SYLLABUS

M.Phil. / Ph.D. Course work

(*w. e. f. academic year 2021-22 and onwards)*

Department of Physics
&
All research centres in Physics
Affiliated to
Savitribai Phule Pune University
(Formerly University of Pune)

Prof. Gotan Jain
Chairman
BOS (Physics), SPPU

Prof. Sandesh Jadkar
Head
Dept. of Physics, SPPU

Prof. Vikas Mathe
Member
Dept. of Physics, SPPU

Prof. Shrikrishna Sartale
Member,
Dept. of Physics, SPPU

Prof. Sanjay Dhole
Member
Dept. of Physics, SPPU

Savitribai Phule Pune University

(Formerly University of Pune)

Syllabus for M.Phil. / Ph.D. Course work: Physics
(*w. e. f. academic year 2021-22 and onwards*)

I. *The total number of credits for M.Phil. / Ph.D. shall be 18*
II. *The course work will be treated as pre-requisite for M.Phil./ Ph.D. programmes.*
III. *The M.Phil./ Ph.D. course work shall consist of the following components, structure and the respective credits.*
IV. *All other rules and regulations regarding the course work shall be adhered as per* Savitribai Phule Pune University *(SPPU), Pune and University Grants Commission (UGC), New Delhi.*

M.Phil. / Ph. D. Course Structure for Physics:

The syllabus will be applicable to all the research centres offering M.Phil./Ph.D. programme in Physics affiliated to the Savitribai Phule Pune University. The course work shall be of 18 credits-

Sr. No.	**Course Code**	**Name of the Subject**	**Credits allotted**	**No of Hours**
1	**Course 1** Phy-Ph.D. 001	Research Methodology.	**04**	**60**
2	**Course 2** Phy-Ph.D. 002	i. Writing research proposal for obtaining financial assistance from national funding agencies, reviews and Seminars.	**01**	**15**
		ii. Writing of Reviews	**01**	**15**
		iii. Seminars	**02**	**30**
3	**Course 3** Phy-Ph.D. 003	Subject specific advanced level course- A) Fundamentals of Physics Revisited B) Advanced Experimental Techniques	**04** **04**	**60** **60**
4	**Course 4** Phy-Ph.D. 004	Publication Ethics *Research centre can have their own course to be run and evaluate* OR *Research centre can adopt a payment basis Publication ethics online course run by the Centre of Publication Ethics*	**02**	**30**
		TOTAL CREDITS	**18**	**270**
Course structure as per University circular available on following link: ***http://collegecirculars.unipune.ac.in/sites/documents/Revised%20PhdMPhilSyllabus2020/M.Phil.Ph.D.%20Course%20Work_04.06.2021.pdf***				

COURSE 1.

Course Code: Phy-Ph.D. 001
Title- Research Methodology.
Credits: 04 (60 hours)

This course is designed by the university for all faculties, which is available on the following link on the university website.

http://collegecirculars.unipune.ac.in/sites/documents/Revised%20PhdMPhilSyllabus2020/Research%20Methodology%20Revised%20Syllabus%20(%20Ph.D.%20Course)_08.092020.pdf

Based on the recommendation for the Physics subject under the faculty of Science and Technology following course is applicable.

Purpose - This course is one of the common courses that will train the M.Phil./Ph.D. student to do research efficiently.

Need of the course - It is observed that most of the M.Phil./Ph.D. entrants are not aware of the philosophy behind the research. Students face many questions such as why a research study has to be undertaken, how the research problem has to be defined, in what way and why the hypothesis has to be formulated, what data has to be collected, which method/technique has to be adopted, why specific technique of analysing data has to be used and a host of similar other questions while performing their research. The present course will facilitate the students to address these issues which help them to execute quality research.

Structure of the course – The course is structured into four different modules. The contents are largely case based so that student understands the practical workability of the course.

