SCHEME OF EXAMINATION

AND

COURSE OF STUDY

CHOICE BASED CREDIT SYSTEM (CBCS)

Ph.D. Course Work

PHYSICS

(w.e.f. 2020-2021)

DEPARTMENT OF PHYSICS

GURUKULA KANGRI (DEEMED UNIVERSITY)

HARIDWAR

Ph.D. Course work	PPH-101 RESEARCH METHODOLOGY, COMPUTATIONAL METHODS AND RESEARCH & PUBLICATION ETHICS			
Time Allotted for End Semester Examination	Marks Allotted for Continuous Assessment	Marks Allotted for End Semester Examination (ESE)	Maximum Marks (MM)	Total Credits
3 Hrs	**30**	**70**	**100**	**06**

NOTE: The question paper shall consist of Two sections (Sec.-A, Sec.-B). Sec.-A shall contain 10 short answer type questions of four marks each and student shall be required to attempt any five questions. Sec.-B shall contain 8 descriptive type questions of ten marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus.

A. RESEARCH METHODOLOGY

1. INTRODUCTION

Definition of Research, Qualities of Researcher, Components of Research Problem, Various Steps in Scientific Research: Hypotheses, Research Purposes, Research Design, Literature searching.

DESIGN AND PLANNING OF EXPERIMENTS, TIME SCHEDULING

Aims and Objectives, Expected outcome, Methodology to be adapted, planning of experiments for achieving the aims and objectives, Importance of reproducibility of research work.

2. DATA COLLECTION

Sources of Data: Primary Data, Secondary Data; Sampling Merits and Demerits of Experiments, Procedure and Control Observations, Sampling Errors - Type-I Error - Type-II Error.

3. STATISTICAL ANALYSIS AND FITTING OF DATA

Introduction to Statistics – Probability Theories - Conditional Probability, Poisson Distribution, Binomial Distribution and Properties of Normal Distributions, Estimates of Means and Proportions; Chi-Square Test, Association of Attributes - t-Test -Standard deviation - Co-efficient of variations. Correlation and Regression Analysis. Introduction to statistical packages, plotting of graphs.

4. SCIENTIFIC WRITING

Steps to better writing, flow method, organization of material and style, Drawing figures, graphs, tables, footnotes, references etc. in a research paper.

Structure and Components of Research Report, Types of Report: research papers, thesis., Research Project Reports, Pictures and Graphs, citation styles,

Use of internet networks in research activities in searching material, paper downloading, submission of papers in arXiv, use of SPIRES database, relevant websites for journals and arXives.

Introduction to Patent laws: Patent laws, process of patenting a research finding, Copy right, Cyber laws.

B. COMPUTATIONAL METHODS AND PROGRAMMING

1. PROGRAMMING WITH C

Fundamentals of C Language

C character set-Identifiers and Keywords-Constants-Variables-Data types- Declarations of variables –Declaration of storage class-Defining symbolic constants –Assignment statement.

Operators: Arithmetic operators-Relational Operators-Logic Operators-Assignment operators- Increment and decrement operators –Conditional operators. **Expressions and I/O Statements:** Arithmetic expressions – Precedence of arithmetic operators-Type converters in expressions –Mathematical (Library) functions –Data input and output-The getchar and putchar functions –Scanf – Printf-Simple programs. **Control statements and arrays:**

If-Else statements –Switch statements-The operators –GO TO –While, Do-While, FOR statements-BREAK and CONTINUE statements. **Arrays:** One dimensional and two dimensional arrays –Initialization –Type declaration-Inputting and outputting of data for arrays –Programs of matrices addition, subtraction and multiplication. **User Define functions:** The form of C functions –Return values and their types –Calling a function – Category of functions. Nesting of functions. Recursion. ANSI C functions-Function declaration. Scope and life time of variables in functions.

2. **NUMERICAL ANALYSIS**

Linear and Non –linear equations

Solution of Algebra and transcendental equations-Bisection, Falsi position and Newton-Rhapson methods-Basic principles-Formulae-algorithms.

Simultaneous equations

Solutions of simultaneous linear equations-Guass elimination and Gauss Seidel iterative methods-Basic principles-Formulae-Algorithms.

Interpolations: Concept of linear interpolation-Finite differences-Newton‘s and Lagrange‘s interpolation formulae-principles and Algorithms.

Numerical differentiation and integration: Numerical differentiation-algorithm for evaluation of first order derivatives using formulae based on Taylor‘s series-Numerical integration-Trapezoidal and Simpson‘s 1/3 rule-Formulae-Algorithms.

