apply the transistor as a switch using different gates (OR, AND and NOT gates).

CO 6: Understand and explain the Digital integrated circuits, simple combinational Circuits, Linear integrated circuits, semiconductor memories etc.

CO 7: Understand modulation techniques and classification of modulation including AM and FM. Explain the fundamentals of optical communication system.

Unit I

Electronics Semiconductor discrete devices (characteristic curves and physics of p-n junction), Schottky, Tunnel and MOS diodes, Bipolar junction transistor, junction field effect transistor (JFET),Metal-oxide-Semiconductor Field effect transistor (MOSFET),unijunction transistor(UJT) and sillicon controlled rectifier (SCR), Opto-electronic devices (Photo-diode, solar cell, LED, LCD and photo transistor), Diffusion of impurities in silicon, growth of oxide.

Unit II

Applications of semiconductor devices in linear and digital circuits- Zener regulated power supply, Transistor (bipolar, MOSFFT, JFET) as amplifier, coupling of amplifier stages (DC, RC and Transformer coupling), RC-coupled amplifier, dc and power amplifier Feedback in amplifiers and oscillators (phase shift, Hartley, Colpitts and crystal controlled) clipping and clamping circuits. Transistor as a switch OR, AND and NOT gates (TIL and CMOS gates).

Unit III

Digital integrated circuits- NAND and NOR gates building block, X-OR gate, simple combinational Circuits -Half and full address, Flip-Flops, Multivibrators (using transistor) and sweep geneator (using transistors, UJT and SCR). shift registers, counters, A/D and D/A coverters, semiconductor memories (ROM, RAM, and EPROM, basic architecture of 8 bit microprocessor (INTEL 8085). Linear integrated circuits- Operational amplifier and its applications-Inverting and noninverting amplifier, adder, integrator, differentiator, waveform generator, comparator and Schmittrigger, Butterwoth active filter, phase shifter,

Unit IV

Communication Electronics-Basic principle of amplitude frequency and phase modulation. Simple circuits for amplitude modulation and demodulation, digital (PCM) modulation and demodulation. Fundamentals of optical communication, Microwave Oscillators (reflex, klystron, megnetron and Gunn diode), Cavity resonaters. Standing wave detector.

Reference books
1. A. Malvino and D. J. Bates: Electronic Principles (Mc Graw Hill Education, India)
2. Boylstad&Neshishkey, "Electronic devices & circuits" , PHI
3. Milliman, J. Halkias, "integrated elctronics", Tata McGraw Hill
4. J. J. CatheySchaum's Outlines "Electronic Devices & Circuits" Tata McGraw Hill.
5. J. D. Ryder," Electronics Fundamentals and Applications", John Wiley-Eastern Publications.
6. A. P. Malvino, D.P. Leach, "Digital Principles and Applications", McGraw Hill Book Co., 4th Edition (1986).
7. Ramakant A. Gayakwad, "Op-amps and Linear Integrated Circuits" PHI
8. Anil Maini, Varsha Agrawal, " Electronic Devices and acircuits" Wiley
9. George Kennedy, " Electronic Communication Systems", Tata McGraw Hill.
10. Dennis Roddy, John Coolen, "Electronic Communication Systems ", Pearson.

Paper 3 (DSE 1) Nonlinear Dynamics (MPH1T03)

Course Outcome

CO1: Learn about basic philosophy of studying the dynamical system qualitatively without solving it exactly.
CO2: Learn about one dimensional flows and various attractors,
CO3: Learn about flows on a circle, linear systems, importance of eigenvalues and eigenvectors, linearization near fixed points.
CO4: Learn about conservative systems as well as reversible systems and their properties.
CO5: Understand bifurcations in various dimensions as well as global bifurcations.

Unit I

Flows on a line, fixed points and their stability, Population growth, Linear Stability Analysis, Existence and Uniqueness, Impossibility of Oscillations, Potentials, Bifurcations, Saddle node, Trans critical, Pitchfork, Examples, Imperfect Bifurcation.(Chapter 2 and 3 of Ref. 1)

Unit II

Flows on a circle, Uniform and Nonuniform Oscillator, Over damped Pendulum, Superconducting Josephson Junction, Fireflies, Examples of Linear System, Classification of Linear System. (Chapter 4 and 5 of Ref. 1)

Unit III

Phase portraits, Existence and Uniqueness, fixed points and their Linearization, Conservative Systems, Reversible Systems, Index theory, Limit Cycles, ruling out Closed Cycles, Poincare-Benedixon theorem, Lienard Systems, Relaxation Oscillations,Weakly Nonlinear Oscillators. (Chapter 6 and 7 Ref. 1)

Unit IV

Bifurcations in detail, Saddle-node, trans critical, pitchfork, Hopf, Global Bifurcations, Hysteresis in Driven pendulum, Coupled Oscillators and Quasiperiodicity (Chapter 8 ofRef. 1)

Reference books:
1.S. W. Strogatz: Nonlinear Dynamics with Applications to Physics, Biology,Chemistry and Engineering. (Perseus)
Edward Ott : Chaos in Dynamical Systems (Cambridge University Press)

Paper 3 (DSE 2) Experimental Techniques in Physics (MPH1T03)

Course Outcomes

CO1: Understand the Different Types of Radiation

CO2: Analyse the characteristics of sensors, classify them, and comprehend the operation principles of various sensors used in materials characterization.

CO3: Acquire a comprehensive understanding of thermal analysis techniques, including Thermo-Gravimetric Analysis (TGA), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC).

CO4: Apply numerical methods to solve problems related to thermal analysis and phase diagrams. 5. CO5: Understand the principles, instrumentation, and operation of the Vibrating Sample Magnetometer (VSM), along with the analysis of hysteresis loops.

CO5: Learn the techniques for measuring complex dielectric constants and understand dielectric relaxation mechanisms. Global and National need

CO6: Gain hands-on experience in applying spectroscopic techniques for the characterization of materials.

CO7: Develop skills to interpret data obtained from different spectroscopic analyses and apply the knowledge to real-world materials. [part of course having focus on skill development]

Unit 1: Radiation Sources, Detectors

Different types of radiations (X-rays, UV-VIS, IR, microwaves and nuclear) - their role in materials characterization- sources - concept of detection and different Detectors: gamma-rays, X-rays, UV-VIS, IR, microwaves and nuclear detectors.

Sensors: Sensor's characteristics, Classification of sensors, Operation principles of sensors such as electric, dielectric, acoustic, thermal, optical, mechanical, pressure, IR, UV, gas and humidity with examples

Unit-II Thermal Analysis Techniques

Thermal analysis: Principle, Instrumentation and Working: Thermo-gravimetric (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC); Phase diagram determination by thermal analysis technique. Graphical analysis affecting various factors. Numericals

Unit III: Dielectric and Magnetic Characterization

Magnetic Characterization: Principle, Instrumentation and Working of Vibrating Sample Magnetometer (VSM), Analysis of Hysteresis loop, SQUID Technique: Principle, Instrumentation and Working. Numericals

Dielectric properties: Dielectric polarization. AC response. Instrumentation and working of impedance analyzer, Measurement of complex dielectric constant, dielectric relaxation mechanism,

Unit IV : Spectroscopic Analysis

Spectroscopic characterization (principle, instrumentation and working): Infra-Red (IR), Fourier Transform Infra-Red (FTIR), Ultraviolet-Visible (UV-VIS), Diffused Reflectance Spectroscopy (DRS), X-ray Absorption (XPS), Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR).

Reference Books:

1. Nuclear Radiation Detectors, S.S. Kapoor, V. S. Ramamurthy, (Wiley-EasternLimited, Bombay)
2. Instrumentation: Devices and Systems, C.S. Rangan, G.R. Sarma and V.S.V. Mani, Tata Mc Graw Hill Publishing Co. Ltd.

3. Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya Publishing House
4. Instrumental Methods of Analysis by H.H. Willard , L.L. Merritt, J.A. Dean, CBS Publishers
5. Characterization of Materials, John B. Wachtman & Zwi. H. Kalman, Pub. ButterworthHeinemann (1992)
6. Elements of X-ray diffraction, Bernard Dennis Cullity, Stuart R. Stock, (Printice Hall, 2001 - Science – 664

Paper 3 (DSE 3) Digital Electronics and Microprocessor (MPH1T03)

Course Outcomes

After successful completion of this course, the student will be able to:

CO 1: Explain number systems, basic logic gates, Boolean algebra and define characteristics of logic families and calculate their parameters.

CO 2: Learn the minimization techniques to simply the hardware requirements of digital circuits, implement it, design and apply for real time digital systems.

CO 3: Understand the working mechanism and design guidelines of different combinational, sequential circuits and their role in the digital system design.

CO 4: Became able to know various types of components-ADC and DAC, memory elements and the timing circuits to generate different waveforms, and also the different logic families involved in the digital system

CO 5: To understand the concepts of Architecture of 8086 Microprocessor.

CO 6: Ability to write assembly language programs to realize various high level language constructs, considering the architectural features, memory design of the underlying hardware. To realize the issues in computer architecture and organization.

CO 7: Ability to interface various programmable devices to the microprocessor and program them to perform data transfer in real life applications.

CO 8: Understand concept of interfacing of peripheral devices and their applications.

Unit–I:

Logic gates, Simplifying logic circuits, Algebric methodSOP (minterm) and POS (maxterm) forms. Karnaugh mapping Fundamental products, pairs,quads, octats, Don’t care conditions. Complementary Karnaugh map. Diagonal adjacencies. NAND-NAND and NOT-NOR networks. Applications of K maps to half adder, full adder. Arithmetic circuits: Number representation, negative numbers, sign and magnitude. 1s and 2 s complement, adder; parallel binary adder, BCD addition, binary multiplication and division

Unit – II

Multiplexers, demultiplexers: IC 74150 multiplexer and IC 74154 demultiplexer, A/D and D/A converters: Weighted resistor and R-2R ladder D/A converters, A/D converter– parallel comparator and Application, ADC 0808, DAC 0800.

Unit -III:

Memories Allied Devices: Design consideration of Bipolar RAM, MOS memory and dynamic RAM, ROM, EXROM and CCD. Read/Write operation. Expanding memory size wordsize and word capacity. FIFO and LIFO. Study of 7489 RAM Magnetic bubble memories.