Sr. No.	Contents	Credits allotted	No of Hours
1	**Module I** - History of research. Indian, Egyptian, Greek ideas methodologies and research in agriculture, chemistry, metallurgy, medical. Ancient Indian research methodology applications.	01	15
2	**Module 2** - Statistical analyses and its significance, Exploratory and confirmatory research, Planned and ad-hoc methods of data collection, Non-response and methods of recovering the missing response, Various software for statistical analysis. The module will consist of case studies of the research performed in various subjects using statistical methods, Error and noise analysis, curve fitting.	01	15
3	**Module 3** – Literature search, selection of research topic (case study based), maintaining laboratory records (case study based). Safety in Laboratories, Ethical considerations, effective verbal and non-verbal communication, field data collection, safety in field.	01	15
4	**Module 4**- Writing research paper and/or thesis, making a presentation, writing a research proposal, and patents in Science, technology	01	15

The contact hours for the course will be 60 hours. The examination for the course will be conducted separately.

References:

1) 'History of the Scientific Methods' by Martin Shuttleworth, https://explorable.com/history-of-thescientific-method.
2) 'The Statistical Analysis of Experimental Data' by, John Mandel, ISBN: 0486646661, ISBN13: 9780486646664

Mode of examination

The internal examination of the course will be separately conducted. The examination mode is decided by the instructor of that course.
The external examination will be conducted at the time of 4th half yearly progress review. The student's implementation of various aspects in research methodologies will be checked.

COURSE 2.

Course Code: Phy-Ph.D. 002
Title- Scientific Writing and Presentation Techniques
Credits: 04 (60 hours)

Purpose – To train the research student to write and present his/her research topic in scientific manner.
Need of the course – Special training to the research students is required for writing review articles and research proposals to get financial assistance. For effective scientific presentation extensive seminar activities are essential. Since the research topic of every student is different, individual training, for both writing and presentation skills, is required to be given by the Research Guide.
Structure of the course – The course is structured into three different modules. The contents are distinct for individual research student.

Sr. No.	Contents	Credits allotted	No of Hours
1	**Module 1** Writing research proposal for obtaining financial assistance from national/international funding agencies- Can include Title, Research Context and Rationale, Research questions, Methodology, Plan of work, Significance of research, Bibliography. As per the requirement or proforma of the funding agencies.	01	15
2	**Module 2** Writing of Reviews- Respective guide should assign and check.	01	15
3	**Module 3** Seminars- At least 3 seminars should be conducted by the guide. Can include - Communication skills (Writing and Oral)-Listening, Speaking and Reading, presentation skills and ethics, Public speaking, workplace communications.	02	30

Mode of examination

Research guide should teach and evaluate this course for each student separately.

COURSE 3

Course Code: Phy-Ph.D. 003A and 003B

Title- Subject specific advanced level course

Phy-PhD 003A: Fundamentals of Physics revisited (04 credits)

Phy-PhD 003B: Advanced Experimental Physics (04 credits)

Credits: 08 *(04 each; 60 + 60 hours)*

Subject - Phy-PhD 003A: Fundamentals of Physics revisited (04 credits)

Purpose – To revise the fundamentals of Physics useful for research

Need of the course – For doing research in any advanced topics it is essential to have thorough background of basics related to the subject. This course is designed in such a way to train a student to meet the essentials of the advance course.

Structure of the course – The course consists of seven modules related to basic physics namely Mathematical methods in physics, Classical mechanics, Electrodynamics, Quantum mechanics, Statistical mechanics, Nuclear and Particle physics and Atoms, Molecules and Solids.

Sr. No.	Contents	No of Hours
1	**Mathematical Methods in Physics:** Application of vector calculus in classical mechanics and electrodynamics. Vector spaces and operator algebra, matrices and their application in quantum mechanics, Linear first order and second order differential equations in physics, Fourier series, Fourier and Laplace transforms, Complex analysis its applications in evaluating integrals.	8
2	**Classical Mechanics:** Lagrange's and Hamiltonian Formalisms, Conservation theorems and symmetry properties, Two- body central force problem- reduction to one body problem, scattering in a central force field. Small oscillations, orthogonal transformations, Eulerian angles, Rigid body motion.	8
3	**Electrodynamics:** Laplace and Poisson equations, boundary value problems, method of images, Electrostatics in dielectric media, Ampere's theorem. Bio-Savart law, electromagnetic induction, Maxwell's equations in free space and in linear isotropic media, Boundary conditions on fields at interfaces, scalar and vector potentials. Gauge invariance. Electromagnetic waves - reflection and refractions, dispersion, interference, coherence, diffraction, polarization, electrodynamics of charged particles in electric and magnetic fields. Time varying fields, plane electromagnetic waves in non-conducting media. Radiation from moving charges and from a dipole, retarded potentials and fields.	8
4	**Quantum Mechanics:** One dimensional problems, Harmonic oscillator, hydrogen atom, spherically symmetric potential: bound states and scattering states, angular momentum algebra, time independent and time dependent perturbation theories, WKB approximation, identical particles and symmetry, quantization of electromagnetic field (Coulomb gauge), Kramers-Heisenberg formula, Thomson, Raleigh and Raman scattering	8

