VIJAYANAGARASRIKRISHNADEVARAYAUNIVERSITY

JNANASAGARACAMPUS,BALLARI-583105

DEPARTMENT OF STUDIES IN

PHYSICS

SYLLUBUS

Master of Science in Physics

(I –IV Semester)

Effective From 2024-25

VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY, JNANASAGARA CAMPUS, BALLARI-583105

Department of Studies in Physics

Programme: Master of Science (M.Sc.) in Physics

Programme Overview:
Duration: 2 Years (4 Semesters) **Programme Code: 901**

The Master of Science (M.Sc.) in Physics programme is designed to prepare students for careers in teaching, research, or industry by equipping them with a broad understanding of physics concepts and training in techniques relevant to various research domains. The programme aims to provide a strong foundation in the principles and applications of physics through a well-structured teaching-learning process, complemented by hands-on experimentation to explore new frontiers in the field.

Programme Educational Objectives (PEOs):

Within 3–4 years after completing the programme, graduates will be able to:

1. Demonstrate competency in physics to analyse and solve contemporary problems.
2. Exhibit research skills, including laboratory techniques, numerical methods, and computer programming.
3. Secure positions in academic and research institutions and/or industry.
4. Display leadership qualities to achieve professional and organizational goals, with a commitment to ethical standards and teamwork.

Programme Outcomes (POs):

Upon completion of the programme, students will be able to:

1. Apply domain knowledge to solve practical problems.
2. Use mathematical techniques to interpret the behavior of physical systems.
3. Design and conduct experiments, analyze data, and interpret results.
4. Propose and undertake research projects, ethically reporting findings with societal and environmental awareness.
5. Collaborate effectively in teams while contributing independently.
6. Communicate physics concepts, applications, and research findings effectively, both orally and in writing.
7. Pursue lifelong learning by staying informed about advancements in physics and related sciences.

VIJAYANAGARASRIKRISHNADEVARAYAUNIVERSITY

Distribution of Courses / Papers in Postgraduate Programme I - Semester as per Choice Based Credit System (CBCS)
Proposed for PG Program in Physics

M.Sc. SEMESTER - I

Category	**Subject code**	**Title of the Paper**	**Marks**			**Teaching hours / week**			**Credit**	**Duration of exams (Hrs)**
			IA	**SEE**	**Total**	**L**	**T**	**P**		
DSC1	24PHY1C1L	Mathematical Methods of Physics	30	70	100	4	-	-	4	3
DSC2	24PHY1C2L	Classical Mechanics	30	70	100	4	-	-	4	3
DSC3	24PHY1C3L	Atomic, Molecular & Optical Physics	30	70	100	4	-	-	4	3
DSC4	24PHY1C4L	Electronics	30	70	100	4	-	-	4	3
SEC1	24PHY1S1LP	Design of Electrical & Electronics Circuits	20	30	50	1	-	2	2	2
DSC3P1	24PHY1C3P	Atomic, Molecular & Optical Physics Lab	30	70	100	-	-	4	2	4
DSC4P2	24PHY1C4P	Electronics Lab	30	70	100	-	-	4	2	4
Total Marks for Semester-I					**650**				**22**	

Distribution of Courses / Papers in Postgraduate Programme II - Semester as per Choice Based Credit System (CBCS)
Proposed for PG Program in Physics

M.Sc. SEMESTER - II

Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of Exams (Hrs)
			IA	SEE	Total	L	T	P		
DSC5	24PHY2C5L	Computational Physics	30	70	100	4	-	-	4	3
DSC6	24PHY2C6L	Quantum Mechanics	30	70	100	4	-	-	4	3
DSC7	24PHY2C7L	Condensed Matter Physics	30	70	100	4	-	-	4	3
DSC8	24PHY2C8L	Nuclear Physics	30	70	100	4	-	-	4	3
SEC2	24PHY2S2LP	Interfacing Physical Devices / Systems	20	30	50	1	-	2	2	2
DSC5P3	24PHY2C5P	Computational Physics-Lab	30	70	100	-	-	4	2	4
DSC7P4	24PHY2C7P	Condensed Matter Physics-Lab	30	70	100	-	-	4	2	4
DSC8P5	24PHY2C8P	Nuclear Physics Lab	30	70	100	-	-	4	2	4
Total Marks for Semester - II					**750**				**24**	

Distribution of Courses / Papers in Postgraduate Programme III - Semester as per Choice Based Credit System (CBCS)
Proposed for PG Program in Physics

M.Sc. SEMESTER - III

Category	**Subject code**	**Title of the Paper**	**Marks**			**Teaching hours/week**			**Credit**	**Duration of exams (Hrs)**
			IA	**SEE**	**Total**	**L**	**T**	**P**		
DSC9	24PHY3C9L	Thermal and Statistical Physics	30	70	100	4	-	-	4	3
DSC10	24PHY3C10L	Analytical Techniques & Instrumentation	30	70	100	4	-	-	4	3
DSE1	24PHY3E1AL	A. Advanced Condensed Matter Physics	30	70	100	4	-	-	4	3
	24PHY3E1BL	B. Advanced Nuclear Physics								
	24PHY3E1CL	C. Optical Spectroscopy								
DSE2	24PHY3E2AL	A. Materials Science	30	70	100	4	-	-	4	3
	24PHY3E2BL	B. Radiation Physics								
	24PHY3E2CL	C. Renewable Energy Physics								
GEC1	24PHY3G1AL	A. Nanomaterials	15	35	50	2	-	-	2	1.5
	24PHY3G1BL	B. Elementary Astrophysics								
	24PHY3G1CL	C. Biophysics								
SEC3	24PHY3S3LP	Research Methodology	20	30	50	1	-	2	2	1
DSC9P6	24PHY3C9P	Thermal and Statistical Physics Lab	30	70	100	-	-	4	2	4
DSC10P7	24PHY3C10P	Analytical Techniques & Instrumentation Lab	30	70	100	-	-	4	2	4
Total Marks for Semester-III					**700**				**24**	

Note: The STUDY TOUR is the part of the curriculum, will be organized by the department for M.Sc. 3rd Semester students to acquaint them with research programme / exposure to the industries, motivating them pursue research / industrial career.

Distribution of Courses / Papers in Postgraduate Programme IV - Semester as per Choice Based Credit System (CBCS)
Proposed for PG Program in Physics

M.Sc. IV-SEMESTER

Category	**Subjectcode**	**Title of the Paper**	**Marks**			**Teaching hours/week**			**Credit**	**Duration of exams (Hrs)**
			IA	**SEE**	**Total**	**L**	**T**	**P**		
DSC11	24PHY4C11L	Advanced Quantum Mechanics	30	70	100	4	-	-	4	3
DSC12	24PHY4C12L	Electromagnetics	30	70	100	4	-	-	4	3
DSE3	24PHY4E3AL	A. Semiconductor Physics	30	70	100	4	-	-	4	3
	24PHY4E3BL	B. Particle Physics								
	24PHY4E3CL	C. Lasers and Optical fibers								
DSE4	24PHY4E4AL	A. Nanoscience	30	70	100	4	-	-	4	3
	24PHY4E4BL	B. Accelerator Physics								
	24PHY4E4CL	C. Astrophysics								
GEC2	24PHY4G2AL	A. Physics in Everyday Life	15	35	50	2	-	-	2	1.5
	24PHY4G2BL	B. Space Research Programs in India and Abroad								
	24PHY4G2CL	C. Exciting Inventions in Physics								
DSC12P8	24PHY4C12P	Electromagnetics Lab	30	70	100	-	-	4	2	4
Project	24PHY4C1R	Research Project	30	70	100		-	8	4	4
Total Marks for IV Semester					**650**				**24**	

(I-IV semester)- Total Marks: 2750 Total Credits: 94

DSC – Department Specific Core, DSE – Discipline Specific Elective, SEC – Skill Enhancement Course, GEC – Generic Elective Course, IA –Internal Assessment, SEE– Semester End Examination, L–Lecture, T – Tutorial, P–Practical.

Semester -I

Course Title: Mathematical Methods of Physics	**Course Code:** 24PHY1C1L
Total Contact Hours: 56 Hours	**No. of Credits:** 04
Formative Assessment Marks: 30	**Duration of ESA/Exam:** 03 Hours
Summative Assessment Marks: 70	**L:T:P::4:0:0**

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Solve differential equations of first & second orders.
2. Apply different transforms to solve mathematical problems of interest in science and engineering.
3. Solve different physical problems which contain complex variables.
4. Formulate and express a physical law in the sense of tensors, and simplify it using coordinate transforms.

DSC1: Mathematical Methods of Physics (24PHY1C1L) Unit wise Syllabus

Unit	Description	Hours
1.	**Differential equations and Special functions** **Differential equations** Ordinary differential equations: First-order homogeneous and non-homogeneous equations with variable coefficients. Second-order homogeneous and non-homogeneous equations with constant and variable coefficients. **Special functions** Legendre functions: Legendre polynomials, Rodrigue's formula, generating function, and recurrence relations. Bessel functions: Bessel functions of first kind, generating function, recurrence relations. Hermite functions: Hermite polynomials, generating function, recurrence relations. Laguerre functions: Laguerre polynomials, generating function, recurrence relations. **(Ref. 1, 2 & 3)**	14
2.	**Fourier series & Integral transforms** **Fourier series** Fourier's theorem, Cosine and Sine series, Change of interval. Complex form of Fourier series. Fourier integral. **Integral transforms** Fourier transforms: Introduction, Properties, Fourier transform of a derivative, Fourier transform of functions of two and three variables, Finite Fourier transforms, Some physical applications. Laplace transforms: Introduction, Properties, Laplace transform of the	14

	derivative of a function, periodic functions, and some special functions, Inverse Laplace Transform - Properties, Convolution Theorem. Some physical applications. (Ref. 1, 2 & 3)	
3.	**Linear Algebra and Matrices** **Linear Algebra**: Scalar Products, real & Complex Vector Space, Metric Spaces, linear operator, algebra of linear operators, Norms, Infinite dimensional Vector Space, Hilbert Space. Matrices: Cayley-Hamiltonian Theorem, matrix representation of operators, orthogonal, unitary & hermatian matrices, diagonalization of matrices, Eigen values & Eigen vectors. (Ref. 1, 5 & 6) **Complex analysis & Vector analysis** **Complex analysis** Complex Numbers, Functions of a complex variable, Properties of analytic functions, Singularities: Taylor and Laurent Series, poles, Cauchy's integral theorem, Cauchy's residue theorem. Some physical applications.(Ref. 1,2& 3) **Vector analysis** Review of vector algebra; vector differentiation and integration; Line, surface, and volume integrations, Gauss and Stoke's theorems. Some physical applications. (Ref. 1, 2 & 3)	14
4.	**Group Theory & Tensors** **Group theory** Groups, subgroups, classes, Homomorphism and isomorphism, Group representation - Reducible and irreducible representations, Character of a representation, character tables. Construction of representations. The three-dimensional rotation group SO(3), The special unitary groups SU(2) and SU(3), The irreducible representations of SU(2), and Representations of SO(3) from those of SU(2). (Ref. 1 & 7) **Tensors** Definition and type of tensors, Contravariant and Covariant tensors, symmetric and antisymmetric tensors, Tensor algebra: Equality, addition and subtraction, tensor multiplication, outer product; contraction of indices, inner product, quotient theorem, Kronecker delta, metric tensor, Christoffel symbols. (Ref. 1 & 8)	14

References:

1. Mathematical Physics by Satya Prakash, S Chand and Sons, NewDelhi, 2019.
2. Advanced Engineering Mathematics by H.K. Dass, S Chand and Company Ltd., 2013.
3. Mathematical Methods for Physicists by George B. Arfken, Hans J Weber, 6^{th} Edi, Elsevier Academic Press, 2005.
4. Mathematical Physics by B. D. Gupta, 3^{rd} Edi, Vikas Publishing House Pvt. Ltd. 2004.
5. T. Lawson, Linear Algebra, John Wiley & Sons, 1996.
6. Linear Algebra – Seymour Lipschutz, Schaum Outlines Series, 4th Edition, 2009.
7. Elements of Group Theory for Physicists by A W Joshi, 3^{rd} Edi, John Wiley & Sons, 1982.
8. Matrices and tensors in Physics by A W Joshi, 4^{th} Edi, New Age International Publishers, 2017.

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Course Title: Classical Mechanics	**Course Code:**21PHY1C2L
Total Contact Hours: 56 Hours	**No. of Credits:** 04
Formative Assessment Marks: 30	**Duration of ESA/Exam:** 03 Hours
Summative Assessment Marks: 70	**L:T:P::4:0:0**

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Solve problems involving particle motion in central force fields.
2. Understand the dynamics of moving and rotating coordinate systems, including the effects of coriolis and centrifugal forces.
3. Apply the principles of rigid body motion and use Euler's equations to solve problems involving rotational dynamics.
4. Utilize Lagrangian and Hamiltonian formulations to describe and solve complex mechanical systems, including understanding the variational Principle.

DSC2: Classical Mechanics (24PHY1C2L)Unit wise Syllabus

Unit	Description	Hours
1	**Motion in a Central Force Field:** Equivalent one body problem (quantitative), Motion in a central force field (quantitative), General features of the motion (qualitative), Motion in an inverse square law force field (qualitative), Equation of the Orbit (quantitative), Nature of the orbits, Kepler's laws of planetary motion (Deduction of third law), Numericals.	14
2	**Moving Coordinate systems:** Coordinate systems with relative translation motions, Rotating coordinate systems (quantitative), Coriolis force, Motion on the Earth (qualitative), Effect of coriolis force on freely falling particle (quantitative), simple applications and numericals.	12
3	**Motion of a Rigid body:** Introduction, Euler's theorem, Angular momentum and kinetic energy (quantitative), Inertia Tensor, Euler's equations of motion (quantitative), Torque free motion (quantitative), Euler's angles (qualitative), motion of symmetric top (quantitative), nutational motion (quantitative). Simple applications and numericals.	14

4	**Lagrangian and Hamilton's Formulation** Constraints and its types, Generalized co-ordinates, D'Alembert's principle (expression for virtual displacement, genealised velocity, virtual work, generalized force), Lagrangian equation of motion (quantitative) and its importance, Symmetries and the laws of conservation, cyclic co-ordinates, velocity dependent potential of electromagnetic field, Rayleigh dissipation function, Configuration space, Basics of variational principle, Hamilton's principle, Hamilton's equations of motion (quantitative) and some applications, Phase space. Simple applications and numericals.	16

References:

1. Classical Mechanics by H Goldstein, Third Edition, Pearson India, 2011.
2. Introduction to Classical Mechanics by R G Takwale and P S Puranik, Tata McGraw-Hill, 1979.
3. Classical Mechanics by N C Rana and P S Joag, Tata McGraw, 1991.
4. Classical Mechanics by J. C. Upadhyaya, Himalaya Publishing House, 2014.
5. Classical Dynamics of particles and systems by J. B. Marian, Academic Press, New York, 1965.

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Course Title: Atomic, Molecular and Laser Physics	**Course Code:**24PHY1C3L
Total Contact Hours: 56 Hours	**No. of Credits:** 04
Formative Assessment Marks: 30	**Duration of ESA/Exam:** 03 Hours
Summative Assessment Marks: 70	**L:T:P::4:0:0**

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Apply the concepts of atomic physics to analyse and interpret spectra of atoms.
2. Apply the concepts of molecular physics to analyse and interpret spectra of molecules.
3. Apply the concepts of laser physics to understand the laser systems and their applications.

DSC3: Atomic, Molecular and Optical Physics (24PHY1C3L) Unit wise Syllabus

Unit	Description	Hours
1.	**Atomic Physics I** Quantum states of an electron in an atom, Spin orbit interaction – Expression for term shift, Quantum mechanical relativity correction for term shift, Hydrogen fine structure, Coupling schemes: LS and jj coupling – Expression for interaction energy, multiplet splitting and Lande interval rule,Spectrum of helium – ortho and para states, Fine structure in alkali spectra, Sodium doublet, Intensity ratio for doublets, Hyperfine structure – Isotope and nuclear spin effects, Width of spectral lines- Natural, Doppler and External effects.(Ref. 1, 2, 3 & 4)	14
2.	**Atomic Physics II** Magnetic moment of a bound electron, Zeeman effect – Types, Magnetic interaction energy, Zeeman splitting in Sodium D-lines, Paschen-Back effect – Magnetic interaction energy, Paschen-Back splitting in Sodium D-lies, Stark effect – Types, Stark effect in hydrogen – weak and strong fields, Chemical Shift in NMR (qualitative).Working Principle of Constant Deviation Spectrometer (CDS) and its uses.Talbot bands, Hartman's formula.(Ref. 1, 2, 3 & 4)	14

3.	**Rotational, Vibrational and Raman spectroscopy** *Rotational/microwave Spectra:* Types of molecules based on rotation, Rotational spectra of rigid diatomic molecule, Intensities of spectral lines, Effect of isotopic substitution, Spectrum of non-rigid rotator (Qualitative), Instrumentation for rotational spectroscopy – Microwave spectrometer, Chemical analysis by microwave spectroscopy. (Ref. 2, 5 & 6) **- 5 Hours** *Vibrational/infrared spectra:* Vibrating molecule as a simple harmonic oscillator, Anharmonic oscillator, Analysis by infrared techniques, (Ref. 2, 5 & 6) **- 4 Hours** *Raman Spectroscopy:*Quantum theory of Raman effect, Pure rotational Raman spectra of linear molecules, Raman activity of vibrations, Rule of mutual exclusion, Vibrational Raman spectra, Comparison of infrared and Raman spectroscopy. Applications of Raman spectroscopy (qualitative). **- 5 Hours**	14
4.	**Electronic Spectroscopy and Laser Physics** Electronic Spectra: Born-Oppenheir approximation, Vibrational coarse structure: progressions, Intensity of Vibrational-Electronic spectra : Franck-Condon principle, Rotational fine structure of Electronic-Vibration transitions, Dissociation and predissociation, Chemical analysis by electronic spectroscopy, (Ref. 2, 5 & 6) **- 6 Hours** *Laser Physics: S*pontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length. Three level lasers versus Four Level lasers with examples, Laser Systems: (a) Nd-YAG Laser (b) Carbon Dioxide Laser, c) Dye Laser, Applications of Laser: (a) Defense – Ranging (b) Eye Surgery: LASIK. C) Isotope separation (Ref.1,2& 7) **- 8 Hours**	14

References:

1. Arthur Beiser, Shobhit Mahajan and S Rai *Choudhury Concepts of Modern Physics* McGraw Hill Education, 7th Edition, 2015.