Unit – IV:

Microprocessor Architecture: Introduction to architecture, pin configuration etc. of 8086, parts of Microprocessor, CPU, memory requirements, instructions, program storage, instruction execution fetch and execute cycles, addressing modes including simple memory paging, direct

scratch and pad addressing. The instruction set including memory reference, immediate conditional jump-shift, change control, stack and program counter, subroutines, flow charts, masking, simple programs.
I/O Systems: Program interrupts including multiple interrupt priorities. Interfacing memory mapping, memory mapped and I/P mapped I/O. Use of decoders, I/O posts. IC 8212., IC 8155 and IC8255 (with block diagram of internal circuits)

Text and Reference Books

1. Design of Digital Systems : P. C. Pitman (Galgotia Pub).
2. Digital Computer Electronics :A. P. Malvino (TMH).35
3. Digital Fundamentals: T. L. Floyd (Universal Book Stall).
4. Theory and Problems of Digital Principles : R. L. Tokheim (TMH).
5. Modern Digital Electronics : R. P. Jain (TMH).
6. Introduction to UP : A. K. Mathur (PHL).
7. Up and Small Digital Computer Systems for Scientist and Engineers L G. A. Korn,(McGraw Hill).
8. An Introduction to Micro-computer: Adam Osborne(Galgotia).
9. Introduction top 4 bit and 8 bit UP : Adam Osborne

Paper 4 (RM) RESEARCH METHODOLOGY (MPH1T04)

Course Outcomes

CO1: Students will understand the fundamental concepts and significance of research, including its objectives, motivations, and the differences between research methods and methodologies.
CO2: Students will able to identify and define research problems, conduct comprehensive literature reviews, and formulate well-constructed hypotheses for scientific investigations.
CO3: Students will develop appropriate research designs and methodologies, distinguish between qualitative and quantitative research approaches, and execute various research methods including surveys, experiments, and data analysis.
CO4: Students will be able to apply ethical principles in scientific research, understand environmental impacts, intellectual property rights, and issues related to commercialization, plagiarism, and reproducibility.

Unit-I Foundations of Research: Meaning, objectives, motivation and significance of research, types and parameters of research, research process, research methods versus methodology, research and scientific method, importance, research process, criteria of good research, multidisciplinary and interdisciplinary research, creativity in research.

Unit-II Research Problem, Literature Review & Hypotheses:

Research Problem: Concept and need, identification of research problem, defining and delimiting research problem. **Literature review:** Meaning, necessity, sources and functions of literature review. Precautions in library use. **Hypothesis:** variables and their linkages, characteristics of good hypothesis. Research question and formulation of hypotheses-directional and non-directional hypotheses, basis for hypotheses.

Unit-III Research Design & Measurements: Need for research design, pure and applied research design, exploratory and descriptive design methodology, qualitative vs. quantitative research methodology, field studies, field experiments vs. laboratory experiments, research design in social and physical sciences. **Survey, assessment and analysis:** Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation.

Unit-IV Ethics in Scientific Research: Environmental impacts - Ethical issues - ethical committees - Commercialisation – Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

Reference books:

- Kothari ,C.R.,**1985**, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
- Kumar,Ranjit, **2005**,Research Methodology-A Step-by Step Guide for Beginners,(2^{nd} Ed.) ,Singapore,Pearson Education.
- Peter, Pruzan, **2016**, Research Methodology-The Aims, Practices and Ethics of Science, Springer International Publishing Ltd.
- Bendat, J. S. and A. G. Piersol (2010). Random Data: Analysis and Measurement Procedures. 4th edition. New York, USA: John Wiley & Sons, Inc.
- Wadehra, B.L. 2000. Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.
- Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes

Practical 1P1 and 1P2

Practical 1 GENERAL (MPH1P01)

1. Study of B-H Curve
2. Determination of e/m of electron by normal Zeeman effect using Febry Perot Etalon.
3. Determination of Lande's factor of DPPH using ESR spectrometer
4. Determination of e/m by Thomson method.
5. Determination of e/m by Busch's helical beam method.
6. Study of paramagnetic to ferromagnetic phase transition.
7. Study of Paramagnetic salt by Guoy's balance
8. Differential scanning Calorimetry
9. Determination of Plank's constant.
10. Determination of Stephan's constant.

Practical 2 ELECTRONICS (MPH1P02)

1. Design of a regulated power supply.
2. Characteristics and applications of silicon controlled rectifier.
3. Design of common emitter Power transistor amplifier.
4. Experiments on bias stability.
5. Negative feedback (Voltage series / shunt and current series / shunt).
6. Astable, Monostable and Bistablemultivibrator.
7. Experiment on FET and MOSFET characterization and application as an
8. amplifier.
9. Experiment on Uni-junction transistor and its application.
10. Digital – I: Basic, TTL, NAND and NOR.
11. Digital – II: Combinational logic.
12. Flip-Flops.
13. Study of modulation (FM, AM, etc.).
14. Operational Amplifier.
15. Differential Amplifier.
16. Microprocessor.

Semester II

Paper 5 (DSC 3) Complex Analysis and Numerical Methods (MPH2T05)

Course Outcomes

CO1: Students will be able to represent complex numbers, analyse limit, continuity and differentiation of functions of complex variables.
Learn analytic functions, Cauchy Reimann conditions.
CO2: Understand Cauchy integral formula and evaluate various real and complex integrals.
CO3:To be able to find roots of nonlinear equations numerically and understand how iterations work.
CO4: To be able to interpolate with evenly or unevenly spaced data
CO5: To be able to integrate given function numerically

Unit I
Definition of Complex Numbers, Equality of Complex Number, Complex Algebra, Conjugate Complex Numbers, Geometrical representation of Complex Number, Geometrical representations of the sum, difference, product and quotient of Complex Number, Cauchy-Rieman Conditions, Analytic functions, Multiply connected regions, Cauchy Theorem, Cauchy Integration formula, Derivatives, problems (Rajput – 283 – 314).
Unit II
Singularities- Poles, Branch Points, Calculus of Residues-Residues Theorem, Cauchy Principle value, Pole Expansion of Meromorphic Functions, Product expansion of entire Functions, problems (Rajput 326 – 384).
Unit III
Methods for determination of zeros and linear and non-linear single variable algebraic and transcendental equations, (Bisection method, false position method, iteration method, Newton-Raphson method, secant method), Finite differences. Newton's formulae (no proofs)
Unit IV
Lagrange's interpolation, Divided differences. Numerical integration, trapezoid rule, simpson's 1/3rd rule, Simpson's 3/8th rule, Linear least squares.
Euler and RungeKutta methods for solving ordinary differential equations. (No proofs)

Reference books

1. Rajput B S, Mathematical Physics, PragatiPrakashan (Meerat) 1999
2. Introductory Methods of Numerical Analysis: S SSastry
3. Computer Oriented Numerical Methods: V Rajaraman
4. R. V. Churchill, Complex variables and Applications, 7th Edition McGraw Hill
5. Computer oriented Numerical Methods: R.S.Salaria
6. Mathematical Physics: H.K.Dass
7. Higher Engineering Mathematics : B. S. Grewal

Paper 6 (DSC 4) Statistical Physics (MPH2T06)

Course Outcomes
CO 1: Students will be able to understand various models in statistical mechanics, and apply statistical tools to solve the problems in Physics.
CO 2: Students will be able to identify the connection between statistical mechanics and thermodynamics.
CO 3: Students will be able to understand Bose's concept of fifth state of matter and any possibility of sixth state of matter or not.
CO 4: Students will be able to understand the significance and characteristics of phase transitions and critical phenomena.

Unit I

Fundamentals of classical statistical mechanics, microstate and macrostate, distribution function, Liouville's theorem, Gibbs Paradox, ensembles (micro-canonical, canonical and grand-canonical), partition function, free energy and connection with thermodynamic quantities, energy and density fluctuations

Unit II

Fundamentals of quantum statistical mechanics, BE and FD Statistics, Symmetry of wave functions, Boltzmann limit of Bosons and Fermions, Ideal Bose system: Bose-Einstein condensation, Behaviour of ideal Bose gas below and above Bose temperature, Photons and liquid helium as bosons, Superfluidity of He^4

Unit III

Ideal Fermi system: Weak and strong degeneracy, Fermi function, Fermi energy, Behaviour of ideal Fermi gas at absolute zero and below Fermi temperature, Fermionic condensation, Free electrons in metals as fermions, Electronic specific heat, Determination of Fermi temperature, Cluster expansion for classical real gas, Virial equations of states.

Unit IV

Introduction to Phase Transitions; First Order Phase Transition (Clausius-Clapeyron Equation); Phase Transition of Second Order; Order Parameter; Landau Theory of Phase Transition of Second Order; Ising Model of Phase Transition of Second Order; Time Dependant Correlation Function; Power Spectrum of Fluctuation; Brownian Motion, Einstein's theoretical analysis of Brownian motion, Langevin theory of Brownian motion.

Text and Reference Books:

1. Fundamentals of Statistical Physics: B. B. Laud
2. Statistical Mechanics: R. K. Pathria
3. Statistical Mechanics: S. K. Sinha
4. Statistical and Thermal Physics: F. Reif
5. Statistical Mechanics: K. Huang
6. Statistical Mechanics: Loknathan and Gambhir
7. Statistical mechanics: R. Kubo
8. Statistical Physics: Landau and Lifshitz

Paper 7 (DSE 4) Spectroscopy (MPH2T07)

Course Outcomes

CO 1: Sudents should understand Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom, Zeeman effect, Paschen-Bach effect, Stark effect, Lamb shift, X-ray spectra, Moseley's law.

CO 2: Rotational spectra of rigid diatomic molecules, isotope effect in rotational spectra, intensity of rotational lines, non–rigid rotor, rotational spectra of polyatomic molecules. Stark effect. Microwave spectroscopy. Basics of IR spectra, vibrating diatomic molecule, analysis by IR technique, Fourier transform IR spectroscopy and structure determination.

CO 3: Classical and quantum theory of Raman scattering, rotational Raman spectra, vibrational Raman spectra. Study of phase transitions and proton conduction in solids using Raman spectroscopy, Resonance Raman scattering, Surface enhanced Raman scattering. Photoacoustic Raman scattering.

CO 4: NMR spectrometer, NMR spectra of solids, NMR imaging, ESR spectroscopy, Mossbauer spectroscopy, Laser spectroscopy.

Unit I

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Features of one-electron and two electron atoms, Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings, Hund's rules, Spectral transitions of helium, Spectral terms of equivalent electrons, Zeeman effect, Paschen-Bach effect, Stark effect, Lamb shift, X-ray spectra, Moseley's law.

Unit II

Types of molecules, rotational spectra of rigid diatomic molecules, isotope effect in rotational spectra, intensity of rotational lines, non–rigid rotor, rotational spectra of polyatomic molecules. Stark effect. Microwave spectroscopy. Basics of IR spectra, vibrating diatomic molecule, diatomic vibrating rotator, asymmetry of rotation-vibration band, vibrations of polyatomic molecules, rotation-vibration spectra of polyatomic molecules, analysis by IR technique, Fourier transform IR spectroscopy and structure determination.