5	**Statistical Mechanics:** Probability theory, statistical description of macroscopic systems, phase space, ensembles, partition function, laws of thermodynamics, thermodynamic potentials and Maxwell's relations. Chemical potential, free energy and connection with thermodynamic quantities. Ideal gas, Classical and quantum statistics, degenerate electron gas, BoseEinstein condensation, realization of Bose-Einstein condensate in the laboratory.	8
6	**Nuclear and Particle physics:** Basic nuclear properties, liquid drop model, nuclear forces, nuclear shell structure, interaction of charged particles and electromagnetic radiation with matter, basic principles of particle detectors, radio-active decays, nuclear reactions, fundamental forces, Gellmann-Nishijima formula Quark model, CPT invariance in different interactions, parity non-conservation in weak interactions.	8
7	**Atoms, Molecules and solids:** Electrons in atoms, exchange symmetry of wavefunctions, atomic and molecular spectra and their explanations including spin-orbit coupling, fine structure, relativistic corrections, spectroscopic terms and selection rules, hyperfine structure, Zeeman, Paschen-Back and Stark effects. Crystal classes and systems, lattice vibration, free electron theory, energy bands in solids, electronic structure of quantum confined structures, impurity levels in doped semiconductor structures. Electron transport, dielectrics, Clausius-Mosstti equation, ferroelectricity, dia-, para, ferro-, antiferro- and ferri-magnetism, superconductivity	12

References:

1) Mathematical Methods for Physicists A comprehensive Guide, George B. Arfken, Hans J. Weber and Frank E. Harris, (Academic Press Elsevier)
2) Classical Mechanics, N. C. Rana and P. S. Joag (Tata McGraw Hill)
3) Introduction to Electrodynamics, David J. Griffiths, (Prentice Press)
4) Quantum Physics, Stephen Gasiorowicz (John Wiley & Sons Inc.)
5) Fundamentals of statistical and thermal physics, Fedrick Reif (McGraw Hill)
6) Concepts of Nuclear Physics, B.L. Choen (Tata McGraw Hill)
7) Quantum Physics, Robert Eisberg and Robert Resnick, (John Wiley and Sons)

Mode of examination

The examination mode is decided by the teachers of this course or research centre will have their own mode of conduction of the examination.

Subject - Phy-Ph.D. 003B: Advanced Experimental Physics (04 credits)

Purpose – To train the students for various tools to be used during the course of time.

Need of the course – During the course of research work to execute the objectives of the research problem it is essential to understand the basics of the experimental techniques for proper measurements and analyses.

Structure of the course :– The course consists of four different modules, which covers different aspects of advanced experimental techniques.

