

**II SEMESTER – MASTER OF PHYSICS**

Sl. No	Subject Code	Subject Title	Teaching Scheme Hours / Week		Examination				Student contact hours	Credits
			Theory	Practical	Duration (hrs)	I.A. Marks	Theory/ Practical	Total Marks		
1	16MScPHCT21	Quantum Mechanics-I	04	-	03	20	80	100	4	04
2	16MScPHCT22	Atomic, Molecular & Optical Physics (General)	03	-	03	20	80	100	3	03
3	16MScPHCT23	Electronics (General)	03	-	03	20	80	100	3	03
4	16MScPHCT24	Material Science	02	-	1.5	10	40	50	2	02
5	16MScPHOT25	Modern Physics (Open Elective Course)	04	-	03	20	80	100	4	04
6	16MScPHCP26	Practical-I (Electronics and FORTRAN Programming)	-	03	03	20	80	100	03	02
7	16MScPCP27	Practical-II (Atomic, Molecular & Optical Physics)	-	03	03	20	80	100	03	02
8	16MScPHSS28	Self Study: Research Methodology/ C Programming.		04	---	100	--	100	02	02
<b>TOTAL</b>			<b>16</b>	<b>10</b>		<b>210</b>	<b>520</b>	<b>750</b>	<b>24</b>	<b>22</b>

# SYLLABUS

## II SEMESTER

### Course 16MScPHCT21: Quantum mechanics – I

No. of hours per week: 4

No. of credits: 4

#### Unit I

**Basic Principles:** Hermitian operators, Eigenfunctions, eigenvalues and orthonormalization of eigenfunctions, completeness. State functions as probability amplitude and the principle of superposition. Momentum, Hamiltonian and energy operators, Schrodinger equation. Probability density and probability current density, expectation values, Ehrenfest theorem; basic postulates of quantum mechanics.

10 hours

#### Unit II

**Simple Applications:** Eigenvalues and eigenfunctions of free particle, Dirac delta function and its properties; particle in a square well; simple harmonic oscillator by polynomial method; barrier transmission: leakage of free particle through a thick rectangular potential barrier, transmission and reflection coefficients.

10 hours

#### Unit III

**Hydrogen atom:** Reduction of two-body problem to a single particle problem. Center-of-mass and relative motions; eigenvalues and eigenfunctions. Hydrogen-like atom, eigenvalues of energy and eigenfunctions, parity of eigenfunctions; angular momentum, expression for the three cartesian components and the square of the angular momentum, their commutation relations, expression for the operators in polar coordinates, eigenvalues and eigenfunctions in terms of polar coordinates; eigenvalues and eigenfunctions of the square and z-component of angular momentum.

10 hours

#### Unit IV

**Time-Independent Perturbation Theory:** Eigenvalue of energy and eigenfunction in the first order approximation (the case of a system with non-degenerate energy levels). Application to anharmonic oscillator and to the ground state of Helium atom. **Time-Dependent Perturbation Theory:** First order perturbation, Transition from one discrete level to the other, to continuum states, Fermi Golden rule, another discrete level through an harmonic perturbation, to resonance transitions. Interaction of radiations with a system of atoms, transition dipole moment, Einstein A and B coefficients.

10 hours

### Unit V

**Elastic Scattering:** Differential and total cross-section, phase analysis. Significance of the partial waves and phase shifts, S-wave scattering from a square well potential. The Born approximation, derivation of the expression for differential scattering cross-section, condition for validity of the approximation: application to square well potential and screened coulomb potential.

10 ours

### Text Books

1. Quantum Mechanics – Theory & Applications (3rd Ed): A.K. Ghatak & Loknathan, MacMillan India Ltd. 91984)
2. A Text of Quantum Mechanics: P.M. Mathews & K. Venkatesan, Tata McGraw-Hill, New delhi (1982)
3. Quantum Mechanics (2nd ed.), G. Aruldhas, Prentice Hall India Pvt.Ltd., New Delhi (2009).