Unit III

Classical and quantum theory of Raman scattering, rotational Raman spectra, vibrational Raman spectra, mutual exclusion principle, Raman spectrometer, Fourier transform Raman spectrometer, Structure determination of various types of molecules using Raman spectroscopy, Study of phase transitions and proton conduction in solids using Raman spectroscopy, Resonance Raman scattering, Surface enhanced Raman scattering. Photoacoustic Raman scattering.

Unit IV

Electronic spectra of diatomic molecules, progressions and sequences, Franck – Condon principle, Rotational fine structure of electronic-vibrational spectra, Fortrat parabola, Dissociation and predissociation energy, Photoelectron spectroscopy, NMR spectrometer, NMR spectra of solids, NMR imaging, ESR spectroscopy, Mossbauer spectroscopy, Laser spectroscopy.

Reference Books:

1. Physics of Atoms and Molecules: Bransden and Joachain.
2. Introduction of Atomic Spectra, H.E. White, McGraw Hill
3. Spectroscopy (Vol. 2 & 3), B.P. Straughan & S. Walker, Sciencepaperbacks 1976
4. Molecular Spectra and Molecular Spectroscopy (Vol. 1), G. Herzberg
5. Introduction to Atomic Spectra: HG Kuhn
6. Fundamentals of molecular spectroscopy, C.B. Banwell
7. Introduction to molecular Spectroscopy, G. M. Barrow
8. Raman Spectroscopy, D.A. Long, McGraw Hill international, 1977
9. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill
10. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G.Herzberg, Van Nostard.
11. Infra-Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall. Vol. 1 & 2
12. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India
13. Molecular Structure and Spectroscopy, G. Aruldas, Prentice Hall India.
14. NMR spectroscopy, H. Gunther, 2nd edition John Wileny and Sons, 1995.

Paper 7 (DSE 4) Communication electronics (MPH2T07)

Course Outcomes

1. Understand Modulation Techniques: Explain the necessity and classification of modulation, including AM and FM.
2. Analyze Propagation Effects: Assess the effects of the environment on radio wave propagation, including ground wave, sky wave, and tropospheric scatter propagation.
3. Understand Antenna Fundamentals: Explain basic antenna considerations, radiation patterns, and parameters such as radiation density, gain, and Friis transmission formula.
4. Understand High-Frequency Transmission: Evaluate high-frequency transmission lines, including coaxial cables and waveguides, and discuss their attenuation and propagation characteristics.
5. Analyze Optical Fibers: Explain the propagation of light in optical fibers, including step index and graded index fibers, and evaluate their attenuation and dispersion characteristics.
6. Optical Communication Systems: Apply numerical methods to analyze the performance of optical communication systems, including fiber optic signal attenuation, dispersion, and bandwidth.

UNIT I: Modulation AM and FM (Transmission and reception)

Modulation, necessity of modulation, classification, parameters of amplitude modulation, power consideration AM generation techniques, DSBFC, DSBSC, SSB, square law diode modulator. balanced modulator, frequency discrimination method, phase shift method, AM detection, AGC, AM transmitter and receiver, radio receiver characteristics, signal to noise ratio, limitations of amplitude modulation, Frequency modulation. Parameters of frequency modulation, power considerations, noise triangle, pre-emphasis and de-emphasis, FM generation techniques, direct and indirect methods, FM transmitter and receiver, AFC, FM detection: Forsley Seely method, Phase discriminator.

UNIT II : Propagation of radio waves

Electromagnetic radiation, Radio waves and their properties, basic propagation mechanisms, effects of environment on propagation, basic modes of propagation, ground wave propagation, sky wave propagation, tropospheric scatter propagation, ionosphere and its effect on sky wave propagation, multipath sky wave propagation, different parameters of ionosphere that affects propagation, critical frequency, maximum usable frequency, skip distance, fading, theories of ionosphere (Eccles- Larmer theory, magneto ionic theory), Space wave propagation, radio horizon, line of sight communication..

UNIT III : Antenna and TV

Antenna, basic considerations, radiation patterns, antenna parameters, antenna radiation density, antenna gain, Friis transmission formula, antenna apertures, effective radiated power, radiation measurement, antenna resistance, band width, beam width, dipole antenna, antenna array, loop antenna, helical antenna, Yagi-Uda antenna, turnstile antenna. Horn antenna, reflector antenna. Lens antenna, slot antenna, effect of ground on antennas, antenna coupling at different frequencies, micro wave antenna. Satellite communication, parabolic reflector, dish antenna, Fundamentals of image transmission, TV camera tubes, TV transmitter and receiver.

UNIT IV: Transmission Lines

Basic principle, Transmission media, fundamentals of transmission lines, Voltage and current relations on transmission line, propagation constant, characteristic impedance, reflection coefficient, input impedance, impedance matching, quarter wave transmission line as impedance transformer, high frequency transmission lines, co=axial cable, attenuation along coaxial cable, cables of low attenuation, propagation of radio waves between two parallel lines, wave guide modes, TE10 mode and cut off wavelength, cavity resonator, optical fibres, light propagation in cylindrical wave guide, step index and graded index fibers, attenuation and dispersion in fibers.

Reference Books

1. George Kennedy & Davis: Electronics Communication Systems
2. Millar & Beasley: Modern Electronics Communication
3. R.R Gulani: Monochrome and colour television (Wiley Eastern Limited)
4. Taub and Schilling: Principle of Communication Systems (TMH)
5. Simon Gaykuti: Communication Systems (John Wiley & Sons Inc. 1994)

Paper 7 (DSE 4) Energy Devices (MPH2T07)

Course outcomes

CO1: Analyse the goals for sustainable energy development and the role of renewable resources in meeting these objectives. Environment and Sustainability Integrated into the Curriculum

CO2: Identify challenges and opportunities in the existing energy infrastructure. Local + regional need

CO3: Classify and compare different types of energy devices based on their applications and mechanisms.

CO4: Examine the thermodynamic principles governing energy harvesting and storage processes.

CO5: Evaluate the challenges and potential solutions in utilizing advanced materials for solid-state battery technology.

CO6: Explore the advantages, disadvantages, and applications of various fuel cell types.

CO7: Explore industrial hydrogen generation processes and the associated materials challenges.
CO8: Analyze photovoltaic cell materials, their processing, and characterizations.

Unit-I
Energy need and goals for our environment, strategies for sustainable energy development, focusof greenhouse emission and present energy technology, global renewable energy needs and probable solutions.
Fundamental concepts: Introduction, types of energy devices, fundamental mechanism of energy devices, theoretical model and thermodynamic aspects of energy harvesting and storage. Advanced materials for alternative energy technology in solid state batteries, fuel cell and solar cell:

Unit-II
Energy storage: Introduction of Present storage technologies: capacitors, supercapacitor, pseudocapacitor and rechargeable batteries. Solid state batteries, chemical kinetics and its use to develop rate equations and the basic current-voltage behavior for electrochemical events. Concepts of diffusion, migration, and convection are developed for charged and uncharged species-flow through batteries, metal-air batteries and Li-S and Na-S batteries. Materials challenges and role of materials engineering for improving battery performance.

Unit-III
Hydrogen Energy: Fundamental aspect of fuel cell and electrolyzer systems- Fuel cells –advantages and disadvantages, classification, efficiency- emf of fuel cells, hydrogen/oxygen fuel cell, criteria for the selection electrode and electrolyte, methanol fuel cell, solid oxide fuel cells, phosphoric acid fuel cells, molten carbonate fuel cell, proton exchange membrane fuel cell, biochemical fuel cell. Thermochemical water splitting cycles, industrial hydrogen generation process and materials challenges,

Unit-IV
Solar Cells: principle of photovoltaic technology, thermodynamics, and their physical properties.Fundamental limits of photovoltaic, theoretical limits of solar-cells. Source of radiation – solar constant– solar charts – Measurement of diffuse, global and direct solar radiations. Photovoltaic cell materials,their processing and characterizations, abundant materials and low-cost fabrication strategies. Design and materials selection strategies for effective energy harvesting. Specific

materials developments and different design aspects for covering wider window of solar spectrum, spectrum absorption criteria.
Principles of Si-solar cells, thin-film (chalcogenides and chalcopyrites) solar cells, multi-junction solar cells, Gratzel cells (Dye-sensitized solar cell) present status issues and challenges. Newly emerged other types of solar cells, including, quantum dot solar cells, plasmonic, and perovskite solar cells.

References:

1. High-Efficiency Solar Cells: Physics, Materials, and Devices (Springer Series in Materials Science)Author: Xiaodong Wang and Zhiming M. Wang
2. Physics of Solar Cells: From Basic Principles to Advanced Concepts Author: Peter Würfel

3. Dye-sensitized Solar Cells by Kuppuswamy Kalyanasundaram
4. Energy Storage: Fundamentals, Materials and Applications by Robert Huggins
5. Lithium-Ion Batteries: Science and Technologies edited by Masaki Yoshio, Ralph J. Brodd,Akiya Kozawa
6. Hydrogen and Fuel Cells: Emerging Technologies and Applications by Bent Sørensen.

Paper 7 (DSE 4) Luminescence (MPH2T07)

Course Outcomes
Students will be able to
CO-1: Identify and differentiate between various types of luminescence and explain their respective mechanisms of light emission.
CO-2: Develop an understanding of phosphor configuration, doping techniques, role of rare earth ions in phosphor activation & comprehend the mechanisms of self-luminescence, energy transition, and color tunability in phosphor materials.
CO-3: Acquire knowledge of various synthesis approaches for luminescent materials & understand the importance of precursor selection and stoichiometry in chemical reactions.
CO-4: Develop proficiency in utilizing a range of advanced analytical techniques and interpret experimental data accurately for research and practical applications.
CO-5: Analyse and evaluate the diverse applications of phosphors in lighting & understand the significance of phosphors in various technological advancements and real-world scenarios.

Presently, phosphor also used in radiation dosimetry, plant cultivation, LED lighting, forensic, road signature boards, road signal lighting, solar cell and also medical science specially cancer therapy applications. Students benefited by all above knowledge and developed the theoretical skill for lighting industries and related company for job opportunity. Today in India there is not a single company for production of phosphors, so that students may chance for open start-up or small-scale industry.

Unit I
Introduction of luminescence:
Introduction of Luminescence, models, type of luminescence, photoluminescence, electroluminescence, thermoluminescence, bioluminescence, mechanoluminescence, lyoluminescence, ionoluminescence and their mechanisms.

