Deccan Education Society's

FERGUSSON COLLEGE (AUTONOMOUS), PUNE

Syllabus for T. Y. B. Sc. (Physics) with honours

[NEP 1.0]

(B.Sc. Semester-VII and VIII)

With Effect From

2026-2027

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
VII	Phy-401	Classical Mechanics-II	**4**
	Phy-402	Mathematical Methods In Physics-II	**4**
	Phy-403	Elective-I Electronics	**4**
	OR		
	Phy-404	Elective-I Electronic Instrumentation	
	Phy-445	Research Methodology (Theory)	**4**
	Phy-411	Physics Practical Laboratory-11 (General Lab-I)	**2**
	Phy-412	Physics Practical Laboratory-12 (Computational Lab) / Project	**2**
		Total Semester Credits	**20**
VIII	Phy-451	Quantum Mechanics-II	**4**
	Phy-452	Atoms, Molecules And Solids	**4**
	Phy-453	Elective–II Materials Science	**4**
	OR		
	Phy-454	Elective-II Astronomy And Astrophysics-II	
	Phy-495	OJT/ FP	**4**
	Phy-461	Physics Practical Laboratory-13 (General Lab-II)	**2**
	Phy-462	Physics Practical Laboratory-14 (Electronics Lab)	**2**
		Total Semester Credits	**20**
		Total Credits for Fourth Year UG	**40**

Program Outcomes (POs) for B.Sc. Programme	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of an graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**Social competence:** Display the understanding, behavioural skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependently 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.

Deccan Education Society's

Fergusson College (Autonomous), Pune

Program Specific Outcomes (PSOs) and Course Outcomes (COs) 2026-27

Department of Physics

Programme: B.Sc. Physics

PSO No.	Program Specific Outcomes (PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic competence** 1. **Develop** and **demonstrate** an understanding of the concepts related to heat, thermodynamic laws, electric field due to static charge distribution, Newtonian mechanics, wave properties of light, Newtonian mechanics, inertial and non-inertial frames of reference, radioactivity, elementary particles, quark model, physical systems from nano-scale to macroscopic scale, magnetostatics, Maxwell's equations and plane wave generation and quantum mechanical systems. Associate the fundamental concepts in physics and interpret information. 2. **Demonstrate independent** thinking and scientific temper. **Categorize**, calculate and **solve** problems using concepts of physics.
PSO2	**Personal and Professional Competence** 1. Carry out laboratory-oriented numerical calculations and be capable in data visualization and interpretation. Perform, demonstrate and analyse experimental work with suitable techniques in physics to study the phenomena related to light, scientific instruments, material process, electrical and electronics applications. 2. Carry out the calculations in classical mechanics, quantum mechanics, mathematical methods and solids with advance techniques using computations and C-programming. 3. Analyse experimental results and interpret graphs. 4. Formulation of ideas, scientific writing and authentic reporting, effective presentation and communication skills through group discussion.
PSO3	**Research Competence** 1. Apply Physics concepts of thermodynamics, mechanics, wave optics, electronics and nuclear physics in day to day life. Integrate core concepts studied in materials science, electronics, and optics during experimentations and projects. 2. Integrate and explore techniques of synthesis, characterization of different materials and techniques of astronomical data analysis. Cultivate concepts of measurement techniques in physics and relate physics concepts in day to day life. 3. Integrate core physics subjects during experimentation and projects. 4. Apply numerical methods to solve various complex physical problems. 5. Identify and interpret research literature, formulate ideas, write reports and review articles related to all subjects in physics.
PSO4	**Entrepreneurial and Social competence** Enhance and empower the students with their self-reliance capabilities through the understanding of advance techniques, use of programming language, material processing, mathematical and classical concepts, advancement of electronics ideas with reference to advance techniques with their industrial applications. 1. Employ experimental skills in industrial applications.

	2. Develop scientific temperament and social awareness through internships and science popularization. Awareness of ethical issues: emphasis on academic and research ethics. 3. Outline the use of renewable sources for sustainable development of human beings. 4. Execute social competence including effective use of computer languages to meet global competencies in technological world.

Semester VII		
PHY-401	**Classical Mechanics-II** **Major-Theory**	
	No. of Credits: 04 **No. of 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.