2. Raj Kumar, KedarNath Ram Nath *Atomic and Molecular Spectra* (KNRN) Publishers, 5th Ed.– Reprint 2019.
3. H.C. White, *Introduction to Atomic Spectra* McGraw-Hill Education / Asia, 1963.
4. S.P. Kuila, *Concepts of Atomic Physics* New Central Book Agency (P) Ltd. (NCBA), Kolkata, 2018.
5. C N. Banwell and E. M. McCash *Fundamentals of Molecular Spectroscopic*, Tata McGraw-Hill Publishing Co., Ltd., New Delhi, 5th Ed., 2008.
6. Herzberg Gerhard, D.Van *Molecular Spectra* Nostrand Company Inc., Vol.I, 2005.
7. William T. Silfvast, *Laser Fundamentals* Cambridge University Press, 2nd Ed., 2004.

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Course Title: Electronics	**Course code:** 24PHY1C4L
Total Contact Hours: 56	**Course Credits:** 04
Internal Assessment Marks: 30 marks	**Duration of SEE:** 03 hours
Semester End Examination Marks: 70 marks	**L:T:P::4:0:0**

Course Outcomes:

By the end of this course, students will be able to:

1. Understand semiconductor physics, carrier concentration, p-n junctions, and I-V characteristics.
2. Analyze & design transistor circuits with biasing & frequency response.
3. Design circuits using operational amplifiers for filters and oscillators.
4. Apply Boolean algebra to simplify digital circuits and design sequential, A/D, and D/A conversion systems.

DSC4: Electronics (24PHY1C1L) Unit wise Syllabus

Unit	Description	Hours
1.	**Physics of Devices** Fundamentals of semiconductors. Intrinsic and extrinsic types of semiconductors, their carrier concentrations, Variation with temperature and doping levels. The electrical conduction mechanism in semiconductors Fermi level theory.Theory of p-n junctions, depletion region, current-voltage (V-I) characteristics, junction breakdown, carrier generation-recombination, mobility, and the drift-diffusion current. (Ref. 1, 2.)	**14**
2.	**Transistors and Amplifiers** Transistor action, transistor configurations Common Emitter (CE), Common Base (CB), and Common Collector (CC). BJT transistors using hybrid models, biasing techniques, voltage divider bias and frequency response.operation of Field Effect Transistors (FETs) and MOSFETs, small-signal models, biasing, and amplifier configurations: common drain and common gate. feedback mechanism in oscillators and the criteria for oscillation: Phase-shift and Wein-bridge oscillators.(Ref. 3, 4.)	**14**
3.	**Operational Amplifiers and Applications** Fundamental concepts of operational amplifiers (op-amps), differential amplifiers and the characteristics of ideal op-amps. open-loop and closed-loop	**14**

	op-amp configurations, demonstrate of op-amps to design inverting and non-inverting amplifiers, integrators, and differentiators, design of active filters using op-amps, low-pass, high-pass, band-pass, and band-reject filters, signal generators, phase-shift oscillators and crystal oscillators, (Ref. 5, 6)	
4.	**Digital Electronics and Conversion Circuits** Boolean algebra and its application, designing and simplifying digital circuits. Karnaugh maps to simplify Boolean expressions, logic gate families: AND, OR, NAND, and NOR gates. pulse waveform operations of logic gates Boolean expressions using AND-OR and NAND-NOR logic gates.sequential circuits, flip-flops (RS, JK, D, and T flip-flops), design binary counters and shift registers. A/D and D/A conversion circuits, sampling, quantization, and error analysis. (Ref.7,8)	**14**

References

1. S. M. Sze, *Semiconductor Devices: Physics and Technology*, Wiley
2. Ben G. Streetman, *Solid State Electronic Devices*, Pearson
3. D. Neamen, *Electronic Circuit Analysis and Design*, McGraw-Hill
4. A.S. Sedra and K.C. Smith, *Microelectronic Circuits*, Oxford University Press
5. R. A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, Pearson
6. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw-Hill
7. M. Morris Mano, *Digital Logic and Computer Design*, Pearson
8. A. Anand Kumar, *Fundamentals of Digital Circuits*, PHI

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Course Title: Design of Electrical & Electronics Circuits	**Course code:** 24PHY1S1LP
Total Contact Hours: 36	**Course Credits:** 02
Internal Assessment Marks: 20 marks	**Duration of SEE:** 02 hours
Semester End Examination Marks: 30 marks	**L:T:P::1:0:2**

Course Outcomes (COs):

By the end of this course, students will be able to:

1. Understand and apply fundamental principles of electricity and electronics.
2. Design and analyze various electrical circuits, including passive and active components.
3. Utilize modern software tools for circuit simulation and analysis.
4. Gain hands-on experience in building and testing electrical circuits, enhancing problem-solving and practical skills.

SEC1: Design of Electrical & Electronics Circuits (24PHY1S1LP) Unit wise Syllabus

Unit	Description	Hours
1.	**Measurement and Principles of Electricity** Instruments of Measurement: Understanding accuracy, precision, sensitivity, and resolution. Range of measurements, significance of parameters. Errors in Measurements: errors and loading effects. Fundamental Concepts: AC and DC circuits, voltage, current, resistance, capacitance, and inductance. Applications: R, RC, LC, and RLC circuits, passive filters. **Hands-on Sessions:** Analysing circuit configurations and understanding their applications.	**12**
2.	**Electric Motors** Types of Motors: AC and DC motors, working principles, and applications. Basic Design Concepts: construction and functioning of electric motors. Interfacing Techniques: DC or AC sources to control motors. **Hands-on Sessions:** Modelling and controlling a PWM (Pulse Width Modulation) controlled DC motor using Indus coin board.	**12**
3.	**Introduction to Virtual Lab** Open-source Software, introduction to Python, Installation Syntax overview, variables and data types, Basic operations.	**12**

	Open source hardware: ExpEyes Kit, -components, sources, and connectors. **Hands-on Sessions:** Producing sinusoidal waves, V-I characteristic of a diode, Light Dependent Resistors (LDRs), and charging and discharging processes in RC and LCR circuits using ExpEyes Kit.	

Recommended Textbooks and References

1. Floyd, T. L. *Electronic Devices*. Pearson Education.
2. Hayt, W. H., &Kemmerly, J. E. *Engineering Circuit Analysis*. McGraw-Hill.
3. Sen, A. K. *Principles of Electric Machines and Power Electronics*. Wiley.
4. Ghosh, D. &Ghosh, S. *Simulation of Electric and Electronic Circuits*. Springer.
5. S.A.Nasar,Schaum‟soutlineseries *ElectricCircuits*,TataMcGrawHill
6. LabManualpreparedbyIUAC,New Delhi

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Course Title: Atomic, Molecular and Laser Physics Lab	**Course Code:** 24PHY1C3P
Total Contact Hours: 56 Hours	**No. of Credits:** 02
Formative Assessment Marks: 30	**Duration of ESA/Exam:** 4 Hours
Summative Assessment Marks:70	**L:T:P::4:0:0**

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Design experiments to study atomic spectra of atoms.
2. Analyse spectra of molecules.
3. Use laser light to determine properties of light.

DSC3P1:Atomic, Molecular & Optical Physics Lab (24PHY1C3P)

List of Experiments

1. Wavelength of sodium light using Michelson's Interferometer.
2. Determination of doublet separation by using Michelson's Interferometer.
3. Determination of Rydberg constant using diffraction grating and hydrogen discharge tube.
4. Study of absorption spectrum of iodine vapour and determination of force constant.
5. Study of Talbot bands.
6. Constant deviation Spectrometer.
7. Verification of Hartman's formula.
8. Study of Zeeman effect.
9. Study of Stark effect.
10. Analysis of rotational spectrum.
11. Analysis of Vibrational spectrum.
12. Verification of Beer's law.
13. Temporal and spatial coherence of laser light.
14. Wavelength of Laser light by single slit diffraction method.
15. Wavelength of Laser light by double slit interference method.
16. Diffraction halos (Lycopodium powder particle size determination).
17. Ultrasonic velocity in liquids using Spectrometer / spectral shift.

Note:

1. Minimum of EIGHT experiments must be carried out.
2. Experiments may be added as and when required with the approval of BoS.

References:

1. University Practical Physics by D.C. Tayal, Himalaya Publishing House, First Millenium Edition, 2000.
2. Advanced Practical Physics for Students by B.L. Flint and H.T. Worsnop, Asia Publishing House, 1971.
3. A Text Book of Practical Physics, I. Prakash& Ramakrishna, KitabMahal, 11th Edition, 2011.
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn,Heinemann Educational Publishers, 4th Edition, 1985.

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Course Title: Electronics Lab	**Course code:** 24PHY1C4P
Total Contact Hours: 56	**Course Credits:** 02
Internal Assessment Marks: 20 marks	**Duration of SEE:** 04 hours
Semester End Examination Marks: 30 marks	**L:T:P::0:0:4**

Course Outcomes (COs)

Upon completing this course, students will be able to:

1. Measure DC/AC voltages and frequencies using a cathode ray oscilloscope.
2. Analyze and evaluate the design of rectifiers and filters for effective signal processing.
3. Design inverting and non-inverting amplifiers and assess their operations & frequency responses.
4. Construct and minimize logic circuits using digital components, including flip-flops and Karnaugh maps.

DSC4P2: Electronics (24PHY2C4P)

List of Experiments

1. Studies on Cathode Ray Oscilloscope: Measure DC/AC voltages and frequencies of sine and square signals; determine unknown frequencies using Lissajous figures.
2. Full-Wave Bridge Rectifier: Using Diodes: Design and study the performance of CR, L, and π-type filters.
3. Study of Bias Configurations for CE Transistor: Analyze fixed bias and voltage divider bias configurations.
4. Study of Astable Multivibrator Using Transistors: Conduct frequency studies.
5. Design of Inverting Amplifier Using Op-Amp (741, 351): Study its mathematical operations.
6. Design of Non-Inverting Amplifier Using Op-Amp (741, 351): Analyze frequency response.
7. Design and Study of Frequency Response of Weinbridge Oscillator Using Op-Amp.
8. Design and Construction of Logic Gates: Create logic gates using diodes and transistors, and verify their truth tables.
9. Construction of Karnaugh Maps: Create Karnaugh maps for three and four variables.
10. Boolean Expressions and Logic Circuits:
    (a) Convert Boolean expressions into logic circuits and design them using logic gate ICs.
    (b) Minimize a given logic circuit.
11. Flip-Flop Design: Design JK & RS flip-flop circuits using IC7412 and study truth tables.
12. Study of A/D and D/A Conversion Circuits.

Note:

1. A minimum of eight experiments must be conducted.
2. Additional experiments may be added as needed, subject to the approval of the BoS.

References:

1. R. Boylestad & L. Nashalsky *Electronic Devices & Circuit Theory*, Pearson, 10th Ed., 2009.
2. A.P. Malvino and D. Leach *Digital Principles and Applications*, TMH, 1991.
3. F. Robert Coughlin and Frederick F. Driscoll *Operational Amplifiers and Linear ICs*.
4. H.H. Willard, L.L. Merrit, J.A. Dean, & F.A. Settle, J.K. Jain *Instrumental Methods of Analysis*(6th Ed.) CBS Publishers, 1986.

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Semester -II

Course Title: Computational Physics	**Course Code:** 24PHY2C5L
Total Contact Hours: 54 Hours	**No. of Credits:** 04
Formative Assessment Marks: 30	**Duration of ESA/Exam:** 03 Hours
Summative Assessment Marks: 70	**L:T:P::4:0:0**

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Write C-Program to simple situations.
2. Solve physical problems using numerical techniques.
3. Apply partial differential equations to physical systems.
4. Explain the basic concepts of probability and statistics.
5. Compute errors in any physical problems and experiments.

DSC5: Computational Physics (24PHY2C5L) Unit wise syllabus

Unit	Description	Hours
1.	**C Programming** Compiler and interpreter, constants and variables, arithmetic expressions, data types, input and output statements, control statements, switch statements,loop statements, format specifications, arrays, algorithms, flowcharts, functions. Simple C programs i) area of a triangle ii) to check the entered letter is an vowel or consonant using switch iii) computing the sum and average of ten numbers using one dimensional arrays iv) to calculate Fibonacci series using while loop v) sorting numbers in ascending and descending order vi) computing the factorial of a number using for loop vii) addition of two matrices using arrays. (Ref. 1 & 2)	14
2.	**Numerical Techniques** Numerical methods. Solutions of algebraic and transcendental equations: Bisection and Newton-Raphson methods. Interpolation: Newton's and Lagrange's methods. Curve fitting: Method of least squares (Linear, Quadratic and Exponential), .Numerical differentiation – Newton's formula, Integration: Trapezodal rule, Simpson's 1/3 and 3/8 rules. Solutionof first order ordinary differential equations: Runge-Kutta methods. (Ref: 3&4).	14

3.	**Partial Differential Equations and applications in Physics** Basic Concepts of PDEs, Modeling: Vibrating String, Wave Equation, Solution by Separating Variables – Discussion of Eigen functions, D'Alembert's Solution of the Wave Equation, Modeling: Heat Flow from a Body in Space - Heat Equation, Heat Equation Solution by Fourier Series -Steady Two-Dimensional Heat Problems, Heat Equation: Modeling Very Long Bars - Solution by Fourier Integrals and Transforms, Laplace's Equation in Cylindrical and Spherical Coordinates. (Ref: 5).	14
4.	**Probability** Introduction, Basic probability theorems, Conditional probability - Theorem, permutations and combinations – Theorems, Random variables – Introduction, Discrete random variables and distributions, Continuous random variables and distributions, mean and variance of a distribution, Transformation of mean and variance, Binomial distribution, Poisson distribution and Normal distribution. (Ref: 5 & 6). **5 Hours** **Mathematical Statistics** Introduction, Concept of random sampling, Point estimation of parameters – Maximum likelihood method, Confidence intervals - Normal distribution with known and unknown σ^2, Chi-square distribution, Central Limit theorem (without proof). (Ref: 5 & 6) **5 Hours** **Experimental measurements and errors** Types and sources of experimental errors, significant digits in measurements, evaluation of errors in derived quantities with more than one variable, propagation of errors, mean and standard deviation, estimation of error, reporting experimental results with error bars. (Ref: 7 & 8). **4 Hours**	14

References:

1. P. B. Kotur, *Computer Concepts & C Programming*Sapna Book House (P) Ltd., Bangalore, 2013.
2. E Balaguruswamy, *Programming in ANSI – C*, 2ndEdition, Tata McGraw Hill, 1992.
3. S.S. Sastry, *Introductory Methods of Numerical Analysis* PHI Learning Pvt. Ltd., 5th Ed., 2019.
4. Mathematical Physics by Satya Prakash, Sultan Chand & Sons, 6th Edition, 2019.

5. Erwin Kreyszig*Advanced Engineering Mathematics*, 10th Ed., John Wiley and Sons, Inc.
6. George Arfken and Hans J.,*Mathematical Methods for Physicist*, Academic press San Diego, 1995
7. Experimental errors and uncertainty, Rochester University notes, Web link: http://www2.ece.rochester.edu/courses/ECE111/error_uncertainty.pdf
8. Introduction to experimental errors, Susan Cartwright, University of Sheffield, weblink: https://www.sheffield.ac.uk/polopoly_fs/1.14221!/file/IntroToExperimentalErrors_y2.pdf

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Course Title: Quantum Mechanics	**Course code:** 24PHY2C6L
Total Contact Hours: 56	**Course Credits:** 04
Internal Assessment Marks: 20 marks	**Duration of SEE:** 03 hours
Semester End Examination Marks: 70 marks	**L:T:P::4:0:0**

Course Outcomes (COs):

Upon completing this course, students will be able to:

1. Develop a strong foundation in quantum mechanics and its experimental background.
2. Solve basic quantum problems like particle motion in potential wells and harmonic oscillators.
3. Grasp the formalism of quantum mechanics, including operators and Dirac notation.
4. Apply approximation methods and representation theory to complex systems and scattering problems.

