M.Phil / Ph.D. Physics

SYLLABUS
(Effective from the Academic year 2020 – 2021 and onwards)

DEPARTMENT OF PHYSICS

KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed to be University Established Under Section 3 of UGC Act, 1956)
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### DEPARTMENT OF PHYSICS

**FACULTY OF ARTS, SCIENCE & HUMANITIES**  
**RESEARCH PROGRAM – M.Phil /PhD in Physics**  
*(2020–2021 Batch and onwards)*

<table>
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<tr>
<th>Course code</th>
<th>Name of the course</th>
<th>Instruction hours / week</th>
<th>credits</th>
<th>Maximum Marks (100)</th>
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<td>20RPHY101</td>
<td>Paper-I: Research Methodology and Pedagogy</td>
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<td>20RPHY201</td>
<td>Paper-II: Research Publication Ethics</td>
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<td>20RPHY301</td>
<td>Paper III: Special Paper I-Solar Energy and Utilization</td>
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<td>20RPHY302</td>
<td>Paper III: Special Paper II-Thin Film Physics</td>
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<td>20RPHY305</td>
<td>Paper III: Special Paper V-Concepts of Nanophysics and Nanotechnology</td>
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<td>20RPHY306</td>
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20RPHY101 PAPER – I: RESEARCH METHODOLOGY & PEDAGOGY

Unit – I
Ethics of Research – Objectives of Research – Historical Background of Physics Research – Research Works of Sir C.V. Raman, S.Chandrasekhar and Venkaraman Ramakrishnan (Nobel prize works only) (Nobel Lectures) – Experimental Research in Physics – Design of the experiment, Apparatus to be used, Results and Interpretation – Theoretical Research in Physics – Theory, Models, Methods to solve the problems, results and Interpretation – Literature Survey on Thesis Writing – Online literature survey – Science Citation Index – Impact factor of a journal – Thesis writing.

UNIT II -PROBABILITY DISTRIBUTIONS
Mean, Median peak value, and Standard Deviation – Binomial Distribution – Poisson Distribution – Gaussian or Normal Error Distribution – Modes of distributions.

Error Analysis

UNIT III - NUMERICAL INTEGRATION
Trapezoidal and Simpson's 1/3 rule for single integrals - Error estimates - Trapezoidal and Simpson's rule for double integrals

Interpolation: Two points Gaussian quadrature - Three points Gaussian quadrature - Cubic spline interpolation

Eigen values: Power method - Jacobi method (Only 2 x 2 and 3 x 3 matrices)

Simulation techniques: Monte Carlo simulation – Fuzzy logic.

UNIT IV- COMPUTER APPLICATIONS IN PHYSICS RESEARCH

Programming in C: Constants - Variables - Data types - Operators and Expressions - Input/Output Statements - Control statements - Functions - Arrays - One, two, multidimensional array declarations and initializations
Simple applications using C - Program: Program to integrate tabulated function using Trapezoidal rule - Program to integrate tabulated function using Simpson's 1/3 rule - Program to compute the solution of first order differential equation of the type \( y' = f(x,y) \) using RK4 method - Program to compute first order differential equation \( y' = f(x,y) \) using Milne's method - Program to compute the interpolation value at a specified value from a set of table points using natural cubic spline interpolation.

UNIT V-PEDAGOGICAL METHODS IN HIGHER LEARNING

Historical perspectives: Objectives and role of higher education – Learning and learning hierarchy – Information processing – Learning and outcomes – Motivation.

Education evaluation: A conceptual framework – Methods of evaluation – Self evaluation and student evaluation in higher education – Question banking – Diagnostic testing and remedial teaching.

SUGGESTED READINGS

3. P.Kandasamy - Numerical methods, K.Thilgavathy and K.Gunavathi, S.Chand and company limited
UNIT I

Philosophy and Ethics:
Introduction to Philosophy: Definition, nature and scope, concept, branches - Ethics: Definition, moral philosophy, nature of moral judgments and reactions.