### Reference Books:

4. Quantum Mechanics (2nd Ed): V.K. Thankappan, new Age International (P) Ltd. (1993)
5. Introduction to Quantum Mechanics: L. Pauling & E. Bright Wilson, McGraw-Hill, N.Y.(1935)
6. Quantum Mechanics(3rd ed): L.I. Schiff, McGraw-Hill, N.Y.(1968)
7. Quantum Mechanics: E. Merzbacher, 2nd ed., Wiley, N.Y.(1970).

## Course 16MScPHCT22: Atomic, Molecular & Optical Physics (General)

Teaching hours per week: 3

No. of Credits:3

### Unit I

**Atomic Spectroscopy** Quantum states of an electron in an atom. LS and JJ coupling schemes. Terms for equivalent and nonequivalent electron atom. Spectra of one electron systems. Qualitative idea of the following: Electron spin, spin orbit interaction, fine structure, relativity correction and radiation correction (Lamb Shift). Electric dipole selection rules. Intensity rules. Penetrating and non-penetrating orbits, quantum defect. Alkali type spectra. Spectrum of helium. Normal and anomalous Zeeman effect. Paschen-Back effect. Stark effect.

Hyperfine structure and isotopic shifts

10 hours

## Unit II

**Molecular Spectroscopy** Born-Oppenheimer approximation. Rotational spectra of diatomic molecules. Vibrational spectra of diatomic molecules. Rotation- Vibration spectra of diatomic molecules. Electronic spectra of diatomic molecules. Hund's cases. Vibrational structure of electronic transition. Selection rules. Rotational fine structure:  $-\Sigma^1 \Sigma^1$  transition. Franck-Condon principle. Intensity of bands in absorption and emission. Isotopic effect. Infrared and Raman spectra of linear molecules.

10 hours

## Unit II

**Laser Physics** : Absorption, spontaneous and stimulated emission. Einstein coefficients, Transition probability and lifetime of an atom in an excited state. Population inversion. Laser rate equations: The three level and four level systems. He-Ne laser. CO<sub>2</sub> laser. Semiconductor laser. Properties of laser beam: directionality, monochromaticity, intensity, coherence (temporal and Spatial). Applications of lasers.

12 hours

## unitIV

**Fiber optics** Types of fibers – single mode and multimode with different refractive index profiles. Ray theory of transmission, total internal reflection, acceptance angle, numerical aperture, skew rays. Optical fiber connectors, fiber alignment and joint loss, bending loss, fiber splices.

08 hours

### Textbooks:

1. Introduction to Atomic Spectra : H.E. White, McGraw – Hill, Tokyo (1934)
2. Physics of Atoms and Molecules – 2nd Ed., Brans den B.H. and Joachain C.J., Pearson Education, India (2006)
3. Elementary Atomic Structure (2nd ed.) : G. K. Wood gate, Clarendon Press, Oxford (1980)
4. Molecular Spectra & Molecular Structure – Vol I : Herzberg, D. Van Nostrand Co. Princeton, J. J. (1945)
5. Spectroscopy – Vol. 3: S. Walker & B. P. Strauhghan, Chapman & Hall, Lon (1976)
6. Fundamentals of Molecular Spectroscopy : C. N. Banwell and McCash, Tata Mc Graw-Hill Co., 4th revised edition, (9th reprint, 2000)
7. Lasers and Non-Linear Optics : B. B. Laud, Wiley Eastern Ltd., New Delhi (1991).

