Fergusson College (Autonomous)

Pune

Learning Outcomes-Based Curriculum

for

M. Sc. Physics

With effect from June 2023

Implementation of NEP-2020 for Two Year PG program

(As per GoM GE 16/05/2023)

Illustrative Credit distribution structure for Two Years PG (M.Sc.) and Ph. D. Programme

Year (2Yr PG)	Level	Sem. (2 Yr)	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Electives					
I	6.0	Sem I	12-14 (2*4+2*2 Or 3*4+2)	4	4			20-22	PG Diploma (after 3 Yr Degree)
		Sem II	12-14 (2*4+2*2 Or 3*4+2)	4		4		20-22	
Cum. Cr. For PG Diploma			24-28	8	4	4	-	40-44	
Exit option: PG Diploma (40-44 Credits) after Three Year UG Degree									
II	6.5	Sem III	12-14 (2*4+2*2 Or 3*4+2)	4			4	20-22	PG Degree After 3-Yr UG Or PG Degree after 4- Yr UG
		Sem IV	10-12 (2*4 +2 or 3*4)	4			6	20-22	
Cum. Cr. for 1 Yr PG Degree			22-26	8			10	40-44	
Cum. Cr. for 2 Yr PG Degree			46-54	16	4	4	10	80-88	
2 Years-4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree									
	8.0		Course Work Min. 12 (3*4)		Training in Teaching / Education/ Pedagogy: 4			16 + Ph.D. Work	Ph.D. in Subject

Abbreviations: Yr.: Year; Sem.: Semester; OJT: On Job Training: Internship/ Apprenticeship; FP: Field projects; RM: Research Methodology; Research Project: RP; Cumulative Credits: Cum. Cr.

Table-2: Department wise Courses Titles as per NEP guidelines

(Science faculty)

Semester	Paper Code	Paper Title	Credits
I	**PHY-501**	**Classical Mechanics**	**4**
	PHY-502	**Mathematical Methods in Physics**	**4**
	PHY-503	**(Elective –I: Electronics)**	**4**
	PHY-504	**OR (Elective-II: Electronic Instrumentation)**	
	PHY-510	**Research Methodology (Theory)**	**4**
	PHY-520	**Practical - I**	**2**
	PHY-521	**Practical - II**	**2**
		Total Semester Credits	**20**
II	**PHY-551**	**Quantum Mechanics**	**4**
	PHY-552	**Atoms, Molecules and Solids**	**4**
	PHY-553	**(Elective–I: Materials Science)**	**4**
	PHY-554	**OR (Elective-II: Thin Film Physics)**	
	PHY-560	**On Job Training / Field Project**	**4**
	PHY-570	**Practical - III**	**2**
	PHY-571	**Practical - IV**	**2**
		Total Semester Credits	**20**
		Total PG-I Credits	**40**

Semester	Paper Code	Paper Title	Credits
III	PHY-601	Electrodynamics	4
	PHY-602	Statistical Mechanics	4
	PHY-603 OR	(Elective-I Experimental Techniques in Physics)	4
	PHY-604	(Or Elective-II Atmospheric Science)	
	PHY-610	Research Project	4
	PHY-620	Practical: Physics Practical Laboratory-V (Special Lab-I) (Materials Science)	2
	PHY-621	Practical: Physics Practical Laboratory-VI (MATLAB)	2
		Total Semester Credits	20
IV	PHY-651	Solid State Physics	4
	PHY-652	Nuclear Physics	4
	PHY-653 OR	(Elective-I Astronomy and Astrophysics)	4
	PHY-654	(Or Elective-II Physics of Nanomaterials)	
	PHY-660	Research Project	6
	PHY-670	Practical: Physics Practical Laboratory-VII (Special Lab-II) (Atmospheric Science + Astronomy and Astrophysics)	2
		Total Semester Credits	20
		Total PG-II Credits	40

Program Outcomes (POs) for M. Sc. Programme	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the discipline that form a part of an postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	**Social competence:** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise and help reach conclusion in group settings.
PO4	**Research-related skills and Scientific temper:** Infer scientific literature, build sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge**: Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence**: Perform independently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics**: Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability**: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

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Fergusson College (Autonomous), Pune