PHY-401; Classical Mechanics-II
Major-Theory

Unit No.	Title of Unit and Contents	No. of Lectures
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.	**15**
II	**Variational principle and Hamiltonian formulation:** Variational principle, Euler's equation, applications of variational principle, shortest distance problem, Brachistochrone, 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.	**15**
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.	**15**
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.	**15**

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 Publishing Company 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.

PHY-402	**Mathematical Methods in Physics-II** **Major-Theory**	
	No. of Credits: 04 **No. of 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.	

PHY-402: Mathematical Methods in Physics-II

Major-Theory

Unit No.	Title of Unit and Contents	No. of Lectures
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)*	**15**
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)*	**15**

III	**Special functions:** Legendre function - Generating function, Recurrence relations and their differential equations, Orthogonality properties. Hermite function – Generating function, Recurrence relations and their differential equations, Orthogonality properties. Laguerre's function- Generating function, Recurrence relations and their differential equations, Orthogonality properties. Bessel function - Generating function, Recurrence relations and their differential equations, Orthogonality properties, Bessel's function of first kind, Spherical Bessel function, Associated Legendre function, Spherical harmonics. *(References: 3, 6)*	**15**
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, Solution of differential equations by Laplace transform, Electric circuit, Solution of simultaneous differential equations by Laplace transform, Solution of partial differential equations by Laplace transform, Laplace transform of Dirac Delta function. *(References: 3, 6-10)*	**15**

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-Graw Hill 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.

PHY-403	**Electronics** **Elective-Theory**	
	No. of Credits: 04 **No. of 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, SMPS, voltage regulators and digital circuits.	
CO5	Compare performance parameters of Op-amps and discrete circuits.	
CO6	Design different circuits for dedicated applications.	

PHY-403: Electronics
Elective-Theory

Unit No.	Title of unit and Contents	No. of Lectures
I	**Applications of special function ICs:** IC 555 Timer: Introduction (Block diagram, Pin diagram, Astable and monostable multivibrator operations). Applications: Ramp generator, PWM and PPM, IC 566 as VCO and its applications, Study of PLL IC 565: Block diagram and its applications. OPAMP IC 741 pin diagram and applications: Active filters: LPF, HPF, BPF, and Notch filter 1st and 2nd order with designing. Constant current source using PNP transistor. IC 8038 as function generator. ***References*****:** 1 to 5	**15**
II	**Regulated power supply** Concept of Voltage Regulator using discrete components. Types of power supplies: series and shunt regulators, CVCC, SMPS working principle and types. Advantages and disadvantages of SMPS. Three pin regulators. (IC 78XX, 79XX as fixed voltage positive and negative regulators, IC LM 317, IC LM 337 as variable positive and negative voltage regulators. Basic low and high voltage regulator and foldback current limiting using IC 723. Concept and applications of DC - DC converter (buck and boost converter). ***References*****:** 4, 5, 6	**15**
III	**Digital Electronics** **1.** Combinational Logic Design: Introduction, Boolean identities, K – map (2, 3 and 4 variable), **2.** Design and implementations of: Decoders, Encoders, Multiplexers, De-multiplexers, Use of MUX and DEMUX in Combinational Logic design. Code Converters (based on – binary, BCD, Gray and Excess – 3 codes). Tri-State logic, buffers, D latch. Seven Segment display, IC 7447 as BCD to seven segment decoder ***References*****:** 8, 11	**15**

IV	**Data transmission systems and Data Converters:** Analog and Digital Transmissions, Pulse Amplitude Modulation, Pulse Width Modulation, Pulse Position Modulation, Time Division Multiplexing, Pulse Modulation, Digital Modulation, Pulse Code Modulation. 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 7106/7107. ***References*****:** 7, 8, 9, 10	**15**

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.
10.	Electronic Communication Systems; 4th. Ed. Kennedy and Davis, (Tata McGraw. Hill, 2004.
11.	Digital Electronics and Logic design by N. G. Palan.

PHY-404	**Electronic Instrumentation** **Elective-Theory**	
	No. of Credits: 04 **No. of 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.	

PHY-404: Electronic Instrumentation
Elective-Theory

Unit No.	Title of unit and Contents	No. of Lectures
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 & 153 to 131) References: 1, 3, and 9.	**15**
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	**15**
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).	**15**
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).	**15**

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).