Unit II
Basic concept of phosphor:
Phosphor Configuration, doping, types of dopants, activator, co-activator, sensitizer, concentration quenching. Rare earth ions and their importance, rare earth activated phosphors, metal ions, metal ions activated phosphors, Self-luminescence Properties, energy transition, energy level diagram, energy transfer mechanism, color tunable mechanism.

Unit III
Synthesis of luminescence materials:
Basics of material synthesis, Precursor selection, Stoichiometry of chemical reaction, synthesis approaches, Different synthesis approach for luminescence materials: Solid state diffusion method, sol-gel method, wet chemical synthesis, Precipitation method, hydrothermal, combustion, ball milling, green synthesis and panjyagavya method of metallic nanomaterials.

Characterization Techniques:
X-ray Diffractometer (XRD), UV-Vis spectroscopy, Photoluminescence (excitation, emission, stokes shift, CIE coordinates, colour purity, dominant wavelength, decay time measurements), Source of Gamma irradiation (^{60}Co and ^{137}Cs), TL Glow Curve reader, optically stimulated luminescence (OSL), Electron paramagnetic resonance (EPR), Scanning Electron Microscope (SEM), Transmission electron microscopy Spectro fluorophotometer, Fourier Transform IR spectroscopy,

Unit IV
Applications of phosphors:
Phosphors applications in lighting: Photoluminescence, CFLs, LEDs, OLEDs, display devices, fingerprint, plan cultivation, X-ray imaging phosphors, phototherapy lamps and its applications, materials for plant cultivation, fingerprint, paint, Phosphors for stress sensor.
Phosphors applications in radiation dosimetry: Thermoluminescences, radiation dosimetry by using thermoluminescence technique, medical radiation dosimetry, high dose measurement dosimetry, industry dosimeter for food safety, space dosimeter.
Phosphors in biomedical applications: Applications as antimicrobial activity, tissue engineering, drug delivery, bio-imaging, cancer treatment, biosensors, nano thermometry

Reference Books

1. Radiation dosimetry phosphors, Sanjay J. Dhoble, Vibha Chopra, Vinit Nayar, George Kitis, Dirk Poelman, Hendrik Swart, Elsevier Publications, 2022.
2. Luminescence: From theory to applications, Cornelis R. Ronda, John Wiley and sons, 2007.
3. Luminescent Materials and Applications, Adrian Kitai, John Wiley and Sons, 2008.
4. Luminescence of Solids, D. R. Vij, Springer New York, NY, 2012.
5. The Fundamental and Applications of Light Emitting Diodes, Govind B. Nair, S. J. Dhoble, Elsevier Publications, 2020.
6. Modern Luminescence from Fundamental Concepts to Materials and Applications Volume 1: Concepts of Luminescence Surender Sharma, Carlos Jacinto da Silva, Daniel Garcia, Navadeep Shrivatava, Elsevier Publications, 2022.

OJT (MOJ2P01)

The number of students are distributed among each teachers for On Job Training(OJT). Students will be evaluated by each teacher.

Practical 2P1 and 2P2

Practical 3 (Computational) (MPH2P03)

1. To find the largest or smallest of a given set of numbers.
2. Bubble sort.
3. To generate and print first hundred prime numbers.
4. Matrix multiplication.
5. To generate and print an odd ordered magic square.
6. Other exercises involving conditions, loop and array
7. Lagrange Interpolation.
8. Method of successive approximation
9. Bisection Method
10. Newton-Raphson Method.
11. Gaussian Elimination
12. Linear Least Squares Fit.
13. Simpson's rule integration.
14. Computation of special functions

Practical 4 (General) (MPH2P04)

1.Study of Focault pendulum
2.Study of Bifilar pendulum
3.Fibre optics
4.Study of waveguide
5.Thickness of thin wire with lasers
6.Measurement of wavelength of He-Ne laser light using ruler.
7.To study Faraday effect using He-Ne laser.
8. Verification of Biot-Savart law.

SEMESTER III

Classical Mechanics (MPH3T08)

Course Outcomes

CO 1: Student should understand basics of classical mechanics, D'Alemberts Principle, Variational Principle, Lagrange's equation, Hamilton's Principle
CO 2: Hamiltonian formalism and canonical transformation and problems.
CO 3: Centre force problem, inverse square problem and Rutherford scaterring.
CO 4: Rigid body dynamics, Euler's angles, Euler's theorem, moment of inertia tensor, eigen values and principal axis transformation,

Unit-I

Survey of elementary principles of mechanics of a particle, Dynamical systems, Phase space dynamics, stability analysis, constraints & their classifications, D'Alemberts Principle, Variational Principle, Lagrange's equation, Hamilton's Principle

Unit-II

Conservation theorems and symmetry properties, Hamiltonian formalism, Hamiltons equations, Routh's procedure for cyclic coordinates, conservation laws
Canonical transformations, Poisson brackets and Poisson theorems, Hamilton-Jacobi Theory

Unit-III

Central force motion, reduction to one body problem, equations of motions and first integrals classification of orbits for inverse square central forces. Two body collisions, Rutherford scattering in laboratory and centre-of-mass frames;

Unit-IV

Rigid body dynamics, Euler's angles, Euler's theorem, moment of inertia tensor, eigen values and principal axis transformation, non-inertial frames and Pseudo forces, Periodic motion,: small oscillations, normal modes.

Text and Reference books:

1. Classical Mechanics: H. Goldstein
2. Classical Mechanics: N.C.Rana and P.S.Joag
3. Classical Mechanics : J. C. Upadhyaya (Himalaya Publishing House)

Quantum Mechanics I (MPH3T09)

Course Outcomes

CO1: To introduce postulates and working principles of quantum mechanics.
CO2: Familiarity with operator and matrix formalism of quantum mechanics.
CO3: To be able to solve Schrodinger equation for simple systems.
CO4: Learn angular momentum operator, spin and be able to add angular momenta.

Unit- I

Time dependent and time-independent Schrodinger equation, continuity equation, wave packet, admissible wave functions, stationary states.
Formalism of wave mechanics, expectation values, quantum mechanical operators for position and momentum in the coordinate representation, Construction of quantum mechanical operators for other dynamical variables from those of position and momentum, Ehrenfest's theorem, momentum eigen functions in the coordinate representation, box normalization and Dirac delta function.
Coordinate and momentum representations, Schrodinger equation in momentum representation,

Unit-II

Brief revision of linear vector spaces, inner or scalar product, Schwarz inequality, state vectors, general formalism of operator mechanics vector, operator algebra, commutation relations, eigen values and eigen vectors, hermitian operators degeneracy, orthogonality eigenvectors of Hermitian operators, noncommutativity of two operators and uncertainty in the simultaneous measurements of the corresponding dynamical variables, the fundamental expansion postulate, representation of state vector, Dirac's bra-ket notations. Matrix representation of operators, change of basis, unitary transformations,
quantum dynamics, Schrodinger, Heisenberg and interaction picture.

Unit-III

Solution of Schrodinger equation for simple problems, 1-D Square well, step and barrier potentials, 1-D harmonic oscillator, zero point energy. harmonic oscillator problem by operator method.
Angular momentum operator, commutation relations, expression for L^2 operator in spherical polar coordinates, Role of L^2 operators in central force problem, eigen value problem for L^2 separation of Schrodinger equation in radial and angular parts, solution of radial equation for hydrogen atom, 3-d square well potential, parity of wave function, parity operator.

Unit-IV

Generalized angular momentum, raising and lowering operators, matrices for J^2, Jx, Jy, Jzoperators,Pauli spin matrices, Addition of angular momenta, Clebich-Gordon Co-efficient, spin angular momentum, spin momentum functions.

Text and Reference Books:

1. Quantum mechanics: E. Merzbacher
2. Quantum mechanics: L.I.Schiff
3. Quantum mechanics: Mathews and Venkatesan
4. Quantum mechanics: Ghatak and Loknathan
5. Quantum mechanics: B.Craseman and J.D.Powell
6. Modern quantum mechanics: J.J.Sakurai
7. Quantum Theory D. Bohm, (Asia Publishing House)
8. Quantum Mechanics: 500 problems with Solutions: Aruldhas (PHI)

ELECTRODYNAMICS (MPH3T10)

Course Outcomes

CO1: Students will understand and able to apply Maxwell's equations to describe the behaviour of electromagnetic waves in different media, including vacuum and matter.

CO2: Students will be able to analyze the characteristics of electromagnetic waves, including plane waves, spherical waves, polarization, and their interactions with various surfaces.

CO3: Students will be able to explain the principles of absorption and dispersion of EM waves in conductors and non-conductors and the implications of permittivity's frequency dependence.

CO4: Students will be able to evaluate the behavior of guided waves in different types of waveguides, including TE, TM, and TEM modes, and understand the design and function of resonant cavities and dielectric waveguides.

CO5: Student will be able toa pply the concepts of scalar and vector potentials, gauge transformations, and retarded potentials to solve problems involving moving charges and radiation from various sources.

CO6: Student will understand the fundamental principles of the special theory of relativity, including Einstein's postulates, Lorentz transformations, and the structure of space-time, and apply these principles to relativistic mechanics and electrodynamics.

Prerequisites: REVIEW OF ELECTROSTATICS AND MAGNETOSTATICS: Laplace and Poisson Equations, Green's Functions Boundary Value Problems – Image Method, Separation of Variables Multipole Expansion, Dielectrics Vector Potential, Magnetic Dipole, Macroscopic Magnetic Media Magnetic Scalar Potential Boundary Value Problems – Image Method, Maxwell's Equations, Vector and Scalar Potentials, Gauge Transformations Poynting's Theorem, EM Conservation Laws

Unit-I

EM Waves: Scalar and Vector Waves, Plane waves, spherical waves, phase and group velocities and wave packets, Electromagnetic plane waves, harmonic plane waves, elliptic linear and circular polarization, Stokes parameters

EM Waves in vacuum: Maxwell's equations, the electromagnetic (EM) wave equation and its, energy and momentum in EM Waves.

EM Waves in matter: Propagation in linear non-conducting media, Reflection and Transmission at normal incidence, Reflection and Transmission at oblique incidence, Reflection and Transmission at a conducting surface

Unit II

Absorption and Dispersion: EM waves in conductors, Reflection at a conducting surface, The frequency dependence of permittivity.

Guided Waves: Wave Guides, TE, TM, TEM modes in a rectangular and cylindrical wave guide, Resonant Cavities, Dielectric waveguides, coaxial transmission line.

