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Aurangabad – 431 004 (MS)**



**Department of Physics**

**Curriculum**

**for**

**Ph. D. Entrance Test - 2016 (PET)**

**(As per UGC – 2016 and Dr. Babasaheb Ambedkar Marathwada  
University Rules)**

## **Section A**

### **Research Methodology**

#### **Unit I: Research Fundamentals:**

Introduction: Definition, objectives of the research, characteristics of the research, what makes people to do research, importance of research

Research categories: Basic research, Applied research-problem solving research and problem oriented research, Some other types of research-evaluation research; performance monitoring research; total quality management (TQM), Types of research, Features of good research study, Entering into the research, Qualities of a good researcher, The research process: Identifying the problem, developing research strategy, collection of data, analysis of collected data, preparation of research report, organization of research report

#### **Unit II: Defining Research Problems:**

Defining the research problem: Identification of research problems, selection of research problem, facts one should know regarding selection of research problem, the process of research problem definition, some facts involved in defining research problem, Formulation of the problems: steps involved in defining a problem, formulation of the problems,

#### **Unit III: Hypothesis Formulation:**

Formulation of hypothesis: Concept of hypothesis, hypothesis testing , Developing the research plan: implementation, interpreting and reporting the findings, Importance of hypothesis of in decision making.

#### **Unit IV: Methods and Techniques of Data Collection:**

Types of data: primary and secondary, distinction between primary data and secondary data, Data collection procedure for primary data: planning the study, modes of primary data collections, primary data observation process, primary data experimentation methods, primary data questionnaires' techniques, limitations of primary data collections, different types of study through primary data; Methods for secondary data collections: secondary data may either be published data or unpublished data, sources of unpublished data, secondary data- internal, secondary data-external.

#### **Unit V: Research Report and Proposal Writing:**

Introduction, research proposal writing: costing, the research proposal, rationale for the study, research objectives, research methodology, target respondents, research Centres, sample size and sample composition, sampling procedures, research project execution, research units; An insight into research report and proposal, research project synopsis, research report writing : types of research reports, guidelines for writing reports; Steps in writing report, report presentation, typing the report, documentation and bibliography, formatting guidelines for writing a good research report / research paper.

**References:**

1. Research Methodology by Dr. S. L. Gupta, Hitesh Gupta ( International Book House Pvt Ltd ( 2013)
2. Basic Research Methods-Gerard Guthrie
3. Principles of Research Methodology- Phyllis G. Supino, Jeffrey S. Borer
4. Research Methodology-methods and techniques- C. R. Kothari
5. Research Design Qualitative, Quantitative. and Mixed Methods Approaches- John W. Creswell
6. Research Methodology -A Step-by-Step Guide for Beginners- Ranjit Kumar
7. Scientific Writing and Communication- Angellka Hofmann
8. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded- Joshua Schimel
9. Handbook of Scientific Proposal Writing- A.YavuzOruc

## **Section B**

### **Unit I : Quantum Mechanics & Statistical Mechanics:**

#### **Quantum Mechanics:**

Origin of quantum mechanics, particle aspects of radiation, wave aspect of radiation, particles versus waves, intermediate nature of microphysical world, quantizations rules, wave packets, Wave function, Operators, Schrodinger equation, continuity equation, expectation values. Ehrenfest's theorem stationary states, boundary and continuity conditions, degeneracy orthogonality and parity, particle in a box.

Angular momentum, commutation relations between  $L_x, L_y, L_z, p_x, p_y, p_z, L^2, r^2$  etc. Angular momentum and rotations. Orbital and Spin angular momentum. Ladder operators  $J_+$  and  $J_-$ . Eigen values of  $J^2$  and  $J_z$ . Lower and upper bounds. Angular momentum matrices for  $j = 1/2$

#### **Statistical Mechanics:**

**The Statistical Basis of Thermodynamics and Ideal classical gas:** Postulates of classical statistical mechanics. Macroscopic and microscopic states. Phase space. Ensemble – microcanonical, canonical & grand canonical, Statistical equilibrium, density distribution of phase point, Liouville's theorem. Partition function of a classical ideal gas, entropy of mixing and Gibbs paradox, Maxwell-Boltzmann distribution law, Entropy of a monoatomic gas.

**Quantum Statistical Mechanics, Cluster Expansion and Co-operative phenomenon and Fluctuations:** Postulate of Quantum statistical mechanics. statistics of indistinguishable particles, MB statistics, FD statistics, BE statistics, properties of ideal Bose – Einstein and Fermi Dirac gases. Bose Einstein condensation. Bragg – Williams approximation, Van der Waals theory of liquid gas transition, Mayer's theory of condensation, Ising model in one and two dimensions. Landau's theory of phase transitions. Brownian motion, transport equation, Langevin theory of Brownian motion, Einstein's theory of Brownian motion, Fokker–Planck equation, fluctuation dissipation theorem.

