SHRI GURU RAM RAI UNIVERSITY

Patel Nagar, Dehradun-248001, Uttarakhand, India

[Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017 & recognized by UGC u/s (2f) of UGC Act 1956]

SYLLABUS FOR

Pre-Ph.D. Physics
School of Applied and Basic Science

(W.E.F 2024-2025)

Pre-Ph.D. Physics

Eligibility for admission:

(i) Any candidate who has passed Master's degree in Physics in any state from recognized University/Institute with not less than 55 % marks in aggregate is eligible for admission, However, SC/ST, OBC and other eligible communities shall be given relaxation as per university rules.

(ii) For admission to PhD programme in related subject, an applicant has to appear RET (Research Entrance Test) conducted by the university followed by university.

(iii) Applicant who have qualified NET/SET/GATE shall be exempted from RET.

Duration of the Programme: Minimum 3 years

STUDY & EVALUATION SCHEME: Choice Based Credit System
Pre-Ph.D. Physics

First Semester

S. No.	Course Category	Couse Code	Course Name	Periods				Evaluation scheme		Subject Total
				L	T	P	C	Sessional (Internal)	External (ESE)	
Theory										
1	Core	PRMC 101	Research Methodology	2	1	1	4	20	60	80
2	Core	PRPC 102	Research & Publication Ethics	1	1	0	2	10	30	40
3	Subject specific core paper	PPHC 103	Techniques of Materials Characterization	4	0	0	4	20	60	80

4	Subject specific Elective paper (Any One)	PPHE 104/PPHE 105/PPHE 106/PPHE 107/PPHE 108	Nanoscience and Nanotechnology/Advanced Materials and Energy Devices/Nuclear and High Energy Physics /Advanced Mathematical Physics /Quantum field theory	4	0	0	4	20	60	80
5	Core	PPHF 108	Field work (Seminar / Conference Presentation / Review literature, Journal club and other activities assigned)	0	2	2	4	80	-	80
6										
Practical										
1										
			Total	11	4	3	18	150	210	360

L – Lecture, T – Tutorial, P – Practical, C – Credit

Examination Scheme: For all course except Research & Publication Ethics and Field work

Components	Sessional (Internal)	External (ESE)
Weightage (%)	20	60

Pre-Ph.D. Physics

Course code	: PRMC 101				
Course Name	: Research Methodology				
Semester /Year	: I				
		L	T	P	C
		2	1	1	4

Course Objective: The objectives of this course is to familiarize students for meaningful knowledge for conducting quantitative and qualitative research methods. Students will gain knowledge in understanding design, methodology and technique, data management, presentation, and data analysis.

Course Contents

Unit 1 - Concept & Types of Research

Meaning and importance of Research – Types of Research – Selection and formulation of Research Problem –Research Design, Classification of Research, Pure and Applied Research, Exploring or Formulative Research, Descriptive Research, Diagnostic Research/Study, Evaluation research/Studies, Action Research, Experimental Research, Analytical Study of Statistical Method, Historical Research. History and basic concepts (validity, reliability, objectivity and subjectivity) characteristics and format. Steps to better writing, flow method, organization of material and style.

[10]

Unit 2 - Methods Research

Surveys, Case Study, Field Studies General Survey of various Methods including Survey Method, Interdisciplinary Method, Case Study Method, Sampling Method, Statistical Method, Observation Method, Interview Method, Schedule Method, Questionnaire Method, Documentary Method, Library Method, Historical Method and Scientific Method. Characteristic Features of Scientific Method; Empirical Verifiable, Cumulative, Self - Correcting, Deterministic, Ethical & Ideological neutrality (Value Free), Statistical Generalizability.