DSC6: Quantum Mechanics (24PHY2C6L) Unit wise Syllabus

Unit	Description	Hours
1.	**Physical Basis of Quantum Mechanics** Experimental background, inadequacies of classical physics: blackbody radiation, Photoelectric effect and atomic spectra, development of quantum theory: Planck's quantum hypothesis and Bohr's model of the hydrogen atom, Uncertainty and complementarity principle, Correspondence principle, Introduction to the Schrödinger wave equation. interpretation of the wave function, normalization, expectation values, Ehrenfest's theorem. inadequacy of quantum theory.(Ref. 1, 2.)	**14**
2.	**Solvable Eigenvalue Problems** Quantum mechanical problems, one-dimensional potential problems: square well potential: finite and infinite potential well,discrete nature of energy, rectangular step potential: particle encountering a potential step, and barrier potential, harmonic oscillator: Hermite polynomials. three-dimensional case, particle in a box and the hydrogen atom.(Ref. 3, 4)	**14**
3.	**General Formalism** General mathematical framework of quantum mechanics. Hilbert space,	**14**

	observables, and quantum operators, Hermitian and unitary operators. Eigenfunctions and Eigenvalue problem, concept of commuting operators. Introduction to Bra-Ket notation, Dirac formalism. general uncertainty relations and quantum mechanical postulates.(Ref. 5, 6)	
4.	**Representation Theory and Approximation Methods** Introduction to the matrix representation of quantum operators and methods, complex quantum mechanical problems. time-independent perturbation theory, variational method, applying to the anharmonic oscillator, ground state of the helium atom. WKB method and application to barrier penetration.(Ref. 7,8)	**14**

References

1. D.J. Griffiths, *Introduction to Quantum Mechanics*, Pearson
2. P.A.M. Dirac, *The Principles of Quantum Mechanics*, Oxford University Press
3. L.I. Schiff, *Quantum Mechanics*, McGraw-Hill
4. Richard L. Liboff, *Introductory Quantum Mechanics*, Addison-Wesley
5. J.J. Sakurai, *Modern Quantum Mechanics*, Addison-Wesley
6. G Aruldas, *Quantum Mechanics*PHILearningPrivate Ltd.
7. R Shankar, *Principles ofQuantum Mechanics*, Plenum Press
8. V. K. Thankappan, *Quantum Mechanics*, Wiley Eastern,

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Course Title:Condensed Matter Physics	Course Code: 24PHY2C7L
Total Contact Hours: 55 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	L:T:P::4:0:0

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain the fundamental concepts of crystal structure.
2. Apply X-ray diffraction methods and analyze bonding types in solids, including calculating binding energies and understanding crystal structures.
3. Identify different crystal imperfections, describe their impact on material properties, and understand the basics of lattice vibrations and phonons.
4. Explain electrical and thermal conductivity in materials, and understand key concepts in semiconductors and superconductors.

DSC7: Condensed Matter Physics(24PHY2C7L) Unit wise syllabus

Unit	Description	Hours
1	**Crystal Structure** Fundamentals of Crystal structure – Crystal lattice and Translation vectors, Unit Cell, Concept of Weigner-Seitz cell, Basis; Symmetry Operations, Point groups and Space groups, Types of Lattices – Two dimensional and three dimensional lattices; Lattice directions and planes (Miller indices), Interplanar spacing (quantitative), Simple crystal structures – Close-packed structures and Loose-packed structures with examples, Crystal structure of diamond and NaCl. (Ref.1 & 4)	14
2	**X-ray diffraction and Bonding in Solids** Basics of X-ray diffraction, Bragg's treatment- Bragg's law, The Von Laue Treatment – Laue's Equations, X-Ray diffraction methods – The Laue's method, Rotating Crystal method and Powder method; Atomic scattering factor, Geometrical scattering factor, structure factor evaluation for SC, BCC and FCC systems and Extinction rules for cubic crystals. Interatomic forces and types of bonding- Ionic, Covalent, Metallic, Van der Waals and Hydrogen bonds; Binding Energy in ionic	14

	crystals (quantitative), Binding energy of crystals of inert gases. (Ref.1, 2 & 4).	
3	**Imperfections in Crystals and Lattice vibrations** Point imperfections - Schottky and Frenkel defects and their equilibrium concentrations; Line imperfections - Dislocations and their types, Stress fields of dislocations; Planar imperfections - Grain boundary; Colour centres – F Centers and other Centers in alkali halides. (Ref.4 & 5) Vibrations of one dimensional monoatomic and diatomic lattices, Phonons, Momentum of Phonons, Specific heat(qualitative).(Ref.1 & 2)	14
4	**Conductivity in Materials:** **Free Electron Theory of Metals:** Qualitative discussion of Free – Electron Model of Metals; Electrical conductivity(quantitative), Electrical Resistivity versus Temperature, Heat Capacity of Conduction Electrons, Fermi Surface, Electrical Conductivity and Effects of Fermi Surface, Thermal conductivity in Metals. (Ref. 2) **Semiconductors**: Types of semiconductors, Conductivity in intrinsic semiconductors and its variation with temperature, Carrier concentration and Fermi level for intrinsic semiconductors, Hall Effect and its applications (Ref.1 ,3 & 4) **Superconductors:** Meissner effect, Critical field and critical temperature, Type I and Type II superconductors, BCS theory (qualitative), Qualitative discussion on MAGLEV.	14

References:

1. R. K. Puri & V. K. Babbar *Solid State Physics*, S. Chand Publications.
2. M. Ali Omar Elementary *Solid State Physics*, Pearson Education.
3. S .O. Pillai,*Solid State Physics,* New Age International.
4. C. Kittel, *Introduction to Solid State Physics* Wiley Eastern Ltd.
5. J.P Srivastava,*Elements of Solid State Physics*, PHI Learning Pvt. Ltd.

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Course Title: Nuclear Physics	**Course Code:** 24PHY2C8L
Total Contact Hours: 56	**No. of Credits:** 04
Formative Assessment Marks: 30	**Duration of ESA/Exam:** 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain the basic properties of the nucleus and nuclear forces.
2. Explain fundamental nuclear reactions and nuclear models.
3. Describe nuclear decay types and the fundamental interaction of radiation with matter.
4. Explain the principles and applications of nuclear radiation detectors.
5. Discuss the basics of nuclear energy, fundamental interactions, and elementary particles.

DSC8: Nuclear Physics (24PHY2C8L) Unit wise syllabus

Unit 1	**Basic properties of nucleus** Nuclear constitution. The notion of nuclear radius and its estimation from Rutherford's scattering experiment; the coulomb potential inside the nucleus and the mirror nuclei. The nomenclature of nuclei and nucleon quantum numbers. Nuclear spin and magnetic dipole moment. Nuclear electric moments and shape of the nucleus. **Nuclear forces** General features of nuclear forces. Bound state of deuteron with square well potential, binding energy, and size of deuteron. Deuteron electric and magnetic moments-evidence for non-central nature of nuclear forces. Yukawa's meson theory of nuclear forces.**(Ref. 1,2,5,6)**	14hrs
Unit 2	**Nuclear Reactions** Reaction scheme, types of reactions, and conservation laws. The balance of mass and energy in nuclear reaction: Q-value, and threshold energy. Energetics of exoergic and endoergic reactions. **Nuclear Models** The Shell Model:Introduction, Evidence for magic numbers, energy level, scheme for nuclei with infinite square well potential, the ground state spins, and parity. The Liquid Drop Model: Nuclear Binding Energy, Bethe-Weizsacker's Semi Empirical Mass Formula.**(Ref. 1,2,5,6)**	14hrs
Unit 3	**Nuclear Decays** Alpha decay: Quantum mechanical barrier penetration, Gamow's theory of alpha decay, Half-life systematics. Beta decay: Continuous beta spectrum, Pauli's Neutrino Hypothesis and Fermi's theory of beta decay, Double beta decay, beta comparative half-life systematics. Gamma decay: Qualitative consideration of multipole character of gamma radiation-Selection Rules,	14hrs

	Gamma ray spectra and nuclear energy levels, Nuclear Isomerism, Internal Conversion (Qualitative). **Interaction of Radiation with Matter** Interaction of Charged Particles with Matter, Ionization Energy Loss, Stopping Power and Range Energy Relations for Charged Particles, Interaction of Gamma Rays: Photoelectric Absorption, Compton Scattering, and Pair Production Processes.Nuclear radiation detectors- G M counter and scintillation detector.**(Ref. 1,2,3,5,6)**	
Unit 4	**Nuclear Energy** Fission Process, Fission Chain Reaction, Four Factor Formula and Controlled Fission Chain Reactions, Energetics of Fission Reactions, Fission Reactor. Fusion Process, Energetics of Fusion Reactions, Controlled Thermonuclear Reactions, Fusion Reactor, StellarNucleosynthesis. **Fundamental Interactions and Elementary Particles** Basic fundamental interactions and their characteristic features. Elementary particles, Classification of Elementary particles, Conservation laws in elementary particle decays. Quark model of elementary particles.**(Ref. 2,5,6,7)**	14hrs

References:

1. The Atomic Nucleus: R D Evans, Tata McGraw Hill Edition, 1955.
2. Nuclear Physics: D C Tayal, Himalaya Publishing House, Fifth Edition, 2015.
3. Introduction to Nuclear Physics: S B Patel, New Age International Pvt. Ltd Publishers, Second Edition, 2010.
4. Introductory Nuclear Physics: Kenneth S Krane, John Wiley & Sons, Inc., 1988.
5. Atomic and Nuclear Physics: S N Ghoshal, S. Chand & Company Pvt. Ltd., 2014.
6. Nuclear Physics and Particle Physics by SatyaPrakash, Sultan Chand & Sons., 2005.
7. Modern Physics by R Murugeshan, S Chand & Company Pvt. Ltd., 17th Revised Edi, 2014.

Course Title: Interfacing of Devices	**Course code:**24PHY2S2LP
Total Contact Hours: 36	**Course Credits:** 02
Internal Assessment Marks: 20 marks	**Duration of SEE:** 02 hours
Semester End Examination Marks: 30 marks	**L:T:P::1:0:2**

Course Outcomes (COs)

By the end of this course, students will be able to:

1. Understand the fundamentals of circuit design, rectifiers, filters, and operational amplifiers.
2. Conduct model-based simulations of electrical and mechanical systems using software.
3. Apply free and open-source tools to simulate and analyze physical systems.
4. Applying AI to solve problems in physics.
5.

SEC2: Interfacing of Devices (24PHY2S2LP) Unit wise Syllabus

Unit	Description	Hours
1.	**Model-Based Simulation of Rectifiers** Review of Physical Devices: Introduction to p-n junction diodes, transistors, and operational amplifiers (Op-amps). Understanding the roles these devices play in circuit design. Rectifier Circuits: Design and simulation of rectifiers, including: Half-wave rectifiers, Full-wave rectifiers, Rectifiers with filters (capacitive and inductive filters) Clipping and Clamping Circuits and their applications in signal processing. (4 h) Hands-on Sessions: Simulation of rectifier circuits. Analysing the performance of rectifiers with filters using ExpEyes on Cell Phone. (8 h)	**12**
2.	**Open-Source Software (FOSS) and Hardware** Introduction to Linux, Installation, Python Libraries for Physics, Interfacing Hardware: PC to CRO Conversion, Model Simulations: Optical Sensors and Radiation Detection using the ExpEyes kit, and building a basic alpha energy spectrometer for radiation detection. (4 h) Hands-on Sessions: Installing and configuring Linux and Python for scientific computing. Python to interface with sensors and perform real-time data collection, Simulation of mechanical and thermal properties using Python and ExpEyes.(8 h)	**12**

3.	**Introduction to Artificial Intelligence in Physics** Foundations of AI: Definition of AI, Machine Learning, and Deep Learning Applications of AI in physics: Basic concepts of algorithms, neural networks, and data processing in AI, AI-driven simulations in classical and quantum physics, AI for solving differential equations and numerical problems, Overview of AI in experimental physics (e.g., particle detection, astronomy) (6 h) Hands-on Training: Introduction to Python and its libraries (NumPy, SciPy, TensorFlow)Basic AI models to predict physical phenomena, Simulating simple physical systems using AI techniques. (6 h)	**12**

References

1. Boylestad, R. &Nashelsky, L. *Electronic Devices and Circuit Theory*. Pearson.
2. Sedra, A. S. & Smith, K. C. *Microelectronic Circuits*. Oxford University Press.
3. Inman, D. J. *Engineering Vibration*. Pearson.
4. Thomson, W. T. *Theory of Vibration with Applications*. Prentice Hall.
5. Downey, A. *Think Python: How to Think Like a Computer Scientist*. O'Reilly.
6. Kumar, A. *Experiments with Python and ExpEYES: A Hands-On Guide*. Open Source Publishing.
7. Melanie Mitchell*Artificial Intelligence: A Guide for Thinking Humans* Farrar, Straus & Giroux, 2019
8. Martin Erdmann*Deep Learning for Physics Research*World Scientific Publishing Co. 2021

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Course Title: Computational Physics Lab	**Course Code:**24PHY2C5P
Total Contact Hours: 56 Hours	**No. of Credits:** 02
Formative Assessment Marks: 30	**Duration of ESA/Exam:** 04 Hours
Summative Assessment Marks: 70	**L:T:P::0:0:4**

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Write a computational program for various numerical techniques.
2. Compute errors in any experimentation.
3. Write a computational program for solution of problems in physics.

DSC5P3: Computational Physics Lab (24PHY2C5P)

List of Computations

1. Solutions of algebraic and transcendental equations: Bisection method.
2. Solutions of algebraic and transcendental equations: Newton-Raphsonmethod.
3. Newton's forward interpolation.
4. Newton's backwardinterpolation.
5. Lagrange's interpolation.
6. Linear least square fitting.
7. Numerical integration by Trapezoidal rule
8. Numerical integration by Simpson's 1/3 rule.
9. Numerical integration by Simpson's 3/8rule.
10. Solution of differential equation by Runge-Kutta Method.
11. Error, Absolute Error, Relative Error and Percentage Error.
12. Programming in C for solution of problems in physics-examples from atomic and molecular physics, nuclear physics, mechanics, electrodynamics, quantum mechanics, solid state physics.

Note:

1. Minimum of EIGHTcomputations must be carried out.
2. Computations may be added as and when required with the approval of BoS.

References:

1. https://www.sanfoundry.com/c-programming-examples-numerical-problems-algorithms/
2. INTRODUCTION TO NUMERICAL ANALYSIS WITH C PROGRAMS by ATTILA M´AT´E, Brooklyn College of the City University of New York, July 2004.

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Course Title: Condensed Matter Physics Lab	**Course Code:**24PHY2C7P
Total Contact Hours: 56 Hours	**No. of Credits:** 02
Formative Assessment Marks:30	**Duration of ESA/Exam:** 04 Hours
Summative Assessment Marks: 70	**L:T:P::0:0:4**

Course Outcomes (COs):

At the end of the course, students will be able to:

1.Design experiments to study properties of crystals.

2.Compute parameters of crystalline materials.

3.Design experiments to study electrical and thermal properties of solids.

DSC7P4: Condensed Matter Physics Lab (24PHY2C7P)

List of Experiments

1. Determination of inter-planar spacing using X-ray powder pattern.
2. Analysis of X-ray diffraction pattern.
3. Structure factor determination: Computations.
4. Intensity calculations of X-ray powder pattern: Computations.
5. Fermi energy of metals.
6. Temperature variation of resistivity of a semiconductor: four probe method.
7. Measurement of resistivity of a semiconductor by four probe method (fixed temperature)
8. Energy gap of semiconductor by four probe method.
9. Determination of Debye's temperature of Lead or Tin.
10. Study of Lattice Dynamics.
11. Activation energy of point defects in metals: Experiment/Computation.
12. Acoustic waves in solids – Measurement of Ultrasonic velocity in solids.
13. Magneto-resistance of semiconductors.
14. Study of Hall Effect in semiconductors.
15. Energy gap of PN-junction diode/LED.

Note:

1. Minimum of EIGHTexperiments must be carried out.
2. Experiments may be added as and when required with the approval of BoS.

References:

1. University Practical Physics by D.C. Tayal, Himalaya Publishing House, First Millenium Edition, 2000.
2. Advanced Practical Physics for students by B.L. Flint and H.T. Worsnop, Asia Publishing House, 1971.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, Kitab Mahal, 11th Edition, 2011.
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers, 4th Edition, 1985.

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Course Title: Nuclear Physics Lab	**Course Code:** 41PHY2C8P
Total Contact Hours: 56 Hours	**No. of Credits:** 02
Formative Assessment Marks: 30	**Duration of ESA/Exam:** 04 Hours
Summative Assessment Marks: 70	**L:T:P::0:0:4**

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Design experiments to Study the properties of the nucleus.
2. Determine the physical parameters of nuclear radiations/radioactive sources.
3. Compute the half-life of any radioactive materials by various methods.

DSC8P5: Nuclear Physics Lab (24PHY2C8P)

List of Experiments

1. Nuclear counting statistics: Verification of Poisson Distribution.
2. GM Counter characteristics: Determination of Operating voltage.
3. Determination of dead time of GM Counter – single source.
4. Verification of inverse square law for nuclear radiation.
5. Attenuation of β-rays in Aluminium.
6. Attenuation of γ-rays.
7. Half life of K-40.
8. Semi empirical mass formula and binding energy analysis.
9. Nuclear radius calculation.
10. Analysis of β-spectrum and half life systematics.
11, Study of Scintillation Detector (NaI)
12. Gamma-ray spectrum using scintillation detector: multi-channel analysis
13. B-ray spectrum using scintillation detector
14. Study of solar cells

Note:

1. Minimum of EIGHT experiments must be carried out.
2. Experiments may be added as and when required with the approval of BoS.