C. RESEARCH & PUBLICATION ETHICS (REP)

1: Philosophy and Philosophy and Ethics

I. Introduction to Philosophy: definition, nature and scope, branches
II. Ethics: definition, moral Philosophy, nature of moral judgments and reactions

2: Scientific Conduct

I. Ethics with respect to science and research
II. Intellectual honesty and research integrity
III. Scientific misconducts: Falsification and Plagiarism (FFP)
IV. Redundant publication: duplicate and overlapping **publications, Salami slicing**
V. Selective reporting and misrepresentation of dada

3: Publication Ethics

I. Publication Ethics: definition introduction and importance
II. Best practices /standards setting initiatives and guidelines: COPE, WAME, etc.
III. Conflicts of Interest
IV. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
V. Violation of publication ethics, authorship and contributorship
VI. Identification of publication misconduct, complaints and appeals
VII. Predatory publishers and journals

4: Open Access Publishing

I. Open access publications and initiatives
II. SHERPA/RoMEO online resource to check publisher copyright & self – archiving policies

III. Software tool to identify predatory publications developed by SPPU
IV. Journal finder/ journal suggestion tools viz. JANE, Elsevier journal finder, Springer journal suggester, etc.

5: Publication Misconduct

A. Group Discussion

I. Subject specific ethical issues, FFP, Authorship
II. Conflicts of interest
III. Complaints and appeals: examples and fraud from India and other open source software tools

6: Databases and Research Metrics

A. Databases

I. Indexing databases
II. Citation databases: Web of science, Scopus, etc.

B. Research Matrics

I. Impact Factor of journal as per journal citation Report, SNIP, SJR, IPP, Cite score
II. Metrics: h-index, g index, i10 index, altmetrics

Text Books and Reference Books

1. "How to write and Publish" by Robert A. Day and Barbara Gastel, (Cambridge University Press).
2. "Survival skills for Scientists" by Federico Rosei and Tudor Johnson, (Imperial College Press).
3. "How to Research" by Loraine Blaxter, Christina Hughes and Malcum Tight.
4. "Probability and Statistics for Engineers and Scientists" by Sheldon Ross, (Elsevier Academic Press).
5. "The Craft of Scientific Writing" by Michael Alley, (Springer).
6. "A Students's Guide to Methodology" by Peter Clough and Cathy Nutbrown, (Sage Publications).
7. Programming with C – Byron Gottfried. Tata McGraw Hill
8. Programming In C – Balaguruswamy, Tata McGraw Hill
9. Numerical Methods, E. Balaguruswamy, Tata McGraw Hill
10. Computer oriented numerical methods-Rajaraman

References

Bird, A. (2006). *Philosophy of Science*. Routledge.

MacIntyre, Alasdair (1967) *A Short History of Ethics.* London.

P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865

National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. National Academies Press.

Resnik, D. B. (2011). What is ethics in research & why is it important. *National Institute of Environmental Health Sciences*, 1–10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm

Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179–179. https://doi.org/10.1038/489179a

Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance(2019), ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

Ph.D. Course work	PPH-102			
	THIN FILM TECHNOLOGY & NANOSTRUCTURES			
Time Allotted for End Semester Examination	Marks Allotted for Continuous Assessment	Marks Allotted for End Semester Examination (ESE)	Maximum Marks (MM)	Total Credits
3 Hrs	**30**	**70**	**100**	**06**

NOTE: The question paper shall consist of Two sections (Sec.-A, Sec.-B). Sec.-A shall contain 10 short answer type questions of four marks each and student shall be required to attempt any five questions. Sec.-B shall contain 8 descriptive type questions of ten marks each and student shall be required to attempt any four questions. Questions shall be uniformly distributed from the entire syllabus.

UNIT-1

THIN FILM TECHNOLOGY

Classification of Thin films configurations; Film deposition method: Physical vapor deposition, Chemical vapor deposition, Spray pyrolysis, Sputtering (RF, DC); Modes of film growth by vapor deposition: from vapor to adatoms, from adatoms to film growth, growth modes based on surface energies; film microstructure: Epitaxial films, polycrystalline films, Origin of films stress: classification, stress in epitaxial films, stress in polycrystalline films, consequence of stress in film; effect of substrate temperature, deposition angle and thickness on thin film formation.

UNIT-II

POLYMERS & CERAMICS

Characteristics, Application and Processing of polymers; Polymerization, Polymer types: Stress– Strain behaviour, melting and glass transition, thermosets and thermoplasts; Characteristics, Application and Processing of Ceramics, glasses and refrectories.