<u>Program Specific Outcomes (PSOs) and Course Outcomes (COs) 2023-24</u>

Department of Physics

Programme: M.Sc. Physics

Program Specific Outcomes (PSOs) for M. Sc. Physics	
PSO No.	**Program Specific Outcomes(PSOs)** **Upon completion of this programme the student will be able to**
PSO1	**Academic competence**: (i) **Associate** the universal applications of physics in all disciplines. **Articulate** fundamental and advance concepts, principles and processes underlying physical phenomena in different branches ranging from classical mechanics to quantum mechanics and extended to electrodynamics, statistical mechanics, atomic, molecular and solid state physics, nanomaterials and electronic science. (ii) **Demonstrate** mathematical, statistical and computational ability in problem solving. **Demonstrate** and **explain** various mathematical techniques, numerical methods, experimental techniques to broaden independent thinking and scientific temper.
PSO2	**Personal and Professional Competence:** (i) Execute experimental and project work independently. (ii) Carry out laboratory oriented numerical calculations and experimental data interpretation. Analyse self-generated data through experiments as well as archival data (iii) Formulation of physics concepts, effective presentation and communication skills through seminars and group discussions. Develop skills of technical report writing along with precise presentation with effective communication. Apply appropriate concepts and various methods to solve wide range of problems. Incorporate the hands-on training of soldering to connect electronic components for designing circuits for device applications.
PSO3	**Research Competence:** (i) Use of in-house laboratory setup for building instrumentation. Integrate and interpret data. Evaluate the research findings in materials sciences and astrophysics. Apply experimental skills for interdisciplinary research work. Review of research papers, books for publications in journals. Apply experimental skills for projects / research and need for interdisciplinary research Carry out projects in basic, applied and interdisciplinary science to develop conceptual understanding and an orientation towards research. Interpret and analyse the results of the research project. Integrate mathematical / statistical and computational data to analyse and formulate theories. Implement Projects and research paper writing and book reviews.
PSO4	**Entrepreneurial and Social competence:** Enhance analytical skills and research aptitude in specific areas related to physics including materials science, thin film technology, solar energy, radiation dosimetry, astrophysics, atmospheric science, energy generation and storage for academic

	research and industrial applications. Develop job oriented analytical skills on an advanced level needed in industry, consultancy, education, research or public administration. **(i)** Employ and develop skills in specific areas related to physics and engineering for industrial application, production and technology development and transfer. **(ii)** Develop social awareness through internships and science popularization programs. Execute awareness of ethical issues: emphasis on academic and research ethics, need and value of lifelong learning, international perspective, importance of academic and research ethics, human rights, scientific misconduct, intellectual property rights and issues related to cyber laws and plagiarism.

Course Outcomes (COs) and Syllabus

F.Y. M. Sc. Semester I		
Title of the Course and Course Code	**CLASSICAL MECHANICS (PHY-501)**	**Credits : 04** **Hours : 60**
On completion of the course, the students will be able to:		
CO1	Describe various approaches for finding solutions of equations of motions.	
CO2	Discuss and give examples of constraints and methods of eliminating them.	
CO3	Apply different mathematical tools and techniques to find solutions of problems in Mechanics.	
CO4	Compare and contrast different approaches of solving equations of motion.	
CO5	Evaluate the generating functions and assess different mathematical transformations.	
CO6	Develop the techniques to analyze motions in accelerated, frames of references.	

Unit No.	Title of Unit and Contents
Unit-I	**Constrained motion and Lagrangian formulation:** Constraints and their types. Generalized coordinates, Lagrange's equations of motion, including velocity dependent potentials. Properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation. Concept of symmetry, invariance under Galilean transformation.
Unit-II	**Variational principle and Hamiltonian formulation:** Variational principle, Euler's equation, applications of variational principle, shortest distance problem, Brachistrochrone, Geodesics of a Sphere. Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles.
Unit-III	**Canonical transformations and Poisson brackets:** Legendre transformations, Generating function, Conditions for canonical transformation and problem. Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, (statement only), invariance of Poisson Bracket under canonical transformation.
Unit-IV	**Non inertial frames of references, central force:** Rotating frames of reference, inertial forces in rotating frames, Larmour precession, electromagnetic analogy of inertial forces, effects of Coriolis force, Foucault's pendulum.

References:

1. Classical Mechanics by H. Goldstein, Narosa Publishing Home, New Delhi.
2. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher.
3. Classical Mechanics by P. V. Panat, Narosa Publishing Home, New Delhi.
4. Classical Mechanics by N. C. Rana and P. S. Joag, Tata Mc-Graw Hill PublishingCompany Limited, New Delhi.
5. Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
6. Classical Mechanics by J. C. Upadhyaya, Himalaya Publishing House.

7. Analytical Dynamics E. T. Whittaker, Cambridge University Press.

Title of the Course and Course Code	**Mathematical Methods in Physics (PHY-502)**	**Credits : 04** **Hours : 60**
On completion of the course, the students will be able to:		
CO1	Describe the concepts of Complex analysis, Fourier and Laplace Transformations.	
CO2	Discuss basic theory of Linear Algebra, Matrix algebra and special functions.	
CO3	Apply mathematical tools, special functions on polynomials to solve physical problems and identify mathematical concepts related to physics to generate solutions.	
CO4	Outline the basic elements of complex analysis and formulate the important integral theorems. Determine the residues of a complex function and use the residue theorem to compute certain types of integrals.	
CO5	Analyze concepts of vector space, matrix algebra and inner product spaces.	
CO6	Construct Fourier series, Fourier and Laplace transforms to solve mathematical problems relevant to the physical sciences.	