UNIT II

Scientific Conduct:

UNIT III

Publication Ethics:
Publication Ethics: Definition, introduction and importance - Best practices / standards setting initiatives and guidelines: COPE, WAME, etc. - Conflicts of interest - Publication Misconduct: definition, concept, problems that lead to unethical behavior and vice versa, type - Violation of publication ethics, authorship and contributor ship - Identification of publication misconduct, complaints and appeals - Predatory publishers and journals.

UNIT IV

Publication Misconduct:
Group Discussions: Subject specific ethical issues, FFP, authorship - Conflicts of interest - Complaints and appeals: examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools

UNIT V

Databases and Research Metrics:
Database : Indexing database - Citation database: Web of Science, Scopus, etc. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score - Metrics: h-index, g index, i10 index, altmetrics.
UNIT VI

Development of e-content & IP:

PRACTICE

Open Access Publishing:
Open access publications and initiatives - SHERPA / RoMEO online resource to check polisher copyright & self-archiving policies - Software tool to identify predatory publications developed by SPPU - Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

References:
UNIT I - RADIATION GEOMETRY

UNIT II - FUNDAMENTALS OF HEAT TRANSFER

UNIT III - SOLAR THERMAL SYSTEMS

UNIT IV - PHOTOVOLTAICS
Description of the photovoltaic effect – Electrical characteristics calibration and efficiency measurement – silicon solar energy converters – Thermal generation of recombination centers silicon. Role of thin films in solar cells Properties of thin films for solar ells
CdSe, CdTe, In P, Ga As, Cd Cu₂, Cu In SnO₂, Cd₂SnO₄ ZnO)- Transport properties of metal films – poly crystalline film silicon solar cells (Photovoltaic characteristics, junction analysis loss mechanisms) Amorphous silicon solar cells (Structural compositional optical and electrical properties)

UNIT V- ENERGY STORAGE AND SOLAR APPLICATIONS

SUGGESTED READINGS
5. Rai, G.D. Thermal performances testing of FPC and CPC
UNIT I- PREPARATION OF THIN FILMS

UNIT II- THICKNESS MEASUREMENT AND NUCLEATION AND GROWTH IN THIN FILM
Theories of thin film nucleation – Four stages of film growth incorporation of defects during growth.

UNIT III- ELECTRICAL PROPERTIES OF METALLIC THIN FILMS

UNIT IV- TRANSPORT PROPERTIES OF SEMICONDUCTING AND INSULATING FILMS

UNIT V - OPTICAL PROPERTIES OF THIN FILMS AND THIN FILMS SOLAR CELLS

**SUGGESTED READINGS:**

1. Anderson, J.C. The use of thin films in physical investigation, 1968,
2. Berry, Koil and Harris. Thin films technology, 1968 Princeton ; London : Van Nostrand
UNIT I - FUNDAMENTALS OF CRYSTAL GROWTH

UNIT II - THEORIES OF CRYSTAL GROWTH

UNIT III - EXPERIMENTAL CRYSTAL GROWTH-PART-I: MELT GROWTH TECHNIQUES.

UNIT IV- EXPERIMENTAL CRYSTAL GROWTH-PART-II: SOLUTION GROWTH TECHNIQUES.
Growth from low temperature solutions: Selection of solvents and solubility – Meir’s solubility diagram – Saturation and supersaturation – Metastable zone width – Growth by

UNIT V -EXPERIMENTAL CRYSTAL GROWTH-PART-III: VAPOUR GROWTH TECHNIQUES


SUGGESTED READINGS

UNIT I
Crystalline solids – space lattice – the basis and crystal structure; crystal translational vectors, symmetry operation primitive lattice cell and unit cell symmetry elements, Fundamental type of lattice, atomic packing, atomic radius, lattice constants and density, crystal structure other cubic structure – type of bonding – Ionic bonding – Energy of formation of NaCl molecules, Madelung constants – potential energy of diagram of ionic molecules – calculation of repulsive exponent – Born Haber cycle characteristics of ionic bond.