References:

1. Experiments in Nuclear Science, ORTEC Applications Note. ORTEC (1971).
2. Practical Nucleonics by F. J. Pearson and R. R. Osborne.
3. Experimental Nucleonics by E. Bleuler and G. J. Goldsmith, Rinehart.
4. The Atomic Nucleus by R.D. Evans

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Semester -III

Course Title: Thermal and Statistical Physics	Course Code: 24PHY3C9L
Total Contact Hours: 56 Hours	Number of Credits: 04
Formative Assessment Marks:30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks:70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Apply the basic ideas in thermodynamics and statistical mechanics to physical situations.
2. Use various partition functions to determine thermodynamic potentials.
3. Apply various distribution functions to physical systems.
4. Analyse thermodynamical systems using fluctuations and can analyse phase equilibria in various thermodynamical situations.

DSC 09: THERMAL AND STATISTICAL PHYSICS (24PHY3C9L)

Unit	Description	Hours
1	**Basic thermodynamic and statistical concepts** Introduction, Spontaneous, reversible, and irreversible processes (Qualitative),The laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell's relations and their applications. Microscopic and Macroscopic states, The semiclassical approximation: phase space- μ-space -Γ-space, Chemical potential (Qualitative), Ergodic hypothesis and Liouville's theorem (Proof). Probability distribution - Binomial, Poisson and Gaussian distributions; Ensembles: The probability distribution and their thermodynamic relations in microcanonical, canonical and grand canonical ensembles, Physical Problems.**(Ref. 1, 2, 4, 5)**	**14**
2	**Classical statistics** Concept of partition function, Partition function of a system of particles, The translation partition function, Entropy of a perfect gas: Gibbs paradox - Sackur-Tetrode equation, Boltzmann Equipartition theorem, Rotational partition function, Vibrational partition function, Electronic partition function, and their contributions to thermodynamic quantities. Maxwell-Boltzmann distribution – velocity & energy, Deduction of average speed, mean square speed and most probable speed by Maxwell-Boltzmann distribution, Physical Problems. **(Ref. 2, 3, 4, 5)**	**14**
3	**Quantum statistics** Introduction, Quantum statistics of identical particles, The symmetric and anti-symmetric wave functions, Bosons and Fermions, Bose-Einstein and Fermi-Dirac distributions. Weak and strong degeneracy of perfect gases, Ideal Bose systems: Photon gas –Radiation pressure, Radiation density and emissivity, Bose-Einstein condensation, Phonon gas - specific heat of solids by Einstein and Debye's theories. Ideal Fermi Systems: Fermi energy, Mean energy of Fermions at T=0K, Fermi Gas in Metals, Atomic nucleus as an ideal Fermion gas, Electronic specific heat in metals, Pauli paramagnetism. **(Ref. 1, 4, 5)**	**14**

4 **Fluctuations and Phase Equilibria** **14**

Fluctuations in canonical, grand canonical and microcanonical ensembles. The Brownian motion - Langevin equation. Random walk problem, Diffusion: Einstein relation for mobility. Onsager reciprocity relations. Thermoelectric phenomena. **(Ref. 2, 4, 5)**

Phase Equilibria

Equilibrium conditions, First- and second-order phase transitions, phase diagram, Clausius-Clapeyron equation: Liquid-Vapour equilibria – vapour pressure curve, Heat capacity of vapour in equilibrium, Compressibility of vapour; Sublimation curve. Phase transition in ferromagnetic materials, Liquid helium, Chemical equilibrium, Saha-Ionisation formula. **(Ref.1, 4, 5)**

References:

1. Fundamentals of Statistical Mechanics by B.B. Laud, New Age International Pvt. Ltd., Second Edition, 2012.
2. Statistical Mechanics and Properties of Matter by E.S.R. Gopal, Ellis Horwood Limted Chichester Publisher, 1974.
3. Thermal Physics by by S.C. Garg, R.M. Bansal and C.K. Ghosh, Mc Graw Hill Education(India) Private Limited, 2012.
4. Fundamentals of Statistical Mechanics and Thermal Physics by F. Reif, Mc Graw Hill Book Company, New York.
5. Statistical Mechanics by Satya Prakash Kedar Nath Ram Nath, Meerut, Delhi, 2021.

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Course Title: Analytical Techniques & Instrumentation	Course Code: 24PHY3C10L
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):
At the end of the course, students will be able to:
1. Explain the fundamentals of analytical instrumentation techniques.
2. Analyze atomic absorption, emission & photoluminescence of chemical species using absorption and emission spectroscopy.
3. Analyze vibrations of molecules using IR and Raman spectroscopic techniques.
4. Explain the principles and applications of X-ray, electron and magneton spectroscopy in material characterization and analysis.

DSC10: ANALYTICAL TECHNIQUES & INSTRUMENTATION (24PHY3C10L)

Unit	Description	Hours
1	**Fundamentals of analytical instruments:** Electromagnetic spectrum, Types of chemical analysis, Elements of analytical instrument, Sensors and transducers, Classification of transducers, Performance characteristics of Transducers, Smart sensors, Signal processing in analytical instruments, Read out systems, types of instrumental methods, classification of analytical instruments. Performance requirements of analytical instruments: Errors in chemical analysis, Types of Errors, Accuracy and precision, Significant figures, Application of statistical methods, Signal to noise ration. Sensitivity, Selectivity, Specificity, Resolution, Range, Limit of detection, Linearity. Instrument Calibration techniques: Calibration curve method, Standard addition method, Method of Internal standard, Validation. (Ref: 1)	14
2	**Absorption and emission spectroscopy:** Atomic absorption spectroscopy: Principle, Instrumentation (Radiation sources, Burners and flames, Atomization, Optical system, Electronic system, Sampling system), Applications. Atomic emission spectrophotometer: Instrumentation, Plasma excitation sources (Direct coupled plasma, Inductively coupled plasma, Microwave induced plasma). UV-Visible Absorption spectroscopy: Beer-Lamberts law, Deviations from Beer's Law, Instrumentation: radiation sources, monochromators, detectors, recording system, sample cells; construction and working of single and double beam absorption spectrometers, applications. Photoluminescence: Principles of fluorescence and phosphorescence, Jablonski diagram, factors affecting fluorescence and phosphorescence, Instrumentation of spectrofluorimeter and phosphorescence spectrometer. (Ref: 1-6)	14
3	**Infrared and Raman Spectroscopy:** Infrared absorption spectroscopy: Range of Infrared Radiation, Modes of vibrations, Basic components of IR spectrophotometers (Radiation sources, monochromators, slits, mirrors, sample cells, sampling substance, and	14

detectors) single beam and double beam IR spectrometers; sample handling techniques, Fourier transform infrared spectrometer, comparison between FT and dispersive IR techniques. (Ref: 1,2)
Raman Spectroscopy: Raman effect: Principle, characteristic properties of Raman lines, Raman spectrometer (Sources, sample chamber, Detectors), FT Raman spectrometer, applications, comparison between Raman and Infrared Spectroscopy. (Ref: 1,2)

4 X-ray, Electron and Magneton Spectroscopy: 14
X-ray Diffraction: Bragg's law, X-ray diffraction methods and associated instrumentation, applications.
Electron spectroscopy: Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM). Scanning Tunnelling Electron Microscopy (STEM), Atomic Force Microscopy (AFM).
Magneton Spectroscopy: Vibrating-sample magnetometer (VSM), Nuclear magnetic resonance spectrometer (NMR), Electron spin resonance (ESR).

References:

1. Handbook of Analytical Instruments, R.S. Khandpur, 3rd Edition, Tata McGraw-Hill, (2015).
2. Instruments Methods of Chemical Analysis, Chatwal and Anand, Himalaya Publishing House, (2019).
3. Instrumental Method of Analysis, Willard, Merritt, Dean and Settle, CBS Publishers and Distributors, Delhi (1986).
4. Principles of Instrumental Analysis, 7th Edition, D. A. Skoog, F. J. Holler, S. R. Crouch, Cengage India Private Limited, (2020).
5. Methods of Experimental Physics, Dudley Williams, Academic press, New York, (1976).
6. Experimental Spectroscopy, Sawyer, Prentice-Hall publisher, (1946).

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Course Title: Advanced Condensed Matter Physics	Course Code:24PHY3E1AL
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):
At the end of the course, students will be able to:
1. Determine physical parameters of solids using reciprocal lattice and band structure models.
2. Determine transport properties of solids using related theories.
3. Analyse dielectric and optical properties of solids using basic principles of physics.
4. Analyse magnetic properties of solids using various theories/models.
5. Explain properties of superconductors based on classical and quantum concepts.

DSE 01: ADVANCED CONDENSED MATTER PHYSICS (24PHY3E1AL)

Unit	Description	Hours
1	**Reciprocal Lattice and Band structure in Solids:** Concept of Reciprocal lattice, Method of Construction, Reciprocal Lattice Vectors, Properties of Reciprocal lattice, Expression for length of Reciprocal lattice vector in terms of interplanar spacing, Reciprocal lattice to SC, BCC and FCC, Bragg's law in Reciprocal Lattice, Brillouin Zones and their construction, Brillouin Zone of BCC and FCC Lattice. (Ref.1,2) Nearly free electron model – origin and magnitude of energy gap; Tight Binding Model – Band width and effective mass in linear lattice and cubic lattice; Augumented Plane Wave (APW) method of band structure calculation. (Ref.2,3,4)	14
2	**Transport Properties:** Boltzmann transport equation, Boltzmann Transport Equation for Electrons and Lorentz solution, Chamber's Equation, Sommerfeld's theory of electrical conductivity, Thermal conductivity of metals and Widemann –Franz law, Criticism of Sommerfeld's theory, Relaxation time, Mean free path, The additive Nature of Resistivity – Mathiessen's rule, Thermoelectric effects, Magneto-resistance. (Ref.5)	14
3	**Dielectric and Optical Properties:** **Static Fields:** Polarisation mechanism in dielectrics, Types of polarisation mechanisms, Macroscopic description of static dielectric constant, Static electronic and ionic polarisabilities of molecules, Orientational polarization, Static dielectric constant of gases, Internal field according to Lorentz, Static dielectric constant of solids – Clausius-Mosotti formula.(Ref.6) (8 h) **Alternating fields:** Complex dielectric constant and dielectric losses, Dielectric losses and relaxation time, Classical theory of electronic polarization and optical absorption. (Ref. 6) (5 h)	14
4	**Magnetic and Superconducting Properties** Classification of magnetic materials, Atomic origin of magnetism, Langevin diamagnetism, Paramagnetism -Classical and quantum theories; Magnetism in	14

metals – Spin-paramagnetism, diamagnetism; Ferromagnetism in insulators – Curie-Weiss law, Molecular field theory, Antiferromagnetism and ferrimagnetism, Ferromagnetism in metals, Ferromagnetic domains–Hysteresis curve, Principle and Theory of Paramagnetic resonance and Nuclear magnetic resonance. (Ref.3,4). (9 h)

Superconducting properties: Review of superconductivity, Thermodynamics of Superconducting Transition, Electrodynamics of Superconductors - London Equations, Coherence Length, Single Particle Tunneling, Josephson Tunneling – DC and AC Josephson Effect, Application-SQUID (Ref. 2) (5 h)

References:

1. Solid State Physics by R. K. Puri & V. K. Babbar, S. Chand Publications.
2. Introduction to Solid State Physics by C. Kittel, Wiley Eastern Ltd
3. Elementary Solid State Physics by M. Ali Omar, Pearson Education.
4. Elements of Solid State Physics by J.P Srivastava, PHI Learning Pvt. Ltd.
5. Solid State Physics by S.L. Gupta and V. Kumar, K. Nath & Co.
6. Solid State Physics by A. J. Dekker, McMillan and Co. Ltd.

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Course Title: Advanced Nuclear Physics	Course Code: 24PHY3E1BL
Total Contact Hours: 56 Hours	Number of Credits: 04
Formative Assessment Marks-30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks-70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Analyse structure of nuclei using various models.
2. Analyse two nucleon systems and nuclear reactions.
3. Explain fundamentals of heavy ion physics.
4. Use neutron physics to describe various nuclear processes and to apply various nuclear techniques in advanced nuclear physics.

DSE 01: ADVANCED NUCLEAR PHYSICS (24PHY3E1BL)

Unit	Description	Hours
1	**Nuclear Models** **Shell model:** Evidences for shell structure, energy levels according to harmonic oscillator intermediate potentials - effect of spin-orbit interaction. Shell model Prediction of ground state spin, parity of odd-A nuclei and odd-odd nuclei - Nordheim’s rules, magnetic moments of odd-A nuclei Schmidt limits. **Collective model:** Introduction, Nuclear deformations and collective motions of nucleons. Vibrational model- Vibrational excitation and vibrational energy levels for even-even nuclei, rotational model- Nuclear rotational motion and rotational energy spectra for even-even and odd A nuclei. **Fermi gas model**: Fermi energy of nucleons, Fermi momentum and level density; nuclear matter. **(Ref. Evans, Roy and Nigam, Satya P, D C Tayal)**	**14**
2	**Two nucleon systems**: The ground and Excited states of deuteron, tensor nature of nuclear force and its range. Neutron-proton scattering at low energies, scattering length, Effective range theory in n-p scattering, proton-proton scattering at low energies, Analysis of n-p and p-p scattering, high energy n-p and p-p scattering. Interpretation of n-p and p-p scattering. **Nuclear reactions**: Nuclear reactions and cross sections, partial wave analysis of nuclear reactions-expressions for scattering and reaction cross sections and their interpretations - shadow scattering. Resonance theory of scattering and absorption. Breit-Wigner formula for l=0. **Compound nucleus model:** model and continuum theory of cross-section. **(Ref. Roy and Nigam, Krane, Satya P, D C Tayal)**	**14**
3	**Optical model -** mean free path - optical potential and optical model parameters, optical model at low energy, Kapur-Pierls dispersion formula for potential scattering and experimental results. **Direct Reactions**: Transfer reactions - semiclassical description. Theory of stripping and pickup reactions, Plane wave Born approximation (PWBA) - its predictions of angular distributions - modifications - distorted wave Born approximation (DWBA) - spectroscopic factors and their significance. **Heavy Ion Physics**: Special features of heavy ion reactions. Qualitative treatment of remote electromagnetic interaction Coulomb excitations; close	**14**

encounters, grazing collisions and particle transfer. Direct and head on collision, compound nucleus and quasi molecule formation.**(Ref: Roy and Nigam, Mermier and Sheldon Vol. II)**

4 Neutron Physics **14**

Introduction, Properties of neutron, Classification of neutrons according to energy - neutron sources. Ultrafast neutrons, Neutron detectors, Neutron detection from nuclear reactions. BF3 counters, He-3proportional counters, fission detectors, activation method for neutron flux measurement. Recoil counters, neutron time of flight technique. Slow neutron detection through nuclear reaction, slow neutron cross section measurements, neutron monochromators.

Nuclear techniques:

X-ray Fluorescence (XRF) - Basic principle, instrumentation and application, Neutron Activation Analysis (NAA) – Basic Principle, Instrumentation and application, Proton Induced X-ray Emission (PIXE)- Basic Principle, Instrumentation and application, Positron annihilation- Basic Principle, Sources, Experimental details, Ion beam analysis-Rutherford back scattering.

(Ref: S N Ghoshal and H R Verma)

References:

1. The Atomic Nucleus: R D Evans, Tata McGraw Hill Edition, 1955.
2. Nuclear Physics: R R Roy and B P Nigam, John Wiley & Sons, Inc., 1967.
3. Physics of Nuclei and Particles: P Mermier and E Sheldon, Volume-I,Academic Press, Inc., 1970.
4. Physics of Nuclei and Particles: P Mermier and E Sheldon, Volume-II,Academic Press, Inc., 1969.
5. Nuclear Physics: D C Tayal, Himalaya Publishing House, Fifth Edition, 2015.
6. Nuclear Physics & Particle Physics: Satya Prakash, Sultan Chand and Sons, 2005.
7. Introduction to Nuclear Physics: S B Patel, New Age International Pvt. Ltd Publishers, Second Edition, 2010.
8. Introductory Nuclear Physics: Kenneth S Krane, John Wiley & Sons, Inc., 1988.
9. Atomic and Nuclear Physics: S N Ghoshal, S. Chand& Company Pvt. Ltd., 2014.
10. H R Verma, Atomic and Nuclear Analytical Methods: XRF, Mössbauer, XPS, NAA and Ion-Beam Spectroscopic Techniques. Springer.

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Course Title: Optical Spectroscopy	Course Code:24PHY3E2BL
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):
At the end of the course, students will be able to:
1. Analyse UV and visible spectroscopy of molecules.
2. Analyse fluorescence spectroscopy of molecules.
3. Explain time domain and frequency domain techniques for lifetime measurements.
4. Describe the working of Refractometry, Polarimetry, and Circular Dichroism instrumentation.