Unit No.	Title of Unit and Contents
I	**Complex Analysis:** Complex variable, Function of a complex variable, Limit of a function of a complex variable, Continuity, Differentiability, Analytic functions, Cauchy-Riemann Equations, Harmonic Functions, Complex Integration, Cauchy integral theorem, Cauchy integral formula, Derivatives of analytic functions, Power Series-Taylor's theorem, Laurent's theorem, Calculus of Residues, Cauchy's Residue theorem, Evaluation of real definite integrals. *(References: 1-3)*
II	**Linear Algebra:** **Vector Spaces and Operators:** Vector spaces and subspaces, Linear Spans, Linear dependence and independence, Basis and Dimensions. **Matrix algebra:** Matrix representation of a linear operator, Change of basis, Polynomials of matrices, Characteristic polynomial, Cauchy-Hamilton theorem, Diagonalization, Eigenvalues and Eigenvectors. **Inner Product Spaces, Orthogonality:** Inner product spaces, Orthogonality, Orthogonal sets and basis, Gram-Schmidt orthogonalization process. *(References: 4, 5)*
III	**Special functions:** Legendre, Hermite and Laguerre function – Generating function, Recurrence relations and their differential equations, Orthogonality properties, Bessels's function of first kind, Spherical Bessel function, Associated Legendre function, Spherical harmonics. *(References: 3, 6)*
IV	**Fourier series and integral transforms:** Fourier Series: Definition, Dirichlet's condition, Convergence, Parseval's identity, Fourier Integral and Fourier transform, Convolution theorem, Applications of Fourier Transform to solve differential equations, Laplace transform and its properties,

	Applications of Laplace transform to solve differential equations, Laplace transform of Dirac Delta function. *(References: 3, 6-10)*

References:

1. Complex Variables and Applications – J.W.Brown, R.V.Churchill, 7th Edition, Mc-Graw Hill.
2. Complex Variables – Schaum's Outlines Series, 2nd Edition, Tata Mc-GrawHill Edition.
3. Higher Mathematical Physics- H.K.Dass& Dr. Rama Verma-S. Chand. & Co. Pvt. Ltd
4. Linear Algebra – Schaum's Outlines Series- 3rd Edition, Tata Mc-Graw Hill Edition.
5. Matrices and Tensors in Physics, A. W. Joshi, 3rd Edition, New Age International.
6. Mathematical Methods for Physicists – Arfken& Weber – 6th Edition-AcademicPress, N.Y.
7. Mathematical Methods in the Physical Sciences – Mary Boas, John Wiley & Sons.
8. Fourier series - Seymour Lipschutz, Schaum's Outlines Series. Tata Mc-Graw Hill Edition
9. Laplace Transform - Seymour Lipschutz, Schaum's Outlines Series. Tata Mc-Graw Hill Edition
10. Mathematical Methods in Physics – B. D. Gupta.

Title of the Course and Course Code	**Electronics (PHY-503)**	**Credits : 04** **Hours : 60**
On completion of the course, the students will be able to:		
CO1	List special and general purpose integrated circuit chips.	
CO2	Explain internal block diagram and working of the ICs.	
CO3	Illustrate the use of dedicated ICs in different circuits.	
CO4	Explain working of circuits using operational amplifiers, timers, PLLs and SMPS.	
CO5	Compare performance parameters of Op-amps and discrete circuits.	
CO6	Design different circuits for dedicated applications.	

Unit No.	Title of unit and Contents
I	**Applications of special function ICs:** Study of Timer IC 555: Block diagram, Astable and monostable multivibrator circuits. Study of VCO IC 566 and its applications. Study of PLL IC 565: Block diagram, applications like frequency multiplier, FSK, FM demodulator. Function generator using two OPAMPs with variable controls, Astable and monostable multivibrators using OPAMP. ***References*:** 1 to 5
II	**Regulated power supply** Concept of Voltage Regulator using discrete components. Types of power supplies: series and shunt regulators, CVCC, SMPS. Three pin regulators. (IC 78XX/79XX, IC LM 317). Basic low and high voltage regulator and foldback current limiting using IC 723.Concept and applications of DC - DC converter. ***References*:** 4, 5, 6
III	**A. Digital Logic circuits I: Combinational Logic:** Review of Boolean identities and its use to minimize Boolean expressions. Minimization of Boolean expressions using Karnaugh map (up to 4 variables). **B. Digital Logic circuits II: Sequential Logic:** Review of synchronous, asynchronous and combinational counters (4-bit). Decade counter IC 7490 with applications. Shift registers using IC 7495: applications as SISO, SIPO, PISO and PIPO. Up-down counter