Unit 3 - Data Collection and Data Analysis [10]

Collection, Objectives and Classification of Data, Aims, Methods and Objects of Tabulation of Data, Forms and Processes of Interpretation and Presentation of Data. Primary, Secondary and Tertiary Data. Construction and adaptation of instruments, administration of questions and tests. Data organization in SPSS & Excel, Graphical representation of data. Definition and Aims of Content Analysis, Problems of Content Analysis, Computer and Content Analysis Discussion and Interpretation of results, Testing of Hypothesis: Logical and Statistical Techniques.

[10]

Unit 4- Report Writing

Locating Information on a Topic of Interest, Acquiring Copies of Articles of Interest, The Nature of Scientific Variables, Conceptual Versus Operational Definitions of Variables, Levels of Measurement, Various Paradigms, The Basic Format for a Research Report, Identification of the Parts of a Research Report, Citation and Referencing Styles, Essentials of Report Writing, Aids for Writing Good Research Report.

[8]

Text Books:

TB1. Ganesan R, Research Methodology for Engineers, MJP Publishers, Chennai. 2011
TB2. C.R.Kothari, "Research Methodology", 5th edition, New Age Publication,
TB3. Cooper, "Business Research Methods", 9th edition, Tata McGraw hills publication

Reference Books:

RB1. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.
RB2. Bordens K.S. and Abbott, B.b.: Research Design and Methods, McGraw Hill, 2008.
RB3. Morris R Cohen: An Introduction to logic and Scientific Method (Allied Publishers) – P 197-222; 391–403

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	To develop understanding of the basic framework of research work.
CO2	To develop an understanding of various research designs and techniques.
CO3	To identify various sources if information for literature review and data collection.
CO4	To develop an understanding of the ethical dimension of conduction applied research.
CO5	Appreciate the components of scholarly writing and evaluate its quality.
CO6	To create the research design and experimental approaches to conduct research.

Course code	:	PRPC 102			
Course Name	:	Research & Publication Ethics (RPE)			
Semester /Year	:	I			
		L	T	P	C
		1	1	0	2

Course Objective: The objectives of this course is to convey the principles of ethical research. Students will gain the knowledge of hands-on experience to identify research misconduct and predatory publications.

Course Contents

Unit 1 - Philosophy and Ethics

1. Introduction to philosophy: definition, nature and scope, concept, branches.
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions.

Unit 2 - Scientific Conduct [3]

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, and Plagiarism (FFP)
4. Redundant publication: duplicate and overlapping publication, salami slicing
5. Selective reporting and misrepresentation of data

Unit 3 - Publication Ethics [5]

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals Practice

[7]

Unit 4- Open Access Publishing

1. Open access publications and initiatives
2. SHERPA / ROMEO online resource to check publisher copyright and self-archiving policies
3. Software tools to identify predatory publications developed by SPPU
4. Journal finder / journal suggestion tools viz. JANE, Elsevier journal Finder, Springer, Journal Suggester, etc.

Unit 5- Publication Misconduct

A. Group Discussion (2 Hours)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad.

B. Software tools (2 Hours)

 Use of plagiarism software like Turnitin, Urkund and other open source software tools.

[4]

Unit 6- Databases and Research Metrics

A. Databases (4 Hours)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 Hours)

1. Impact factor of journal as per journal Citation report, SNP, SJR, IPP, Cite score 2. Metrics: h-index, g index, i10 index, altimetrics

[7]

Text Books:

TB1. Todorovich M, Kurtz P, The Ethics of Teaching and Scientific Research, Sidney Hook.

TB2. Michael P Marder (2004) Research Methods for Science. Oxford Press

TB3. Murthy S N, Bhojanna U (2008) Business Research Methods Excel Books

Reference Books:

RB1. Kambadur M K, Ghosh A, Singhvi A K, (2019) ETHICS in, Science Education, Research and Governance, Indian National Science Academy New Delhi, India

RB2. Erlbaum J L L, (2003) Ethics and Values in Industrial-Organizational Psychology.

