As per NEP 2020

M.Sc. Physics

(Effective from Academic Year 2024-2025 onwards)

Pandit Deendayal Upadhyaya Shekhawati University

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Curriculum Structure

Session 2024-2025 onwards

Name of the Program: Master of Physics

Year: First | **Semester: I (Pawas)**

	Course Code	Course Title	Contact Hrs per Week			Credits	Weightage (%)		
			L	T	P		CW$	MTE	ETE
Pawas Semester I	**Discipline Specific Core (DSC):**								
	24MPH9101T	Classical Mechanics	4	0	0	4	10	20	70
	24MPH9102T	Quantum Mechanics	4	0	0	4	10	20	70
	24MPH9103T	Classical Electrodynamics	4	0	0	4	10	20	70
	24MPH9104P	Practical	0	0	8	4	-	-	100
	Discipline Specific Elective(DSE):								
	24MPH9105T	Numerical Methods and Computer Fundamentals	4	0	0	4	10	20	70
	OR								
	24MPH9106T	Laser Physics	4	0	0	4	10	20	70
	Value Added Course(VAC):								
	---	---	--	--	--	2	--	--	--
	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):								
	---	---	--	--	--	--	--	--	--
		Total				22			

Summary: I Semester (Pawas)		Credits
S.N.	Particulars	
1.	Discipline Specific Core(DSC):	16
2.	Discipline Specific Elective (DSE):	04
3.	Value Added Course (VAC):	02
4.	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):	00
	Total	22
$CW (Class work): It would include attendance, class test/quiz test/assignments, ppt, play, learn by fun activities etc.		

Note: VAC to be selected from the list of VAC courses for PG, given on University website.

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Curriculum Structure

Session 2024-2025 onwards

Name of the Program: Master of Physics

Year: First | **Semester:** II (Vasant)

	Course Code	Course Title	Contact Hrs per Week			Credits	Weightage (%)		
			L	T	P		CW$	MTE	ETE
Vasant Semester II	**Discipline Specific Core (DSC):**								
	24MPH9201T	Research Methodology	4	0	0	4	10	20	70
	24MPH9202T	Electronics	4	0	0	4	10	20	70
	24MPH9203T	Atomic and Molecular Physics	4	0	0	4	10	20	70
	24MPH9204P	Practical	0	0	4	4	-	-	100
	Discipline Specific Elective(DSE):								
	24MPH9205T	Nanotechnology	4	0	0	4	10	20	70
		OR							
	24MPH9206T	Mathematical Physics	4	0	0	4	10	20	70
	Value Added Course(VAC):								
	---	---	--	--	--	2	--	--	--
	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):								
	---	---	--	--	--	--	--	--	--
		Total				22			

Summary: II Semester (Vasant)		Credits
S.N.	**Particulars**	
1.	Discipline Specific Core(DSC):	16
2.	Discipline Specific Elective (DSE):	04
3.	Value Added Course (VAC):	02
4.	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):	00
	Total	22
$CW (Class work): It would include attendance, class test/quiz test/assignments, ppt, play, learn by fun activities etc.		

Note: VAC to be selected from the list of VAC courses for PG, given on University website.

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Curriculum Structure										
For Session 2024-2025 onwards										
Name of the Program: Master of Physics										
Year: Second								**Semester: III (Pawas)**		
Pawas Semester III	**Course Code**	**Course Title**	**Contact Hrs. per Week**			**Credits**	**Weightage (%)**			
			L	T	P		CW$	MTE	ETE	
	Discipline Specific Core (DSC):									
	24MPH9301T	Solid State Physics	4	0	0	4	10	20	70	
	24MPH9301P	Advance Physics Lab - I	0	0	8	4	--	--	100	
	Discipline Specific Elective (DSE): (Select any Four)									
	24MPH9302T	Condensed Matter Physics	4	0	0	4	10	20	70	
	24MPH9303T	Advance Quantum Mechanics	4	0	0	4	10	20	70	
	24MPH9304T	Experimental Techniques in Physics	4	0	0	4	10	20	70	
	24MPH9305T	Opto-electronics	4	0	0	4	10	20	70	
	24MPH9306T	Plasma Physics	4	0	0	4	10	20	70	
	24MPH9307T	Microwave Electronics and Communication	4	0	0	4	10	20	70	
	Value Added Course (VAC):									
	---	---	--	--	--	2	--	--	--	
	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):									
	--	--	--	--	--	--	--	--	--	
		Total				**26**				