	***References*: 7, 8**
IV	**Data Converters:** Analog to digital converters: Binary weighted type, R-2R ladder type, Study of IC 0808. Digital to analog converters: Single slope, Dual slope, Flash, Counter type, Continuous type, Simultaneous type, Successive approximation type, Study of IC 7106 ***References*: 7, 8, 9**

References:

1. Operational Amplifiers: G. B. Clayton (5th edition)
2. OPAMPS and Linear Integrated Circuits: Ramakant Gayakwad, Prentice Hall
3. Linear Integrated Circuits: D. Roy Choudhary, Shail Jain
4. Electronic Principles: A. P. Malvino, TMH
5. Power Supplies: B. S. Sonde
6. SMPS, Inverters, Converters: Gottlieb
7. Digital Principles and Applications: Leach and Malvino
8. Digital Electronics: R. P. Jain
9. Data Converters: B. S. Sonde.

Title of the Course and Course Code	**Electronic Instrumentation (PHY-504)**	**Credits : 04** **Hours : 60**
On completion of the course, the students will be able to:		
CO1	Describe the evolution and history of units and standards in Measurements.	
CO2	Summarize the various parameters that are measurable in electronic instrumentation.	
CO3	Employ appropriate instruments to measure given sets of parameters.	
CO4	Identify the construction of testing and measuring set up for electronic systems.	
CO5	Evaluate instrumentation concepts which can be applied to Control systems	
CO6	Specify the usage of various instrumentation standards.	

Unit No.	Title of unit and Contents
I	**General Background and Measurements:** **1.1** General configuration and functional description of measuring instruments, few examples of instruments and their functional description. (Ref.1: #2.1 to 2.4). Input output configuration of measuring instruments, methods of correction of unwanted inputs. (Ref.1: #2.5) **1.2** Qualities of measurements (Ref. 9 Ch#1) Static characteristics, Errors in measurement, Types of errors, sources of errors (Ref. 9 Ch#1) Dynamic characteristics: Generalized mathematical model of measurement System, order of instruments: zero, first and second order. Step, ramp and frequency response of first order instruments (Ref.1: # 3.3 pp 94 to 115 & 123 to 131) References: 1, 3, and 9.
II	**Transducers** 2.1 Electrical transducers, resistive, strain gauge, thermistor, inductive transducers, variable reluctance, LVDT, pressure inductive, capacitive transducers, piezoelectric transducer, photoelectric, magneto resistive sensors. Transducers for displacement, velocity, acceleration.

	2.2 Fluid flow, fluid rate and velocity. Various temperature transducers: Acoustic temperature sensor, high temperature measurement using a cooled thermocouple (Ref.1), Humidity sensors, conductivity measurements, PMT, Optical pyrometry (with at least one application of each transducer) References: 9
III	**Signal Conditioners and Data Acquisition and Conversion** 3.1 Signal conditioners: Op-amps, instrument amplifier, bridge, phase sensitive detector (References: 9: Chapter 17). 3.2 Data acquisition and conversion D to A and A to D converters, Data loggers, ADC digital transducer (optical transducer) Data acquisition system. ICs available: ADCs, DACs (Ref 9).
IV	**Indicators, Display System and Recorders** 4.1 Digital display system with LED and LCD. Printers: principle of Laser printers only 4.2 Introduction to microprocessor based instruments, with suitable examples. Stepper motor controller and basic idea of process control (References: 9).

References:

1. Measurement Systems- Applications and Design.4th Edn E.O. Doeblin.
2. Measurement System – Applications and Design by E.O. Doblin and Manik
3. Instrumentation, Measurement and Systems. Nakra and Chaudhary
4. Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W. D. Cooper (Pearson)
5. Instrumentation, Devices and Systems. Rangan, Mani and Sarma Prentice Hall Of India.18
6. Process Controlled Instrumentation by C.D. Johnson
7. Elements of Electronic Instrumentation and Measurement. 3rd Edn. Joseph Carr. (Pearson)
8. Sensors and Transducers, Patranabis
9. Electronics Instrumentation, Kalsi (Tata Mcgraw-Hill).

Title of the Course and Course Code	**Research Methodology (PHY-510)**	**Credits : 04** **Hours : 60**
On completion of the course, the students will be able to:		
CO1	Learn the various aspects of the research process, framing useful research questions, research design, data collection, analysis, writing and presentation	
CO2	Understand the research problem, methods/techniques to be adopted	
CO3	Apply statistical tools for analysing the data while performing their research	
CO4	Develop skills in qualitative and quantitative data analysis and presentation	
CO5	Analyse for fitting, errors in the measurements and able to withdraw conclusions from the analysed data	
CO6	Execute a quality research paper and patents in science and technology	

Unit No.	Title of unit and Contents
I	History of research. Indian, Egyptian, Greek ideas methodologies and research in agriculture, chemistry, metallurgy, medical. Ancient Indian research methodology applications.
II	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.
III	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.
IV	Writing research paper and/or thesis, making a presentation, writing a research proposal, and patents in Science, technology.