DSE 05: OPTICAL SPECTROSCOPY (24PHY3E2BL)

Unit	Description	Hours
1	**Ultraviolet and Visible Spectroscopy:** Origin and theory of ultraviolet spectra, Beer-Lambert's law, Types of transitions in inorganic and organic molecules ($\sigma \to \sigma^*, n \to \sigma^*, \pi \to \pi^*$, $n \to \pi^*$), The shape of UV absorption curves, Transition probability, Chromophore and related terms: Bathochromic and Hypsochromic shift; Hyperchromic, Hypochromic effect; Auxochrome, Effect of conjugation, solvent effects, Choice of solvents, Instrumentation: construction and working of single and double beam spectrophotometers, Applications.	14
2	**Fluorescence Spectroscopy:** Fluorescence, Jablonski Diagram, Characteristics of Fluorescence Emission, Fluorescence Lifetimes and Quantum Yields, Fluorescence Anisotropy, Timescale of Molecular Processes in Solution, Molecular Information from Fluorescence: Emission Spectra and the Stokes Shift, Quenching of Fluorescence, Fluorescence Polarization or Anisotropy, Resonance Energy Transfer, Intrinsic or Natural Fluorophores, Extrinsic Fluorophores, DNA Probes, Chemical Sensing Probes and Special Probes, other Fluorescent Proteins, Long-Lifetime Probes: Lanthanides, Transition Metal–Ligand Complexes, Proteins as Sensors. Construction and working of Spectrofluorometer: Light Sources, Monochromators, Optical Filters, Detectors.	14
3	**Time Domain and Frequency Domain Lifetime Measurements:** Overview of Time-Domain and Frequency-Domain Measurements, Meaning of the Lifetime or Decay Time, Phase and Modulation Lifetimes, Examples of Time-Domain and Frequency-Domain Lifetimes, Construction and Working of Time-Correlated Single-Photon Counting Instrument, Applications of TCSPC, Theory of Frequency-Domain Fluorometry, Frequency-Domain Instrumentation.	14
4	**Refractometry, Polarimetry, and Circular Dichroism:** Refractometry: Refractive index, Effect of wavelength and temperature on RI, Instrumentation of Abbe Refractometer, Applications.	14

Polarimetry: Optical activity, types of molecules analyzed by polarimetry, Instrumentation of Polarimeter, Applications.
Circular Dichroism Spectroscopy: Circularly polarized light, Optically active molecules, Optically rotator dispersion, Circular dichroism and Instrumentation for measurements, Applications.

References:

1. Instruments Methods of Chemical Analysis, Chatwal & Anand, Himalaya Publishing House, (2019).
2. Handbook of Analytical Instruments, R.S. Khandpur, 3rd Edition, Tata McGraw-Hill, (2015).
3. Fundamentals of Molecular Spectroscopic, C N. Banwell and E. M. McCash, Tata McGraw-Hill Publishing Co., Ltd., New Delhi, 5th Edition, (2008).
4. Principles of fluorescence spectroscopy, Joseph R Lakowicz, 3rd Ed. Springer, New York, (2006).
5. Lasers & Nonlinear Optics, Laud B B, New Age International (P) Limited, Publishers, (2011).
6. Nonlinear Optics-Basic Concepts, Mills D L, Narosa Publishing, (1991).

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Course Title: Materials Science	Course Code:24PHY3E1CL
Total Contact Hours: 55 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):
At the end of the course, students will be able to:

1. Explain the basics of engineered materials and their properties.
2. Analyze the behavior of elastic and plastic materials.
3. Analyze the behavior of polymer and nano - materials.
4. Describe the applications of different materials in science and technology.

DSE 01: MATERIALS SCIENCE (24PHY3E1CL)

Unit	Description	Hours
1	**Introduction to Engineering Materials :** Materials Science and Engineering, Classification of Engineering Materials, Levels of Structure, Structure - Property Relationships in Materials. Equilibrium and Kinetics: Stability and Metastability, Basic Thermodynamic functions, The statistical nature of entropy, The kinetics of thermally activated processes. Review of ionic, covalent and molecular bindings, bond angle, bond length and bond energy, lattice energy - Madelung constant cohesive energy, vander Waal's Interaction- Lennard- Jones Potential, closed packed structure-packing efficiency and density of materials.	14
2	**Elastic and plastic behaviour of materials:** Atomic model of elastic behaviour-rubber like Elasticity-anelastic behaviour, viscoelastic behaviour, fracture of materials-Ductile and brittle fracture – Ductile brittle transition, Protection against fracture. Plastic deformation by slip-shear strength of perfect and real crystals- CRSS ratio, Maximum stress to move dislocation, Methods of strengthening crystalline materials against plastic deformation-strain hardening, grain refinement, solid solution strengthening, precipitation strengthening.	14
3	**Elements of polymer science**: Monomers- Polymers- classification of polymers, synthesis of polymers-chain polymerization, step polymerization, Industrial polymerization methods, Average molecular weight- weight, number & viscosity, size of polymer molecule. Microstructure of polymers- chemical, geometric, random, alternating and block polymers. Phase transition-Polymer melting and glass transition, stereo isomerism, degree of crystallinity. Process of plastic materials: Moulding- compression, injection, blow, extrusion, spinning.	14
4	**Nanomaterials:** Introduction, size effect: quantum confinement effect, Different form of nanostructures: 2-d, 1-d and 0-d nanostructures, Synthesis of nanomaterials,	14

Physical Methods of Synthesis: High Energy Ball Milling, Physical Vapour Deposition, Laser Ablation, Electric Arc Deposition; Chemical Methods of Synthesis: Synthesis of Metal and Semiconductor Nanoparticles by Colloidal Route, Sol-Gel Method, Hydrothermal Synthesis; Biological Methods of Synthesis: Synthesis Using Microorganisms, Synthesis Using Plant Extracts.

References:

1. Elements of Materials Science and Engineering, H. Lowrence, V. Vlack, Addison Wesley, (1975).
2. Introduction to Ceramics, W. D. Kingery, H. K. Bower, D. R. Uhlmann, 2nd Edition, Wiley, (1976).
3. Foundations of Materials Science and Engineering, W. F. Smith, J. Hashemi, 5thEdition, McGraw Hills International Edition, (2009).
4. Materials Science and Engineering, V. Ragharan, 5th Edition, Prentice Hall, (2011).
5. Structure & Properties of materials- Rose, Shepard, Wulff, Wiley, (1987).
6. Polymer Science, V. R. Gowariker, N.V. Vishwanathan, Joydev Shreedhar, John Wiley and Sons, Inc. (1987).
7. Text of Polymer Science, Fred. W. Billmeyer, 3rd Edition, John Wiley and Sons, Inc. (1984).
8. Nanotechnology: Importance and applications, M H Fulekar, I. K. International Pvt. Ltd., (2010).
9. A Textbook of Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill Education, (2017).
10. Nanotechnology: Principles and Practices, 3nd Edition, Sulabha K. Kulkarni, Springer International Publishing, (2015)

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Course Title: Radiation Physics	Course Code:24PHY3E2AL
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):
At the end of the course, students will be able to:
1. Understand fundamental radiation physics, radioactivity, and radiation sources.
2. Analyze the interaction of different types of radiation with matter and their effects.
3. Apply radiation measurement techniques and safety principles for protection and regulation.
4. Explore nuclear electronics and industrial applications of radiation in various sectors.

DSE 02: RADIATION PHYSICS (21PHY3E2AL)

Unit	Description	Hours
1	**Basic Radiation Physics** Atomic and nuclear structure: Rutherford’s and Bohr’s atomic models, nucleus and its constituents. Isotopes, isobars, isomers, and their significance in radiation physics. Electromagnetic radiation: Ionizing and non-ionizing radiation. Radioactivity: Radioactive decay, decay constant, half-life, biological half-life. Types of ionizing radiations: Alpha, beta, and gamma radiations; radioisotopes. Radiation sources: Natural and artificial radioactive sources. **(Ref. 1, 2, 3)**	**14**
2	**Interaction of Radiation with Matter** Stopping power, energy loss characteristics, and particle range, Energy loss in thin absorbers and scaling laws, Interaction of fast electrons: Specific energy loss, electron range, and transmission curves, Interaction of gamma rays: Photoelectric absorption, Compton scattering, and pair production, Gamma-ray attenuation: Attenuation coefficients, absorber mass thickness, cross-sections. Neutron interactions: Slowdown interaction, fast neutron interaction, neutron cross-sections. Radiation exposure and dose concepts: Dose equivalent and radiation risk assessment.**(Ref. 4, 5, 6)**	**14**
3	**Radiation Measurements, Quantities, Units and Protection:** Radiation detection principles: GM detectors, scintillation detectors, semiconductor detectors, SSNTDs, and TLDs, Radiation quantities and units: Activity, exposure, absorbed dose, equivalent dose, and effective dose, Linear energy transfer (LET) and its implications. Radiation protection: Objectives, committees, and regulatory bodies (ICRP, AERB, NCRP).ALARA principle, occupational exposure limits, embryo/fetus protection. Public exposure regulations and safety measures.**(Ref. 7, 8)**	**14**
4	**Nuclear Electronics and Industrial Applications** **Nuclear electronics:** Preamplifier circuits, linear and pulse amplifiers, pulse shaping, Pulse discriminators: Coincidence and anti-coincidence circuits, single/multichannel analyzers. Measurement techniques: Collimation,	**14**

shielding, geometry, and calibration.

Industrial applications: Non-Destructive Testing: Thickness measurement, pipeline corrosion, flaw detection in jet engines, mineral analysis. Sealed source applications: Industrial radiography, gauging applications (density, moisture, level, thickness).Radiotracer techniques: Leak detection, flow rate, and mixing measurements. Gamma radiation processing plants: Sterilization of medical products, food irradiation. Material enhancement: Radiation crosslinking of plastics, vulcanization of rubber, electrostatic control applications.**(Ref. 9, 10)**

References:

1. G.F. Knoll, Radiation Detection and Measurement, Wiley, 4th Edition.
2. J. Turner, Atoms, Radiation, and Radiation Protection, Wiley, 3rd Edition.
3. H.C. Ferns, Introduction to Nuclear Physics and Radiation Physics, Prentice Hall.
4. J.R. Lamarsh, Introduction to Nuclear Engineering, Pearson, 3rd Edition.
5. E. Segre, Nuclei and Particles, W.A. Benjamin.
6. F.H. Attix, Introduction to Radiological Physics and Radiation Dosimetry, Wiley.
7. K. Thayalan, The Physics of Radiology and Imaging, Jaypee Publications.
8. Ghoshal S N, ‘Atomic and Nuclear Physics’, Vol. I & II (S Chand & Company.
9. R.L. Murray, Introduction to Nuclear Science, Pergamon Press.
10. S. Glasstone, Sourcebook on Atomic Energy, Krieger Publishing.

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Course Title: Renewable Energy Physics	Course Code:24PHY3E2CL
Total Contact Hours: 55 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Understand renewable energy resources and their impact.
2. Analyze solar energy technologies and applications.
3. Explain wind and ocean energy systems.
4. Evaluate bioenergy and hydrogen fuel technologies.

DSE 02: RENEWABLE ENERGY PHYSICS (24PHY3E2CL)

Unit	Description	Hours
1	**Fundamentals of Renewable Energy & Energy Conservation** Introduction, Definition of Power and energy, difference between power and energy, Importance of Energy Consumption as Measure of Prosperity, Per Capita Energy Consumption, Classification of Energy Resources. Energy Demand and Consumption Patterns: Global and national energy demand trends, Per capita energy consumption and economic development, Future projections and sustainable energy needs **(8 h)** Energy Conservation and Efficiency Strategies: Importance of energy conservation in industry, transport, and residential sectors, Energy-efficient appliances, buildings, and lighting, Government policies and energy conservation acts, Energy Storage Technologies: Primary and secondary Batteries, Renewable energy policies at the global and national levels. **(6 h) , (Ref. 1, 6, 8)**	**14**
2	**Advanced Solar Energy Technologies** **Concentrated Solar Power (CSP) Systems**: Types of CSP: Linear Fresnel, Parabolic Reflectors, Solar Towers, Working principle and applications in large-scale energy production. Solar Energy Storage Technologies: Thermal energy storage using molten salts and phase-change materials, Battery storage solutions for solar energy **(7 h)** **Photovoltaic Materials and Advanced Solar Cell Technologies**: Working principle of solar cells, First, second, and third-generation solar cells, Advanced materials: Perovskite solar cells, quantum dot solar cells Thin-Film Solar Cells and Emerging Trends: Types of thin-film solar cells: Amorphous silicon, Cadmium Telluride, Copper Indium Gallium Selenide, Applications in flexible and transparent solar panels.**(7 h)(Ref. 2, 4, 7)**	**14**
3	**Emerging Wind & Ocean Energy Technologies** Wind Turbine Design and Blade Aerodynamics: Wind turbine classification: Horizontal-Axis and Vertical-Axis Wind Turbines, Aerodynamics of wind blades and Betz’s limit. Differences between onshore and offshore wind farms, Advantages and challenges of offshore wind installations. Energy storage for wind energy, including pumped hydro and battery storage.**(6 h)** **Tidal Energy:** Mechanism, Types, and Energy Conversion Technologies, Tidal barrages, tidal stream generators, and dynamic tidal power, Case studies of tidal	**14**

energy projects worldwide.**(4 h)**
Ocean Thermal Energy Conversion: Mechanism of wave energy conversion devices, OTEC working principle and applications. Technological and environmental challenges**,** Future trends in marine energy technologies. **(4 h) (Ref. 3, 5, 7, 9)**

4 Modern Bioenergy & Hydrogen Economy **14**

Biomass Pyrolysis and Biofuel Production: Biomass conversion via pyrolysis, gasification, and fermentation,Types of biofuels: Bioethanol, biodiesel, and biogas. Advanced Biogas Technologies and Upgradation: Anaerobic digestion process and types of biogas plants, Biogas upgradation to biomethane for commercial applications. Algae as a source of third-generation biofuels, Microbial Fuel Cells for bioelectricity generation. **(7 h)**
Hydrogen Production from Renewable Sources: Green hydrogen production using electrolysis, Hydrogen production from biomass and solar-driven water splitting, Fuel Cell Technologies: Proton Exchange Membrane Fuel Cells, Solid Oxide Fuel Cells, Direct Methanol Fuel Cells and Alkaline Fuel Cells. Hydrogen Storage, Hydrogen safety and handling guidelines. Hydrogen as a clean alternative to fossil fuels, Global hydrogen economy trends and policies. **(7 h) (Ref. 2, 4, 7)**

References:

1. John Twidell & Tony Weir, Renewable Energy Resources, 3rd Ed., Routledge, 2021.
2. S. P. Sukhatme & J. K. Nayak, Solar Energy: Principles of Thermal Collection and Storage, 4th Ed., Tata McGraw-Hill, 2017.
3. G S Sawney, Non-Conventional Energy Resources, PHI Learning Pvt. Ltd 2012
4. D. Y. Goswami, F. Kreith, J. F. Kreider, Principles of Solar Engineering, 3rd Ed., CRC Press, 2015.
5. B. H. Khan, Non-Conventional Energy Resources, 3rd Ed., McGraw Hill, 2017.
6. G. Boyle, Renewable Energy: Power for a Sustainable Future, 4th Ed., Oxford University Press, 2017.
7. Bent Sørensen, Renewable Energy: Physics, Engineering, Environmental Impacts, Economics & Planning, 5th Ed., Elsevier, 2017.
8. S. A. Abbasi & N. Abbasi, Renewable Energy Sources and Their Environmental Impact, PHI Learning, 2010.
9. V. Sundararajan, Ocean Energy: Tide and Tidal Power, CRC Press, 2017.

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Course Title: Nanomaterials	Course Code:24PHY3G1AL
Total Contact Hours: 30 Hours	No. of Credits: 02
Formative Assessment Marks: 15	Duration of ESA/Exam: 1.5 Hours
Summative Assessment Marks: 35	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Understand the fundamental principles of nanoscience, quantum effects, and material properties at the nanoscale.
2. Learn various synthesis techniques and characterization methods for nanomaterials.
3. Explore nanotechnology applications in medicine, particularly in drug delivery and biomedical advancements.

GEC 01: NANOMATERIALS (24PHY3G1AL)

Unit	Description	Hours
1	**Introduction to Nanoscience and Nanomaterials:** Introduction to the science of low-dimensional materials, quantum effects and confinement in 1D, 2D, and 3D structures. fundamental concepts: density of states, excitons, and Coulomb blockade. classification of nanostructures, size control of metal nanoparticles. The optical, electronic, and magnetic properties, surface plasmon resonance and bandgap variations at the nanoscale. Applications in catalysis, electronic devices, and emerging technologies.	10
2	**Synthesis and Characterisation of Nanomaterials:** Synthesis techniques in nanotechnology, top-down and bottom-up approaches. The top-down methods: ball milling and laser ablation, bottom-up methods: sol-gel, hydrothermal, and green synthesis techniques. characterization of nanomaterials: X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and dynamic light scattering (DLS).	10
3	**Nanotechnology for Nanomedince:** Role of nanotechnology in medicine, drug delivery systems. nanoparticles for targeted drug delivery, drug formulation, and controlled release mechanisms. The biomedical applications of nanotechnology in cancer treatment, tissue regeneration, growth, and repair. manufacturing of nanoparticles, nanopowders, nanocrystals, and targeting ligands for efficient drug delivery. applications of nanotechnology in medicine, its impact on drug discovery and pharmaceutical development.	10

References

1. C. N. R. Rao, Nanomaterials and Nanochemistry, Cambridge University Press.
2. K. K. Chattopadhyay & A. N. Banerjee, Introduction to Nanoscience & Nanotechnology, PHI Learning.
3. T. Pradeep, Nano: The Essentials – Understanding Nanoscience and Nanotechnology, Tata McGraw-Hill.
4. B. Bhushan, Springer Handbook of Nanotechnology, Springer.
5. M. Ferrari, Nanotechnology and Drug Delivery, Springer.
6. V. Labhasetwar& D. Leslie-Pelecky, Biomedical Applications of Nanotechnology, Wiley.

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Course Title: Elementary Astrophysics	Course Code:24PHY3G1BL
Total Contact Hours: 30 Hours	No. of Credits: 02
Formative Assessment Marks: 15	Duration of ESA/Exam: 1.5 Hours
Summative Assessment Marks: 35	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain the basics of astrophysics and telescopes.
2. Identify stars and its parameters based on their spectra.
3. Identify various types of galaxies.
4. Describe the structure and evolution of the universe.