Summary: III Semester (Pawas)		**Credits**
S.N.	**Particulars**	
1.	Discipline Specific Core(DSC):	**08**
2.	Discipline Specific Elective (DSE):	**16**
3.	Value Added Course (VAC):	**02**
4.	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):	00
	Total	**26**
$CW (Class work): It would include attendance, class test/quiz test/assignments, ppt, play, learn by fun activities etc.		

Note: VAC to be selected from the list of VAC courses for PG, given on University website.

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Curriculum Structure										
For Session 2024-2025 onwards										
Name of the Program: Master of Physics										
Year: Second							Semester: IV (Vasant)			
Vasant Semester IV	Course Code	Course Title	Contact Hrs. per Week			Credits	Weightage (%)		
			L	T	P		CW$	MTE	ETE
	Discipline Specific Core (DSC):								
	24MPH9401T	Nuclear and Particle Physics	4	0	0	4	10	20	70
	Discipline Specific Elective (DSE): Select any Two								
	24MPH9401P	Advance Physics Lab - II	0	0	8	4	--	--	100
	24MPH9402T	Statistical Physics	4	0	0	4	10	20	70
	24MPH9403T	Astronomy and Astrophysics	4	0	0	4	10	20	70
	24MPH9404T	High Energy Physics	4	0	0	4	10	20	70
	Value Added Course (VAC):								
	---	----	-	-	-	-	--	--	--
	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C): Select Any One								
	24MPH9401S	Seminar	--	--	--	8	--	--	100
	24MPH9401V	Project	--	--	--	8	--	--	100
		Total				20			

Summary: IV Semester (Vasant)		Credits
S.N.	Particulars	
1.	Discipline Specific Core (DSC):	04
2.	Discipline Specific Elective (DSE):	08
3.	Value Added Course (VAC):	00
4.	Seminar/Internship/Apprenticeship/Project/Community Outreach (S/I/A/P/C):	08
	Total	20
$CW (Class work): It would include attendance, class test/quiz test/assignments, ppt, play, learn by fun activities etc.		

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Semester - I

Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of advanced classical mechanics. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts.

Learning Outcomes

On completion of the course the student will be able to understand the Concepts of constraints, Lagrangian formulation with their applications. Student will get knowledge about Hamiltonian formulation with their applications as well as about canonical transformations and action angle variables.

Course Title:	**Classical Mechanics**	**Course Code: 24MPH9101T**
Total Lecture hour 60		**Hours**
Unit I	**Holonomic and nonholonomic constraints**: D-Alembert's Principle, Generalized. coordinates, Lagrangian, Lagrange's equation and its applications, Velocity dependant potential in Lagaragian formulation. Generalized momentum, Legendre transformation, Hamiltonian, Hamilton's Canonical equation. Conservation principle and Noether's theorem. Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and scope and isotropy of space respectively.	15
Unit II	**Calculus of variations and its application** : simple problems, Hamilton's variational principle, Derivation of Lagrange's and Hamilton. Canonical equation from Hamilton's variational principle. Extension of Hamilton's Principle for nonconservative and nonholonomic systems. Method of Lagrange's multipliers	15
Unit III	**Canonical transformation:** integral in variants of Poincare: Lagrange's and Poisson brackets ascanonical invariants. Equation of motion in Poisson bracket formulation, Infinitesimal contact transformation and generators of symmetry, Liouville's theorem, Hamilton Jacobi equation and its applications.	15
Unit IV	**Action angle, variable adiabatic invariance of action variable** : The Kepler problem in action angle variables, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications, Orthogonal transfonnation, Eulerian angles, Euler theorem, Eigen values of the inertia tensor, Euler equations. Force free motion of a rigid body.	15

Reference Books:

1	Classical Mechanics by Goldstein, Pearson Publications.
2	Classical Mechanics by Landau and Lifshitz, Reed educational and Professional Publishing Ltd.
3	Classical Mechanics by A. Raichoudhary, Oxford University Press, USA.
4	Classical Mechanics by J.M. Finn, Laxmi Publications.
5	Classical Mechanics by J.C. Upadhyaya, Himalaya Publishing House.
6	Classical mechanics by T. Kibble &F.H. Berkshire, Imperial College Press.

Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of Quantum mechanics. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts with advanced problems in Quantum mechanics.

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Learning Outcomes

On completion of the course the student will be able to understand the Dirac notations with postulates, essential relation of Quantum mechanics and how they are helpful in coordinate representation. Student will also understand about the the time independent perturbation, symmetries and angular momentum and also about the Hamiltonian matrix with different applications.

Course Title:	Quantum Mechanics	Course Code: 24MPH9102T
Total Lecture hour 60		**Hours**
Unit I	Hilbert space and Wave functions: Bases, Dimension, Subspaces, Dual spaces, Inner product spaces. Dirac notation, Orthonormality and Completeness. Linear operators, Matrix representations, Change of basis, Eigenvalues and Eigen Kets, Degeneracy, Commutation relations, uncertainty relation, Position operator and position eigen Kets, momentum operator and momentum eigen Kets. Wave functions in position and momentum space.	15
Unit II	Time-Evolution of the System's state, Eigen Kets and Energy Value problems (particle in a box, harmonic oscillator), potential barrier, quantum mechanical tunnelling and alpha decay, the Hydrogen atom problem, the Ehrenfest theorem, coherent states, the classical limit.	15
Unit III	Time independent perturbation theory: Non degenerate and degenerate and its applications (weak field and strong field cases), Variational method and its use in the calculation of ground state and excited state energy, time dependent perturbation theory and Fermi's golden rule, selection rules, System of identical Particles, Pauli exclusion principle, spin statistics, WKB approximation method for 1-D problems.	15
Unit IV	Angular Momentum Operators and their Eigen Values, Matrix representations of the angular momentum operators and their eigenstates, Coordinate representations of the orbital angular momentum operators and their eigen states (spherical harmonics), Addition of angular momentum, Clebsch-Gordon coefficients,Pauli matrices and spinors.	15

Reference Books:

1	Quantum Mechanics: A Modern Approach by Ashok Das and A. C. Melissinos, Gordon and Breach Science Publishers.
2	Quantum Mechanics by P.A.M. Dirac, Oxford University Press.
3	Quantum Mechanics by E. Merzbacher, second Edition, John Wiley & Sons.
4	Quantum Mechanics: Relativistic theory by L.P.Landau and E.M. Lifshitz, Pergamon press.
5	Quantum Mechanics : Theory and Applications by A. Ghatak and S. Loknathan, Third edition, Mac. Millan India Ltd.
6	Nouredine Zettili, Quantum Mechanics Concepts and Applications, Wiley.
7	David J Griffiths, Introduction to Quantum Mechanics, Printice Hall.

Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of Classical electrodynamics. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts with advanced problems in Classical electrodynamics.

Learning Outcomes

On completion of the course the student will be able to understand the basics of electrodynamics like method of point charges, Gauss law, Poisson' and Laplace equations. He will also get knowledge about multipole

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expansions, Maxwell equations, Propagation of EM waves in different mediums and about the EM radiation produced by moving charge, Electromagnetic field tensor.