PHY-445	**Research Methodology** **RP-Theory**	
	No. of Credits: 04 **No. of 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	

PHY-445: Research Methodology
RP-Theory

Unit No.	Title of unit and Contents	No. of Lectures
I	History of research. Indian, Egyptian, Greek ideas methodologies and research in agriculture, chemistry, metallurgy, medical. Ancient Indian research methodology applications.	**15**
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.	**15**
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.	**15**
IV	Writing research paper and/or thesis, making a presentation, writing a research proposal, and patents in Science, technology.	**15**

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

PHY-411	**Physics Practical Laboratory-11** **Major-Practical**	
	No. of Credits: 02 **No. of Hours:60**	
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.	

PHY-411: Physics Practical Laboratory-11
Major-Practical

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

PHY-412	**Physics Practical Laboratory-12 / Project Major-Practical**	
	No. of Credits: 02 No. of Hours:60	
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.	

PHY-412: Physics Practical Laboratory-12 / Project
Major-Practical

Sr. No.	Title of the Experiment
1.	Using of Least Square Method (Linear and Exponential) to fit the Given Data (Photodiode Data)
2.	Bisection Method
3.	Regula Falsi Method
4.	Newton-Rapson 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.	Range-Kutta 2^{nd} order Method
13.	Range-Kutta 4^{th} order Method

Semester VIII		
PHY-451	**Quantum Mechanics-II** **Major-Theory**	
	No. of Credits: 04 **No. of 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.	

PHY-451: Quantum Mechanics-II
Major-Theory

Unit No.	Title of Unit and Contents	No. of Lectures
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.	**15**
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.	**15**
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).	**15**

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.	**15**

References:

1.	A Text-book of Quantum Mechanics by P. M. Mathews and K. Venkatesan.
2.	Quantum Mechanics Nouredine Zettili, 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).

PHY-452	**Atoms, Molecules and Solids** **Major-Theory**	
	No. of Credits: 04 **No. of 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	

PHY-452: Atoms, Molecules and Solids
Major-Theory

Unit No.	Title of Unit and Contents	No. of Lectures
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	**15**
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	**15**
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 10.5, 10.7, 10.8, 10.19	**15**

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*:** Kittel, Ch.2, Ch. 4, Ch.5 and Ref.5: Ch.2	**15**

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 Kittel 7th Edition
5. Solid States Physics, A.J. Dekkar.
6. Physics of atoms and molecules, B. H. Bransden and C. J. Joachain

PHY-453	**Materials Science** **Elective-Theory**	
	No. of Credits: 04 **No. of Hours: 60**	

On completion of the course, the students will be able to:	
CO1	Describe the mechanisms 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.

PHY-453: Materials Science
Elective-Theory

Unit No.	Title of unit and Contents	No. of Lectures
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.	**15**
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.	**15**
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	**15**
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.	**15**

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. Raghavan. 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.

PHY-454	**Astronomy and Astrophysics-II** **Elective- Theory**	
	No. of Credits: 04 **No. of Hours: 60**	
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Define the basic principles of telescopes, detectors, adaptive optics, interferometers, and signal-to-noise ratio in astronomical observations.	
CO2	Explain the working principles of antennas, diffraction patterns, field-of-view, resolution, and the operation of single-dish and array-based radio telescopes.	
CO3	Apply the principles of radio interferometry and aperture synthesis to interpret observational data from facilities such as VLA and GMRT.	
CO4	Analyze the fundamental radiative processes, photon distribution functions, radiative transfer through a medium, and opacity effects in astrophysical systems.	
CO5	Evaluate stellar structure equations, energy generation mechanisms, and evolutionary tracks in the HR diagram for stars of different masses.	
CO6	Design theoretical or computational models of galaxies incorporating self-gravity, spiral structure, supermassive black holes, and active galactic nuclei to explain observed galactic phenomena.	