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.
3. Research Methodology Methods and Techniques by C.R. Kothari, New Age International (P) Ltd. Publishers.

Title of the Course and Course Code	**Practical - I: Physics Practical Laboratory-I (General Lab-I) (PHY-520)**	**Credits : 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		
CO1	Tabulate the appropriate experimental data accurately and keep systematic record of general laboratory experiments.	
CO2	Discuss the results, findings using the physical scientific framework and learn experimental tools.	
CO3	Interpret professional quality of textual and graphical presentations of laboratory data and computational results.	
CO4	Analyze various experimental results by developing analytical abilities to address real applications.	
CO5	Evaluate possible causes of discrepancy in practical experimental observations and results in comparison to theoretical results.	
CO6	Develop the skills related to betterment in education and research.	

Sr. No.	Title of the Experiment
1.	**Photoconductivity:** **a)** To plot the current voltage characteristics of a CdS photo-resistor at constant irradiance. **b)** To measure the photocurrent as a function of irradiance at constant voltage.
2.	**Speed of Light:** To determine the speed of light using transit time of light pulse as a function of a reflecting mirror.
3.	**Faraday Effect:** Rotation of the polarization plane Φ and 2Φ as a function of the magnetic field.
4.	**Dielectric constant:** **a)** To Measure the charge Q on a plate capacitor as a function of the applied voltage E. **b)** To determine the capacitance C as a function of area A of plates. **c)** To determine the capacitance C with different dielectrics between the plates. **d)** To determine the capacitance C as a function of the distance d between the plates.
5.	**Millikan's Oil Drop Method:** To measure the rise and fall times of the oil droplets at different voltages having

	different charges. **a)** To determine the radii of droplets. **b)** To determine the charge ‘**e**’ on the droplets.
6.	**Michelson’s Interferometer:** To determine the wavelength of He-Ne LASER by using Michelson’s Interferometer apparatus.
7.	**Specific Heat of Solids:** To determine the specific heat of copper, lead and glass.
8.	**Electron Spin Resonance:** To study the Electron Spin Resonance and to determine Lande’s g-factor
9.	**Frank-Hertz experiment:** To study the discrete energy levels using Frank-Hertz experiment
10.	**G. M. Counter:** Characteristics of GM tube using β-ray source.
11.	**Zeeman Effect**
12.	**Stefan’s constant** – Black Body Radiation

Title of the Course and Course Code	**Practical - II: Physics Practical Laboratory-II (Computational Lab) (PHY-521)**	**Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Identify the objectives of a given data computation-based experiments.	
CO2	Interpret the proper numerical method of data computation.	
CO3	Implement proper use of data to solve given problem.	
CO4	Analyse the data for a given numerical method and the obtained results.	
CO5	Evaluate the accuracy of common numerical methods.	
CO6	Compile their computational skill to solve common and scientific problems.	

Sr. No.	Title of the Experiment
1.	Fitting of the Given Data (Photodiode Data) by using Least Square Method (Linear and Exponential)
2.	Bisection Method
3.	Regula Falsi Method
4.	Newton-Raphson Method
5.	Secant Method
6.	Successive Approximation
7.	Gauss Elimination Method, Gauss Seidel Iterative Method
8.	Use of Lagrange Interpolation & spline Interpolation Method
9.	Trapezoidal and Simpson’s Rule
10.	Gaussian Quadrature Formulae
11.	Euler’s Method
12.	Runge-Kutta 2^{nd} order Method
13.	Runge-Kutta 4^{th} order Method

F.Y. M. Sc. Semester II		
Title of the Course and Course Code	**Quantum Mechanics (PHY-551)**	**Credits : 04** **Hours : 60**
On completion of the course, the students will be able to:		
CO1	Recall and outline basic postulates of Quantum Mechanics and Simple stationary state problem.	
CO2	Explain theory of angular momentum, spin matrices and compute Clebsh-Gordan Coefficient.	
CO3	Demonstrate and interpret solutions of Schrodinger equation for stationary state problems.	
CO4	Categorize different applications of approximation methods to solve time dependent and time independent Hamiltonian systems.	
CO5	Compare different approximation methods in terms of validity.	
CO6	Specify problems based on concepts of stationary states, angular momentum and approximation method.	