Course Title:	Classical Electrodynamics	Course Code: 24MPH9103T
Total Lecture hour 60		**Hours**
Unit I	Coulomb's law, concept of fields, Gauss's law and its applications, electrostatic energy, Poisson and Laplace equations, The Method of Images; Point charge in the presence of a grounded conducting sphere , point charge in the presence of a charged insulated conducting sphere, point charge near a conducting sphere at a fixed potential, conducting in a uniform electric field by method of images , Green's function method, boundary value problems	15
Unit II	Multipole expansion, Biot-Savart law, differential equation for static magnetic field, vector potential, magnetic field from localized current distributions. Maxwell's equations in different mediums, boundary conditions on the fields at interfaces, Vector and Scalar potentials in electrodynamics, gauge invariance and gauge fixing, Coulomb and Lorentz gauges. Displacement current. Electromagnetic energy and momentum, Poynting Theorem. Conservation laws.	15
Unit III	Electromagnetic waves in free space, in dielectric medium; reflection and refraction at interfaces. Fresnel's Formula, Change of phase on reflection, Polarization on reflection and Brewster's law, Total Internal reflection. Wave equation in conducting medium, reflection and transmission at metallic surface, skin effect and skin depth. Frequency dispersion in dielectrics and metals. Dielectric constant and anomalous dispersion. Wave propagation in one dimension, group velocity. Wave guides, propagation modes in waveguides, resonant modes in cavities. Dielectric waveguides.	15
Unit IV	Dynamics of charged particles in static and uniform electromagnetic fields, EM Field of a localized oscillating source. Fields and radiation in dipole and quadrupole approximations. Antenna; Radiation by moving charges, Lienard- Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula. Electromagnetic field tensor, transformation of four potentials and currents, tensor dissipation of Maxwell's equations.	15

Reference Books:

1	Classical Electrodynamics, by J.D. Jackson, Wiley India Pvt.
2	Introduction to Electrodynamics, by D.J. Griffiths, Cambridge University Press, Fourth Edition
3	Classical theory of Electrodynamics, by Landau and Lifshitz
4	Electrodynamics of continuous media, by Landau and Lifshitz
5	Electromagnetic Fields and Waves, by P. Lorrain, and D. Corson, CBS Publishers
6	Principles of Electromagnetism, by Matthew N. O. Sadiku, S.V. Kulkarni, Oxford University Press; Sixth edition
7	Electromagnetic Waves, by R K Shevgaonkar, McGraw Hill Education; first Edition

Learning Objectives

The objective of the course in practical physics is to provide students with a comprehensive understanding of Practical Physics. The course aims to develop their knowledge and skills in developing experimental physics. This will help to improve their interests in experimental domain.

Learning Outcomes

Through the experiments, students will develop their practical skills in experimental techniques, data collection, analysis and interpretation. They will also enhance their understanding of fundamental concepts and principles in physics lab. The lab experience foster critical thinking, problem solving abilities and application of theoretical knowledge to real world scenarios. The inclusion of new experiments should be approved by the Convener, Board of studies before starting the academic session. It is essential to have an experimental setup of at least ten experiments listed below.

Course Title:	Practical	Course Code: 24MPH9104P
1	In case of number of experiments performed is less than eight, his marks shall be scaled down in the final examination. Laboratory examination paper will be set by external examiner out of eight or more experiments available at the center. **List of Experiments (any Ten):** 1. To design a single stage amplifier of a given voltage gain and lower cut of frequencies. 2. To determine Lo. Co. and Rf of a given coil and to study the variations of Rf with frequency. 3. To design a RC coupled two stage amplifier of a given gain and the cut off frequencies. 4. To study Hartley oscillator. 5. To Study Transistor bias Stability. 6. To design a Multivibrator of given frequency and study its wave shape. 7. To study the characteristics of FET and use it 0 design an relaxation oscillator and measure itsfrequency. 8. To study the characteristics of an operational amplifier. 9. To study the characteristics of a UJT and use it to design a relaxation oscillator and measure itsfrequency. 10. To study the addition, integration and differentiation properties of an operational amplifier. 11. Determine Planck constant using solar Cell. 12. To determine Planck constant and work function by a photo-cell. 13. To study regulated power supply using (A) Zener diode only (b) Zener diode with a series transistor (c) Zener diode with a shunt transistor. 14. To verify Fresnel's formula; 15. To study the percentage regulation and variation of Ripple factor, with load for a full wave rectifier. 16. To study analog to digital and digital to analog conversion. 17. To study a driven mechanical oscillator. 18. To verify Hartmann's formula using constant deviation spectrograph. 19. To find e/m of electron using Zeeman effect. 20. To find Dissociation energy to I. 21. Study of CH Bands. 22. Salt Analysis / Raman effect (Atomic). 23. Design and study of pass filters. 24. Michelson Interferometer. 25. Fabry perot Interferometer. 26. Determination of velocity of Ultrasonic waves. 27. Study of Elliptically polarised light by Babinet Compensator. 28. Veafication of Cauchy's Dispersion relation. Study of DC gate control characteristics and Anode current characteristics of SCR	

Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of Numerical analysis and computer fundamentals. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts with

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advanced problems in Numerical analysis and computer fundamentals.

Learning Outcomes

On completion of the course the student will be able to understand about different errors in numerical analysis, different interpolations, direct and indirect iterative methods, solution of nonlinear equations, different approximation methods to solve problems and also about the basics of computer fundamentals which will be more helpful.

Course Title:	**Numerical Methods & Computer fundamentals**	**Course Code: 24MPH9105T**
Total Lecture hour 60		**Hours**
Unit I	Errors in numerical analysis: Source of error, Round off error, Computer Arithmetic, Error Analysis, Condition and stability, Approximation, Functional and Error analysis, the method of undetermined coefficients. Use of interpolation formula, Iterated interpolation. Inverse interpolation, Hermite interpolation and Spline interpolation, Solution of Linear equations, Direct and Iterative methods, Calculation of eigen value and eigen vectors for symmetric matrices.	15
Unit II	Solution of Nonlinear equation: Bisection method, Newton's method, modified Newton's method, method of Iteration, Newton's method and method of iteration for a system of cosuation Newton's method for the case of complex roots.	15
Unit III	Integration of a function: Trapezoidal and Simpson's rules. Gaussian quadrature formula, Singularintegrals, Double integration. Integration of Ordinary differential equation: Predictor - corrector methods, Runga-Kutta method, Simultaneous and Higher order equations. Numerical Integration and Differentiation of Data, Least-Squares Approximations, Fast Fourier Transform.	15
Unit IV	Some elementary information about Computer: CPU, Memory, Input/ Output devices, Super, Miniand Micro systems, MS-DOS operating system, High Level Languages, Interpreter and Compiler. Programming: Algorithm and Flowchart.	15

Reference Books:

1	A Ralston and P. Rabinowitz, A First Course in Numberical analysis Mc Graw Hill (1985)
2	S.S. Sastry, Introductory Methods of Numerical Analysis. Prentice hall of India (1979).
3	Numerical analysis by P.Kandasamy and et. Al., S. Chand and Company

Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of Lasers in Physics. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts.

Learning Outcomes

On completion of the course the student will be able to understand about Laser and Laser rate equations. It also helps them to understand about the concepts and usefulness of optical fibres and different phenomena.

Course Title:	**Laser Physics**	**Course Code: 24MPH9106T**
Total Lecture hour 60		**Hours**
Unit I	Introduction, Physics of interaction between Radiation and Atomic systems including: Stimulated emission, emission line shapes and dispersion effects Einstein coefficients; Line shape function, Line-broadening mechanisms, Condition for amplification by stimulated emission, the meta-stable state and laser action. 3-level and 4-level pumping schemes.	15

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Unit II	Laser Rate Equations: Two-, three- and four level laser systems, condition for population inversion, gain saturation;Carrier wave communication and necessity of communication at optical frequencies Introduction to optical fibers, concepts of core and cladding, necessity of cladding structure, Total internal reflections, evanescent wave, penetration depth and propagation concept of evanescent waves	15
Unit III	Type of optical fibers, glass fibers, plastic cladded silica fibers, single mode and multi-mode optical fibers, index Profiles of the optical fibers step index and graded index core optical fibers. Numerical aperture, Experimental technique to measure numerical aperture of the optical fiber ,Ray paths and pulse dispersion in optical waveguides, Ray paths in homogeneous and square law profiles	15
Unit IV	Calculation of dispersion in terms of relative core cladding refractive index parameter, Transit time calculation in step index and parabolic index waveguide, Material dispersion, material dispersion in pure and doped silica, Zero material dispersion wavelength (ZMDW)	15