PHY-454: Astronomy and Astrophysics-II
Elective- Theory

Unit. No.	Title of Unit and Contents	No. of lectures
I	**Telescope and Detectors** Reflecting, Refracting Telescopes, Schmidt Cassegrain, Spectrometers, Photometers, CCD’s, Filters, Aberrations, Adaptive Optics effects of Atmospheric turbulence, A. O. systems and components, correction of wave front distortion. Large mirrors and Telescope Arrays, interferometers, detectors and their characteristics, Signal to noise ratio and detection limits. Auxiliary optics for Telescopes.	**15**
II	**Antennas and Receivers:** Practical aspects of Antenna, Field-of-view, resolution, diffraction patterns, Single-dish telescope, shaped reflectors and antenna arrays **Interferometry:** Resolution, aperture synthesis, survey of radio observatories, VLA, GMRT etc., data analysis pipeline using one of these as an example	**15**
III	**Radiative processes:** Overview of radiation theory and Larmor formula; Different radiative processes: Thomson and Compton scattering, Bremsstrahlung, Synchrotron [detailed derivations are not expected] radiative equilibrium, Planck spectrum and properties; Line widths and transition rates in QT of radiation; Qualitative description of which radiative processes contribute in which waveband/astrophysical system; Distribution function for photons and its moments; Elementary notion of radiation transport through a slab; Concept of opacities.	**15**
IV	**Stellar physics:** Basic equations of stellar structure; stellar energy sources; qualitative description of numerical solutions for stars of different mass; homologous stellar models; stellar evolution; evolution in the hr-diagram.	**08**

V	**Galactic physics:** Milky Way Galaxy; Spiral and Elliptical galaxies; Galaxies as self-gravitating systems; Spiral structure; Supermassive black holes; Active galactic nuclei.	**07**

References:

1	Modern Astrophysics, B. W. Carroo and D. A. Ostlie, (Addison-Wesley).
2	The Physical Universe, F. Shu, (University Science books).
3	The Physics of Astrophysics, Volume I and II, F. Shu, (University Science books).
4	Astronomical Optics, Daniel J. Schroeder, Academic Press.
5	Telescopes and Techniques, C. R. Kitchin, (Springer).
6	Observational Astrophysics, R. C. Smith, (Cambridge University Pres).
7	Detection of Light: from the Ultraviolet to the Submillimeter, G. H. Rieke, (Cambridge University Press).
8	Astronomical Observations, G. Walker, (Cambridge University Press).
9	Astronomical Photometry, A. A. Henden & R. H. Kaitchuk, (Willmann-Bell).
10	Electronic Imaging in Astronomy, I. S. McLean, (Wiley-Praxis).
11	An introduction to radio astronomy, B. F. Burke & Francis, Graham-Smith, (Cambridge University Press).
12	Radio Astronomy, John D. Kraus, (Cygnus-Quasar Books).

PHY-495	**On Job Training (OJT) / Field Project (FP)** **Major** **Theory/Practical**	
	No. of Credits: 04 **No. of Hours: 120**	

PHY-461	**Physics Practical Laboratory-13** **Major-Practical**	
	No. of Credits: 02 **No. of Hours:60**	
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.	

PHY-461: Physics Practical Laboratory-13
Major-Practical

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 G. M. 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.

PHY-462	**Physics Practical Laboratory-14** **Major-Practical**	
	No. of Credits: 02 **No. of Hours:60**	
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	

PHY-462: Physics Practical Laboratory-14
Major-Practical

Sr. No.	Title of the Experiment
1.	Diode Pump Staircase generator using UJT
2.	Fold back Power Supply
3.	Crystal Oscillator & Digital Clock
4.	Voltage Control Oscillator using IC-566
5.	Function generator using IC -8038
6.	Opto-coupler using OPAMPs and IC MCT-2E
7.	Constant current source using OP-AMP
8.	Digital to Analogue Converter (DAC) using R-2R and Binary ladder
9.	Active filters using OP-AMP (Low pass, High pass, Notch type)
10.	Study of Multiplexer & De-multiplexer
11.	Study of IC 7447 as BCD to seven segment Decoder
12.	Design, built and test oscillator – Wien Bridge Oscillator
13.	Lock-in-amplifier and measurement of low resistance & mutual inductance
14.	Study of IC-555 timer as monostable multivibrator
15.	Study of IC-555 timer as linear ramp generator
16.	Study of IC-555 timer as Pulse width modulator / Pulse position modulator
17.	Phase locked loop (PLL) application using IC565
18.	Study of MOD-2, 5, 10 counter using IC 7490
19.	OPAMP as logarithmic amplifier
20.	Study of IC LM317 as adjustable positive voltage regulator