Unit III

Potentials: Scalar and Vector potentials, Gauge transformations, Coulomb Gauge and Lorentz Gauge, Retarded Potentials, Lienard-Wiechert Potentials, the fields of a moving point charge.

Radiation: Electric dipole radiation, Magnetic dipole radiation, Radiation from an arbitrary source, Power radiated by a point charge, radiation reaction.

Unit IV:

The special theory of relativity: Einstein's postulates, the geometry of relativity, the Lorentz transformations, the structure of space-time.
Relativistic Mechanics: proper time and proper velocity, relativistic energy and momentum, relativistic kinematics, relativistic dynamics.
Relativistic Electrodynamics: Magnetism as a relativistic phenomenon, how the fields transform, the field tensor, Electrodynamics in tensor notation, the 4-vector potential.

Text & Reference Books

1.Introduction to Electrodynamics by David J. Griffiths

2. Electricity & Magnetism – B. Ghosh.

3.Electromagnetic Theory and Electrodynamics' by Satya Prakash

X-ray Spectroscopy (MPH3T11)

Course Outcomes

Students will be able to understand

CO 1: Basic concepts of production of X-rays, Designing concepts conventional of X-ray generators, Basics of Advanced radiation source Synchrotron and its advantages over conventional sources.
CO 2: Interaction of X-rays with the matter, Applications of X-rays based on different physical processes involved after interaction of x-rays with matter.
CO 3: The method of X-ray radiography and its applications in medical and industrial fields. Details of materials characterization techniques based on X-ray photoelectron/Auger electron spectroscopies and X- ray fluorescence spectroscopy.
CO 4: Designing concepts of different X-ray spectrographs, Understanding the concepts and methods of x-ray detection. Gaining the knowledge to select proper spectrograph and detectors for particular application.
CO 5: Different theoretical concepts regarding X-ray spectra and their interpretation. Knowledge about calculating relative intensities of spectral lines.
CO 6: Interpretation of X-ray absorption spectra. Experimental techniques for obtaining X-ray absorption spectra and its important applications.
CO 7: The concept of dispersion of X-rays and its significance.

Unit I

Production of X-rays: Continuous and characteristic X-ray spectra. X-ray emission from thick and thin targets. Efficiency of X-ray production.Various types of demountable and sealed X-ray tubes.
Basics of high-tension circuits and vacuum systems used for the operation of X-ray tubes. Synchrotron radiation: Production and properties of radiation from storage rings, Insertion devices.

Unit II

Absorption of X-rays: Physical process of X-ray absorption. Measurement of X-ray absorption coefficients. Units of dose and intensity. Radiography, Microradiography and their applications.
X–ray fluorescence: Fluorescence yield. Auger effect.X–ray fluorescence analysis and its applications. Techniques and applications of Photoelectron spectroscopy and Auger electron spectroscopy.

Unit III

X-ray spectroscopy: Experimental techniques of wavelength and energy dispersive x-ray spectroscopy.

Bragg and double crystal spectrographs. Focusing spectrographs. Dispersion and resolving power of spectrographs, Photographic and other methods of detection, resolving power of detectors.

X–ray emission and absorption spectra. Energy level diagram. Dipole and forbidden lines, Satellite lines and their origin, Regular and irregular doublets. Relative intensities of X- ray lines.

Unit IV

Chemical Effects in X-ray Spectra: Chemical effects in X-ray spectra. White line, Chemical Shifts of absorption edges, Fine structures (XANES and EXAFS) associated with the absorption edges and their applications.

Dispersion Theory: Dispersion theory applied to X-rays, Calculation of the dielectric constant, Significance of the complex dielectric constant, Refraction of X-rays, Methods for measurement of refractive index

Text and Reference Books

1. A. H. Compton and S. K. Allison: X-rays in Theory and Experiment
2. J. A. Nielsen and D. Mc. Morrow: elements of Modern X-ray Physics.
3. M. A. Blokhin: X-ray Spectroscopy.
4. E. P. Bertin: Principles and Practice of X-ray Spectrometric Analysis.
5. C. Bonnelle and C. Mande: Advances in X-ray Spectroscopy.
6. D. C. Koningsberger and R. Prins: X-ray Absorption Principles, Applications, Techniques of EXAFS, SEXAFS and XANES.
7. C. Kunz: Synchrotron Radiation.

Materials Science (MPH3T11)

Course Outcomes

Students will be able to:

CO 1: Understand the principles of thermodynamics, phases of different systems in materials.

CO 2: Analyse the kinetics of phase transformations, nucleation and growth techniques for the formation of crystal structure.

CO 3: Study the concept of heat treatment of steels and Al-alloys, Solidification and Casting.

CO 4: Understand the concept of synthesis of materials and its importance.

CO 5: Study the synthesis of materials with different physical and chemical techniques, implicate the same for the synthesis of different materials.

CO 6: Acquire the ability to understand and analyse the processing of different materials, sintering methodologies etc.

CO 7: Study vitrification reactions, phenomenon of particle coalescence, Quenching: concept, glass formation etc. in different material system.

Unit-I

Review of general principles of thermodynamics: Entropy. Internal energy. Free energy. Chemical potential. Entropy of mixing. Free energy of ideal and regular solid solutions. Phase rule.Types of phase diagrams. Study of Fe-C,Cu-Ni,Cu-Zn,CaO-SiO_2systems.

Unit–II

Phase Transformations: Kinetics of phase transformations. Homogeneous and heterogeneous nucleation and growth. Continuous and discontinuous reactions. Precipitation, spinodal and eutectoidal transformation. Heat treatment of steels and Al-alloys. Solidification and Casting. Zone refining. Single crystal growth techniques.

Unit-III

Concept of Synthesis: Concept of equilibrium and nonequilibrium processing and their importance in materials science.
Synthesis of materials: Physical method – Bottom up: cluster beam evaporation, Ion beam deposition, Gas evaporation, Chemical method – Hydrothermal, combustion, bath deposition with capping techniques and top down: Ball milling. Solvated metal atom dispersion–thermal decomposition–reduction methods–colloidal and micellar approach.

Unit-IV

Processing of materials: Metallic and nonmetallic, Ceramics and other materials. Only basic elements of powder technologies, calcination, compaction, sintering methodologies: Conventional heating, Microwave, Electric discharge vitrification reactions, with different example, phenomenon of particle coalescence, porosity. Quenching: concept, glass formation.

Text & Reference books:

1. Mats Hillert, Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic Basis, Cambridge University Press; 2 edition
2. V. Raghvan : Materials Science.
3. Chemical approaches to the synthesis of inorganic materials, C.N.R. Rao WileyEasternLtd.1994.
4. Materials Science &Engineering–An Introduction, by W.D. CALLISTER

Basic Nanoscience and Nanotechnology (MPH3T11)

Course Outcomes

CO 1: Students will be able to create knowledge about basic idea of nanomaterials, Quantum wells, wires, dots, Colour tuning of phosphors with particle size and activators.
CO 2: Students will be studies the difference synthesis of nanomaterials, analyse the materials with different applications, especially green synthesis for bio-applications and chemical methods for industry application.
CO 3: Student understand the characterized of nanomaterials and evaluate the specific study by different technique such as UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Scanning Electron Microscopy, Transmission Electron Microscopy.
CO 4: Students apply the idea on the basis on characterization of nanomaterials for scientific and biological applications. Specifically, on the perovskite nanomaterials and semiconductor nanomaterials for LED, display and Metal nanomaterials for bio-applications.

Unit I

Introduction to Nanoscience:

Free electron theory and its features (Introduction), Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size, Size dependence properties. Determination of particle size, Increase in width of XRD peaks of nano-particles, shift in photoluminescence peaks, Colour tuning of phosphors with particle size and activators.

Unit II

Synthesis of Nanomaterials:

High energy Ball Milling, Physical vapour deposition, Green synthesis by using plants, Chemical vapour deposition, Micro emulsions, Sol-gel method, Combustion method, Wet chemical method, Spray pyrolysis, Panchagavya methods.

Unit III

Nanomaterials Characterizations*:*

X-ray diffraction, UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Tunnelling Electron Microscopy, Atomic Force Microscopy, Vibration Sample Magnetometer, Spintronic

Unit IV

Nanomaterials Properties and Applications*:*

Energy nanomaterials for power saving, storage and generation, perovskite nanomaterials and semiconductor nanomaterials for LED, display, super capacitor and solar cell. Metal nanomaterials for bio-applications. Nanomaterials for defence and space devices (two or three applications). Mechanical, Thermal, Electrical, Optical, Magnetic, Structural properties of nanomaterials.

Text and reference books:

1. H.S.Nalwa; Hand book of Nanostructure materials and nanotechnology; (Vol.1-5), Acad. Press, Boston, 2000
2. C.P.Poole Jr., F.J.Owens; Introduction to Nanotechnology, John Wiley and sons, 2003
3. T.J.Deming; Nanotechnology; Springer Verrlag, Berlin, 1999
4. W.D.Callister Jr., Materials Science and Engineering, 6th Eds, WSE Wiley, 2003
5. S.K.Kulkarni; Nanotechnology: Principles and Practical; Capital Publ. Co. New Delhi
6. Rainer Waser,; Nanoelectronics and Information technology; Wiley VCH.
7. Fausto, Fiorillo ; Measurement and Characterization of Magnetic materials
8. Bhushan; Hand Book of Nanotechnology
9. Janos H., Fendler; Nanoparticles and Nanostructured Films
10. T.Pradip; Nano: The Essentials
11. Liu; Hand Book of Advanced Magnetic Materials (4 Vol.)
12. Lakhtakia; Nanometer Structure

Computational Modelling and Simulation(MPH3T11)

Course Outcomes

CO1: Students will gain a foundational understanding of Density Functional Theory, focusing on its principles, the variational approach, and the self-consistent field method

CO2: Students will develop practical skills in applying Density Functional Theory (DFT) to perform electronic structure calculations and analyze material properties.

CO3: Students will gain expertise in computational techniques and theories for electronic structure analysis using Gaussian software, with applications in molecular and material science.

CO4: Students will utilize MATLAB Simulation capabilities for solving mathematical problems, performing data analysis, and simulating electronic circuits.