Reference Books:

1	Principles of lasers by O. Svelto, Springer, Fifth Edition
2	Lasers by Anthony ESiegman, University Science Books; Revised Ed.
3	Lasers and Non-linear optics: B. B. Laud, Wiley
4	Lasers: Theory and Applications: K. Thyagarajan and A.K. Ghatak, Springer, First Edition (1981)
5	Introduction to Fiber Optics by John Crisp, Newnes, Third Edition (2007)
6	Fundamental of Photonics: B.E.A.Saleh and Teich, John Wiley & Sons; 1st edition

Semester – II

Learning Objectives

The objective of the course is to provide basic understanding of how to pursue research and to learn research methods. It also provides understanding of methods of data collection and methods of analyzing them.

Learning Outcomes

On completion of the course the student will be able to understand the basics of research which are very helpful for them for research purpose.

Course Title:	**Research Methodology**	**Course Code: 24MPH9201T**
Total Lecture hour 60		**Hours**
Unit I	Introduction and definition of Research, characteristics of Research, Objectives of Research, Nature, and importance of Research, Research process, the difference between Research method and Research process, Scientific method, steps in Scientific method, Distinction between Scientific and Non-scientific method, Inductive and Deductive Logic.	15
Unit II	Types and methods of Research:- Introduction, Pure and Applied Research, Exploratory or Formulative Research, Descriptive Research, Diagnostic Research, Evaluation Studies, Action Research, Experimental Research, Historical Research, Surveys, Case study, Field studies, Research Design:- Introduction, Meaning & Definitions, Need and Importance, types of Research designs. Formulating of Research problem, Steps in Formulation of Research problem.	15

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Unit III	Hypothesis:- Meaning, Significance of Hypothesis, types of Hypothesis, Sources of Hypothesis, Characteristics of Good Hypothesis. Sampling:- Basis, Advantages and Limitations of Sampling, Sampling Techniques, Probability, and Non- Probability Sampling methods. Sample design.	15
Unit IV	Methods and Techniques of Data collection:-Distinction between Primary and Secondary Data, Data Collection for Primary data. Processing of data.	15

Reference Books:

1	Srivastava, S. C.: Foundation of Social Research and Economics Techniques, Himalaya Publishing House
2	Sharma H.D. and Mukherji S. P.: Research Methods in Economics and Business, New York: The Macmillan Company.
3	Gerber R. and Verdoom, P.J.: Research Methods in Economics and Business, New York, The Macmillan Company, 1992.
4	Krishnaswami O.R.: Methodology of Research in Social Sciences, Himalaya Publishing House
5	Courtis J.K. (ed.) Research and Methodology in Accounting & Financial Management

Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of advanced Electronics. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts.

Learning Outcomes

On completion of the course the student will be able to understand the different applications of Semiconductor devices, Oscillators, Transistors, Operational amplifier, Differential amplifiers. He/She becomes able to understand about the multivibrators, Combinational circuits, Sequential circuits. This will help them a lot in research field of electronics and communication.

Course Title:	Electronics	Course Code: 24MPH9202T
Total Lecture hour 60		
		Hours
Unit I	Semiconductor devices: p-n junction diodes and its I-V characteristics, clipper and clamper circuits, Field effect devices: JFET and MOSFET transistors, Bipolar Junction transistor: transistor as an amplifier, stability factor, Biasing of FET and BJT, switching action of a transistor, oscillator's devices using transistors: Colpitts, Hartley, RC phase shift, Wein bridge oscillators	15
Unit II	Differential amplifier: its structure and working, DC analysis, common mode- and differential-gain, CMRR, Operational amplifier (OP-amp): Block diagram of typical OP- amp, OP-amp characteristics, inverting and non-inverting amplifiers. OP- amp with negative feedback: voltage series feedback -effect of closed loop gain, input resistance, bandwidth, and output offset voltage, voltage follower. Practical OP-amp: input offset voltage – input bias current-input offset current, total output offset voltage. OP-amp applications including summer, subtractor, multiplier, divider, integrating and differential circuits, Instrumentation amplifier, log and antilog amplifiers, op-amp as comparator, Schmitt trigger.	15
Unit III	Multivibrators using transistors: Astable, Monostable and Bistable multivibrators, Basic idea of IC 555 timer and its applications as multivibrators and square wave generator. Boolean algebra, de-Morgan's theorem, Karnaugh mapping, Simplification of logical functions using K- Map, Minterm, Maxterm, Adder, Subtractor, Combinational circuits: Comparator, Multiplexers, Demultiplexers, Decoders,	15