UNIT-II1

CHARACTERIZATION TECHNIQUES

Electrical, Optical and Mechanical method for determination of thickness of films, Transmission electron microscopy (TEM), Scanning electron microscopy (SEM); Scanning tunneling microscopy (STM); Atomic force microscopy (AFM).

X–ray diffraction, data manipulation of diffracted X–rays for structure determination; X–ray fluorescence spectrometry for element detection with concentration; Auger electron spectroscopy (AES), X–ray photoelectron spectroscopy (XPS), Secondary ion mass spectroscopy (SIMS)

UNIT-IV

INTRODUCTION AND SYNTHESIS OF NANOMATERIALS

Basic idea of Nanomaterials and Nanotechnology, Physical Methods: inert gas condensation, arc discharge, Laser ablation, molecular beam epitaxy, electron deposition, ball milling; electron beam lithography; Chemical Methods: sol–gel, micelles and micro emulsions.

Nanoparticles: Introduction to Nanoparticles; Metal Nanoclusters: magic numbers, theoretical modeling of nanoparticles, geometric structure, electronic structure, reactivity, magnetic clusters, bulk to nanotransition; Semiconducting nanoparticles: optical roperties, photofragmentation, columbic explosion; Rare gas and molecular clusters.

UNIT-V

QUANTUM NANOSTRUCTURES

Introduction to quantum wells wires and dots**;** preparation using lithography; Size and dimensionality effects: size effects, conduction electrons and dimensionality, potential wells, partial confinement, properties dependent on density of states, single electron tunneling; Application: Infrared detectors, Quantum dot Lasers.

Carbon Nanostructure: Carbon molecules: nature of carbon bond; new carbon structures; Carbon clusters: small carbon clusters, structure of C60, alkali doped C60; Carbon nanotubes: fabrication, structure, electrical properties, vibrational properties, mechanical properties, Application of carbon nanotubes: field emission and shielding, computers, fuel cells, chemical sensors, catalysis.

Text Books and Reference Books

1. Thin Film Materials–Stress, defect, formation and surface evolution: L.B. Freund and S.Suresh–Cambridge.
2. Thin Film Phenomena: K.L. Chopra–Mc Graw Hill Book, Comp., 1979.
3. Thin Film fundamentals: A. Goswami–New age International, 2007.
4. Material Science and Engg: W.D. Callister–John Wiley, 2001.
5. Elements of X–ray Diffraction (3rd Edition): B.D. Cullity, S.R. Stock–Prentice Hall, 2001.
6. X–ray Fluorescence spectroscopy: R. Jenkins–Wiley Interscience, New York, 1999.
7. Methods of Surface Analysis: J.M. Walls– Cambridge University Press, 1989.
8. The principles and Practice of Electron Microscopy: Ian M. Watt–Cambridge University Press, 1997.
9. Modern techniques for surface science: D.P. Woodruff and T.A. Delchar–Cambridge University Press, 1994.
10. Introduction to Nanotechnology: Charles P. Poole Jr. and Franks J. Qwens,–John Wiley & Sons, 2003.
11. Solid State Physics: J.P. Srivastva–Prentice Hall, 2007.
12. Nanotubes and Nanowires: CNR Rao and A Govindaraj–Royal Society of Chemistry, 2005.

Ph.D. Course work		PPH-103			
		HETEROSTRUCTURES, QUANTUM WELLS AND DEFECTS IN SOLIDS			
Time Allotted for End Semester Examination		Marks Allotted for Continuous Assessment	Marks Allotted for End Semester Examination (ESE)	Maximum Marks (MM)	Total Credits
	3 Hrs	**30**	**70**	**100**	**06**

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UNIT – 1

HETEROSTRUCTURES

General properties of heterostructures, Growth of heterostuctures: MBE & MOCVD, Band Engineering, Band Diagrams of different heterostructures, Superlattice devices, Doped Heterostuctures: Modulation Doping, band diagram of modulation doped layer, MODFET, electrostatic potential, conduction band and gate bias, threshold voltage, gate–channel capacitance, screening by 2D electron gas, layered structures, band structure modifications by strain, Quantum wires and dots.

UNIT – II

QUANTUM WELLS

Solution of Schrodinger wave equation in one dimensional square wells of finite and infinite depths, parabolic and triangular wells, Low dimensional systems, sub–bands and their occupation, Two and three dimensional quantum wells: cylindrical, two dimensional parabolic and spherical wells, Quantum wells in heterostructures, Tunneling transport in semiconductors, potential step, square barrier, T–matrices, Tunneling current in one, two and three dimensions, Resonant Tunneling through Quantum Wells, Coulomb Blockade and single electron devices, Tunneling in Heterostructures, Intervalley transfer.