Unit- I

Computer Application in Physics: Computational Physics, Monte Carlo Method, Random Numbers, Non Uniform distribution, Numerical Solutions of Schrodinger equations, Born Oppenheimer approximation, Hartee Fork Approximation, Hohenberg-Kohn Theorems, Kohn – Sham equation

Unit-II

Density Functional Theory: Introduction of Density functional theory, Electronic structure calculation on simple Solids,The variational principle and self-consistent Field Approach, Pseudopotential: Brillouin zone, Band Calculation, First Principle Calculation, Classical Molecular Dynamics

Unit-III

Electronic Structure Methods by using Gaussian : Numerical Integration and Grids, Basic sets, Density Fitting Basis Sets, Atomic Charge distribution, Wave function stability , Computing vibrational properties, Classical energy minimization techniques : Energy minimization by simplex, steepest descent, conjugate gradient and Newton-Raphson methods, Hartee Fock Theory, Schrodinger's Equation and Molecular Hamiltonian, couple cluster Theory, Moller Plesset Perturbation Theory, Isodesmic Reaction, NMR Shielding Tensor Component, Franck-Condon Analysis

Unit-IV

MATLAB & SIMULINK : Introduction and Fundamentals of MATLAB: Variable & Values, Scripts, Loops, Logical Functions, M-Files, Matrices, Solution of simultaneous equation in MATLAB, Curve Fitting and Interpolation, Numerical Differentiation , Electronic Circuit Simulation by MATLAB

Reference Books

[1] Density Functional Theory: A Practical Introduction, by. Sholl, and J. A. Steckel,, *Wiley*

[2] Electronic Structure: Basic Theory and Practical Methods by R. M. Martin,

[3] Computational Physics,by J. M. Thissen Cambridge University Press

[4] Computational Statistics by Geof H. Given and Jennifer A. Hoeting

[5] Simulation Modeling and analysis by, Averill M. Law and W. David Kelton

[6] Essentials of Computational Chemistry: theories and models , by Christopher J. Cramer

[7] MATLAB forBeginner: Gentle Approch, Peter Issa Kattan

[8] John Wiley, 2004Physical Modelling In MATLAB, by Allen Downey

[9] Differentials Equations with applications and Historical notes by Simmons G.F

Semester III List of Practical's (3PI) (MPH3P05)

Materials Science

1. Crystal structure determination by powder diffraction.
2. Study of microstructures of metal alloys.
3. Dislocation in alkali halide crystals.
4. Crystal growth from slow cooling of the melt.
5. Thermal analysis of binary alloy.
6. Differential thermal analysis of BaTiO3-PbTiO3 solid solution.
7. To study electrochemical method of corrosion control.
8. Dielectric behavior of LiNbO3 and BaTiO3 in crystals and ceramics.
9. Electrical conductivity of ionic solids.
10. To test hardness of a material by Brinell hardness tester.
11. Photo elasticity study.
12. Multiple beam interferometric study of surfaces.
13. Thermal conductivity of bad conductor. 14. Thermal expansion coefficient of metals.
15. Study of transport property in solid electrolytes.
16. Verification Nernst law/Oxygen sensor.
17. Determination of Thermoelectricity Power.

X-Rays

1. Study of Crystal Models.
2. X-ray Diffraction Photograph of a Metal Foil by transmission (Hull Method).
3. X-ray Diffraction Photograph of a Metal Foil by Back Reflection.
4. Powder Photograph by Debye Scherrer Method, Computer Analysis.
5. Laue Photograph and Gnomonic Projection.
6. Rotation oscillation Photograph.
7. Diffraction of X-rays by Liquids.
8. Bragg's Spectrometer: Uhler and Cooksey's method. 55
9. Bent Crystal (Cauchois) Transmission Type Spectrograph: Study of K and L Absorption Edges.
10. Bent Crystal (Cauchois) Transmission Type Spectrograph: Study of K and L Emission Spectra.
11. Measurement of Intensities of Emission Lines, Computer Analysis.
12. Study of Satellite Lines. 13. Analysis of XANES Spectrum, Computer Analysis.
14. Analysis of EXAFS Spectrum, Computer Analysis.
15. Determination of Planck's constant by X-rays.
16. X-ray Fluorescence Spectrum Analysis.
17. Absorption Coefficient for X-rays by G. M. / Scintillation Counter.
18. Characteristics of G. M. tube.
19. Compton Effect.
20. Operation of a Demountable X-ray Tube.

Nanoscience and Nanotechnology

1. Synthesis of metal oxide nanoparticles by wet chemical method.
2. Deposition of thin films by spray pyrolysis technique.
3. Synthesis of inorganic nanomaterials by combustion method.
4. Synthesis of nanomaterials by sol-gel method.
5. Synthesis of conducting polymer nanofibres by chemical oxidation method.
6. Study of optical absorption of nanoparticles.
7. Determination of particle size of nanomaterials from x-ray diffraction.
8. Study of photoluminescence of well-known luminescent nanoparticles.
9. Deposition of thin films by spin coating method.
10. Thermoluminescence study of nanomaterials.
11. Deposition of thin films by dip coating technique.
12. Study of particle size effect on luminescence.
13. Electrical characterization of nanostructured materials.
14. Synthesis of metal oxide nanoparticles by hydro-thermal method.
15. Deposition of thin film in vacuum.
16. Electrical resistivity of nanomaterials using four probe method
17. Photoluminescence study of prepared red/blue/green luminescent nanomaterials.
18. Characterization of nanomaterials using SEM/TEM.
19. Computer modelling methods for studying materials on a wide variety of lengthand time scales.

Computational Modelling and Simulation

1. Energy band calculation by quantum expresso.
2. Determine solution of simultaneous equations by matlab.
3. Curve fitting and interpolation by matlab
4. Simulate electronic circuit by matlab.
5. Determine vibration state of molecule by Gaussian.

Project/Dissertation (MRP3P01)

SEMESTER IV

Nuclear and Particle Physics (MPH4T12)

Course Outcomes

On completion of the course, student will be able to

CO1 – Describe basic properties of nuclei, nuclear interactions, nuclear structure and reactions.
CO2 – Identify the strengths and limitations of various nuclear models.
CO3 – Relate theoretical predictions and measurements of Quantum mechanical reasoning in classification of processes in subatomic world.
CO4 – Apply the knowledge of basic laws of conservation and momentum in the determination of particle properties and properties of processes in the subatomic world.
CO5 - Work on elementary problem solving in nuclear and particle physics, and relating theoretical predictions and measurement results.
CO6 – Demonstrate the ability to critically evaluate the results in nuclear and particle physics.

UNIT 1

Nuclear structure and properties: size, radii, shape, charge radius, spin, parity, nuclear & atomic mass, binding energy, electric and magnetic moment of nuclei, isospin.

Nuclear forces and two body problems: Ground state of deuteron, Wave equation of deuteron & its solution, Excited states of deuteron, Normalization of the deuteron wave function, radius of deuteron, Low energy neutron-proton scattering, Scattering length, Spin dependence of n-p interaction, Charge independence and charge symmetry.

UNIT 2

Nuclear Models: Liquid drop model, Bethe- Weizsacker formula, Applications of the Semi-empirical binding energy formula, Nuclear shell structure, Single particle states in nuclei, Applications of extreme single particle shell model, Collective model.

Radioactivity: Alpha particles and Geiger-Nuttall law, Beta particles & Fermi theory of allowed beta decay, Allowed & forbidden transitions, selections rules in beta decay, Gamma decay & Radiative transitions in nuclei, Nuclear isomerism & Internal conversion.

UNIT 3

Nuclear reactions: Types of nuclear reactions, Conservation laws, Compound nucleus hypothesis, Direct reactions, Nuclear fission & its Bohr-Wheeler theory, Nuclear fusion & Thermonuclear reaction, Power & Nuclear reactors in India.

Nuclear radiation detectors: Proportional counter, Geiger-Muller counter, Scintillation detector, Semiconductor detectors, Cherenkov detector.

Particle accelerators: Linear accelerators, Van de Graaff, Cyclotron, Betatron, Ion beam accelerators, Accelerators in India.

UNIT 4

Elementary Particles: Fundamental Interactions in nature, Classification of elementary particles, Conservation laws, Resonance particles, Symmetry Classification of Elementary particles, Quark Hypothesis, Quark structures of Mesons and Baryons, Quantum Chromodynamics, Charmed quark, Beauty & Truth, Unification of weak and Electromagnetic Interaction, Higgs boson.

Text & Reference books

1. Introductory Nuclear Physics, Kenneth S Krane, Wiley, New York ,1988.
2. Nuclear and Particle Physics: Brian Martin.
3. Atomic and Nuclear Physics: S.N. Ghoshal.
4. Introduction to Particle Physics: D. Griffiths.
5. Introduction to Nuclear Physics: F. A. Enge, Addison Wesley (1975)
6. Introductory Nuclear Physics: Burcham

Quantum Mechanics II (MPH4T12)

Course Outcomes

CO1: Students will develop a knowledge and understanding of perturbation theory, level splitting and radiative transitions.
CO2: Students will be knowing about the Einstein's coefficients and relating them to lasers.
CO3: Students will be able calculate the ground state and excited state energies of various systems by using variational principle, WKB method, perturbation methods and Born Oppenheimer approximation.
CO4: Students will know about scattering in different frames and can easily calculate scattering amplitude and scattering cross section.
CO5: Students will be able to write total energy and wave function for system of identical particles.
CO6: Students will gain knowledge about relativistic wave equations along with understanding of spin, spin-orbit interactions, magnetic moment due to spin.

Unit- I

Time independent perturbation theory, first order perturbation theory applied to non-degenerate states, second order perturbation extension to degenerate state, Application of perturbation theory to the ground state energy, He atom (calculation given in Pauling and Wilson)

Normal and anomalous Zeeman effect, First order Stark effect in the ground and first excited states of H atom and second order Stark effect of H atom, an-harmonic oscillator.

Unit II

Time dependent perturbation theory, transition rate, Fermi Golden rule, constant perturbation harmonic in time, radiative transitions, absorption and induced emission, atomic radiation, dipole approximation, Einstein's atomic radiation, Einstein's A and B coefficients and their calculations.

Approximation methods: W. K. B. method and its application to barrier penetration. Variational principle and its application to simple cases like ground state of He atom

Unit III

System of identical particles, exchange and transposition operators, totally symmetric and antisymmetric wave function and their expressions for a system of non-interacting particles, statistics of systems of identical particles. Born-Oppenheimer approximation.

Scattering theory, scattering cross-section in laboratory and centre of mass system, scattering by a central potential, Partial wave method, phase shifts and their importance, scattering by a square well potential and a perfectly rigid sphere, resonance scattering.

Unit IV

Relativistic wave equation, the Klein-Gordon equation and initial difficulties in interpreting its solutions, Dirac's relativistic equation, Dirac's matrices, explanation of the spin of the electron, equation for an electron in an electromagnetic field and explanation of the magnetic moment due to the electron spin, spin-orbit interaction, solution for hydrogen atom in Dirac's theory, negative energy states and their qualitative explanations.