RB3. Barbara H. S., Joan E. Sieber; Gary B. Melton Research Ethics: A Psychological Approach By

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	To develop an understanding of research ethics, publications misconduct and plagiarism.
CO2	To develop Intellectual honesty and research integrity.
CO3	To identify various sources of information for data bases and research matrices.
CO4	To develop an understanding of open access publication and initiatives.
CO5	Appreciate the components of scholarly writing and evaluate its quality.
CO6	To create the research matrices based on cite score.

Course code	: PPHC 103				
Course Name	: Techniques of Materials Characterization				
Semester /Year	: I				
		L	T	P	C
		4	0	0	4

Course Objective: The objectives of this course is to gain knowledge in understanding various techniques and tools for studying the substructure and atomic structure of materials. The course broadly covers various characterization techniques including optical microscopy, X-ray diffraction, scanning electron microscope, transmission electron microscope, atomic force microscopy, UV-Vis spectroscopy, thermogravimetric analysis.

Course Contents

Unit 1

Optical Microscopy: Optical microscope - Basic principles & components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarised light, Hot stage, Interference techniques), Specimen preparation, Applications.

[9]

Unit 2

Diffraction Methods: Fundamentals of crystallography: an atom, unit cell, a cubic system (SC, BCC, FCC & Diamond cubic), Atomic Packing factor, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction and Neutron diffraction.

[10]

Unit 3

Surface Analysis: Interaction of electrons with solids, scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Energy dispersive spectroscopy(EDS). Atomic force microscopy(AFM), scanning tunnelling microscopy(STM).

[8]

Unit 4

Spectroscopy: X-ray photoelectron spectroscopy. Atomic absorption spectroscopies, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy. Photoluminescence spectroscopy.

[8]

Unit 5

Thermal Analysis: Thermo gravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry, Thermo mechanical analysis and dilatometry. [8]

Text Books:

TB1. ASM Handbook: Volume 10: Materials Characterization; Crankovic; ASM International; (1986)

TB2. Sibilia J.P., A Guide to Materials Characterization and Chemical Analysis, VCH (1997)

TB3. Smallman, R.E., and Bishop, R.J., Metals and Materials – Science, Processes, Applications, Butterworth-Heinemann (2013). **Reference Books:**

RB1. Cullity, B.D. Elements of X-Ray Diffraction, Addison Wesley (1967)

RB2. Microstructural Characterization of Materials; Brandon & Kaplan; Wiley; 2008

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Describe optical microscopy, fundamentals of crystallography, electron microscopy, photoelectron spectroscopy, absorption spectroscopies, and photoluminescence spectroscopy and thermal analysis.
CO2	Understand the optical microscopy, fundamentals of crystallography, electron microscopy, photoelectron spectroscopy, absorption spectroscopies, and photoluminescence spectroscopy and thermal analysis.
CO3	Applying the optical microscopy, fundamentals of crystallography, electron microscopy, photoelectron spectroscopy, absorption spectroscopies, and photoluminescence spectroscopy and thermal analysis to understand the pro
CO4	Analyzing the various microscopy techniques, optical, electron, photoelectron, absorption spectroscopies, and photoluminescence spectroscopy and thermal analysis. fundamentals of crystallography,
CO5	Evaluate the fundamental constant of crystallography, optical, electron microscopy, photoelectron spectroscopy, absorption spectroscopies, and photoluminescence spectroscopy and thermal analysis.
CO6	Solve and rectifying optical related problems, finding the crystallographic constants, electron microscopy, photoelectron spectroscopy, absorption spectroscopies, and photoluminescence spectroscopy and thermal analysis.

Course code : PPHE 104				
Course Name : Nanoscience and Nanotechnology				
Semester /Year : I				
	L	T	P	C
	4	0	0	4

Course Objective: The objectives of this course is to impart the knowledge of nanotechnology which covers various synthesis approaches for preparing different nanostructures and their applications.