#### **References :**

1. Quantum Mechanics: Concepts and Applications, N. Zettili (John Wiley and Sons)
2. Statistical Mechanics; B. K. Agrawal, Melvin Eisner, New Age International Pvt. Ltd. New Delhi.
3. Fundamental of Statistical Mechanics; B. B. Laud, New Age International Pvt. Ltd. New Delhi.
4. Statistical Mechanics; R. K. Patharia, Butterworth – Heinemann Published by Elsevier a division of Reed Elsevier India Pvt. Ltd. New Delhi.
5. Introduction to Statistical Mechanics, S K Sinha, Narosa publishing house Pvt. Ltd New Delhi.
6. Statistical Mechanics, Gupta, Kumar, Pragati prakashan Meerut.

## Unit II : Classical Mechanics & Mathematical Methods in Physics:

### Classical Mechanics:

Constraints, Classification of Constraints, Principal of Virtual Work, D'Alembert's principal and its applications (Problems only), **Lagrangian formulation:** Generalized coordinates, Lagrange's equations of motion, theorem on total energy, Lagrangian and Hamiltonian of relativistic particles and light rays. **Variational Principle:** Variational principle, Euler's equation, applications of variational principle. Stability of orbits, condition for closure, integrable power laws, Kepler's problems, orbits of artificial satellites, Virial theorem. **Poisson Brackets:** Jacobi-Poisson theorem, Jacobi identity, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Foucault's pendulum, small oscillations, Normal co-ordinates and applications to vibrations of linear in triatomic molecules. Liouville's theorem for Hamiltonian mechanics.

### Mathematical Methods in Physics:

Matrices-Eigen values and Eigen vectors, inverse of matrix, rotation of matrix, complex numbers, De Moivre's theorem, Problems on complex numbers. Fourier series, Fourier series representation of even and odd function, Fourier transform, Fourier sine and cosine transform, Laplace transform of elementary function and problems.

### **References:**

1. Classical Mechanics, by H. Goldstein, 2<sup>nd</sup> Edition (Published by Narosa Publishing House Pvt. Ltd., New Delhi (2001) ISBN 10:8185015538 / ISBN 13:9788185015538.
2. Classical Mechanics, by N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991), ISBN 10: 0074603159 ISBN 13: 9780074603154.
3. Classical Mechanics, by Gupta, Kumar and Sharma, Pragati Prakashan, Meerut (2012). ISBN number 9350063808 / 9789350063804.
4. Classical Mechanics by J. C. Upadhyaya, Himalaya Publishing House (2015), ISBN Number: 978-93-5142-798-8, Book Edition: 2<sup>nd</sup>.
5. Mathematical Physics- B.S. Rajput, Pragati Prakashan **ISBN No.** : 978-93-5008-837-3.
6. Engineering Mathematics H. K. Dass **ISBN**, : 9788121937078.
7. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press. ISBN-13 9780521139878.

### **Unit III: Electronics & Electrodynamics and Plasma Physics:**

#### **Electronics:**

**Operational amplifier and** its applications: Symbol and terminals, the ideal op-amp, the practical op-amp. Operational amplifier parameters: Input offset voltage, Input offset current, Input bias current, Input impedance, Output impedance, Open loop voltage gain, Common – Mode rejection ratio, Slew rate. Inverting, non - inverting amplifier, Adder, Subtractor, Integrator, differentiator, Comparator & Schmitt's trigger. Wave form generators: Astable Multivibrator, Monostable Multivibrator, and Wien Bridge Oscillator.

**Timing Circuits, Numbers systems, and Codes:** Integrated circuit timer: Block diagram of IC – 555, Monostable, Astable Multivibrator using IC-555 Decimal, Binary, & Hexadecimal numbers systems, and its arithmetic's. BCD and Gray code. AND, OR, NOT operations, NAND and NOR operations, NAND and NOR as building blocks, Exclusive – OR operation.

#### **Electrodynamics and Plasma Physics:**

**Electromagnetic waves and field vectors:** Maxwell's equation in free space, plane wave in free space, dispersion of electromagnetic waves, Poynting vector in free space, polarization of electromagnetic wave, wave equation in terms of scalar and vector potential.