8. An Introduction to Lasers & their Applications : Donald C. O' Shea, W. Russell Callen & William T. Rhodes, Addison-Wesley, N. Y. (1977).
9. Optical Fiber & Communications Principles & Practice : John M. Seniors, Prentice Hall Intl. Ltd. London (1992)

**Reference Books:**

1. Fundamentals of Spectroscopy (2nd ed ): B. Narayan, Allied Publishers Ltd., New Delhi (1999).
2. Principles of Lasers : O. Svelto, Plenum Press, N. Y. (1982).
3. Laser Electronics : Joseph T. Verdeyen, Prentice-Hall of India Pvt. Ltd. NewDelhi (1989).
4. Lasers : Theory & Applications : K. Thyagarajan & A. Ghatak, MacMillan India, New Delhi (1981).
5. Laser Principles & Applications : J. Wilson & J.F.B. Hawkes, Prentice-Hall Intl. Inc. (1983)
6. Fiber Optics Sensors : D. A. Krohn, Instrument Soc. Am. (1988).
7. Encyclopedia of Lasers & Optical Technology : Robert A. Meyars, Academic Press, Cal. (1991).
8. Fiber Optic Communication : D. C. Agarwal, Wheeler Pub. (1993).
9. Optoelectronics – An Introduction : J. Wilson & J.F.B. Hawkes, Prentice – Hall Intl. Inc. (1983).
10. Laser Fundamentals : W.Q. Silvast

**Course 16MScPHCT22: Electronics (General)**

Teaching hours per week 3

Number of credits 3

**Unit I**

**Semiconductor Devices:** pn-Junction, depletion region, junction potential and junction capacitance, I-V characteristics of pn-junction, Zener diode, Zener diode as a voltage regulator. Tunnel diode, SCR and TRIAC. **JFET and MOSFET:** The junction field effect transistors (JFET), basic structure and operation, characteristics, parameters, biasing, voltage divider biasing. JFET as an amplifier, common-source, common-drain and common-gate. Metal Oxide semiconductors (MOSFET), inversion layer, the enhanced MOSFET and depletion MOSFET and their characteristics, PMOS, NMOS & CMOS (qualitative).

10 hours

**Unit II**

**Operational Amplifier:** Ideal Op-Amp and practical O-Amp, Input modes and

parameters, open loop Op-Amp configuration. Op-Amp with negative feed-back, inverting, non-inverting and differential amplifiers. Feedback configurations – voltage series feedback amplifier, voltage shunt feedback amplifier and differential amplifier. Summing, scaling and averaging amplifier, instrumentation amplifier, integrator and differentiator **Op-Amp applications:** Active filters- types, first and second order active low and high pass filters. Oscillators-basic principles, types, phase shift oscillator, Wien bridge oscillator, triangular wave generator.

10 hours

## **Unit II**

**Digital Electronics:** Boolean operations and expressions, Boolean analysis of logic gates, simplification of Boolean expression. Karnaugh map: two, three and four variable map, product of sums (POS) and sum of products (SOP) simplification. **Digital logic gates:** AND, OR, NAND and NOR gates, AND-OR and NAND- NOR implementation of Boolean Expressions. Logic gate operation with pulse waveforms.

10 hours

## **Unit IV**

**Combinational Logic circuits:** Adder, parallel binary adder, subtractor, comparators, decoders, BCD to seven segment decoder, encoders, code conversion, multiplexers, demultiplexers, parity generators and checkers. **Sequential circuits:** Latches, Flip-flops, Edge triggered flip-flops, SR, JK, Master- Slave JK, D, T flip-flops, counters, synchronous and asynchronous counters, ripple counters, registers, shift registers, timing sequences, memory units, random access memory (RAM).

10 hours

### **Text Books:**

1. Operational Amplifier and Linear IC's: Robert F. Coughlin and Frederick F. Driscoll, PHI publications (1994).
2. Op-Amps and linear Integrated Circuits :R Gayakwad, PHI publications, New Delhi (2000).
3. Digital Principles and Applications: A.P. Malvino and D. Leach, TMH Publications (1991).
4. Digital fundamentals – 8<sup>th</sup> edition: Thomas L Floyd, Pearson Education (2003)

### **Reference Books:**

1. Microelectronics Circuits: Adel S. Sedra and Kenneth C. Smith, Oxford University Press (1991).
2. Digital Computer fundamentals, Thomas C. Bartee, McGraw Hill Ltd. (1977).
3. Digital Logic and Computer Design: Morris Mano. Prentice Hall of India Pvt.Ltd New Delhi (2000).
4. Logic Circuit Design: Alan W. Shaw, Sanders College Publication Company (1999).

