GUJARAT VIDYAPITH: AHMEDABAD
Department of Biogas Research and Microbiology
Faculty of Science and Applied Science, Sadra,
SUBJECT: PHYSICS
Ph.D. Entrance Test - SYLLABUS

Part – 1
(Research Methodology) (50%)

Unit I:- Working on a Research Problem

Scientific research – Aim and motivation – Principles and ethics – Identification of research problem: Determining the mode of attack – Current status – Literature survey – Abstraction of a research paper – Access using Internet web tools – e-mail – Impact and usefulness of the research problem – Role of research guide – Guidance and rapport – Preparation and presentation of Scientific reports; need and methods – Power point and poster – Writing of synopsis and dissertation and thesis.

Unit –II: Scientific writing

Communicating information: General aspects of scientific writing, reporting practical and project work, writing literature surveys, research papers and reviews, organizing a poster display, giving an oral presentation

Research Report: Format of research proposal, Format of the research report, style of writing the report, references and bibliography.

Growth techniques

Growth of Single Crystals

Introduction to Methods of Growth of Crystals, Czochralski Method, Bridgman andStockbarger Methods, Zone Melting and Zone Refining Methods, Impurity LevelingFactor, Verneuil Method, Molten Flux Method.

Vapor Phase Transport Methods and Thin Film Growth

Hydrothermal Methods, Vapor Methods, Fundamental of Epitaxial Growth of Thin Layers.

Unit III:- Advanced Characterization techniques

Structural characterization: single crystal and powder X-ray diffraction **Chemical analysis**: Electron Probe Microanalysis-EDAX, Auger Electron Spectroscopy (AES), X-ray photoelectron spectroscopy (XPS) **Electrical characterization**: Two probe & Four probe method, Van der Pauw method of sheet resistivity, I-V characteristics, Hall effect by van der Pauw method.

Imaging Techniques (Microscopy) Scanning Electron Microscopy (SEM)

Physical Basis and Primary Modes of Operation, Instrumentation, Sample Requirements, FESEM, Advantages over conventional SEM, Applications

Transmission Electron Microscopy (TEM)

Basic Principle, Resolution, Sensitivity, TEM Operation, Image Mode, Specimen Preparation

Scanning Tunneling Microscopy (STM) and Scanning Force Microscopy (SFM) Introduction, Instrumentation, Topography, Profilometry, Sample Requirements

Spectroscopy

UV-Vis

Introduction, principle of UV-vis spectroscopy, Beer-Lambert's law, molar absorbility, absorbing species, containing π, σ and η electrons, charge transfer absorption, Instrumentation of UV-Vis spectroscopy: Radiation Sources, Wavelength Selectors, Monochromators, Sample Handling, Detectors, Signal Processing and Output Devices, Types of UV-Visible Spectrometers: Single Beam Spectrometers, Double Beam Spectrometers, Photodiode Array Spectrometer, applications

FT-IR

What is FT-IR, Why IR spectroscopy, Principle of IR spectroscopy, Theory of infrared absorption, vibrational modes, infrared ranges, Typical Instrumentation, use of FT-IR, typical spectral analysis

Unit IV: - High Performance Computing

High performance computing basics – Elements of Fortran 90/95 – Constants

and variables – Arithmetic expressions – I/O statements – Logical expressions – Conditional and control statements - Arrays – Functions and subroutines – Format statements – Advanced features: Procedures, modules, recursive functions and generic procedures – Applications Software and Libraries: MATLAB, MATHEMATICA, GNUPLOT, LATEX, LAPACK, BLAS, and FFTW (basics only).

Books for Study and References

1. J. Anderson, B.H. Durston and M. Poole, *Thesis and Assignment writing* (Wiley Eastern, New Delhi, 1977).
2. Rajammal Devadas, *Hand Book of Methodology of Research* (R.M.M. Vidyalaya Press, 1976).
3. *Internet: An Introduction*, CI Systems School of Computing, Jaipur (Tata McGraw Hill, New Delhi, 1999).
4. C.R. Kothari*, Research methodology: Methods and Techniques*, (New age International, New Delhi, 2006).
5. A Hand books of Methodology of Research by Rajammal P. Devdas and K. Kulandaivel, Sri Ramkrishnan Mission Vidyalaya Press, Coimtore.
6. Thesis and assignment Writing by Janathan Andorson, et. al. Narosa Publication
7. Research- How to plan, Speak and Write about it by C.Hawkins and M.Sorgi, Narosa Publishing House
8. Web Site of Inflibnet, UGC, CSIR, INSA, DST.
9. C.R. Kothari*, Research methodology: Methods and Techniques*, (New age International, New Delhi, 2006).
10. M. William and D. Steve, Instrumental Methods of Analysis (CBS Publishers, New Delhi, 1986).
11. Michael Sayer and A. Mansingh, Measurement, Instrumentation and Experiment Design in Physics and Engineering, Printice Hall of India, New Delhi.
12. Troy Baer, *An Introduction to FORTRAN 90,* Ohio Supercomputer Centre, Columbus, OH, USA
13. V. Rajaraman and C. Siva Ram Murthy, *Parallel computers – Architecture and Programming*, Prentice Hall of India, New Delhi.

14. H. K. Dass, *Mathematical Physics,* S. Chand & Company, New Delhi (2003).

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SUBJECT: PHYSICS
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Part - 2
(Subject Related) (50%)

I. Mathematical Methods of Physics

Vector algebra and vector calculus. Linear algebra, matrices, Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Elementary probability theory, random variables, binomial, Poisson and normal distributions.

II. Classical Mechanics

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics-moment of inertia tensor. Non-inertial frames and pseudoforces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Special theory of relativity-Lorentz transformations, relativistic kinematics and mass-energy equivalence.

III. Electromagnetic Theory

Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic

waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields.

IV. Quantum Mechanics

Wave-particle duality. Schrodinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time-independent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles.

V. Thermodynamic and Statistical Physics

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Blackbody radiation and Planck's distribution law.

VI. Electronics and Experimental Methods

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells,

photo-detectors, LEDs). Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters.

Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting,

Linear and nonlinear curve fitting, Transducers (temperature, pressure/ vacuum, magnetic fields, vibration, optical, and particle detectors) Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding. Fourier transforms, modulation techniques.

High frequency devices (including generators and detectors).

VII. Atomic & Molecular Physics

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

VIII. Condensed Matter Physics

Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion

in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. kinds of liquid crystalline order. Quasi crystals.

IX. Nuclear and Particle Physics

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nature of the nuclear force, Evidence of shell structure, single-particle shell model, its validity and limitations. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.

Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Quark model, baryons and mesons. C, P, and T invariance.. Parity non-conservation in weak interaction.