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	Encoders.	
Unit IV	Sequential circuits: flip-flops; S-R, J-K, T, D, Master-Slave. Counters: synchronous-asynchronous binary, modulus counters (MOD-3, MOD -6, MOD -10), Shift Registers, Basic D to A conversion: weighted resistor, DAC binary R-2R ladder, basic A to D conversion.	**15**

Reference Books:

1	Electronic Devices and Circuit theory, R. L. Boylestad, L. Nashelsky, Pearson publication.
2	Electronic Principles, A. P. Malvino, McGraw Hill.
3	Digital Principles and Applications, A. P. Malvino, D. P. Leach, McGraw Hill publication
4	OP-AMP and Linear Integrated Circuits, Ramakanth. A. Gayakwad, PHI.
5	Digital Circuits and design, S. Salivahanan, S. Arivazhagan, VPH.

Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of advanced Atomic & Molecular Physics. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts.

Learning Outcomes

On completion of the course the student will be able to understand the different approximation methods to find out stationary states or the solution of Schrodinger equation. It helps them to understand the concept of Zeeman, Stark, Raman effect and also about different spectroscopy branches like Infrared, Microwave etc. I also make an understanding about the effect of magnetic moment and spin also.

Course Title:	**Atomic and Molecular Physics**	**Course Code: 24MPH9203T**
Total Lecture hour 60		**Hours**
Unit I	Hydrogen Atom : Gross structure energy spectrum, probability distribution of radial and angular (l=1,2) wave ,functions (no derivation), effect of spin, relativistic correction to energy levels and fine structure, magnetic dipole interaction and hyperfine structure, the Lamb shift (only an qualitative description). Fine structure in alkali Spectra, Equivalent and non equivalent electrons.	**15**
Unit II	Interaction with External Fields: Normal Zeeman Effect, Anomalous Zeeman Effect, Paschen back effect, Stark Effect, Two electron systems, LS and JJ coupling, determination of nuclear spin and nuclear g factors, transition probabilities and line width, Doppler, natural collision and stark broadening.	**15**
Unit III	Spectroscopy: General features of the spectra of one and two electron system- singlet, doublet and triplet characters of emission spectra, general features of Alkali spectra, rotation andvibration band spectrum of a molecule, P,Q and R branches, Raman spectra for rotational and vibrational transitions, comparison with infra red spectra. General features of electronic spectra. Frank and Condon's principle.	**15**
Unit IV	General features of electronic spectra. Frank and Condon's principle.Electronic Spectra of Diatomic molecules, Electronic Spectra of poly atomic molecules, Molecular Photoelectron Spectroscopy, General Introduction -Resonance Spectroscopy, NMR Spectroscopy, ESR Spectroscopy.	**15**

Reference Books:

1	Elementary Atomic Structure, G. K. Woodgate , Second Edition Clarendon Press, Oxford.
2	T.A. Littlefield- Atomic and Molecular Physics.
3	Quantum Physics of Atoms. Molecules, Solids and Nuclear Particles by Eisberg and Resnik, Wiley and Sons.
4	Atomic Spectra by White, Mcgraw Hill

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5	Molecular Spectra by Herzberg, Read Books.
6	Atomic & Molecular spectra by Rajkumar, LASER, KNRN Publishers.
7	Colin N. Banwell and Elaine M McCash, Fundamentals of Molecular Spectroscopy.

Learning Objectives

The objective of the course in practical physics is to provide students with a comprehensive understanding of Practical Physics. The course aims to develop their knowledge and skills in developing experimental physics. This will help to improve their interests in experimental domain.