Text and References Books:

1. E. Merzbacher, Quantum Mechanics (Wiley and Sons-Toppon)
2. J. L. Powell and B. Crasemann, Quantum mechanics (B I Publications)

3. L. I. Schiff, Quantum Mechanics (McGraw-Hill)
4. Quantum Mechanics: Aruldhas
5. Pauling and Wilson, Introduction to Quantum Mechanics
6. A.K. Ghatak and Lokanathan, Quantum Mechanics (Macmillan, India)
7. Quantum Mechanics: 500 problems with Solutions: Aruldhas (PHI)

Solid State Physics (MPH4T14)

Course Outcomes

CO1: Students will be able to create knowledge on the electrons moving in one and three dimensional potential wells, quantum state and degeneracy, density of states, electrical and thermal conductivity of metals. Also evaluate the study on the basis of band theory.
CO2: Student understand the atomic motions, adiabatic principle, harmonic approximation, dispersion relations, acoustic and optical phonons as well as understand the Dulong and Petit'slaw, Einstein and Debye models for lattice dynamic theory.
CO3: Students apply the idea on the basis of semiconductor and magnetics properties of solid materials and create knowledge for conductivity and paramagnetism study of materials.
CO4: Students understand the study of superconductor on the basis of Type I and II super conductors, Meissner effect, isotope effect, and concentrate of high temperature superconductor for future study.

Unit I

Free Electron Theory: Electrons moving in one and three dimensional potential wells, quantum state and degeneracy, density of states, electrical and thermal conductivity of metals, relaxation time and mean free path, the electrical resistivity of metals, thermonic emission. Seebeck effect, thermoelectric power.
Band Theory: Bloch theorem, the Kronig- Penney model, construction of Brillouin zones, extended and reduced zone schemes, effective mass of an electron, tight binding approximation. Fermi surface.

Unit II

Lattice Dynamics: Energy of atomic motions, adiabatic principle, harmonic approximation, cyclic boundary condition. Lattice vibrations of linear monoatomic and diatomic chains. Dispersion relations, acoustic and optical phonons.
Theories of lattice specific heat, Dulong and Petit'slaw, Einstein and Debye models, T3 law, Born procedure, anharmonicity and thermal expansion.

Unit III

Semiconductors: Free carrier concentration in semiconductors, Fermi level and carrier concentration in semiconductors, effect of temperature on mobility, electrical conductivity of semiconductors, Hall effect in conductors and semiconductors.
Magnetic Properties
Quantum theory of paramagnetism, magnetism of iron group and rare earth ions,.exchange interactions. Pauli paramagnetic susceptibility

Unit IV

Superconductivity

Type I and II super conductors, Meissner effect, isotope effect, microwave and infrared properties. Elements of B. C. S. theory, tunnelling Josephson effect. Ginzsburg- Landau theory and application to Josephson effect: d-c Josephson effect, a-c Josephson effect. Vortices and type I & type II superconductors, high temperature superconductor (elementary).

Text and Reference books:

1. C. Kittle: Introduction to Solid State Physics (2nd and 4th Edition).
2. A. J. Dekker: Solid State Physics.
3. Kubo and Nagamiya : Solid State Physics.
4. Feynman Lectures: Vol. III.
5. Board and Huano : Dynamical Theory of Crystal Lattice.
6. N. W. Ashcroft and D. Mermin: Solid State Physics.

X-Ray Diffraction (MPH4T15)

Course Outcomes

Students will be able to understand.

CO1: Concepts of crystal classes, lattices, symmetries, methods of Crystallographic Projections, Point groups, space groups and relationship between real and reciprocal lattice.
CO2: Different X-ray Scattering processes involved in X-ray diffraction.
CO3: Physical Basis of X-ray Crystallography, Different theoretical concepts to interpret and analyse x-ray diffraction pattern.
CO4: Different X-ray diffraction based experimental techniques used for materials characterization.
CO5: Interpretation of different phase formation phenomenon in materials using x-ray diffraction technique.
CO6: Comparison of different diffraction techniques with that of x- diffraction. Advantages, disadvantages and applicability.

Unit I

Space lattice and unit cell of a crystal, Choice of a unit cell, Crystal systems, Bravais lattices, Crystal faces and internal arrangement, Miller indices, Law of rational indices, Indices of a direction. Point groups, Space groups.
Perspective projections: Gnomonic projection, Stereographic projection, Orthographic projection.
Reciprocal lattice concept: Graphical construction, Relation to interplanar spacing, Interpretation of Bragg's law.

Unit II

Scattering of X-rays: Thomson scattering, Compton scattering, wave mechanical treatment of scattering, scattering by a pair of electrons, Theory of scattering by a helium atom, Scattering by many electrons, Experiments on scattering by monatomic and polyatomic gases, liquids and amorphous solids.

Unit III

Physical Basis of X-ray Crystallography: Atomic and crystal structure factors, Structure factor calculations, integrated intensity of reflection. Different factors affecting the intensity of diffraction lines in a powder pattern. Dynamical theory X-ray diffraction.

The Fourier Transform, electron density projections in crystals, Application to X-ray diffraction.

Unit IV

Experimental Methods of Structure Analysis: Laue method, Debye-Scherrer method, rotation Oscillation method, Weisenberg camera, sources of systematic errors and methods of attaining precision. Principles of energy dispersive and time analysis diffractometry. Methods of detecting and recording diffraction patterns.

Structures of metals and alloys. Phase transformations, Order-disorder phenomenon. Superlattice lines. Determination of grain size. Other Diffraction Techniques: Electron and neutron diffraction techniques and theirapplications. Comparison with X-ray diffraction.

Text and Reference Books:

1. A. H. Compton and S. K. Allison: X-rays in Theory and Experiment.
2. N. F.M. Henry, H. Lipson and W. A. Wooster: The interpretation of X-ray DiffractionPhotographs.
3. K. Lonsdale: Crystals and X-rays.
4. B. D. Cullity: elements of X-ray Diffraction.
5. M. M. Woollfson: X-ray Crystallography.
6. M. J. Buerger: X-ray Crystallography.
7. Bacon: Neutron Physics.

Properties of Materials (MPH4T15)

Course Outcomes

CO1: Knowledge and skills to understand and analyse the mechanical response of materials
CO2: Identify various forms of corrosion and design corrosion prevention techniques.
CO3: Analyzing Types and Mechanisms of Diffusion in metals, alloys, and ionic solids.
CO4: Understanding ionic conduction mechanism and Experimental Skills in Solid State Ionics.

Unit-I Mechanical response of Materials:

Elasticity, model of elastic response, inelasticity, viscoelasticity, stress –strain curves, concept of various mechanical properties such as hardness, yield strength, toughness, ductility, yield toughness, ductility, brittleness, stiffness, young modulus, shear modulus, shear strength, Frenkel model, Peierls -Nabarro relation, Plastic deformation

Unit-II Corrosion and degradation of materials:

Electrochemical considerations – Corrosion Rates-Prediction of corrosion rates- -Passivity- Forms of corrosion – Corrosion prevention- Oxidation- Corrosion of Ceramic Materials- Degradation of Polymers

Unit-III

Laws of diffusion. Solution of Fick's diffusion equation under simple boundary conditions. Types of diffusion. Diffusion and concentration gradient. Compositional dependence of diffusion. Diffusion in metals and alloys, Methods of determining diffusion coefficients. Diffusion in ionic solids. Diffusion and conductivity.

Unit-IV

Solid State Ionics: Types of Ionic Solids-Fast Ionics Solids-Point Defect Type-Sub Lattice type – Fast Ionic materials – alkali metal ion conductors - β aluminas- Silver ion conductors-Cation conductors- Oxygen ion conductors – Halide ion conductors – Proton conductors – Electronic conductors with ionic transport.

Reference Books

1. Martin Eden Glicksman, Diffusion in Solids: Field Theory, Solid-State Principles, and Applications,Wiley-Interscience;1edition
2. A.R. West, Solid State Chemistry.
3. S. Chandra, Superionic Solids.
4. Principles of Electronic Ceramics, L.L.HenchandJ.K. West, (John Wiley & Sons, NewYork,1990).
5. Materials Science &Engineering–An Introduction, by W.D. CALLISTER

Applied Nanoscience and Nanotechnology (MPH4T15)

Course Outcomes

CO 1: Students will be able to understand accurate description of optical properties of material and basics of non-linear optics at nanoscale.

CO 2: Students will be able to understand the basic magnetic parameters, the magneto-transport in nanoscale systems and gain the knowledge of basic mechanisms for tuning the magnetic properties.

CO 3: Students will be able to implicate the basic knowledge of Nano-CMOS to design the circuit and physical design for the single electron transistor.

CO 4: Students will be able to know the meaning of composite materials and their differences with respect to conventional materials.

CO 5: Students will be able to analyses the essential data on nanoscale materials dispersed in, or chemically bonded with metal/ceramic/polymer matrix.

Unit – I:

Nanophotonics: Fundamentals of photonics and photonic devices, Lasers, CFLs, LEDs, OLEDs, wall paper lighting, Display devices, X-ray imaging nanophosphers, Photo therapy lamps and its applications, Nanomaterials for radiation, Dosimetery special for thermoluminescence. Optical stimulated luminescence, Luminescence solar concentration.

Unit – II:

Nanomagnetics: Basics of Ferromagnetism, effect of bulk nanostructuring of magnetic properties, dynamics of nanomagnets, nanopore containment, giant and colossal magnetoresistance, applications in data storage, ferrofluids, Superparamagnetism, effect of grain size, magneto-transport, Magneto-electronics, magneto-optics, spintronics.

Unit – III:

Nanoelectronics: Top down and bottom up approach, CMOS Scaling, Nanoscale MOSFETs, Limits to Scaling,System Integration, Interconnects;

NanoDevices: Nanowire Field Effect Transistors, FINFETs, Vertical MOSFETs, Other Nanowire Applications, Tunneling Devices, Single Electron Transistors, Carbon nanotube transistors, Memory Devices,

Unit – IV:

Nanocomposites: Classification of nanocomposites, Metallic, ceramic and polymer nanocomposites, Tribology of polymeric nanocomposites, Nano ceramic for ultra-high temperature MEMS, optimizing nanofiller performance in polymers, Preparation techniques, Graphene/Fullerene/Carbon nanotube (CNT) polymer nanocomposites, One dimensional conducting polymer nanocomposites and their applications

Text and reference books

1. H.S.Nalwa; Hand book of Nanostructure materials and nanotechnology; (Vol.1-5),Acad. Press, Boston, 2000
2. C.P.Poole Jr., F.J.Owens; Introduction to Nanotechnology, John Wiley and sons,2003
3. C. Furetta; Hand book of thermoluminescence; World Scientific Publ.
4. S.W.S. McKEEVER; Thermoluminescence in solids; Cambridge Univ. Press.
5. Alex Ryer; Light measurement hand book; Int. light Publ.
6. M.J.Weber; Inorganic Phosphors; The CRC Press.
7. T.J.Deming; Nanotechnology; Springer Verrlag, Berlin, 1999
8. W.D.Kalister Jr., Materials Science and Engineering, 6th Eds, WSE Wiley, 2003
9. Gusev; Nanocrystalline Materials
10. C. Delerue, M.Lannoo; Nanostructures theory and Modelling
11. Fausto, Fiorillo ; Measurement and Characterization of Magnetic materials
12. Bhushan; Hand Book of Nanotechnology
13. Janos H., Fendler; Nanoparticles and Nanostructured Films
14. T.Pradip; Nano: The Essentials

Acoustics & Ultrasonics (MPH4T15)

Course Outcomes

CO 1: Student will have the understanding of basic fundamentals of ultrasonics along with its interaction in liquids and gases.