GEC 01: ELEMENTARY ASTROPHYSICS (24PHY3G1BL)

Unit	Description	Hours
1	**Basics of Astrophysics and Telescopes:** Scales and Dimensions, Night Sky, Constellations, Earth, Sun, and the Solar System, Retrograde Motion of Planets, Sidereal Time. Basic Optics, Types of telescopes. Telescope mounting systems. Optical telescopes, Infrared, Ultraviolet, X-ray and Gamma-ray telescopes. Schmidt telescopes.	**10**
2	**Stars, Stellar Spectra, and Classification:** Stellar Spectra, Harvard Classification of Stellar Spectra, Saha Equation (qualitative), HR Diagram, Star Clusters and Association, Distance and Age Determination of Clusters Using Color-Magnitude Diagram, Solar System, Solar Atmosphere (Photosphere, Chromosphere, Corona).	**10**
3	**Galaxies and the Universe:** The Milky Way – our galaxy, Classification of galaxies, Origin and evolution of galaxies, Measuring galaxy properties, The distances to other galaxies, The structure of the Universe, The evolution of the Universe.	**10**

References

1. Introduction to Stellar Astrophysics, E. Bohm-Vitense, 3rd Volume, CUP, 1989.
2. Astrophysics and Stellar Astronomy, T.L. Swihart, Wiley 1968.
3. An Introduction to Astrophysics Baidyanath Basu, PHI.
4. A Text book of Astrophysics and Cosmology, V.B. Bhatia, New Age.
5. Stars and Galaxies, K.D. Abhyankar, University Press.
6. An introduction to Astrophysics and Cosmology by Andrew Norton – 2016

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Course Title: Biophysics	Course Code:24PHY3G1CL
Total Contact Hours: 26Hours	Number of Credits:2
Formative Assessment Marks-20	Duration of ESA/Exam: 1.5 Hours
Summative Assessment Marks-30	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain fundamentals of biophysics.
2. Describe the energetics of biological processes.
3. Describe the physics of sensory organ systems.

GEC 01: BIOPHYSICS (24PHY3G1CL)

Unit	Description	Hours
1	**Cell biology** Cell Doctrine, Organization and structure of prokaryotes and eukaryotes, nucleus, cytoplasm, plasma membrane, mitochondria-structure, golgi apparatus, membranes, ribosomes, lysozomes.(**Ref.4, Sybesma, P Narayanan**)	**10**
2	**Molecular biology** The gene, structure of DNA and RNA, Photosynthesis – Photosynthetic unit, Chlorophyll, Bacterial photosynthesis, Photophosphorylation and Carbon fixation, Fermentation and Respiration - Aerobic and Anaerobic oxidation, Kreb’s cycle, The respiratory chain. **(Pattabhi,Sybesma, P Narayanan**)	**10**
3	**Sensory systems** The senses, Neuronal coding of receptor signals, sensory signal processing, the viual receptor-The vertibrate retina, visual pigments, color vision, The auditory receptor - Hearing, The Ear, The auditory receptor cells, Contractility - Muscles. **(Pattabhi,Sybesma, P Narayanan**)	**10**

References

1. An introduction to Biophysics, C Sybesma, Academic, 1977.
2. Biophysics, V Pattabhi and N Gautham, Narosa 2002.
3. Essentials of Biophysics, P Narayanan, New Age 2001.
4. www.khanacademy.org/test-prep/mcat/cells/eukaryotic-cells/a/organelles-article.

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Course Title: Research Methodology	Course Code:24PHY3S3LP
Total Contact Hours: 30 Hours	No. of Credits: 02
Formative Assessment Marks: 20	Duration of ESA/Exam: 01 Hours
Summative Assessment Marks: 30	

Course Outcomes (COs):
At the end of the course, students will be able to:
1. Understand fundamentals and importance of research.
2. Understand Research design, data interpretation and report writing.
3. Identify Indexing databases &Citation databases.
4. Calculate research metrics.
5. Perform activities related to research methodology.

SEC 03: RESEARCH METHODOLOGY (24PHY3S3LP)

Unit	Description	Hours
1	**Introduction to Research:** Meaning of Research, Objectives of Research, Types of Research, Research approaches, Significance of Research, Research methods versus Methodology, Research and scientific method, Research process, Criteria of Good Research. Defining Research problem, Selecting the problem, Necessity of defining the problem, Technique involved in defining a problem, Examples of research problems. Research Programs / Ph.D. programs at National Institutes, Eligibility criteria for Ph.D. / Research programs, Various scholarships for pursuing Ph.D./Research programs, Career Options after research/Ph.D.	**07**
2	**Research Design, Interpretation, Report writing, Research Database and Research metrics:** Research design: Meaning of Research design, Need for Research design, Features of a Good design, Important concepts relating to Research design, Different Research designs, Basic principles of experimental design. Interpretation and Report writing: Meaning of interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of report writing, Different steps in writing a report, Layout of the research report, Types of reports, Oral presentation, Mechanics of writing a Research report. Research Databases: Indexing databases & Citation databases: Web of Science, Scopus etc. Research Metrics: Impact Factor of Journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score, h-index, i10 index.	**07**
3	**Practical / Hands on Sessions on Research Methodology:** 1. Basics of using Origin software – Worksheet for data points, Graphing, Naming axes, Figure captions, Varying Font size & style, Ticks & labels, Smoothening of a plot, Colouring fonts. 2. Least-square fitting of a data for straight line using origin software using origin software. 3. Plotting of Pie Charts and Bar graphs using origin software.	**16**

4. Mean, Standard deviation, variance and other statistical parameters using origin software.
5. Journal search: Searching journals in Scopus / Web of science / any other with impact factor between 0-2, 2.1-4.0, 4.01 – 6.00, 6.01-8.00 and more than 8 (at-least 5 journals for each case).
6. Google scholar citations: Searching Google scholar citations, h-index and i-10 index of at-least 10 researches at VSKUB and 10 researchers at IIT/IISc/any other National Institutes.
7. Literature survey: Collect / Download at-least 10 research papers on a given topic and write a brief report for each paper (1/2 page).
8. Reading of a research paper of interest and preparing a report on area of research, materials and methods and important results.
9. Technical Presentation of a Research paper of interest.
10. Visit to nearby Research Facilities and preparation of report on facilities.

References:

1. C.R. Kothari, Research Methodology: Methods and Techniques, II Ed. New Age International Publishers, (2009).
2. Shanthibhushan Mishra, Shashi Alok, Handbook of Research Methodology, I Ed, 2017, Edu creation Publishers.
3. Basic Statistical Tools in Research and Data Analysis (www.ncbi.nlm.nih.gov).

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Course Title: Thermal and Statistical Physics Lab	Course Code:24PHY3C9P
Total Contact Hours: 52 Hours	No. of Credits: 02
Formative Assessment Marks: 30	Duration of ESA/Exam: 04 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Design an experiment / a computation technique in statistical physics.
2. Conduct an experiment / perform a computation in statistical physics.
3. Analyse data and interpret the results related to statistical physics.

DSC9P6: THERMAL AND STATISTICAL PHYSICS LAB (24PHY3C9P)

List of Experiments

1. Study of Binomial distribution.
2. Study of Poisson distribution.
3. Study of Gaussian Distribution.
4. Study of variation of MB, BE and FD statistics at different temperatures- Computation.
5. Study of Bose-Einstein condensation - Computation.
6. Study of theories of specific heat – Computation.
7. Specific Heat in Metals.
8. Debye temperature of solids.
9. Study of Black body Radiation.
10. Measurement of Planck's constant.
11. Study of Seeback and Peltier effects.
12. Fourier analysis studies.
13. Measurement of Magnetic susceptibility.
14. Measurement of Curie temperature (Magnetic/Electrical).
15. Measurement of thermal conductivity.

Note:

1. Minimum of EIGHT computations must be carried out.
2. Computations may be added as and when required with the approval of BoS.

References:

1. University Practical Physics by D.C. Tayal, Himalaya Publishing House, First Millenium Edition, 2000.
2. Advanced Practical Physics for students by B.L. Flint and H.T. Worsnop, Asia Publishing House, 1971.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, Kitab Mahal, 11th Edition, 2011.
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers, 4th Edition, 1985.

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Course Title: Analytical Techniques & Instrumentation Lab	Course Code:24PHY3C10P
Total Contact Hours: 52 Hours	No. of Credits: 02
Formative Assessment Marks: 20	Duration of ESA/Exam: 04 Hours
Summative Assessment Marks: 30	

Course Outcomes (COs):
At the end of the course, students will be able to:
1. Design an experiment / a computation technique to measure material properties.
2. Conduct an experiment / perform a computation to measure material properties.
3. Analyse data and interpret the results related to material properties.

DSC10P7: ANALYTICAL TECHNIQUES & INSTRUMENTATION LAB (24PHY3C10P)

List of Experiments
1. Determination of ‘g’ factor using Electron spin resonance spectrometer.
2. Fourier analysis of different complex waves, existence of different harmonics and measure their relative amplitudes.
3. Study of the Dispersion relation for “Mono-atomic Lattice”. Determination of the Cut-off frequency and Comparison with theory.
4. Study of the Dispersion relation for the Di-atomic Lattice, Acoustical mode and Energy Gap. Comparison with theory.
5. Measurement of numerical aperture and acceptance angle of the given optical fibre.
6. Determination of Dielectric constant of given liquid.
7. Determination of Dielectric constant of given solid.
8. Measurement of Dipole moment of Organic molecules by Solvatochromic technique.
9. Identification of type of vibrations in organic molecules by IR spectroscopic technique and determination of force constant.
10. Design of simple pendulum experiment using ExpEyes kit.
11. Simulation of range of heavy ions in materials using SRIM software.
12. Determination of lattice constant of a given powder XRD pattern of a sample.
13. Determination of size of the NPs using Debye-Scherrer method.
14. Study of Beta / Alpha spectrometer- single/multichannel analyser.
15. Study of Gamma spectrometer-single/multichannel analyser.

Note:
1. Minimum of EIGHT experiments must be carried out.
2. Experiments may be added as and when required with the approval of BoS.

References:
1. University Practical Physics: D.C. Tayal, Himalaya Publishing House, 1st Ed., 2000.
2. Advanced Practical Physics for students: B.L. Flint and H.T. Worsnop, Asia Publishing House, 1971.
3. A Text Book of Practical Physics, I. Prakash & Ramakrishna, Kitab Mahal, 11th Ed., 2011.
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers, 4th Edition, 1985.

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Semester -IV

Course Title: Advanced Quantum Mechanics	Course Code:24PHY4C11L
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Apply time-dependent perturbation theory to quantum systems.
2. Understand quantum statistics and multi-particle spin dynamics.
3. Analyze symmetries and conservation laws in quantum mechanics.
4. Comprehend relativistic quantum mechanics and field quantization.

DSC11: ADVANCED QUANTUM MECHANICS (24PHY4C11L)

Unit	Description	Hours
1	**Time-Dependent Perturbation theory** Perturbation theory for time evolution in quantum mechanics, Schrodinger, Heisenberg, and interaction pictures, first and second-order transition amplitudes and their physical implications, Applications: first-order theory with constant perturbations, the derivation of Fermi's Golden Rule for wide and closely spaced levels, and scattering by a potential. Harmonic perturbation theory, atomic interactions with electromagnetic radiation, dipole transitions, selection rules, and Einstein A and B coefficients. The sudden and adiabatic approximation and its role in quantum transitions. (Ref. 1, 2, 3)	14
2	**Identical particles and spin:** Introduction to the indistinguishability of identical particles, the construction of symmetric and antisymmetric wave functions, and the classification of bosons and fermions. The Pauli exclusion principle, singlet and triplet states of the helium atom and the exchange integral. Spin angular momentum concepts, connection between spin and statistics, mathematical treatment of angular momentum, eigenvalues, eigenvectors, and matrix representations, analysis of the addition of angular momenta and Clebsch-Gordon coefficients for simple cases: j_1 =1/2, j_2=1/2 and j_1=1, j_2=1/2. (Ref. 4, 5, 6)	14
3	**Symmetry Principles:** Symmetry and conservation laws, fundamental role of symmetry in quantum mechanics: conservation laws and degeneracy. The space-time symmetries, displacement in space (leading to conservation of linear momentum), displacement in time (leading to conservation of energy), and rotation in space (leading to conservation of angular momentum). Space inversion (parity) and time reversal invariance. introduction to supersymmetry and supersymmetric quantum mechanics. (Ref. 7, 8)	14
4	**Relativistic Quantum Mechanics and Field Theory** Relativistic wave equations, Klein-Gordon and Dirac equations, plane wave solutions and significance of negative energy states. The Dirac matrices, spin angular momentum of the Dirac particle, and the non-relativistic limit of the Dirac equation. The interaction of electrons with electromagnetic fields, spin	14

magnetic moments, spin-orbit interaction, and the Dirac equation for a particle in a central field are examined with applications to fine structure of hydrogen. Relativistic quantum field theory, Lagrangian and Hamiltonian formalisms, second quantization, and the quantization of the real scalar field. The classical and quantum theories of the electromagnetic field, commutation relations, covariant perturbation theory, and an introduction to Feynman graphs, applications to the Lamb shift. (Ref. 8, 9)

References:

1. Sakurai, J. J., & Napolitano, J. (2017). Modern Quantum Mechanics (2nd ed.). Pearson.
2. Schiff, L. I. (1968). Quantum Mechanics (3rd ed.). McGraw Hill.
3. Cohen-Tannoudji, C., Diu, B., &Laloë, F. (2005). Quantum Mechanics (2nd ed.). Wiley.
4. Dirac, P. A. M. (1981). *The Principles of Quantum Mechanics* (4th ed.). Oxford Univ. Press.
5. Shankar, R. (2011). *Principles of Quantum Mechanics* (2nd ed.). Springer.
6. Messiah, A. (1999). *Quantum Mechanics* (Vol. 1 & 2). Dover Publications.
7. Wigner, E. (1959). *Group Theory and Its Application to the Quantum Mechanics of Atomic Spectra*. Academic Press.
8. Peskin, M. E., & Schroeder, D. V. (1995). *An Introduction to Quantum Field Theory*. Westview Press.
9. Greiner, W. (2000). Relativistic Quantum Mechanics (3rd ed.). Springer.

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Course Title: Electromagnetics	Course Code: 24PHY4C12L
Total Contact Hours: 56 Hours	Number of Credits: 04
Formative Assessment Marks - 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks -70	

Course Outcomes (COs):
After completion of this course student should able to
1. Illustrate and describe the physical concepts of static electric fields.
2. Illustrate and describe the physical concepts of static magnetic field.
3. State the fundamental laws to identify and apply appropriate theoretical techniques to solve a range of different problems in electromagnetism.
4. Analyze the propagation of radiation and wave in different media.

DSC12: ELECTROMAGNETICS (24PHY4C12L)

Unit	Description	Hours
1	**Electrostatics** Introduction, Divergence and curl of electrostatic field, Gauss law in integral and differential forms with applications, Poisson's and Laplace's equations, Boundary conditions and Uniqueness theorems, electrostatic potential, Multipole expansion of the potential of a Localized Charge Distribution-monopole and dipole terms. The electric field of a dipole, dipole-dipole interaction, the energy of a Point Charge Distribution. The method of images: The classic image problem-induced surface charge-Force and energy. The electrostatic field in matter, polarisation, macroscopic field equations. The electrostatic energyin dielectric media. The electrostatic boundary conditions. The physical problems in electrostatics. (Ref. Griffiths, Laud, Schaum's)	**14**
2	**Magnetostatics** Introduction, Divergence and curl of B, Biot-Savart law-the magnetic field of a steady current-magnetic flux density due to a circular coil carrying current, Ampere's law-the magnetic field due to solenoid-two long co-axial solenoids. Magnetic vector potential, multipole expansion of vector potential of a localized current distribution, magnetic fields in matter-magnetization-torques and forces on magnetic dipoles-effect of magnetic fields on atomic orbits-the magnetic field inside matter, magnetostatic boundary conditions, The physical problems in magnetostatics. (Ref. Griffiths, Marion, Laud)	**14**
3	**Time-changing Electric and Magnetic Fields** The non-steady currents and charges, Lorentz force law and Faraday's law of induction-the induced electric field. Maxwell's equations – Maxwell's Equation from Ampere's Law-scalar and vector potentials-Maxwell's equations in matter. The macroscopic equations and boundary conditions. The electromagnetic potential, Gauge transformations-Coulomb and Lorentz gauges. Energy in the electromagnetic field. Poynting's theorem and energy-momentum conservation. (Ref. Kraus and Carver, Griffiths)	**14**

4 **Electromagnetic Radiation and Electromagnetic Waves** **14**

Electromagnetic Radiation: Retarded potentials, Lienard-Wiechert potentials, electric and magnetic dipole radiation, fields of a point charge in motion, power radiated by a point charge, review of Lorentz transformations, magnetism as a relativistic phenomenon, transformation of electric and magnetic fields, electrodynamics in tensor notation, potential formulation of relativistic electrodynamics.

Electromagnetic waves: The wave equation, light and its electromagnetic character. Plane Waves in free space, energy and momentum in electromagnetic waves, Electromagnetic waves in matter-propagation in linear media-Reflection and transmission in normal and oblique incidence, waves in conducting and non-conducting media. Wave guides-TE Waves in rectangular wave guides-the coaxial transmission line. (Ref. Griffiths)

References:

1. Introduction to Electrodynamics, D JGriffths, PHI, Third Edition, 2012.
2. Electromagnetics, B.B. Laud, New Age International PVT. LTD (1987).
3. Classical Electrodynamics, JD Jackson, 4^{th}Edition, John Wiley & Sons, 2005.
4. Classical Electromagnetic Radiation: J B Marion, Academic press, New York (1968).
5. Electromagnetics, John D Kraus, Keith R Carver, Second Edition, McGraw-Hill Kogakusha Ltd., 1973.
6. Electromagnetics – Theory and Problems, Schaum's outline Series, 2^{nd} Edition, McGraw-Hill 1993.