## Course 16MScPHCT24: Material Science

Teaching hours per week 2

Number of credits 2

**Materials:** Classification of materials, levels of structure, Structure-property relationship in materials. Crystalline and non crystalline states.

**Types of materials:** Inorganic solids, polymers, liquid crystals (soft matters), nuclear fissile materials, magnetic materials and semiconductors.

**Crystal growth:** Crystal growth from melt: Bridgmann technique, crystal pulling by Czocharalski's method. Growth from solutions, hydrothermal method, gel method, zone refining method of purification and electrochemical deposition method.

**Solid phases and phase diagrams :** Single and multiphase solids, solid solutions and Hume-Rothery rules, intermediate phase, the intermediate and interstitial compounds, properties of alloys; solid solutions and two component alloy systems; phase diagram, Gibbs phase rule, lever rule, first, second and third order phase transitions with examples; some typical phase diagrams: Pb-Sn and Fe-Fe<sub>2</sub>O<sub>3</sub>, Eutectic, eutectoid peritectic and peritectoid systems.

**Phase Transformations:** Time scale for phase changes; nucleation and growth, nucleation kinetics, the growth and overall transformation kinetics, applications; transformation in steel; precipitation processes, solidification and crystallization, glass transition recovery re-crystallization and grain growths.

### References:

- 1) Elements of material science and engineering L H VanVleck Addison Wesley 1989 6<sup>th</sup> edn
- 2) Material science and engineering V Raghvan Prentice Hall of India 3<sup>rd</sup> edn
- 3) Material science and processes S K Hazra Choudhary Indian Distr Co 1977
- 4) Introduction to solids L V Azaroff Tata McGraw Hill
- 5) Crystal growth B R Pamplin Pergamon press

## Course 16MScPHOT25: Modern Physics (Open elective course)

Teaching hours per week 4

Number of credits 4

### Unit I

**Blackbody Radiation:** Nature of Blackbody spectrum; classical radiation laws & their limitations; Planck's radiation law & quantum hypothesis. Simple examples/problems. **The Photoelectric Effect:** Apparatus used to study the Photoelectric Effect; laws of Photoelectric Effect; Einstein Photoelectric Equation. Simple examples. **X-rays:** Nature & production of X-rays; the Bragg's law; Bragg's X-ray crystal spectrometer. **The Compton Effect:** X-ray Compton scattering from an electron; experimental set-up for Compton Scattering. Simple problems

10 hours

### Unit II

**Atomic Structure:** Hydrogen spectrum; the Bohr model; experimental measurement of the Rydberg Constant; Franck Hertz Experiment. **Matter Waves:** The de Broglie wavelength & its relation with the Bohr Model; Davisson – Germer experiment. Heisenberg Uncertainty Principle. Momentum – position & energy – time relations. Simple examples. **Quantum Physics:** Idea of wave function & probability. One-dimensional Schrodinger wave equation: Its application to the particle in a box and Hydrogen atom; Energies & wave functions

10 hours

### Unit III

**Molecular structure:** Bonding Mechanisms: ionic bonds; Covalent bonds; the Hydrogen bond; Van-der Waal's Bonds. Molecular vibration & rotation Spectra. Molecular Orbitals: Hydrogen molecular ion & molecule; bonding in complex molecules. **Solid State Physics:** Ionic solids; covalent solids; metallic solids; molecular crystals; amorphous solids. Classical Models of electrical & heat conductivities in solids; Ohm's law; Weidman – Frenz law; the quantum view point. **Lasers:** Absorption, Spontaneous & Stimulated emissions; Population Inversion; laser action; typical gas (He – Ne/ CO<sub>2</sub>) characteristics