Unit No.	Title of Unit and Contents
I	**Introduction, Basic postulates of Quantum Mechanics, Simple stationary state problem:** Inadequacy of classical Physics, Formation of wave packet and uncertainty principle, Schrodinger's wave equation and probability interpretation. Basic Postulates of Quantum mechanics: **i)** The state of the system: probability density, superposition principle, **ii)** Observable and operators: self adjoint operator, commutation **iii)** Measurement in Quantum mechanics: Expectation value, complete sets of commutating operator, eigen value and eigen function. **iv)** Time evolution of system's state: time evolution operator, stationary states time independent potentials Simple stationary state problem: particle in a rigid box and a non-rigid box, potential barrier, hydrogen atom.
II	Set of discrete and continuous eigenvalues, completeness and closure property, physical interpretation of eigen value and eigen function and expansion coefficient. Dirac notation: Hilbert space, Dirac's bra and ket notation, dynamical variables and linear operators, projection operators, unit operator, unitary operator, matrix representation of an operator, change of basis, unitary transformation. Eigen values and eigen functions of simple harmonic oscillator by operator method.
III	**Angular Momentum:** General formalism of angular momentum, matrix representation of angular momentum, geometrical representation of angular momentum, Orbital angular momentum: Eigen value equation of L^2 and $L_z$operator. Functions of Orbital and Spin angular momentum, General theory of spin, Pauli theory of spins (Pauli's matrices) Addition of angular momenta, Computation of Clebsch-Gordon coefficients in case (J_1=1/2, J_2=1/2).

IV	**Approximation Methods:** Approximation methods for stationary states: Time-independent perturbation theory - Non degenerate and Degenerate perturbation theory. Variational method, Time-dependent Perturbation theory - Transition amplitude 1^{st} and 2^{nd} order, transition probability, Approximation Methods for constant and Harmonic perturbation, Fermi's golden rule.

References:

1. A Text-book of Quantum Mechanics by P. M. Mathews and K. Venkatesan.
2. Quantum Mechanics NouredineZettili, A John Wiley and Sons, Ltd., Publication
3. Quantum mechanics by A. Ghatak and S. Lokanathan
4. Quantum Mechanics by L. I. Schiff
5. Modern Quantum mechanics by J. J. Sakurai
6. Quantum Physics by R. Eisberg and R. Resnick
7. Introduction to Quantum Mechanics by David J. Griffiths
8. Introductory Quantum mechanics by Granier, Springer Publication.
9. Introductory Quantum Mechanics, Liboff, 4^{th} Edition, Pearson Education Ltd
10. Principles of Quantum Mechanics, Shankar R. II^{nd} Edition (Plenum, 1994).

Title of the Course and Course Code	**Atoms, Molecules and Solids (PHY-552)**	**Credits : 04** **Hours : 60**
On completion of the course, the students will be able to:		
CO1	Describe the theories explaining the structure of atoms and the origin of observed spectra.	
CO2	Explain different types of spectra.	
CO3	Calculate quantities associated with different types of spectra exhibited by atoms, molecules and solids, heat capacities using different models and structural properties.	
CO4	Analyze spectra and identify the effect of magnetic and electric fields on it.	
CO5	Determine the observed dependence of atomic spectral lines on externally applied electric and magnetic fields.	
CO6	Associate electromagnetic spectrum with the rotational, vibrational and electronic spectra of diatomic molecules, and specify the types of transitions based on selection rules. Compare different structures exhibited by materials	

Unit No.	Title of Unit and Contents
I	**Atoms:** Atomic structure and atomic spectra, quantum numbers, Pauli's exclusion principle, electron configuration, Terms for equivalent and non-equivalent electrons, Hund's rules, origin of spectral lines, selection rules, spectra of one electron atoms, spectra of two electron atoms, fine structure and hyperfine structure, Normal Zeeman effect and Anomalous Zeeman effect, Paschen- Back effect ***Reference*:** Banwell, Articles 5.1, 5.2, 5.3, 5.4, 5.6

II	**Molecules:** Molecular Spectra: Rotational and vibrational spectra for diatomic molecules, Electronics spectra of diatomic molecules, vibration course structure, vibrational analysis of band structure, Frank – Condon principle, Dissociation energy and dissociation products, rotational fine structure of electronic vibrational transitions, electronic angular momentum in diatomic molecules. ***Reference*****:** Aruldhas, Articles 9.1 to 9.11
III	**Resonance Spectroscopy:** ESR: Principles of ESR, ESR spectrometer, total Hamiltonian, hyperfine structure. ***Reference*****:** Aruldhas, Articles 11.1 to 11.5 NMR: Magnetic properties of nucleus, resonance condition, NMR instrumentation, relaxation process, chemical shift, applications of NMR. ***Reference*****:** Aruldhas 10.1 to 10.4, 10.7
IV	**Crystal Diffraction & Lattice Vibrations of Solids:** Laue theory of X-ray diffraction, Geometrical structure factor, Atomic scattering factor, calculations for sc, bcc, fcc, hcp and diamond structure. Vibrational modes of monatomic linear lattice & diatomic linear lattice, Acoustic and optical modes of vibration, Brillouin zone, Phonon. Lattice heat capacity, Einstein model and Debye model of lattice heat capacity, Normal and Umklapp processes. ***Reference*****:** Kittle, Ch.2, Ch. 4, Ch.5 and Ref.5: Ch.2