UNIT – III

ELECTRON DYNAMICS

Semiclassical dynamics of electrons in a magnetic field, semiclassical approach to magenetotransport, Quantum mechanical approach to electrons in uniform magnetic fields, Landau levels, Aharonov–Bohm effect, De–Haas effect, Shubnikov–de–Haas Effect, Quantum Hall Effect, Fractional Quantum Hall Effect.

UNIT – IV

OPTICAL PROPERTIES OF QUANTUM WELLS

General Theory of optical properties of Quantum Wells; Kramers–Kronig relations, optical –response functions, sum rules, valence band structure: Kane model, energy bands in a quantum well, interband Transitions in quantum wells, Absorption spectrum, optical gain and lasers, Excitons in two and three dimensions, Excitons in a quantum well.

UNIT – V

DEFECTS AND DIFFUSION IN SOLIDS

Point defects: Impurities, Vacancies–Schottky and Frankel vacancies, Color centers and coloration of crystals, F–centres, Line defects (dislocations), Edge and screw dislocations, Berger Vector, Slip, Planar (stacking) Faults, Grain boundaries, Low angle grain oundaries, Frank Reed Mechanism and Dislocation Multiplication, the Hydration energy of ions, Activation energy for formation of defects in ionic crystals, interpretation of diffusion in alkali halides, Ionic conductivity in pure alkali halides.

Text Books and Reference Books

1. Physics of Low Dimensional Semiconductors – John H Davies-Cambridge University Press – 1998.
2. Low Dimensional Semiconductor Heterostructures – Keith Barnham & Dimitri Vedensley – Cambridge University Press – 2001.
3. Physics of Semiconductors and their Heterostructures – Jasprit Singh – Mc Graw Hill, 1994.
4. An Introduction to solid state Physics–C. Kittel–Wiley Eastern Ltd., New Delhi, 1979.
5. Solid State Physics–A. J. Dekkar–Mc Millian India Ltd., New Delhi, 2004.
6. Principles of Solid State Physics–R. A. Levy–New York Academy, 1968.
7. Elementary Solid State Physics–Omar–Addison Wesly, 1975.
8. Introduction to solid state Physics–Ashcroft and Mermin–New York Holt, 1976.

Ph.D. Course work	PPH-104			
	ATMOSPHERIC PHYSICS & BIO-ELECTROMAGNETISM			
Time Allotted for End Semester Examination	Marks Allotted for Continuous Assessment	Marks Allotted for End Semester Examination (ESE)	Maximum Marks (MM)	Total Credits
3 Hrs	**30**	**70**	**100**	**06**

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UNIT I

THERMODYNAMICS OF ATMOSPHERE & CLOUD PHYSICS

Thermal structure of atmosphere, Gas laws, Hydrostatic equation, First law of thermodynamics, Adiabatic processes, Water vapour in air, Static Stability, Second law of thermodynamics. Theory of nucleation of water vapour & cloud condensation nuclei, Microstructure of warm clouds, Cloud liquid water content & entrainment, Growth of cloud droplets in warm clouds, Microphysics of cold clouds, Artificial modification of clouds & precipitation: modification of warm & cold clouds, inadvertent modification.

UNIT II

ATMOSPHERIC ELECTRICITY & LIGHTNING

Fair weather atmospheric electric fields and currents, Mechanisms of cloud electrification: precipitation powdered & connective mechanisms, electrochemical charge separation, charge structure of the clouds, thundercloud electric fields. Lightning initiation in a thundercloud, Cloud to ground and intra-cloud lightning, Positive lightning, Lightning super bolts, Lightning fields: electric & magnetic fields, radiations from lightning, application of the lightning electric field measurements. Lightning sprites.

UNIT III

RADIATIVE TRANSFER & ATMOSPHERIC MEASUREMENT TECHNIQUES

Spectrum and Quantitative description of radiation, Black body radiation, Physics of scattering, absorption & emission, Radiative transfer in planetary atmosphere, Radiation balance on the top of atmosphere. Basic concepts of non-conventional energy sources, viz. solar energy & wind energy.

Ground based measurements of temperature, pressure and humidity, Airborn measurement of above parameters, Measurement of air, water and noise pollutions, Measurement of precipitation, Measurement of cloud parameters using Radar.