10 hours

### Unit IV

**Magnetism:** Magnetic Moment; Magnetization. Magnetic Materials: Diamagnetic, Paramagnetic & Ferromagnetic materials. Superconductivity Phenomenon. **Nuclear Structure:** Nuclear properties: Charge, mass, size & structure; Nuclear spin & magnetic Moment; Nuclear magnetic Resonance (NMR) Phenomenon. Binding Energy & nuclear forces. Radioactivity: Decay constant, half life.

10 hours



## Unit V

**Nuclear Fission/ Fusion:** Fission – basic process; a simple model; a typical nuclear reactor. Fusion: Basic process; stellar energy.**Relativity:** The Michelson – Morley Experiment. Postulates of Special theory of relativity; time dilation; length contraction; simultaneity of events;  $E = mc^2$ .

10 hours

### Textbooks:

1. Modern Physics (2nd Ed) Serway, Moses & Moyer, Saunders College Pub, 1997.
2. Fundamentals of Physics extended with Modern Physics (4<sup>th</sup> Ed) Halliday, Resnick & Walker, John Wiley, 1993.
3. Concept of Modern Physics, (6<sup>th</sup> edition) Arthur Beiser, McGraw Hill Publishing company.
4. Modern Physics, Kenneth Krane, Wiley India limited.

## Course 16MScPHCP26: Practical I( Electronics and FORTRAN Programming)

Teaching hours per week 4

Number of credits 4

- 1) Construction of Astable and Monostable Multivibrator using IC- 555 timer and calculation of frequency.
- 2) Construction of adder, subtractor, differentiator and integrator using Op-Amp 741.
- 3) FET- characteristics, biasing and its applications as an amplifier.
- 4) MOSFET characteristics and application as an amplifier.
- 5) SCR- characteristics and its applications as a switching device.
- 6) Construction of decoder and encoder using NAND and NOT gates and verification of truth tables.
- 7) Construction of Karnaugh map for three and four variables.
- 8) R-2R ladder network D/A converter and its characteristics.
- 9) Design of low pass, high pass and band pass active filters using Op-Amp 741, and

calculation of cut off frequency. Study of triggered SR, JK and D-flip-flops.

- 10) Construction of Wein bridge oscillator using Op-Amp 741 and comparison of its theoretical and practical values.
- 11) Simplification of Boolean expression and implementation using 2-input NAND gate IC7400.
- 12) Asynchronous & Synchronous Counters

**(Minimum of 80% of the listed experiments per paper should be performed).**

1. Microelectronics Circuits : Adel S. Sedra and Kenneth C. Smith, Oxford University Press (1991).
2. Electronic devices and circuits: R. Boylestad and Nashalsky: PHI publications (1999).
3. Electronics Principles: A.P. Malvino, TMH Publications (1984).
4. Operational Amplifier and Linear IC's: Robert F. Coughlin and Frederick F. Driscoll, PHI publications (1994).
5. Op-Amps and Linear Integrated Circuits : R. Gayakwad, PHI publications, New Delhi (2000).
6. Elementary Solid State Physics : M.A. Omar, Addison Wesley Pub. Ltd. New Delhi (1993).
7. X-ray Diffraction : B.D. Cullity, Addison-Wisley Ltd. New York (1972).
8. Introduction to Solid State Physics: C. Kittel, Wiley Eastern Ltd. Bangalore, (1976).
10. Advanced Practical physics : (9th Edition) B.C. Worsnop & H.T. Flint Methuen & Co. Ltd. Lond (1951).
11. Instrumental Methods of Analysis : (6th Edition) H.H. Willard, L.L. Merrit, J.A. Dean & F.A. Settle, J.K. Jain for CBS Publishers (1986).
12. Experiments in Modern Physics: A.C. Melissinos academic press (NY) (1966).