References:

1. Fundamentals of Molecular spectroscopy, C. N. Banwell and Elaine Mc Cash
2. Molecular structure and Spectroscopy, G. Aruldhas.
3. Quantum Physics, Robert Eisberg and Robert Resnik
4. Introduction to Solid States Physics, Charles, Kittle 7th Edition

   Solid States Physics, A.J. Dekkar.

Title of the Course and Course Code	**Materials Science (PHY-553)**	**Credits : 04** **Hours : 60**
On completion of the course, the students will be able to:		
CO1	Describe the mechanism and factors affecting the solidification process in metals and alloys.	
CO2	Examine critical awareness of the relevance of phenomenon and laws governing solid solution formation.	
CO3	Calculate the sintering time for diffusion.	
CO4	Determine the phase rules, phase diagrams of single and multi-component systems.	
CO5	Evaluate theory of the atomistic and defect structures, to determine the result in the microstructure and influence the properties of metals and alloys.	
CO6	Develop learning skills and systematic understanding of the crystal structure/property/ processing relationships of metals and alloys.	

Unit No.	Title of unit and Contents
I	**Defects in Solids:** Elastic and inelastic behaviour, Point defects: vacancies, interstitials, Schottky defects and Frenkel defects, non-stoichiometry. Line defects: edge and screw

	dislocations. Properties of dislocations, force on dislocation, energy of dislocation, dislocation density, interaction between dislocations (cross-slip and climb), Frank-Read source, plastic deformation, motion of dislocation, creep. Surface defects: grain boundaries, stacking fault. Volume defect: twin boundary.
II	**Diffusion in Solids:** Mechanism of Diffusion, Fick's first law of diffusion, Fick's second law of diffusion, solution to Fick's second law (error function), Atomic model of diffusion, Applications based on the second law, experimental determination of D'corrosion resistance of duralumin, decarburization of steel.
III	**Solid Solutions and metallurgical thermodynamics** Solid solubility: types of solid solutions, factors governing solid solubility (Hume - Rothery rule), atomic size in solid solutions, size factor, Laws of thermodynamics, Auxiliary thermodynamic functions, Measurement of changes in enthalpy and entropy, Richard's rule, Trouton's rule, Chemical reaction equilibrium, Thermodynamic properties of solutions
IV	**Phase diagrams:** Gibb's phase rule: proof, explanation and application to single (mono) component (H_2O) and binary phase diagram, Thermodynamic origin of phase diagrams, Lever rule, types of phase diagrams (examples of eutectic, peritectic, monotectic, eutectoid, peritectoid, syntactic reaction). Experimental determination of phase diagrams.

References:

1. Elements of Materials Science and Engineering (5th edition), Lawrence H. Van Vlack, Addison- Wesley Publishing Co. ISBN: 0-201-08089-3
2. Materials Science and Engineering – A First Course (5th edition), V. Raghvan. PHI Learning Pvt. Ltd, New Delhi, ISBN: 978-81-203-2455-8
3. Physical Metallurgy (Part I) R. W. Cahn and P. Hassen, North Holland Physics Publishing, New York.
4. Materials Science, G. K. Narula, K. S. Narula and V. K. Gupta, Tata Mc-Graw Hill Publishing Co. Ltd, New Delhi, ISNN: 0-07-451796-1
5. Materials Science and Metallurgy for Engineers, V. D. Kodgire and S. V. Kodgire, Everest Publishing House, ISBN: 81-86314-008
6. Introduction to Materials science for engineers (6th edition)-J. F. Shaekelford and M. K. Murlidhara- Pearson Education.
7. Experiments in Materials Science – Prof. E. C. Subbarao. et.al.
8. Experiments in Materials Science – V. Raghavan.

Title of the Course and Course Code	**Thin Film Physics (PHY-554)**	**Credits : 04** **Hours : 60**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe thin film thickness measurement techniques.	
CO2	Explain theories of thin film growth.	
CO3	Illustrate different theoretical models to study properties of thin films.	
CO4	Compare and contrast bulk properties with thin film properties of materials.	

CO5	Test different properties of thin films.
CO6	Write a report on development of thin film sensors and devices.