Course Contents

Unit 1

Nano science and nanotechnology, historical perspective, classification of nano materials density of states in 1-D, 2-D and 3-D bands, variation of density of states and band gap with size of crystal, surface to volume ratio, aspect ratio, quantum confinement.

[8]

Unit 2

Homogenous and heterogeneous growth, nano materials synthesis; top-down and bottom-up approaches, ball milling, PVD, CVD, sol-gel technique, atomic manipulation, lithographic techniques.

[8]

Unit 3

Nature of Carbon Clusters, Discovery of C60, Structure, Fabrication and properties; Carbon based nanomaterials; single walled and multiwalled carbon nanotubes, graphene: discovery, synthesis and structural characterization, fullerenes, carbon dots, metallic and metal oxide nano particles, quantum dots and quantum wires.

[10]

Unit 4

Bulk Nano Structure Materials: Methods of Synthesis, Solid Disorders Nano Structures, Mechanical Properties, Nano Structure Multilayers, Metal Nano Cluster, Composite Glasses, Porous Silicon.

[6]

Unit 5

Applications of nano materials; nano sensors, nano machines, nano computers, solar energy conversion, nanomaterials for data storage, photonics, plasmonics, chemical and biosensors, nanomedicine, drug delivery.

[8]

Text Books:

TB1. Cao, G., Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Emperial College Press (2011)
TB2. Edward L. Wolf: Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, 2nd ed., Wiley-VCH (2015)
TB3. Handbook of Nano Structured Materials and Nano Technology: Nalva

Reference Books:

RB1. Poole, Jr. CP and Owens, FJ, "Introduction to Nanotechnology", Wiley (2006) RB2. Nano Technology: Richard Booker and Earl Boysen

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Describe the nanoscience and nanotechnology, top-down and bottom-up synthesis approaches, carbon-based nanomaterials, various applications of nano materials.
CO2	Understand the nanoscience and nanotechnology, synthesis approaches, carbon-based nanomaterials, various applications of nano materials, modern device applications
CO3	Apply various synthesis approaches in nanotechnology, carbon-based nanomaterials for various applications, modern device applications
CO4	Analyzing the nanoscience and nanotechnology, synthesis approaches, carbon-based nanomaterials, various applications of nano materials, modern device applications
CO5	Evaluate various nanomaterials in the nanoscience and nanotechnology, synthesis approaches, carbon-based nanomaterials, various applications of nano materials.
CO6	Solve and fabricate various nanomaterials in the nanoscience and nanotechnology, top-down and bottom-up synthesis approaches, carbon-based nanomaterials, various applications of nano materials.

Course code	: PPHE 105			
Course Name	: Advanced Materials and Energy Devices			
Semester /Year	: I			
	L	T	P	C
	4	0	0	4

Course Objective: The objectives of this course is to learn advance and smart materials, properties and application-based selection with special attentions to the applications in energy devices.

Course Contents

Unit 1

Introduction to advanced materials: theories and physical mechanisms, concept of Fermienergy, work function and electron affinity, equilibrium and non-equilibrium condition, linear and nonlinear characteristics. Interaction between materials of different chemical origin; organic and inorganic species; motifs and functions, bio-functional structure.

[8]

Unit 2

Carbon based materials: ACs, Graphene, CNTs, and MWNTs. Conjugates and nanoconjugates of conductive polymers, copolymers, and their hybrid electrode materials. Organic and inorganic hole and electron transport materials, their efficiency and properties.

[8]

Unit 3

Classification of soft materials, surface energy and interactions, Van der Waals interactions, Electrostatic interaction, entropy-driven interactions, hydrogen bonding, hydrophobic, interactions, solvophobic interactions.
[8]

Unit 4

Concept of energy production and storage; Emerging trends in LEDs and optoelectronic devices; Electrochemical capacitors and supercapacitors: principle, design and development, efficiency and properties, performance and applications; Piezoelectric and pyroelectric devices; Photochromic and electrochromic devices; Magneto-hydrodynamics and magnetic fluids

[10]

Unit 5

Rechargeable batteries; Solar batteries and solar charger; Solar cells: organic, inorganic and dye sensitized; Hydrogen production and storage using hybrid materials; Fuel cells: SOFC, PEFC, PAFC, MCFC design, development and properties.