Sr. No.	Contents	No of Hours
1	**Module 1: Interaction of radiation and energetic particles with matter** Basic phenomena in case of low energy and high energy interactions (keV and MeV energies) of photons, γ-rays, electrons, protons, neutrons, ions etc. Applications of these processes in synthesis of thin films, coatings, evaporation, sputtering (like plasma, processing, ion-beam processing, LASER processing) and in X-ray photoelectron spectroscopy (XPS).	15
2	**Module 2: Spectroscopic Techniques** Resolution of spectrometer/ instrument (general), Resolving power and influence of different experimental parameters on it. Sensitivity of Measurement. Accuracy of measurements. Instrumental errors and measurement errors. Atomic and molecular spectroscopy UV-vis-NIR absorption spectroscopy, Electronic transition in solids, Transmission reflection and absorption coefficient Infrared spectroscopy, Molecular vibration spectroscopy, Rotational spectroscopy, Bond analysis. Raman spectroscopy. Resonance spectroscopy Angular momentum, Magnetic moments and energy levels, Magnetic resonance, Nuclear Magnetic Resonance, Chemical shifts Fine structure and Intensity variations. Mossbauer spectroscopy Analysis of the spectra.	15
3	**Module 3: Microstructural analysis techniques** Atomic absorption, emission spectroscopy - fundamental of optical atomic spectrometry, Atomic emission spectroscopy. Atomic fluorescence spectrometry. Comparison of Atomic spectroscopies. X-ray diffraction principles, structure factor and diffraction intensity calculations, Rietveld analysis. Scanning electron and Transmission electron microscopy, Field emission microscopy, scanning Tunnelling microscopy, Atomic force microscopy.	15
4	**Module 1: Essentials of measurement and analysis** Noise and Signal handling Signal to noise ratio, Johnson Noise and Nyquist theorem, Shot noise, Means of reducing noise. Grounding – shielding, pre-amplifier, Considerations sampling theorem, filters – ADCs/DACs Foamier Transform, Laplace and Fast Fourier Transforms. Data analysis Lorentzian, Gaussian, least square fitting of the spectra. (curve fitting) Deconvolution of spectrum, Derivative peak shapes, Analysis of spectra by taking examples of Raman, X-ray photo-electron, etc. spectra.	15

References:

1. Introduction to analysis and processing of signals, Paul Lynn, Howard W. (Sams and Company, 1983).

2. Probability, Random Variables and Stochastic Process, A. Papoulis, international student Edition (McGraw-Hill International Book Company, 1984)
3. *Vacuum Physics and Techniques,* T. A. Delchar, Chapman and Hall.
4. *Vacuum technology,* A. Roth, (North Holland, Elsevier Science B.V. 1990)
5. *High vacuum techniques,* J. Yarwood, (Chapman and Hall, Londong, 1967)
6. *Nuclear Radiation Detectors,* S.S. Kapoor, V. S. Ramamurthy, (Wiley-Eastern Limited, Bombay)
7. *Experimental Principles and Methods below 1K,* O. U. Lounasmaa, (Academic Press, London and New York, 1974)
8. *Thermometry at ultra-low temperatures,* W. Weyhmann in Methods of Experimental Physics, Vol. II (R. V. Coleman, Academic Press, New York and London, 1974).
9. *Cryophysics,* K. Mendelssohn, Interscience (London, 1960)
10. *Characterization of Materials,* John B. Wachtman & Zwi. H. Kalman, Pub. Butterworth Heinemann (1992)
11 Handbook of Spectroscopy, G. Gauglitz and T. Vo-Dinh (WILEY-VCH Verlag GmbH & Co, 2003)

Mode of examination

The examination mode is decided by the teachers of this course or research centre will have their own mode of conduction of the examination.

COURSE 4.

Course Code: Phy-Ph.D. 004
Title- Publication Ethics.
Credits: 02 (*30 hours)*
Research and Publication Ethics:
Two Credit course, approved by UGC and compulsory for all Ph.D. students. The link for the same is given below.
http://sppudocs.unipune.ac.in/sites/circulars/MPhilPhDAdmission%20Circulars/Research%20and%20Publication%20Ethics.pdf?Mobile=1&Source=%2Fsites%2Fcirculars%2F%5Flayouts%2Fmobile%2Fdispform%2Easpx%3FList%3Df5fad69e%252Dd3e8%252D4ac5%252D90f6%252D0786c34fce20%26View%3D0ea15891%252D5dd2%252D436a%252Dbe77%252D0bedc1d2817a%26ID%3D186%26CurrentPage%3D1

Sr. No.	Contents	No of Hours
Theory		
1	Philosophy and Ethics	4
2	Scientific Conduct	4
3	Publication Ethics	7
Practice		
1	Open Access Publishing	4
2	Publication misconduct	4
3	Database and Research Metrics	7
	Total	**30**

Mode of examination

The examination mode is decided by the teachers of this course or research centre will have their own mode of conduction of the examination.