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Course Title: Semiconductor Physics	Course Code: 24PHY4E3AL
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain fundamental concepts in semiconductors.
2. Analyse optical and magnetic field induced properties in semiconductors.
3. Explain band structure and diffusion in semiconductors.
4. Explain fundamentals and applications of amorphous semiconductors.
5. Analyse performance of various semiconductor devices and heterojunctions.

DSE 03: SEMICONDUCTOR PHYSICS (24PHY4E3AL)

Unit	Description	Hours
1	**Fundamentals of Semiconductors** Classifying materials as semiconductors, Chemical bonds in semiconductors and mechanism of current flow, Forbidden, valence and conduction bands, Band structure for GaAs, silicon and germanium, Mobility, drift velocity and conductivity of intrinsic semiconductor, Carrier concentration in intrinsic semiconductor, Impurity semiconductors – thermal ionization of impurities, Impurity states and band model, Impurity states, energy band diagram and Fermi level. (Ref.1, 4)	14
2	**Optical properties, Magnetic and Electric field effects of Semiconductors** Optical Properties: Interband and Intraband absorption, Fundamental absorption process, Exciton absorption, Free-carrier absorption, Absorption process involving impurities, Photoconductivity, Luminescence. (Ref. 2,4) Magnetic field effects: Cyclotron resonance, Hall effect -– Hall voltage, Hall Coefficient, Mobility and Hall angle, Importance of Hall effect, Experimental determination of Hall coefficient. Electric field effects: High electric field, Hot Electrons, Gunn Effect (Ref. 1,2, 4)	14
3	**Semiconductor Devices** p-n Junction – The junction itself, Junction Transistor, Tunnel Diode, Gunn Diode, Semiconductor laser, Field Effect Transistor, Drift Transistor, Microwave devices, Photodetectors and related devices, Semiconductor Lamp, Solid-State counters, Integrated circuits and Microelectronics (Ref. 2,4,5)	14
4	**Amorphous semiconductors and Semiconductor Heterojunctions** Amorphous semiconductors: Classification, Band structure, Electronic conduction, Optical absorption, switching, Xerography (Ref. 2,4) Heterojunctions: Introduction, General Properties of Heterojunctions, Growth of Heterostructures – Molecular Beam Epitaxy, Metal-Organic Chemical Vapour Deposition, Layered Structures – Tunneling Barrier, Quantum Well, Two Barriers – Resonant tunneling, Super lattice, Modulation Doping (Ref.3)	14

References:

1. Solid State Physics: S.L. Gupta and V. Kumar, K. Nath & Co.
2. Elementary Solid State Physics: M. Ali Omar, Pearson Education.
3. The Physics of Low- Dimensional Semiconductors: John H. Davies, Camb.Univ. Press.
4. Introduction to Solid State Physics: C. Kittel, Wiley Eastern Ltd.
5. Semiconductor devices: S M Sze, M K Lee 3rd ed. Wiley

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Course Title: Particle Physics	Course Code: 24PHY4E3BL
Total Contact Hours: 56 Hours	Number of Credits: 04
Formative Assessment Marks:30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks:70	

Course Outcomes (COs):
At the end of the course, students will be able to:
1. Explain the fundamental elements of particle physics.
2. Apply symmetry transformations and conservation laws in particle interactions.
3. Describe particle dynamics, including relativistic effects and scattering phenomena.
4. Utilize standard models and particle accelerators to study elementary particles.

DSE 01: PARTICLE PHYSICS (24PHY4E3BL)

Unit	Description	Hours
1	**Particle Phenomenology:** Particle Classification, the fundamental particles: **Leptons** - Lepton multiplets and lepton number, neutrinos, neutrino mixing and oscillations, universal lepton interactions, **hadrons** - Flavour independence and charge multiplets, The eightfold way, Review of Quark model, Gell-Mann Nishijima formula. **Pions and other bosons**: Pions - the Yukawa interaction, spin of pions - intrinsic parity - isotopic spin of pions. Pion-nucleon scattering and resonance, Rho, Omega and Eta and K mesons, Muons: nature and properties of muons, muon interaction, **Baryons** – Baryon generation, baryon spin measurements, Hyperons. (**Ref. 1, 3, 2, 4, 5**)	**14**
2	**Symmetry transformations and conservation laws:** Introduction, Symmetries in the Lagrangian Formalism, Symmetries in the Hamiltonian Formalism, Infinitesimal Translations, Infinitesimal Rotations, symmetries in quantum mechanics. The group SU(2) -Introduction, Systems of identical particles, Conservation and violation of Parity, Isospin: an example of the SU(2) group, The extended Pauli principle, consequences of isospin conservation, Charge conjugation, Time reversal, The CPT theorem, The electromagnetic field- Gauge invariance and Maxwell's equations, Polarization and photon spin, Angular momentum, parity, Strange particles: associated production – strangeness quantum number. (**Ref. 2, 4, 8**)	**14**
3	**Particle Dynamics, Relativistic and Scattering phenomena:** **Particle Dynamics:** The Four Forces, Quantum Electrodynamics (QED): The Dirac Equation, Feynman Diagrams, Quantum Chromodynamics (QCD): Heavy quark bound states, Jets and Gluons, Colour Counting, The strong interaction and weak interaction. **Relativistic Kinematics:** Lorentz Transformations, Four-Vectors, Energy and Momentum, Collisions with examples and applications, Relativistic particles and their lifetimes. **Rutherford Scattering:** Rutherford differential cross-section for relativistic and nonrelativistic scattering. (**Ref. 5, 6, 7**)	**14**

4 **Standard Models and Particle Astrophysics:** **14**

Standard Models

Standard Model, the quark model – The SU(3) generators and their representation, quark model of hadrons, mesons and baryons. Beyond the standard model: The Higgs boson, Grand unification, Supersymmetry (SUSY), The SU(5) model, Theories of everything (Qualitative).

Particle accelerators:

DC Accelerators, AC accelerators - Linear and Cyclic accelerators, Fixed target machines and colliders, Synchrotrons – Synchrocyclotron, Electron and proton synchrotrons, Betatrons, Microtrons and cyclotron accelerators, Storage rings, Accelerator shielding - Safety aspects of accelerators, Accelerators in medical and industrial applications. (**Ref. 2, 5,6,7**)

References:

1. Nuclei and Particles, Segre E, II Edn. (Benjamin, 1977).
2. Nuclear and Particle Physics: W.E. Burcham and M. Jobes, Addison Wesley, 1998, ISE.
3. Nuclear Physics, Ghoshal S N, S Chand & Company Pvt.Ltd, Reprint 2014.
4. Nuclear Physics D C Tayal, Himalaya Publishing House, 5th Edition 2011.
5. Introduction to Nuclear and Particle Physics, A Das and T Ferbal, II Edn. World Scientific Publishing Co. Pvt. Ltd. Reprint 2005.
6. Nuclear and Particle Physics – An Introduction, Brian R Martin, John Wiley & Sons, Ltd., 2006.
7. Nuclear and Particle Physics, W S C Williams, Oxford Univ. Press Inc., New York, 1991.
8. Introduction to Atomic and Nuclear Physics, Henry Semat, John R. Albright, Fifth Edition, Fletcher & Son Ltd, Norwich, 1972.

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Course Title: Lasers and Optical fibers	Course Code: 24PHY4E4AL
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain the working performance of various laser systems and their applications.
2. Determine various non-linear optical properties of materials.
3. Use laser spectroscopic techniques for various purpose.
4. Explain the fundamentals and applications of optical fibers.
5. Analyse characteristics of optical fibers, sources and detectors.

DSE 04: LASERS AND OPTICAL FIBERS (24PHY4E4AL)

Unit	Description	Hours
1	**Laser Systems and Applications** Review of laser fundamentals, Laser systems: Argon Ion Laser, Nitrogen Laser, Chemical Lasers, Neodymium : Yttrium Vanadate lasers, Titanium Sapphire Laser, Fiber Lasers, Semiconductor Diode Lasers; Applications of lasers: Thermonuclear reaction, Absolute rotation of earth, Chemistry, Industry, Atmospheric optics, (Ref.1,2)	14
2	**Non-Linear Optics and Laser Spectroscopy** **Non-Linear Optics :** Harmonic Generation; Second Harmonic Generation; Phase Matching; Third Harmonic Generation; Optical Mixing; Parametric Generation of Light; Self Focusing of Light. (Ref.2) **Laser Spectroscopy:** Stimulated Raman Effect; Hyper Raman Effect: Classical quantum mechanical treatments, Coherent Anti-Stoke's Raman Scattering (SARS); Photo Acoustic Raman Spectroscopy (PARS); Saturation-Absorption Spectroscopy; Doppler-Free Two Photon Spectroscopy; Surface Enhanced Raman Spectroscopy. (Ref.2)	14
3	**Optical Fibers - A** Structure of Optical Fibers; Propagation of light through a cladded fibre – acceptance angle & acceptance cone, numerical aperture; Fractional refractive index change, Modes of propagation; Types of Optical fibers, V-number. Materials used in optical fibers; Fabrication methods – Double crucible technique &Vapour oxidation process; Application of optical fibers – Medical, Military, Fiber optic sensors - (temperature, pressure, pollution, liquid level, Interferrometric); optical fiber communication system (qualitative). (Ref. 3)	14
4	**Optical Fibers B** **Transmission characteristics of optical fibers:** Attenuation; Material absorption losses in silica glass fibers – Intrinsic & Extrinsic; Linear scattering losses – Rayleigh & Mie types; Non-linear scattering losses – stimulated Brillouin scattering & stimulated Raman scattering; Fiber Bend losses; Dispersion; Chromatic dispersion – Material dispersion & waveguide dispersion; Intermodal dispersion in multimode fibers	14

LED sources for optical fibers: LED power and Efficiency; LED structures – planar, dome & surface emitter types; Lens coupling to fibers; LED characteristics – optical output power, output spectrum, modulation band width & reliability.

Optical detectors: Performance characteristics of detectors; Optical detection principles; Absorption – Absorption coefficients, Direct and Indirect absorption, III-V alloys; Quantum efficiency; Responsivity; Long wavelength cut-off; p-n and p-i-n photodiodes. (Ref. 3 & 4)

References:

1. Laser Fundamentals by William T. Silfvast, Cambridge University Press, 2nd Edition, 2004.
2. Lasers and Non-linear Optics by B. B. Laud, New Age International Publishers, 3rd Ed. 2011.
3. A Text Book of Engineering Physics by M.N. Avadhanulu & P.G. Kshirsagar, S.Chand Publications, 2012. (ISBN: 81-219-0817-5).
4. Optical fiber communications: The principles and Practice by John M Senior, Pearson Princtice Hall, 3rd Edition, 2009.

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Course Title: Nanoscience	Course Code: 24PHY4E4AL
Total Contact Hours: 56 Hours	No. of Credits: 02
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 100	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Understand quantum confinement, density of states, and size-dependent properties of nanomaterials.
2. Apply synthesis and characterization techniques for nanoscale materials.
3. Analyze emerging trends in nanodevices, nanophotonics, and environmental impacts.
4. Evaluate nanoscience applications in electronics, energy, and biomedicine.

DSE 04: NANOSCIENCE (24PHY4E4AL)

Unit	Description	Hours
1	**Fundamentals of Nanoscience** Introduction to nanoscience and nanotechnology – Length scales in physics, quantum effects, classification of nanostructures, quantum well, quantum wire, quantum dots, surface-to-volume ratio, density of states, excitons, Coulomb blockade. Synthesis and properties of nanomaterials – Optical, electrical, mechanical, and magnetic properties; Surface plasmon resonance,. Size-dependent phenomena – Change in bandgap, melting point, and chemical reactivity. Applications in catalysis, sensors, and microelectronics. **(Ref. 1,2,3)**	**14**
2	**Synthesis and Characterization of Nanomaterials** Synthesis of nanomaterials – Top-down and bottom-up approaches, Ball milling, laser ablation, chemical vapor deposition (CVD), molecular beam epitaxy (MBE), sol-gel synthesis, hydrothermal and green synthesis methods. Characterization techniques – X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), Scanning tunneling microscopy (STM) atomic force microscopy (AFM), Fourier transform infrared spectroscopy (FTIR), and Raman spectroscopy. Structure-property relationship in nanomaterials. **(Ref. 4,5,6)**	**14**
3	**Applications of Nanoscience** Nanomaterials in electronics – carbon nanotubes (CNTs), graphene-based materials, nanosensors, and MEMS/NEMS (Micro/Nano-Electromechanical Systems). Nanoscience in energy – Nanostructured solar cells, hydrogen storage, supercapacitors, and battery technologies. Biomedical applications – Nanoparticles in drug delivery, tissue engineering, and cancer therapy. Environmental applications – Water purification, air filtration, and nanomaterials for sustainable energy **(Ref. 8,9)**	**14**
4	**Emerging Trends in Nanoscience** Nanodevices – Nanoscale transistors, molecular electronics, and spintronics. Nanophotonics – Plasmonics, photonic crystals, and applications in optical communication. Nanomaterials for flexible and wearable electronics. Safety, toxicity, and ethical concerns in nanotechnology. Future perspectives –	**14**

Artificial intelligence in nanotechnology, quantum computing, and nanotechnology in space research. **(Ref. 6,7)**

References:

1. C. N. R. Rao & G. U. Kulkarni, Nanotechnology: Principles and Practices, Springer.
2. K. K. Chattopadhyay & A. N. Banerjee, Introduction to Nanoscience and Nanotechnology, PHI Learning.
3. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press.
4. T. Pradeep, Nano: The Essentials – Understanding Nanoscience and Nanotechnology, Tata McGraw-Hill.
5. B. Bhushan, Springer Handbook of Nanotechnology, Springer.
6. Z. L. Wang, Characterization of Nanophase Materials, Wiley-VCH.
7. R. P. Feynman, There's Plenty of Room at the Bottom, Caltech Lecture Series.
8. M. Ferrari, Nanotechnology and Drug Delivery, Springer.
9. V. Labhasetwar& D. Leslie-Pelecky, Biomedical Applications of Nanotechnology, Wiley.

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Course Title: Accelerator Physics	Course Code:24PHY4E4BL
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Understand the fundamental principles of particle accelerators, including beam dynamics and accelerator components.
2. Analyze different types of accelerators, their working principles, and applications.
3. Apply concepts of radiofrequency acceleration, beam optics, and magnet technology in accelerator design.
4. Evaluate the role of accelerators in scientific research, industry, and medical applications.

DSE 04: ACCELERATOR PHYSICS (24PHY4E4BL)

Unit	Description	Hours
1	**Fundamentals of Accelerator Physics** Introduction to Accelerators: Historical development, classification, and applications. Basic Accelerator Physics: Charged particle motion, Lorentz force, transverse and longitudinal beam dynamics. Beam Optics: Hamiltonian formulation, phase space, beam emittance, betatron oscillations, dispersion, and chromaticity. RF Acceleration: Principles of RF cavities, resonant structures, and synchrotron oscillations. (Ref 1,2)	14
2	**Types of Particle Accelerators** Electrostatic Accelerators: Van de Graaff generators, Cockcroft-Walton accelerators. Linear Accelerators (LINACs): Principles, structure, and applications. Cyclotrons and Synchrocyclotrons: Design principles, resonance condition, and applications. Synchrotrons and Storage Rings: RF acceleration, focusing principles, and beam stability. Fixed-Target vs. Colliding Beam Machines: CERN, Fermilab, and modern collider facilities.(Ref 3,4)	14
3	**Accelerator Technology and Instrumentation** Magnetic Systems: Dipole and quadruple magnets, field gradients, beam steering, and focusing. RF Cavities and Resonators: RF field structures, superconducting RF technology. Beam Diagnostics: Beam profile monitors, wire scanners, current monitors, and beam loss monitoring. Vacuum Systems: Ultra-high vacuum requirements, pumps, and pressure measurements. Cooling and Radiation Shielding: Beam cooling techniques, synchrotron radiation, and shielding design.(Ref 5,6)	14
4	**Applications of Accelerators** Scientific Research Applications: High-energy physics experiments, synchrotron radiation sources, neutron spallation. Medical Applications: Proton therapy, heavy ion therapy, and medical imaging. Industrial Applications: Material processing, isotope production, and food irradiation. Future Trends in Accelerator Physics: Plasma Wakefield accelerators, muon colliders, and compact accelerator technologies. (Ref. 7,8)	14

References:

1. Lee, S. Y. (2018). Accelerator Physics (4th ed.). World Scientific.
2. Conte, M., & MacKay, W. W. (2008). An Introduction to the Physics of Particle Accelerators (2nd ed.). World Scientific.
3. Wiedemann, H. (2015). Particle Accelerator Physics (4th ed.). Springer.
4. Wilson, E. (2001). An Introduction to Particle Accelerators. Oxford University Press.
5. hao, A. W., & Tigner, M. (Eds.). (2013). Handbook of Accelerator Physics and Engineering (2nd ed.). World Scientific.
6. Peggs, S., &Satogata, T. (2017). Introduction to Accelerator Dynamics. Cambridge University Press.
7. Bryant, P., & Johnsen, K. (1993). The Principles of Circular Accelerators and Storage Rings. Cambridge University Press.
8. Reiser, M. (2008). Theory and Design of Charged Particle Beams (2nd ed.). Wiley-VCH.