[6]

Text Books:

TB1. Graphene-based Energy Devices; Rashid bin Mohd Yusoff; Wiley, 2015 TB2. Future Solar Energy Devices; Mihaela Girtan; Springer, 2017

Reference Books:

RB1. Mechanics of Advanced Materials; Vadim V. Silberschmidt; Springer, 2015. RB2. Nanomaterials in Energy Devices; Jun Hieng Kiat; CRC Press, 2017.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Describe the knowledge of advance and smart materials, carbon-based materials, classification of soft materials, concept of energy production and storage/devices.
CO2	Understand the knowledge of advance and smart materials, carbon materials, soft materials, energy production and storage and their devices.
CO3	Apply advance and smart materials carbon-based materials, soft materials, energy production and storage/devices various applications.
CO4	Analyzing problems in fabrication of advance and smart materials, carbon-based materials, classification of soft materials, energy production and storage/devices.
CO5	Evaluate various problems in creation of advance and smart materials, carbon-based materials, classification of soft materials, energy production and storage/devices.
CO6	Solve various problems in creation of advance and smart materials, carbon-based materials, classification of soft materials, energy production and storage/devices.

Course code	: PPHE 106			
Course Name	: Nuclear and High Energy Physics			
Semester /Year	: I			
L	T	P	C	
4	0	0	4	

Course Objective: The objectives of this course is to offer an overview of the concepts and methods in nuclear and particle physics to the students. The course covers basic concepts of nuclear-particle physics including general properties of nucleus, different models of nuclei, quark model, radioactive decay, and sub-nuclear particles.

Course Contents

Unit 1

Properties of nuclear matter, nuclear stability, Alpha, beta and gamma decays with selection rules, Particle emissions, nuclear fission and fusion processes, Production of nuclear energy and working of a reactor, General nature of nuclear force between nucleons.

[8]

Unit 2

Fermi gas model, Shell model, Collective rotational and vibrational models of nuclei, Microscopic description of nuclei using Hartree-Fock theory, Description of simple 1particle1hole excited states using the Tamm-Dancoff and Random Phase approximations (TDA and RPA), General feature of nuclear reactions, nuclear spectroscopy using stripping and pick up reactions.

[8]

Unit 3

Production of beam of charged particles using Linear Accelerator and Tandetron Accelerator; Production of neutron using accelerator, Radiation detection using Si(Li), HPGe, Si-Surface Barrier, MCP and Scintillator detectors; Energy and timing signal processing using Pre-Amplifier, Amplifiers, CFD and TAC; Data Acquisition using SCA, MCA , CAMAC based systems.

[7]

Unit 4

Lepton and quark families, Different types of interactions, Neutrino interaction with matter, Steller neutrinos, Neutrino telescopes, Quark structure of nucleons: Electron-proton scattering, Isospin symmetry, strangeness and hypercharge, SU (3) generators, Meson and Baryon multiplets, Gell-Mann Okubo mass formula; Parton model of hadrons, Bjorken scaling, quark confinement, colour and quark-gluon interactions, quantum chromodynamics (QCD).

[10]

Unit 5

Weak decays and selection rules, current-current interaction and Fermi's theory; P and CP violation in weak interactions; V-A theory of weak interactions, decays of Pions and Muons and calculation of life times, weak interactions of quarks, neutral weak interactions; massive neutrinos and neutrino oscillations.

[7]

Text Books:

TB1. B.R. Martin: Nuclear & Particle Physics
TB2. I. Kaplan: Nuclear Physics
TB3. Nuclear & Particle Physics-B.R. Martin & G. Shaw

Reference Books:

RB1. W. E. Burcham and M. Jobes, (1998), Nuclear and Particle Physics, Addison-Wesley
RB2. Povh, K. Rith, C. Scholz, F. Zetsche, (1995) Particles and Nuclei, Springer
RB3. S E Johansson, J L Compbell, K G Malmquist (1923), Particle Induced X-Ray Emission Spectroscopy, Vol 133, John Wiley & Sons.
RB4. I J R Aitchison and A J G Hey, (1982), Gauge Theories in Particle Physics (Vol. I), Adam Hidger.
RB5. Glenn F. Knoll (1979), Radiation Detection and Measurements, John Wiley & Sons.

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Describe properties of nucleus, models, accelerator, detectors, quark families, decays, reactions between elementary particles.
CO2	Understand the properties of nucleus, various models, accelerator, detectors, quark, decays, reactions of elementary particles.
CO3	Apply the properties of nucleus, detectors, various models, the reactions of elementary particles, accelerator, quark, and decays.
CO4	Analyzing the reactions of elementary particles, the properties of nucleus, detectors, various models, accelerator, quark, and decays.
CO5	Evaluate the properties of nucleus, detectors, various models, reactions of elementary particles, accelerator, quark, and decays.
CO6	Solve reactions of elementary particles, the properties of nucleus, detectors, various models, accelerator, quark, and decays.

Course code	: PPHE 107				
Course Name	: Advanced Mathematical Physics				
Semester /Year	: I				
		L	T	P	C
		4	0	0	4

Course Objective: The objectives of this course is to introduce important topics and numerical methods to impart deeper knowledge and understanding of theoretical physics problems to the students.

Course Contents

Unit 1

Numerical Solutions of ordinary Differential Equations: Solution of ordinary differential (first order, second order and simultaneous) equations by Picard's method, Taylor's, Series, Euler's Method, Runge-Kutta Methods, Predictor- Corrector Methods.

[8]

Unit 2

Numerical Solutions of Partial Differential Equations: Formation and Classification of Partial differential Equation, Solution of One Dimension Wave Equation, and Heat Equation, Two Dimension Heat and Laplace Equation by Separation of variables Method. Jacobi and Gauss- Seidal method.

[8]

Unit 3

Interpolation: Interpolation: Finite differences, difference tables, Newton's Forward and Newton's Backward Interpolation, Gauss Central Difference Formulae, Stirling, Lagrange's and Newton divided difference formula for unequal intervals.

[8]

Unit 4

Numerical Integration and Special Functions: Numerical Integration: Trapezoidal rule, Simpson's one-third rule, Simpson's three-eighth rule. Series solution of ODE of 2nd order with variable coefficient with special emphasis to Legendre and Bessel differential

equation, Legendre polynomial of first kind, Bessel Function of first kind and their properties.

[8]

Unit 5

Statistics: Elements of statistics, frequency distribution: concept of mean, median, mode, Standard derivation, variance and different types of distribution: Binomial, Poisson and Normal distribution.

[8]

Text Books:

TB1. Introductory Methods of Numerical Analysis by S. S. Sastry
TB2. R. K. Jain & S. R. K. Iyenger: Advanced Engineering Mathematics, 4th Edition, Narosa publication, 2014.
TB3. S. C. Gupta & V. K. Kapoor: Fundamentals of Statistics: 11th Edition, Sultan Chand & Sons, (Reprint) 2014.
TB4. Mathematical Methods for Physicists; Arfken, Weber (Academic Press)

Reference Books:

RB1. E. Kreyszig: Advanced Engineering Mathematics, 10th Edition, Wiley publication, 2011.
RB2. B.S. Grewal: Higher Engineering Mathematics, 42nd Edition, Khanna Publication, India, 2012.
RB3. Mathematical Physics: A modern introduction to its foundations; Sadri Hassani (Springer)

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Describe the numerical solutions and skills needed for various theoretical problems of physics.
CO2	Understand the implication of the variety of mathematical techniques.
CO3	Apply various mathematical concepts to build up new theories and simulations.
CO4	Examine special functions and statistics for better understanding of problems.
CO5	Evaluate various statistics for better interpretation of results.
CO6	Solve mathematical problems related in physics.

Course code	:	PPHE 108			
Course Name	:	Quantum Field Theory			
Semester /Year	:	I			
		L	T	P	C
		4	0	0	4

Course Objective: The objectives of this course is to appraise the students regarding the quantum field and its advanced concepts and their use in various situations pertaining to static and dynamic conditions.

Course Contents

Unit 1 - Time independent perturbation theory

Time independent perturbation theory: for non-degenerate and degenerate systems, up to second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom, Zeeman Effect with electron spin. Variation principle, application to ground state of helium atom, WKB approximation.

[7]

Unit 2 - Time dependent perturbation theory

Time-dependent perturbation theory: transition probability (Fermi Golden Rule), application to constant perturbation and harmonic perturbation. Semi-classical treatment of radiation. Einstein coefficients; radiative transitions.

[6]

Unit 3 - Identical Particles

The Schrodinger equation for a system consisting of identical particles, symmetric and anti-symmetric wave functions: Bosons and Fermions, Pauli's exclusion principle.

[5]

Unit 4- Scattering Theory

General considerations: kinematics, wave mechanical picture, scattering amplitude, differential and total cross section. Green's function for scattering. Partial wave analysis: asymptotic behavior of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, Optical theorem. Born approximation; its validity and applications.

[10]

Unit 5- Relativistic Wave Equations and Quantization of wave fields

Generalization of the Schrodinger equation; Klein-Gordon equation, plane wave solutions, charge and current densities, interaction with electromagnetic fields. Dirac Equation; relativistic Hamiltonian, probability density, expectation values, Dirac matrices, and their properties, Covariance of Dirac equation, electron spin and magnetic moment, negative energy sea, hole interpretation and the concept of positron.

[12]

Text Books:

TB1. Relativistic Quantum Mechanics: Wave Equations, 3/Ed; W. Greiner; Springer Int.; 2006.

TB2. Relativistic Quantum Mechanics and Quantum Fields; Katiyar; Campus Books Int.; 2009.

TB3. A First Book on Quantum Field Theory: Lahiri; Narosa Book Distributors Pvt Ltd; 2005

Reference Books:

RB1. Principles of Quantum Mechanics; Shankar; Springer; 2006.

RB2. Quantum Computation and Quantum Information: M. A. Nielsen and I. L. Chuang, Cambridge University Press.

RB3. An Introduction to Quantum Field Theory; Peskin and Schroeder; Westview Press; 1995.

RB4. Zettili N, "Quantum Mechanics: Concepts and Applications", 2nd Ed, John Wiley; 2009

RB5. Griffiths D J, "Introduction to Quantum Mechanics", 2nd Ed, Pearson Education; 2005

Course outcomes (COs):

Upon successful completion of the course a student will be able to

CO1	Describe the time independent perturbation theory, time dependent perturbation theory, identical particles, scattering theory, relativistic wave equations and quantization of wave fields
CO2	Understand the time independent/dependent perturbation theory, identical particles, scattering theory, relativistic wave equations and quantization of wave fields
CO3	Apply time independent perturbation theory, time dependent perturbation theory, identical particles, scattering theory, relativistic wave equations and quantization of wave fields
CO4	Examine the time independent perturbation theory, time dependent

	perturbation theory, identical particles, scattering theory, relativistic wave equations and quantization of wave fields
CO5	Evaluate time independent perturbation theory, time dependent perturbation theory, identical particles, scattering theory, relativistic wave equations and quantization of wave fields
CO6	Solve time independent perturbation theory, time dependent perturbation theory, identical particles, scattering theory, relativistic wave equations and quantization of wave fields