Unit. No.	Title of Unit and Contents
I	**Thin Film Thickness Measurement:** Introduction to thin films Introduction: brief discussion of the bulk and the thin film properties, Thickness Measurement Techniques: Tolansky technique, Talystep (stylus) method, Quartz crystal microbalance, Stress measurement by optical method, Gravimetric method.
II	**Theories and models of thin film growth:** Theories of thin film nucleation**:** Impingement, adsorption and thermal accommodation, the Capillarity model, the Atomistic models, structural consequences of thin film nucleation, the four stages of film growth, the incorporation of defects during growth.
III	**Properties of thin films:** Electrical Properties: Source of Resistivity in Metallic conductors, Influence of thickness on the resistivity of thin films, Hall Effect & Magnetoresistance in thin films, TCR and its effects. Mechanical properties: Adhesion & its measurement with mechanical and nucleation methods, stress measurement by using optical method. Optical properties: Properties of optical film materials, thin film optics, multilayer optical film applications. Antireflection coatings, multilayer films, interference filters, polarizers.
IV	**Emerging Thin Film Materials and Applications:** Patterning techniques (Photolithography), Diamond Films, Thin film resistors, capacitors, Junction devices (Diodes, Transistors, Solar cells), ICs, Thin film sensors (gas and humidity), Thin films for information storage (Magnetic and optical recording), Metallurgical applications, Photo thermal converters, Optical coatings.

References:

1. Handbook of Thin Film Technology: L. I. Maissel and R. Glang, Mc Graw Hill Book Co. 1970, 07-039742-2
2. Thin Film Phenomena: K. L. Chopra, Mc Graw Hill Book Co. 1969
3. Material Science of Thin Films: M. Ohring, Academic Press, 1992, ISBN: 0-12-524990-X
4. Thin Film Process: J. L. Vossen and Kern, Academic Press, 1978.

Title of the Course and Course Code	**Practical - III: Physics Practical Laboratory-III (General Lab-II) (PHY-570)**	**Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Tabulate the appropriate experimental data accurately and keep systematic record of general laboratory experiments.	
CO2	Discuss the results, findings using the physical scientific framework and learn experimental tools.	
CO3	Interpret professional quality of textual and graphical presentations of laboratory	

	data and computational results.
CO4	Analyze various experimental results by developing analytical abilities to address real applications.
CO5	Evaluate possible causes of discrepancy in practical experimental observations and results in comparison to theoretical results.
CO6	Develop the skills related to betterment in education and research.

Sr. No.	Title of the Experiment
1.	**Determination of Band gap** of Ge-semiconductor with variation of temperature by Four Probe method.
2.	**Skin depth:** Skin depth in Al using electromagnetic radiation.
3.	**Gouy's Method:** Measurement of magnetic susceptibility of MnSO4.
4.	**Thermionic emission:** To determine work function of Tungsten filament.
5.	**Hall effect:** To determine charge concentration, conductivity of Ge-semiconductor.
6.	**Measurement of resistivity** of Ge by Four Probe method at room Temperature
7.	**G. M. Counter:** Determination of end point energy of beta rays using GM counter.
8.	**G. M. Counter:** Determination of dead time of GM tube by Double source method.
9.	**Solar cells:** Study of Solar cell characteristics
10.	**Hysteresis:** Study of core losses in transformer
11.	Determination of **Ionic Conductivity** of NaCl
12.	To study **absorption spectra** of Iodine molecule and to determine its **dissociation Energy** using spectrometer.

Title of the Course and Course Code	**Practical-IV: Physics Practical Laboratory-IV (Electronics Lab) (PHY-571)**	**Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define the objectives of a given electronics-based experiments.	
CO2	Interpret the appropriate tests of measuring equipment for an experiment.	
CO3	Demonstrate proper use of circuit connections of desired experiment.	
CO4	Analyse the electrical/ electronic parameters of a given instrument and the obtained results.	
CO5	Review the observations taken during the experimentation and tabulate the results.	
CO6	Design and construct the electronic circuit and build-up required instrumentations	

Sr. No.	Title of the Experiment
1.	Diode Pump Staircase generator using UJT
2.	Fold back Power Supply
4.	Crystal Oscillator & Digital Clock
5.	Voltage Control Oscillator using IC-566
6.	Function generator using IC -8038
7.	Opto-coupler using OPAMPs and IC MCT-2E
8.	Constant current source using OP-AMP
9.	Digital to Analogue Converter (DAC) using R-2R and Binary ladder
10.	Active filters using OP-AMP / IC- 8038(Low pass, High pass, Notch type)

11.	Study of Multiplexer & De-multiplexer
12.	Lock-in-amplifier and measurement of low resistance & mutual inductance
13.	Analog to digital converter (ADC)
14.	IC555-Monosatable and Astable Multivibrator
15.	OPAMP as logarithmic amplifier