### **Course 16MScPHCP27: Practical II (Atomic, molecular & optical physics)**

- 1) Study of Zeeman Effect: Determination of  $e/m$  for an electron.
- 2) To study the numerical aperture and bending loss of an optical fiber.
- 3) Determination of unknown wavelength of a laser source using grating and a laser source of known wavelength.
- 4) Study of interference and diffraction using single and double slits using He-Ne/semiconductor laser source.
- 5) Measurement of wavelength of sodium D line/wavelength separation of sodium D doublet lines using Michelson Interferometer.

- 6) Verification of Beers law.
- 7) Study of Faraday Effect using He-Ne Laser.
- 8) Study of optical Kerr Effect.
- 9) Fortran programming to be taught in lab sessions: **Fortran Programming** : Basic concepts, constants, variables, I/O statement, formatted input and output statements, built-in functions, decision making, branching and looping statements, one and two dimensional arrays, Function subprograms, subroutines, simple programming using FORTRAN 77. Programming on numerical methods: least square curve fitting, Simpson's 1/3 rule.
  - a) Write a fortran program to find gravitational force.
  - b) Write a fortran program to find the energy of a photon.
  - c) Write a fortran program to find the binding energy of a given element.
  - d) Write a fortran program to find rotational energy.
  - e) Write a fortran program to find the energy of hydrogen atom

**(Minimum of 80% of the listed experiments per paper should be performed).**

### **Course 16MScPHCP28: Self Study**

No. of hours per week: 2

No. of credits: 2

#### **RESEARCH METHODOLOGY**

Meaning, Objectives and Characteristics of research - Research methods Vs Methodology - Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research - Developing a research plan.

Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem - Importance of literature review in defining a problem - Survey of literature - Primary and secondary sources - Reviews, treatise, monographs- patents - web as a source - searching the web - Identifying gap areas from literature review - Development of working hypothesis.

Research design and methods – Research design – Basic Principles- Need of

research design — Features of good design – Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models - Developing a research plan - Exploration, Description, Diagnosis, and Experimentation- Determining experimental and sample designs.

IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual Property Rights (IPRs)- A brief summary of: Patents, Copyrights, Trademarks,

Interpretation and report writing - Techniques of interpretation - Structure and components of scientific reports - Different steps in the preparation - Layout, structure and language of the report - Illustrations and tables - Types of report - Technical reports and thesis

#### **REFERENES:**

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
4. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications 2 volumes.
5. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
6. Day, R.A., 1992. How to Write and Publish a Scientific Paper, Cambridge University Press.

### **PROGRAMMING IN 'C'**

Overview of C: History of C, Importance of C, Structure of a C Program. Elements of C: C character set, identifiers and keywords, Data types, Constants and Variables, Assignment statement, Symbolic constant. Input/output: Unformatted & formatted I/O function, Input functions viz. scanf(), getch(), getche(), getchar(), gets(), output functions viz. printf(), putchar(), puts(). Operators & Expression: Arithmetic, relational, logical, bitwise, unary, assignment, conditional operators and special operators. Arithmetic expressions, evaluation of arithmetic expression, type casting and conversion, operator hierarchy & associativity.

Decision making & branching: Decision making with IF statement, IF-ELSE statement, Nested IF statement, ELSE-IF ladder, switch statement, goto statement.

Decision making & looping: For, while, and do-while loop, jumps in loops, break, continue statement.

Functions: Definition, prototype, passing parameters, recursion.

Storage classes in C: auto, extern, register and static storage class, their scope, storage, & lifetime.

Arrays: Definition, types, initialization, processing an array, Strings & arrays.

#### **TEXT BOOKS**

1. Gottfried, Byron S., Programming with C, Tata McGraw Hill
2. Balagurusamy, E., Computing Fundamentals and C Programming, Tata McGraw-Hill