UNIT II Transport Properties of Ionic Conductors

UNIT III

UNIT IV: Experimental Techniques and Methods
Structural characterization – XRD surface Analysis, EXAFS, IPS and Quasi neutron scattering – Thermo dynamical characterization – Differential scanning calorimetry,

UNIT V Electrochemical Techniques and Applications

SUGGESTED READINGS

UNIT I- INTRODUCTION TO NANOTECHNOLOGY
Defining nanotechnology, Historical development – Beyond Moore’s law, Comparison of bulk and nano materials – change in band gap and large surface to volume ratio, Classification of nanostructured materials – one, two and three-dimensional confinement, quantum dots, quantum wires and quantum wells, scope of applications.

UNIT II- SYNTHESIS AND CHARACTERIZATION
Classification of fabrication methods – Top to bottom approach – Ball milling, etching etc bottom to top approach – Physical and chemical methods – Molecular Beam Epitaxy, optical and electron beam lithography, Ion implantation, sputtering, thermal evaporation, pulsed laser deposition, chemical vapor deposition, controlled precipitation, sol gel methods. Grain size determination – XRD (Debye Scherer equation), TEM, AFM, STM and Light scattering techniques. Composition analysis – ICP – AES, EDAX, SIMS.

UNIT III- OPTICAL AND VIBRATIONAL PROPERTIES OF NANOPARTICLES
Basic concepts – Band structure of solids, excitons, effective mass, reciprocal lattice, Brillouin zone, phonons etc. Size and dimensionality effects – Bulk to nano transition – Density of states, potential well - quantum confinement effect – weak and strong confinement regime. Blue shift of band gap - Effective mass approximation (Rigorous mathematical treatment not necessary). Phonon confinement effect and presence of surface modes. Characterization tools - UV – Visible absorption and Photoluminescence techniques, Raman and IR spectroscopy

UNIT IV -CARBON NANOSTRUCTURES

UNIT V - NANOMACHINES AND NANODEVICES
Extension of conventional devices by nanotechniques – Bipolar and MOS transistors – structure and technology, electrical characteristics, limitations, low temperature behavior. Microelectromechanical systems (MEMSs), Nanoelectromechanical systems (NEMSs), Resonant Tunneling Diode, Quantum Cascade lasers, Single Electron Transistors – Operating principles and applications.

SUGGESTED READINGS
1. Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons and Burkhard Raguse “Nanotechnology”, Overseas Press New Delhi 2005
UNIT -1 METHODS OF MATERIALS BULK SYNTHESIS


UNIT-2 PREPARATION OF THIN FILMS
Types of thin Film Growth process - Spin coating - vacuum evaporation - sputtering - Pulsed laser deposition - Vapor Methods – CVD – PVD - Fundamental aspects of Epitaxial Growth methods.

UNIT – 3 STRUCTURAL CHARACTERIZATIONS AND IMAGING TECHNIQUES
X-ray diffraction ((XRD) - Electron and neutron diffraction - elementary ideas of photoelectron spectroscopy (PES) - Basic principle of atomic resolution electron microscopy - Scanning and Transmission electron microscopy (SEM, TEM) - Scanning tunneling and atomic force microscopy (STM, AFM) techniques.

UNIT – 4 OPTICAL CHARACTERIZATIONS AND SPECTROSCOPIC TECHNIQUES
Ultraviolet / visible (UV/Vis) absorption spectroscopy - Raman and Infrared Spectroscopy - Fluorescence spectroscopy - Elementary idea of laser based non-linear techniques. Room temperature as well as low temperature Photoluminescence - Cathode Luminescence - Mössbauer spectroscopy - Impedance spectroscopy

UNIT-5 PHYSICAL PROPERTY MEASUREMENTS
Intensive and extensive properties - Physical property measurements (DSC, DTA, TGA,) - Transport properties (R-T) – Photoconductivity study (C-V, I-V) - Low conductivity measurement (Dielectric Spectroscopy) - P-E loops for ferroelectrics - magnetic properties of bulk and nano phases of material (VSM & SQUID).
Suggested Readings:


