PhD Course Work (2020-21)
Department of Physics, Gauhati University

COURSE PLAN
(Venue: Physics gallery, Department of Physics, GU)

Duration of the Course: 25.2.2021

Time Table:

Days	1st period	2nd period	3rd period
	2PM-3PM	3PM-4PM	4PM-5PM
Monday	Paper IIIA		
Tuesday	Paper II*	Paper I	Paper I
Wednesday	Paper II*	Paper IIIB	
Thursday	Paper IV	Paper V	

Papers and Conveners :

	Name of the paper	Convener
Paper I	Research Methodology	Dr. H.K.Kalita
Paper II	Computer Fundamentals and Programming with Numerical Analysis	Prof. K. Boruah
Paper IIIA	General Physics	Dr Sanjeev Kalita
Paper IIIB	Experimental Techniques	Dr. Bimal K Sarma
	Astrophysics / Cosmology	Dr. Sanjeev Kalita
	Condensed Matter Physics	Prof. Deepali Sarkar
Paper IV	Electronics	Dr. BantyTiru
	High Energy Physics	Prof. Kalpana Bora
	Laser and Spectroscopy	Prof. A. G. Barua
	Nuclear Physics	Prof. B. Bhattacharjee
	Plasma Physics	Prof. M.P.Bora

Paper V	Research and Publication Ethics	Prof. A.G. Baruah

Important Points :

1. ***Instead of Paper-I, scholars can also choose from a SWAYAM paper.**
2. All papers have marks of 100 with 80 + 20 divisions for External and Internal.
3. The number of elective papers can be more or less or can be customised as per admitted students broad specialisations and PhD topic, without being too specific.
4. Classes for Paper IV can be carried out in the respective sister institutes but all other classes are to be held at the Physics Department, GU.
5. All final examinations will be held at the Physics Department, GU.

(Dr. B Tiru)
Coordinator, PhD Course Work (2020-2021)
Department of Physics, GU

21/02/2021

(B.Bhattarchajee)
Prof and Head
Department of Physics, GU

Syllabus for
Pre-Ph.D. Coursework

Physics Department,
Gauhati University.

There are five papers. Paper 1, II, II, IV each with 6 credits (30 lectures) and paper V will have 2 credit. Total credit: 6x4+2=26.

Paper-1: Research Methodology
Paper-II: Computer Fundamentals and Programming with Numerical Analysis
Paper-III: Physics (General)
Paper-IV: Physics (Optional)
Paper V: Research and Publication Ethics

Paper-I
Research Methodology
Total credit : 6

Research Aptitude:

- Research: Meaning, characteristics and types;
- Steps of research;
- Paper, article, workshop, seminar, conference and symposium;
- Thesis writing: its characteristics and format.

Data Interpretation

- Sources, acquisition and interpretation of data;
- Quantitative and qualitative data;
- Graphical representation and mapping of data.

Information and Communication Technology (ICT)

- ICT: meaning, advantages, disadvantages and uses;
- General abbreviations and terminology;
- Basics of internet and e-mailing.

Literature survey of the previous works and search for articles in the library Review of an article in the relevant field and preparation of a short report

Scientific presentation:
One seminar paper- preparation in power point (which includes text, graphs, picture, tables, reference etc.) (oral in power-point/poster); development of communication skills in presentation of scientific seminars- eye to eye contact, facing to audience, question & answer sessions etc.

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

Use of internet in research works

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 etc.

Patent laws, process of patenting a research finding, Copy right, Cyber laws

Paper-II
Computer Fundamentals and Programming with Numerical Analysis;
Total Credit: 6

Fundamentals of computers

Computer fundamentals, hardwares and softwares, different operating systems, application programmes,
some tips on PC maintenance and servicing of PC. 2L

Working in a Linux environment, basic Linux commands, writing scientific documents with Latex, graphic
and visualization, gnuplot; introduction to other useful software tools e.g. mathematica 4L

computer programming: 10L

Programming language(s) - FORTRAN , C (or C++)

Basic Numerical Methods: 8L

Numerical integration (trapezoidal and Simpson's method), numerical differentiation; Diagonalization and inverse of symmetric and non-symmetric matrices, Eigenvalues and eigenvectors.; Root finding (bisection and Newton-Raphson method); Interpolation techniques; Solution of ordinary differential equations (Euler and Runge-Kutta methods).

Statistics and treatment of experimental data: 4L

Data acquisition system, error propagation, curve fitting, Least square method, Sampling and parameter estimation, the maximum likelihood method. Analysis of a time series and search for periodicity. FFT (Fast
Fourier transformation) and power spectrum and any other topics used in physics researches.

Paper-III (A + B)
Physics (General)
Total credit=6

A. General Physics:

Matrix: Eigenvalues and eigenvectors, square root of a matrix; Lorentz transformations in fully relativistic notations, Structure of the Minkowski spacetime, world-line of a point particle and its equation
of motion; covariant formulation of electrodynamics and gauge transformation, classical fields and Euler-Lagrangian equation for fields; salient features of Bose-Einstein statistics and Fermi-Dirac statistics and their applications.

Angular Momentum Formalism: Hydrogen atom problem in spherical coordinates, Angular momentum, addition of angular momentum, Clebsch–Gordon coefficients, Relativistic quantum mechanics, Covariant form of Dirac equation, Dirac gamma-matrices and their properties.

Many body problem in Quantum mechanics: Quasi-particles and collective excitation, Spin wave function and exchange interactions and Heisenberg - Dirac Hamiltonian.

B. Experimental Techniques:

Production and measurements of Low pressure: Rotary, absorption, oil diffusion, Gauges, Pirani, Penning, leak detection; principles and characteristics of LASERS, principle and applications of powder X-ray diffractometer, spectrometer (IR and UV–visible), Fourier transform-infrared (FT-IR) spectrometer SEM,TEM, atomic force microscope, PIXE (Proton-induced X-Ray emission), particle detector and data analysis, wave synthesis and analysis, analog and digital computation.

Paper-IV
Physics: Optional
Total Credit:6

(Only one choice and there is provision to add more optional papers if manpower is available)

1. Astrophysics and Cosmology
2. High Energy Physics
3. Nuclear Physics and Cosmic Rays
4. Condensed Matter Physics
5. Electronics
6. Lasers and spectroscopy
7. Nonlinear Dynamics
8. Plasma physics

I. Astrophysics and Cosmology:

Early Stellar Evolution: Star formation from ISM, Jean's instability, Proto stars, Main sequence, post Main sequence evolution through Helium burning. Low mass stars, High mass stars. Advance stages of evolution. Elements of cosmology, the role of gravity in the cosmology, Newtonian derivation of Friedman equation. Thermal history of the universe, CMBR.

II. **High Energy Physics**:

Introduction to Gauge theory of fundamental interactions, Feynman diagrams in Momentum space and its applications in QED and QCD.
Parton model, Deep-Inelastic Scattering (DIS), QCD-evolution equations.
Standard model of electroweak interaction, Minimal supersymmetric standard
model(MSSM), neutrino
masses and mixing angles.
GUT and string theory

III. Nuclear Physics and Cosmic Rays

Heavy Ion Physics: Relativistics Kinematics,
Nuclear reaction: Compound nucleus hypothesis. Optical model of elastic scattering, average interaction potential for nucleus, energy dependence of the potential, spin orbit coupling, isospin effect. Nuclear reaction using Radioactive ion Beam.
Nuclear Energy: Nuclear fission: Energy release, mass and energy distribution of fission fragments, cross section for neutron induced fission. Chain reaction.
Cosmic Rays: Review of theories of origin – solar, galactic and extragalactic cosmic rays. Supernovae origin, GZK cutoff. Topdown models of EHE cosmic ray origin.

IV Condensed Matter physics:

Band theory and band structure, Quantum theory of magnetism,
Lattice dynamics, Thin Films, different methods of film preparation, condensation, nucleation and growth, defects, characterization, Size effect on transport properties, thin film semiconducting devices. Magnetic thin films
Nanophysics: Definition of nanoparticles, quantum dots, effect of particle size on band gap energy, method of preparation and characterization of nano materials, electrical, optical and magnetic properties of nanomaterials.
Introduction to soft condensed matter.

V. Electronics

Introduction to the science of Automatic Control System, Servo and Robotics**:** Science of Automatic Control System: Definition, information and energy, process characteristics. Basic building block of a servo system, open loop and close loop configurations with first and second order control, servomotor, servomultiplier.
Role of atmosphere on the propagation of EM wave – a brief introduction.
Insitu and Remote probing system:RADAR: Background science, working principles and basic design. Doppler radar: CW and pulse operations.LIDAR: Doppler, fluorecent, aerosol, Rayleigh and Differential absorption LIDAR and their applications.Signal retrieval and processing techniques.

VI. Lasers and Spectroscopy

Atmospheric opacity: Molecular band absorption, spectroscopic characterization techniques: Infra red, Raman and Fluorescence spectroscopy;Threshold condition of laser oscillation: variation of laser power around threshold, ultimate line width of lasers, Modern atomic spectroscopy – cold atoms and Doppler free spectroscopy etc; single atom spectroscopy etc.

Nonlinear optics: Susceptibility, harmonic generation- second and third order effects.

VI I . **Nonlinear Dynamics**:

Nonlinear equations in physics: an overview, Non-linear mechanics. Sensitive dependence on initial conditions. Examples of Chaotic systems: nonlinear electrical system and three-body gravitational problem.

Fractal and fractal dimensions, self-similarity and self-affinity. Cantor sets, Sicrpinski gasket, Koch curve.

One dimensional logical map, fixed points, bifuracations and cobwebs. Period doubling route to chaos.

Gigenbaurn number. Concept of strange attractor and its fractal nature.

Flow in two-D and limit cycle, bifurcations in a two-D linear system. Nonlinear two-D system and linearization. Van der Pol and Duffing oscillations.

Flow in three-D and chaos. Lorenz attractor. Measures of chaos: Poincare map and Lyapunov exponents.

VI I I . **Plasma physics**

Introduction to plasma, definition, concept of temperature, Debye shielding and different plasma parameters. Fluid theory in plasma, Fluid equations of motion, introduction to kinetic theory, diffusion and resistivity in plasma.

Gas discharge processes, dc discharge, rf discharge, capacitive and inductively coupled plasma systems, theory and description of different plasma production systems, Dusty plasma. Fundamentals of plasma processing.

Introduction to controlled thermonuclear fusion, magnetic confinement; Tokamak, Spheromak and ITER.

Nonlinear phenomena in plasma, sheath, Linear and non-linear waves in plasma.

Instability in plasma; streaming instability, ion drag force induced, drift wave instability and parametric instability.

Chaos and time series analysis; Fourier theory, Liapunov exponent, Attractors, self-similarity, Hurst exponent and Fractal dimension.

(Note: Reference books to be supplied at the time of lecture)

Paper-V

Physics: Research and Publication Ethics

Total Credit:2

Course structure

- The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit title	Teaching hours
Theory		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
Practice		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	Total	**30**

Syllabus in detail

THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (3 hrs.)**

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

- **RPE 02: SCIENTIFICCONDUCT (5hrs.)**

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

- **RPE 03: PUBLICATION ETHICS (7 hrs.)**

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 behavior 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

- **RPE 04: OPEN ACCESS PUBLISHING(4 hrs.)**

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

- **RPE 05: PUBLICATION MISCONDUCT (4hrs.)**

A. Group Discussions (2 hrs.)

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 hrs.)

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

- **RPE 06: DATABASES AND RESEARCH METRICS (7hrs.)**

A. Databases (4 hrs.)

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

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

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