CO 2: Students will have the knowledge of architectural acoustics, and will be able to calculate relations between different acoustic parameter for various enclosures.

CO 3: Student will have the knowledge of underwater acoustics and sound transmission losses and masking.

CO 4: Students will have the deep learning of electro acoustic transducers such as microphones and loudspeakers.

CO 5: Students will be able to identify the frequency content of the sound source and will be able to explain the effects of sound propagation.

CO 6: Student will get the understanding of low and high frequency responses and how they affect the design of loudspeakers enclosures.

CO 6: Students will have the understanding of high fidelity stereo surround sound production and its reproduction.
CO 7: Student will get the deep knowledge and understanding of environmental noise.
CO 8: Students will be able to determine overall band levels and speech interference level along with noise criteria for different spaces.

Unit I

Fundamentals of ultrasonics: Acoustic interaction with liquids; Velocity in fluids; Absorption due to heat conduction and viscosity; Single relaxation; internal degrees of freedom; Relaxation in binary mixtures; normal and associated liquids; essential differences in low and high amplitude ultrasonic waves; propagation of low amplitude waves; piezo-electric effect; Propagation in solids; Attenuation due to electron-phonon interaction; phonon-phonon interaction;

Measurement techniques: Optical method, Interference method, Pulse method; Sing-around method; Applications of ultrasound in industrial and medical fields.

Unit II

Architectural acoustics: decay of sound in live and dead rooms; Measurement of reverberation time; effect of absorption on reverberation; sound absorption coefficient; absorbing materials and their uses. public address system and music sound system for auditoria; Instruments used for acoustical tests;

Underwater acoustics: Velocity of sound in sea-water; sound transmission loss in sea water; Refraction phenomena; masking by noise and by reverberation.

Unit III

Loudspeakers, microphones and amplifiers: Idealized direct radiator; typical cone speaker; effect of voice coil parameters; horn loudspeakers; pressure response; woofer, mid-range and tweeter loudspeakers; subwoofers, cross-over networks; Fletcher-Munson curves; Baffles: infinite type, vented type, acoustic suspension type;

Microphones: moving coil type; condenser microphones; Polar response; cardiod response type; Rating of microphone responses; Reciprocity theory and calibration; RIAA equalization; pre-amplifiers; equalization amplifiers; noise filters; Dolby noise reduction; high-fidelity stereo amplifiers; recording and reproduction of sound, home theater recording and reproduction.

Unit IV

Noise: Decibels and Levels: dB scales in acoustics; reference quantities for acoustic intensity, pressure and power; determination of overall levels from band levels; basic sound measuring system using sound level meter; octave band analyzer; acoustic calibrator; Speech interference levels; noise criteria for various spaces; nomogram relating SPL in octave bands to loudness in tones; computation of loudness levels and speech interference levels

Text and reference books

Fundamentals of acoustics: *L.E.* Kinsler and *A.R.* Frey (Wiley Eastern)
Acoustics, sound fields and Transducers : L. Beranek and TJ Mellow (Academic Press)
Noise reduction: L.L. Beranek
Fundamentals of Ultrasonics: J. Blitz *(Butterworths)*
Ultrasonic absorption: A.B. Bhatia
Acoustical tests and measurements: Don Davis

ELECTROCHEMICAL ENERGY STORAGE (MPH4T15)

Course Outcomes

CO1: Students will be able to describe the fundamental concepts and importance of energy storage systems, identify their applications in the power and transportation sectors, and explain the significance of energy storage in electric vehicles.

CO2: Students will be able to explain the working principles of electrochemical energy storage systems, differentiate between primary and secondary batteries, and identify the components and chemistries of lithium-ion and sodium-ion batteries.

CO3: Students will be able to describe the concepts, classifications, and working mechanisms of supercapacitors, distinguish between capacitors, supercapacitors, and batteries, and explain the operational principles and types of fuel cells, including hybrid systems.

CO4: Students will be able to analyze transport phenomena in energy storage systems, including concentration polarization, Warburg impedance, and transport in various media, and apply scaling analysis to evaluate energy storage performance.

Unit I: Energy Storage

Energy storage systems overview, Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors, Importance of energy storage systems in electric vehicles, Current electric vehicle market

Unit II: Batteries

Introduction to electrochemical energy storage and conversion, Working principle of battery, Primary and secondary (flow) batteries, Basic components in Lithium – ion batteries: Electrodes, Electrolytes, and collectors, Major battery chemistries and their voltages, Characteristics of commercial lithium ion cells, Sodium ion rechargeable cell, Introduction to battery pack design

Unit III: Supercapacitor and Fuel Cell

Introduction to Supercapacitor, Concept, Classification and working, Electrochemical double layer capacitor, Pseudo capacitor and Hybrid Supercapacitor, Difference between capacitor and supercapacitor and Battery, Advantages, disadvantages and applications of supercapacitors, Advanced materials and technologies for supercapacitors, Operational principle of a fuel cell, Types of fuel cells, Hybrid fuel cell-battery systems, Hybrid fuel cell-supercapacitor systems

Unit IV: Transport Phenomena

Concentration Polarization, Warburg Impedance, Transport in Solids, Concentrated Solutions, Bulk Electrolytes, Transport in Porous Media, Scaling Analysis of Energy Storage

Reference Books

1. Bagotsky, V.S., Skundin, A.M. and Volfkovich, Y.M., 2015. Electrochemical power sources: batteries, fuel cells, and supercapacitors. John Wiley & Sons.
2. Conway, B.E., 2013. Electrochemical supercapacitors: scientific fundamentals and technological applications. Springer Science & Business Media.
3. Allen, J. and Bard, R.L., 2000. Faulkner. Electrochemical Methods: Fundamentals and Applications, John Wiley and Sons. Inc. New York.

QUANTUM COMPUTING (MPH4T15)

Course outcomes

CO1: Learn about density operator and q-bits and quantum measurements
CO2: Learn about quantum no-cloning
CO3: Learn various quantum algorithms and how they differ from classical algorithms
CO4: Learn about quantum entanglement, EPR paradox and reasons for continuing discussions on foundations of quantum mechanics.

Unit I: Linear Algebra, Quantum Measurement

Review of linear vector spaces and operators: Inner product, Hilbert space; Outer product representation, Matrices, Unitary and Hermitian operators, normal and positive operators; Eigen systems, Spectral decomposition; Tensor product; Functions of operators.
Quantum kinematics: States, superposition; Quantum dynamics: Unitary evolution; Quantum measurements: Measurement postulates, distinguishing between states, projective measurements, No-cloning theorem

Unit II: Qubits and Gates

Single qubit system, Bloch sphere representation; Multiple Qubits: Two qubit states, multiple qubit states; tensor product representation
Circuit model of quantum computation; Single qubit gates, Pauli, Hadamard, phase and T gates, Bloch sphere rotations, Operator decompositions; Two qubit gates, controlled-NOT gate, Controlled-U gates, Toffoli gate, universal quantum gates; Quantum circuits, Bell states and entanglement, Quantum teleportation

Unit III: Density Operators, Entanglement
Quantum entanglement; Density operators; Evolution and state collapse; Ensemble of pure states; unitary freedom in ensemble choice; Quantum postulates with density operator; Pure and mixed bipartite states; Reduced density operator, Schmidt decomposition; Quantum correlations, Bell's inequalities, EPR paradox
Entanglement of pure bipartite states, entanglement entropy; Concepts of entanglement cost and distillable entanglement; Entanglement of mixed states. Peres partial transpose criterion.
Introduction to quantum error correction: necessity of and difficulties in quantum error correction, repetition code, 3-qubit error detection code: detection (syndrome diagnosis) and recovery, rand error correcting codes, 3-qubit phase-flip code, Shor 9-qubit code

Unit IV: Quantum Algorithms and Quantum Cryptography
Quantum algorithms, Deutsch and Deutsch-Jozsa algorithms, Bernstein-Vazirani and Simon's problems, Quantum Fourier transform; Grover's quantum search algorithm
Basic concepts of classical cryptography, keys and the key distribution problem and outline of its solution; One-time pad encryption; Introduction to quantum cryptography. BB84, B92 protocols; Introduction to security proofs for these protocols.

Text books

1. Nielsen, Michael A., and Isaac L. Chuang, *Quantum Computation and Quantum Information*, Cambridge University Press, September 2000, ISBN: 780521635035.

2. N. David Mermin, *Quantum Computer Science: An introduction*, Cambridge University Press (2007), ISBN: 978-0-521-87658-2.

Reference Books / Papers

1. Collin Williams, *Explorations in Quantum Computing* (2nd Ed.), Springer- Verlag, 2011, ISBN 978-1-84628-886-9.
2. Noson S. Yanofsky and Micro A. Mannuci, *Quantum Computing for Computer Scientists*, Cambridge University Press (2008), ISBN: 978-0-521-87996-5.
3. Simon Singh, *The Code Book*, Delacorte Press, March 2002. eISBN: 0-375-89012-2.
4. Gilles Brassard, *Modern Cryptography (A Tutorial)*, Lecture Notes in Computer Science 325, Springer – Verlag, 1988, ISBN 0-387-96842-3.
5. A. Einstein, P. Podosky and N. Rosen, *Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?* Phys Rev., 47, p777, 1935.
6. Asher Peres, *Separability Criterion for Density Matrices*, Phys Rev Lett. 77 (8), p1413, 19 Aug 1996.
7. P. Horodecki, *Separability criterion and inseparable mixed states with positive partial transposition*, Phys Lett A 232, pp. 333-39, 1997.

PROJECT/ Dissertation (MRP4P02)