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Course Title: Astrophysics	Course Code: 24PHY4E4CL
Total Contact Hours: 56 Hours	No. of Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 03 Hours
Summative Assessment Marks: 70	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Apply stellar magnitudes and celestial coordinates to analyze star positions and brightness.
2. Classify stars using spectral analysis and Saha's equation to infer their properties.
3. Explain the processes of star formation and evolution across different stellar types.
4. Describe the Sun's properties, planetary dynamics, and the structure of galaxies and cosmology.

DSE 04: ASTROPHYSICS (24PHY4E4CL)

Unit	Description	Hours
1	**Stellar Magnitudes, Motions, and Distances:** Stellar magnitude sequence, Absolute magnitude and the distance modulus, The bolometric magnitude, Different magnitude standards: The UBV system and six-colour photometry, Radiometric magnitudes, The Colour - Index of a star, Luminosities of stars, Stellar Parallax (Trigonometric) and The units of stellar distances (Parsecs, Light years), Stellar positions - The celestial coordinates: The equatorial system: Right ascension and declination, The ecliptic system: celestial latitude and longitude	14
2	**Stellar Spectra and Classification:** Stellar spectra, Saha's equation of thermal ionization (quantitative), Harvard system of spectral classification, The luminosity effect on stellar spectra, Importance of ionization theory in astrophysics, Spectroscopic parallax, The Hertzsprung-Russell (HR) diagram, Star clusters and associations, Distance and age determination of clusters using color-magnitude diagram.	14
3	**Star Formation and Stellar Evolution:** Virial theorem, Stellar structure equations, Early stage of star formation, protostars, fragmentation, Stellar nucleosynthesis and evolution on the main sequence, degenerate free electron gas, Evolution beyond the main sequence, Population I and II stars, White dwarfs, Pulsars, Magnetars, Neutron star, Black holes, supernova, variable stars.	14
4	**Sun, Star clusters, Galaxies and the Universe:** Solar atmosphere: Photosphere, Chromosphere, Corona, Dynamo mechanism for magnetic field enhancement, Sunspots and the Solar Cycle, Orbital properties of planets, Retrograde motion of planets, Albedo and temperature of planets, Open and global clusters, the structure and contents of Milky way Galaxy, Hubble’s classification of Galaxies, Galaxy rotation curves and Dark matter, big bang theory and the origin of the early universe.	14

References:

1. Introduction to Stellar Astrophysics, E. Bohm-Vitense, 3rd Volume, Cambridge University Press, (1992).
2. Astrophysics and Stellar Astronomy, T.L. Swihart, Wiley (1968).
3. Galaxies; their Structure and Evolution, R.J. Taylor, Cambridge University Press, (1993).
4. Solar System Astrophysics, J.C. Brandt, P. Hodge, McGraw-Hill, (1964).
5. Introduction to Modern Astrophysics, Ostlie and Carroll, Pearson, (2006).
6. An Introduction to Astrophysics Baidyanath Basu, Second Edition, PHI Learning Private Limited, (2010).
7. A Textbook of Astronomy and Astrophysics with Elements of Cosmology, V.B. Bhatia, Alpha Science International Ltd., (2001)
8. Stars and Galaxies, K.D. Abhyankar, University Press, (2001).
9. Pulsar Astronomy, A.G. Lyne and G. Smith, Cambridge University Press, (2012).
10. C. R. Kitchin: Astrophysical Techniques, 4th Edition, CRC Press, (2003).
11. Astronomical Techniques, W. A. Hiltner, University of Chicago Press, (1969).

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Course Title: Physics in Everyday Life	Course Code:24PHY4G2AL
Total Contact Hours: 30 Hours	No. of Credits: 02
Formative Assessment Marks: 15	Duration of ESA/Exam: 1.5 Hours
Summative Assessment Marks: 35	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Explain phenomenon in everyday life using laws of motion.
2. Explain phenomenon in everyday life using projectile motion, friction, periodic motion and law of forces.
3. Explain phenomenon in everyday life using properties of light.

GEC 02: PHYSICS IN EVERYDAY LIFE (24PHY4G2AL)

Unit	Description	Hours
1	**The Laws of Motion:** Qualitative discussion of Newton's first law of motion, Inertia and types of inertia; Examples in everyday life: Falling backward when a bus moves quickly from rest, Moving forward when driver of a bus suddenly applies break, Getting down from a moving bus or train, Athlete taking a short run before a jump. Qualitative discussion of Newton's second law of motion; Examples in everyday life: Pushing a car and a truck, Pushing a shopping cart, Hitting a ball, Rocket launch, Driving a car and car crash. Qualitative discussion of Newton's third law of motion; Examples in everyday life: Pulling an elastic band, Swimming, Standing on the ground or sitting on a chair, Bouncing of a ball and the recoil of a gun.	10
2	**Projectile Motion, Friction, Periodic Motion and Law of Forces:** Qualitative discussion of projectile motion – maximum height, time of flight and range of the projectile; Examples in everyday life: Firing a Canon, Javelin throw, Hitting a Cricket Ball, Archery, Car and Bike Stunts, Disc throw. Qualitative discussion of friction and its types; Examples in everyday life: Walking, Writing, Skating, Lighting a matchstick, Driving of a vehicle on the surface, Flight of aeroplanes, Drilling of a nail into the wall. Qualitative discussion on Law of parallelogram of forces: Swimming, Boat movement, Flying of a bird, Shot of an arrow with Bow, Weight lifting. Qualitative discussion of periodic motion; Examples in everyday life: Swing, Hands of a clock, Motion of earth round the Sun, Motion of Moon around the Earth, Heartbeats, Rocking chair.	10
3	**Properties of Light:** Reflection of light: Qualitative discussion of reflection of light, laws of reflection; Examples in everyday life: Image formation in plane mirrors, Concave mirrors for magnification, focusing of light, Solar power, Convex mirrors for car rear view, security, street lights, Hallways and elevators. Refraction of light: Qualitative discussion of refraction of light, types of refraction; Examples in everyday life: Depth of Pool water, Twinkling stars, Mirages, Rainbows, Magnifying glasses, Peepholes in doors, Lenses used in errors in the eyes.	10

Scattering of light: Qualitative discussion of scattering of light, types of scattering – Rayleigh scattering & Mie scattering; Examples in everyday life: Blue colour of the sky, Blue colour of the ocean, White colour of clouds, Red colour of the Sun during Sunset and Sunrise.
Dispersion of Light: Qualitative discussion of dispersion of light, Dispersion through prism, VIBGYOR; Examples in everyday life: Rainbow, Soap bubbles, CDs, Wet roads.

References:

1. How Things Work–The Physics of Everyday Life by Louis A. Bloomfield, Wiley, 6th Ed. 2016.
2. NCERT 11th and 12th Standards Text Books.
3. https://examples.yourdictionary.com/examples-of-inertia.html
4. https://byjus.com/physics/newtons-second-law-of-motion-and-momentum/
5. https://openstax.org/books/university-physics-volume-1/pages/5-5-newtons-third-law
6. https://studiousguy.com/projectile-motion-examples/
7. https://byjus.com/questions/give-10-examples-of-friction-in-our-daily-life/

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Course Title: Space Research Programs in India and Abroad	Course Code:24PHY4G2BL
Total Contact Hours: 30 Hours	No. of Credits: 02
Formative Assessment Marks: 15	Duration of ESA/Exam: 1.5 Hours
Summative Assessment Marks: 35	

Course Outcomes (COs): At the end of the course, students will be able to:

1. Explain basic ideas of space missions.
2. Recognise major space centers and space scientists in the World.
3. Explain the contributions of ISRO for space missions.
4. Explain the applications of satellite.

GEC 02: SPACE RESEARCH PROGRAMS IN INDIA & ABROAD (24PHY4G2BL)

Unit	Description	Hours
1	**Introduction to Space Missions** Rockets, types and their applications, Orbits - Different types of orbits, Artificial satellites – basic idea and their applications, Introduction to Space Missions, Beginning of Space Missions - World and India, Applications of Space Research, Space crafts, Launching Vehicles. Major Space Centres in the World (at least 10) – brief idea about their location, establishment, capabilities and achievements.	10
2	**Indian Space Research Organisation (ISRO)** About ISRO and its Goals, History of Creation. General Satellite Programmes: The IRS series, The INSAT series. Gagan Satellite Navigation System, Navigation with Indian Constellation (NavIC), Other satellites. Launch vehicles: Satellite Launch Vehicle (SLV), Augmented Satellite Launch Vehicle (ASLV), Polar Satellite Launch Vehicle (PSLV), Geosynchronous Satellite Launch Vehicle (GSLV). Experimental Satellites: Details and applications (Any Five)	10
3	**Applications of satellites and Success Stories of Space missions** Earth Observation Satellites: Details and applications (Any Five), Communication satellites: Details and applications (Any Five), Application of satellites in agriculture, communication, weather forecasting, exploration of natural resources and Global positioning system (GPS). Success stories: Apollo 11, Chandrayaan 1, Mars Orbiter Mission (MoM). Chandrayana 2 and Aditya-L1	10

References:

1. https://www.britannica.com/topic/NASA
2. https://www.isro.gov.in/

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Course Title: Exciting Inventions in Physics	Course Code: 24PHY4G2CL
Total Contact Hours: 30 Hours	Number of Credits: 02
Formative Assessment Marks - 20	Duration of ESA/Exam: 1.5 Hours
Summative Assessment Marks -30	

Course Outcomes (COs):
At the end of the course, students will be able to:
1. Explain about the exciting inventions in atomic and molecular Physics.
2. Explain about the exciting inventions in nuclear and radiation Physics.
3. Explain about the exciting inventions in other areas of Physics.

GEC 02: EXCITING INVENTIONS IN PHYSICS (24PHY4G2CL)

Unit	Description	Hours
1	**Inventions in Atomic and Molecular Physics** *About the discoverer, discovery and Applications of* - a) Discovery of X-rays by Wilhelm Conrad Röntgen. b) The Wave Nature of the Electron by Prince Louis-Victor Pierre Raymond de Broglie. c) Discovery of Raman Effect by Sir Chandrasekhara Venkata Raman. d) Development of Neutron Spectroscopy by Bertram N. Brockhouse. e) Efficient blue light-emitting diode which has enabled bright and energy saving white light sources by Isamu Akasaki.	10
2	**Inventions in Nuclear and Radiation Physics:** *About the discoverer, discovery and Applications of* - a) Discovery of spontaneous radioactivity and Investigations of radiation phenomena by Antoine Henri Becquerel, Pierre Curie and Marie Curie. b) Glimpses at the History of the Nuclear Structure Theory by J. Hans D. Jensen and Maria Goeppert Mayer. c) Rotational Motion in Nuclei by Aage N Bohr. d) Existence of mesons on the basis of theoretical work on nuclear forces by Hideki Yukawa. e) The Neutrino: From Poltergeist to Particle by Frederick Reines.	10
3	**Inventions in Other areas of Physics:** *About the discoverer, discovery and Applications of* - a) Energy production in stars by Hans Albrecht Bethe. b) Development of the holographic method by Dennis Gabor. c) Development of laser spectroscopy by Arthur Leonard Schawlow. d) Physical processes of importance to the structure and evolution of the stars by Subramanyan Chandrasekhar. e) Invention of the integrated circuit by Jack S. Kilby.	10

References:
1. https://www.nobelprize.org/prizes/lists/all-nobel-prizes-in-physics/

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Course Title: Electromagnetics Lab	Course Code: 24PHY4C12P
Total Contact Hours: 52 Hours	No. of Credits: 02
Formative Assessment Marks: 20	Duration of ESA/Exam: 04 Hours
Summative Assessment Marks: 30	

Course Outcomes (COs):

At the end of the course, students will be able to:

1. Design experiments related to electromagnetism.
2. Conduct experiments related to electromagnetism.
3. Analyze and interpret experimental data related to electromagnetism.

DSC12P8: ELECTROMAGNETICS LAB (24PHY4C12P)

LIST OF EXPERIMENTS

1. Magnetic field in a conductor (solenoid).
2. Measurement of Dielectric constant.
3. Magnetic field in Helmholtz coil experiment.
4. Study of Ferromagnetic Hysteresis curve.
5. Study of Magnetic Induction.
6. Study of Biot-Savart Law.
7. Measuring velocity by electromagnetic induction.
8. Study of Eddy Current and Lenz’s law using Transformer Kit.
9. Study of Faraday’s Law of Induction.
10. Study of Ohm’s Law.
11, Study of RC Circuits.
12. Study of LCR Series and Parallel.
13. Study of Kirchoff’s Law.
14. Study of Magnetic field produced by coils.

Note:

1. Minimum of EIGHT computations must be carried out.
2. Computations may be added as and when required with the approval of BoS.

References:

1. Physics Laboratory Manual, David H Lloyd, 3rd Ed., Thomson Higher Education, USA.
2. Practical Physics, J.A. Growther, Sc. D., F. Inst. P, 1922.
3. Practical Physics In S.I., Edward Armitage, John Murray Publishers Ltd., 1972.4.
4. General Physics II Laboratory Manual, IZMIR Institute of Technology. 2020.
5. University Practical Physics, D.C.Tayal (Edited: Ila Agarwal), Himalaya Publishing House, 2000.

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Evaluation Process:

A. Continuous Assessment Scheme (DSC/DSE): Internal

Sl. No.	Component	Maximum Marks
01	Two Session Tests with proper record for assessment (10+10 = 20)	20
02	Assessment of Skill development activities/Seminars/Group Discussion etc., with proper record	05
03	Assignment with proper record	05
	TOTAL	**30**

B. a) SEC Courses: Internal

Sl. No.	Component	Maximum Marks
01	One Session written Tests with proper record for assessment	10
02	Practical test with proper record	10
	TOTAL	**20**

b) SEC Courses: SEE (Internal)

Sl. No.	Component	Maximum Marks
01	Circuit Diagram/Ray diagram/Tabular Column with proper labeling and units.	10
02	Skill (proper readings) and result	12
03	Viva voce	08
	TOTAL	**30**

C. Assessment for Practical: Internal

1	Two practical Test with proper record (10+10)	20
2	Record / Journal	10
	Total	**30**

D. GEC Course : Internal

Sl. No.	Component	Maximum Marks
01	Two Session written Tests with proper record (5 + 5)	10
02	Assessment of Skill development activities/Seminars/Group Discussion etc., with proper record	05
	TOTAL	**15**

E. Practical SEE (Duration: 3 Hrs)

No	Component	Maximum Marks
1	Circuit Diagram/Ray diagram/Tabular Column with proper labeling and units.	20
2	Experimental Skill (proper readings)	20
3	Graph/calculations/Result with Accuracy	20
4	Viva	10
	Total Marks	**70**

F. Project Work Assessment during VI semester: Internal

Activities	C1	C2	Total Marks
Review of Literature and Formulation of Research Problem	10	-	**10**
Research Design & Approach	05	-	**05**
Analysis and Findings	-	05	**05**
Pre-submission Presentation	-	10	**10**
Total	**-**		**30**

G. Semester End examination assessment for Project

Activities	Marks
Dissertation/Report	**30**
Presentation	**15**
Viva-Voce	**15**
Novelty of the work *(Fundamental Research, Applied Research, Adding to Existing Knowledge, New Knowledge, Cost effectiveness, Society, Environment)*	**10**
Total	**70**

H. GEC-SEE

CBCS Question Paper pattern for GEC of PG

Paper Code: Paper Title

Time: 1 hour Max Marks: 30

Instruction: Answer all the Sections

Section – A

1. Answer all the following questions, each question carries ONE marks a)
   b)
   c)
   d)
   e)

Section – B

Answer any FIVE of the following question, each question carries TWO marks 2.
3.
4.
5.
6.
7.
8.

Section – C

Answer any THREE of the following questions, each question carries FIVE marks
9.
10.
11.
12.
13.

THEORY EXAMINATION QUESTION PAPER PATTERN FOR DSC/DSE SUBJECTS
(Semesters I –IV)

M.Sc. Degree Examination; 2024-25
(Semester Scheme 2024-25)

SUBJECT: Physics

Course Name: _______________________________ [Course Code]

Time: 3 Hours **Max. Marks: 70**

Instructions to candidates:

1) All sections are compulsory
2) Draw neat and labeled diagrams wherever necessary.

SECTION-A

[1]. Answer **any four** the following questions: **(4×5=20)**

A)
B)
C)
D)
E)
F)

SECTION-B

Answer any **Four** of the following: **(4×10=40)**

[2].
[3].
[4].
[5].
[6].
[7].

SECTION -C

Answer any **Two** of the following: **(2×5=10)**

[8].
[9].
[10].
[11].

Note for paper setters: Set minimum one question from each Unit.

	VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY *Jnana Sagara' Campus, Vinayaka nagara, Cantonment, BELLARI - 583 105.*	
	Department of Studies and Research in Physics	

Board of Studies

Meeting held on 3rd March 2025

01	Dr. Khadke Udaykumar, Professor, VSK University, Ballari	Chairman-BoS
02	Dr. Thipperudrappa J. Professor & Chairman Dept. Of Physics, VSK University, Ballari	Member Internal Expert
03	Dr. Basavaraj Angadi Professor, Dept. of Physics, Bangalore University, Bangalore	Member External expert
04	Dr. Kotresh M. G. Assistant Professor, VSK University, Ballari	Member Internal Expert
05	Dr. Avinash P. Assistant Professor, VSK University, Ballari	Member Internal Expert