UNIT IV

DIELECTRIC PROPERTIES OF TISSUES

Definition and basic concepts, general relaxation theory, distribution of relaxation times, Kramers - Kronig relations, interfacial polarization (Maxwell-Wagner effect), two slab in series, dilute suspension of spherical particles and membrane covered spheres. Dipolar relaxation mechanism, counterion polarization effects, Dielectric dispersion in conductivity and permittivity of tissues.

UNIT V

BIOLOGICAL EFFECTS OF ATMOSPHERIC RADIATION

Bio-effects of dc and elf electric fields, Bio-effects of static magnetic fields, Bio-effects of elf magnetic fields, Bio-effects of higher frequency radiation, Thermoregulation in presence of microwaves, Therapeutic applications of bio-effects.

Text Books and Reference Books

1. Atmospheric Science - John M. Wallace & Peter V. Hobbs, Academic Press (2006)
2. Meteorology for Scientists and Engineers - Ronald B. Stull, Brocks/Cole Cengage Learning (1995)
3. Dynamic Meteorology - Holton, J.R., 3rd edition, Academic PressN.Yf. (1992).
4. Hand Books of Biological Effect of Electromagnetic Fields-C.Polk & E.Postow,C.R.C.Press,Boca Rain1996.
5. Modern Bioelectricity- A.A. Marino, Marcel Dekker Inc. New York(1988).

Ph.D. Course work	PPH-105			
	COSMOLOGY AND HIGH ENERGY PHYSICS			
Time Allotted for End Semester Examination	Marks Allotted for Continuous Assessment	Marks Allotted for End Semester Examination (ESE)	Maximum Marks (MM)	Total Credits
3 Hrs	**30**	**70**	**100**	**06**

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UNIT I

THE UNIVERSE OBSERVED

The expansion (Hubble diagram), Isotropy & Homogeneity, Age of the Universe, Big Bang Nucleosynthesis, Cosmic Microwave Background Radiation (CMBR).

UNIT II

TENSORS IN GR & EINSTEIN'S EQUATION

Metric Tensor, Parallel Transport, Chirstoffel's Symbols, Covariant Derivative, Geodesic equation, Postulates of GR, Spacetime Curvature, Riemann Tensor, Ricci Tensor, Weyl tensor, Ricci Scalar, Einstein equation, Schwarzschild solution, Geodesic-deviation equation.

UNIT III

STANDARD COSMOLOGY

Notions of homogeneous and isotropic universe, the Friedmann-Lemaitre-Robertson–Walker (FLRW) Metric, the Friedmann equation with solutions in a few distinct cases, (*e.g.,* non-relativistic matter, relativistic matter, vacuum), elementary idea of dark energy and dark matter.

UNIT IV

CLASSICAL AND QUANTUM FIELD THEORY

The field concept, action principle and Lagrangian formulation, Noether's theorem and conservation laws, different types of Green's function, Canonical quantization, Quantum field theory of spin-zero and spin-half particles, commutation and anti-commutation rules.

UNIT V

SYMMETRIES AND ELEMENTARY PARTICLES

U(1), SU(2) and SU(3) symmetries, elementary particles (quarks and leptons), elementary idea of Abelian and non-Abelian gauge theory, basic idea of Higgs mechanism, hadrons and Regge trajectories, quark confinement and QCD.

Text Books and Reference Books

1. An Introduction to Quantum Field Theory – *Michael A. Peskin & Daniel V. Schroeder* – Levant Books, Kolkata – 2005.
2. Quantum Mechanics & Field Theory – *B. K. Agarwal* – Lokbharti Prakashan – 2003.
3. Quantum Field Theory – *Franz Mandl & Graham Shaw* – Wiley – 1984.
4. Elements of Field Theory – *D. C. Joshi* – Transmedia – 2004.
5. Introduction to Elementary Particles – *David Griffiths* – John Wiley & Sons – 1987.
6. Concepts of Particle Physics (Vol II) – *K. Gottfried & V. F. Weisskopf* – Oxford University Press – 1986.
7. Gravity: An Introduction to Einstein's General Relativity – *James P. Hartle* – Pearson Education – 2005.
8. Classical Fields – *Moshe Carmeli* – Allied Publishers – 2005.
9. General Relativity – *Robert M. Wald* – Overseas Press (India) – 2006.
10. Gravitation and Cosmology – *Steven Weinberg* – John Wiley & Sons – 2005.
11. Spacetime and Geometry: An Introduction to General Relativity – *Sean M. Carroll* – Addison-Wesley Longman – 2004.
12. Modern Cosmology – *Scott Dodelson* – Academic Press – 2003.