**Reflection and transmission of Electromagnetic wave:** Laws of reflection and refraction, Brewster angle, Reflection and refraction at the surface of good conductor. Plasma physics - plasma oscillation, Debye shielding, plasma confinement

#### **References::**

1. Electronic Devices by Thomas L Floyd, Charles E. Merrill Publishing Company.
2. Operational Amplifier with Linear Integrated Circuits by William D. Stanley, Fourth Edition, LPE Pearson Education.
3. Op-Amp and Linear Integrated Circuits by R. A. Gaikwad, 4<sup>th</sup> Edition, Prentice Hall of India (2002).
4. Modern Digital Electronics by R. P. Jain, 3<sup>rd</sup> Edition, Tata McGraw Hill Publishing Company Ltd.
5. Digital Fundamentals by Thomas L. Floyd, 2<sup>nd</sup> Edition, Charles E. Merrill Publishing Company.
6. Electrodynamics-Gupta, Kumar, Singh, Pragati Prakashan (Meerut). ISBN 10: 8175568682.
7. Electromagnetic- B. B. Laud / ISBN: 9788122430554. New Age International (P) Ltd. , 2011.
8. Electromagnetic waves and Fields- R. N. Singh/ ISBN: 0074603477.

## **Unit IV: Atomic and Molecular Physics & General Nuclear Physics:**

### **Atomic and Molecular Physics:**

Stern Gerlach experiment, Quantum states of an electron. Quantum numbers. Spectra of Hydrogen atom. Spin angular momentum, orbital angular momentum. Coupling of spin and orbit. Fine structure, spectroscopic terms, selection rules. Spectra of the alkali elements. Interaction energy in L-S and j-j coupling, Hund's rule and term reversal. Zeeman effect in one valence electron atoms, interaction energy, selection rules, Zeeman patterns. Paschen-Back effect, Pauli principle. Hyper fine structure (Qualitative).

### **General Nuclear Physics:**

**General Properties of Nucleus and Radioactivity (Natural and Artificial):** Nuclear size and its determination, nuclear radii by electron scattering and mirror nuclei methods. Binding energy, mass defect, Packing fraction. Semi-empirical mass formula and its applications. Quantum numbers of nuclei, the disintegration constant, half life and the mean life, Successive radioactive transformation, radioactive equilibrium, the natural radioactive series, units of radioactivity.

**Nuclear Radiation detectors, models and accelerators :** Types of detectors, ionization chamber, G.M. Counters, scintillation counter, Liquid drop model, evidence of shell effects, Shell model, single particle shell model, deformed nuclei and collective model, Cockroft and Walton voltage multiplier, Vande Graff machine, tandem accelerators, cyclotron.

### **References:**

1. Introduction to Atomic Spectra H E White McGraw Hill.
2. Introduction to Nuclear Physics; H.A. Enge, Addison- Wesley, 1975.
3. Nuclear Physics; I. Kaplan, 2<sup>nd</sup> edition, Narosa, 1989.
4. The atomic Nucleus; R.D. Evans, Mc Graw- Hill, New York 1955.
5. Nuclear Physics; R.R. Roy and B.P. Nigam, Wiley – Eastern Ltd, 1983.
6. Basic Nuclear physics; B. N. Shrivastava, Pragati prakashan, Meerut.
7. Theory of Nuclear Structure; M. K. Pal, East – west press Ltd. 1982.
8. Nuclear Physics; D.C. Tayal, Himalaya Publishing House, Bombay.
9. Experimental Nuclear Physics; E.Serge, John Wiley and sons, New York, 1959.

## Unit V: Condensed Matter Physics:

**Crystal Structure and Diffraction:** 2d & 3d Bravais lattices, characteristics of cubic lattices, miller indices, symmetry elements, point group and space groups, different crystal structures: hexagonal close packed structure, s.c., b.c.c., f.c.c, Interaction of X-rays with matter, absorption of X-rays, Bragg's law, Experimental methods in X – rays: Laue method, Rotating crystal method, Powder photograph method, X-ray density.

**Superconductivity:** Introduction, Meissner effect, persistent currents, Type I and II superconductors, heat capacity, thermodynamics of the superconducting transition, London equation, Coherence length, BCS theory, flux quantization, Josephson effect, high temperature superconductors.

### Books:

1. Introduction to Solid State Physics – C. Kittel, Willey Eastern Pvt. Ltd.
2. Elementary Solid State Physics – M. A. Omar, Addition Wesley Pvt. Ltd.
3. Solid State Physics – A. J. Dekker, Mcmillan India Ltd.
4. Solid State Physics - Ashcroft and Mermen, Saunders College Publishing New York.
5. Introduction to Solids – L. V. Azaroff McGraw Hill, New York
6. Solid State Physics – S. O. Pillai, New Age International Pvt. Ltd.
7. Solid State Physics – M. A. Wahab
8. Concept in Solid State Physics – J. P. Shrivastava, Prentice Hall Ltd.
9. Solid State Physics – Saxena, Gupta, Saxena,
10. Physical Metallurgy- Peter Haasen