Learning Outcomes

Through the experiments, students will develop their practical skills in experimental techniques, data collection, analysis and interpretation. They will also enhance their understanding of fundamental concepts and principles in physics lab. The lab experience foster critical thinking, problem solving abilities and application of theoretical knowledge to real world scenarios.

Course Title:	Practical	Course Code: 24MPH9204P
1	The inclusion of new experiments should be approved by the Convener, Board of studies before starting the academic session. It is essential to have an experimental setup of at least ten experiments listed below. In case of number of experiments performed is less than eight, his marks shall be scaled down in the final examination. Laboratory examination paper will be set by external examiner out of eight or more experiments available at the center. The experiments performed in semester I should not be included in Semester II. **List of Experiments (Any Ten) :** 1. To design a single stage amplifier of a given voltage gain and lower cut of frequencies. 2. To determine Lo. Co. and Rf of a given coil and to study the variations of Rf with frequency. 3. To design a RC coupled two stage amplifier of a given gain and the cutoff frequencies. 4. To study Hartley oscillator. 5. To Study Transistor bias Stability. 6. To design a Multivibrator of given frequency and study its wave shape. 7. To study the characteristics of FET and use it 0 design an relaxation oscillator and measure its frequency. 8. To study the characteristics of an operational amplifier. 9. To study the characteristics of a UJT and use it to design a relaxation oscillator and measure its frequency. 10. To study the addition, integration and differentiation properties of an operational amplifier. 11. Determine Planck constant using solar Cell. 12. To determine Planck constant and work function by a photo-cell. 13. To study regulated power supply using (A) Zener diode only (b) Zener diode with a series transistor 14. (c) Zener diode with a shunt transistor. 15. To verify Fresnel's formula. 16. To study the percentage regulation and variation of Ripple factor, with load for a full wave rectifier. 17. To study analog to digital and digital to analog conversion. 18. To study a driven mechanical oscillator. 19. To verify Hartmann's formula using constant deviation spectrograph. 20. To find e/m of electron using Zeeman effect. 21. To find Dissociation energy to I. 22. Study of CH Bands. 23. Salt Analysis / Raman effect (Atomic).	

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	24. Design and study of pass filters. 25. Michelson Interferometer. 26. Fabry perot Interferometer. 27. Determination of velocity of Ultrasonic waves. 28. Study of Elliptically polarised light by Babinet Compensator. 29. Verification of Cauchy's Dispersion relation. 30. Study of DC gate control characteristics and Anode current characteristics of SCR.

Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of Nanotechnology. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts with advanced problems in Nanotechnology.

Learning Outcomes

On completion of the course the student will be able to understand the Classifications of nanostructures and about the nucleation and growth process of nanoparticles. He will also get knowledge about different synthesis processes of nanostructure materials with their application in different fields

Course Title:	**Nanotechnology**	**Course Code: 24MPH9205T**
Total Lecture hour 60		**Hours**
Unit I	**Nanoscale Systems: Introduction and classification of nanostructures,** Length, energy, and time scales - Quantum confinement of electrons in semiconductor nanostructures: Quantum confinement in 3D, 2D, 1D and zero dimensional structures-Size effect and properties of nanostructures- Landauer - Buttiker formalism for conduction in confined geometries - Top down and Bottom up approach.	15
Unit II	**Basics & Synthesis process:** Excitons and excitonic Bohr radius – difference between nanoparticles and quantum dots - Preparation through colloidal methods - Epitaxial methods- Chemical vapour deposition (CVD. PECVD, MOCVD) **Synthesis process:** MBE growth of quantum dots spectroscopy of Quantum Dots: Absorption and emission spectra - photo luminescence spectrum -optical spectroscopy- linear and nonlinear optical spectroscopy	15
Unit III	**Synthesis of Nanostructure Materials:** Gas phase condensation --Vacuum deposition -Physical vapor deposition (PVD), Vacuum evaporation, e-beam evaporation, sputtering (DC, RF, Magnetron Sputtering) — laser ablation, Sol-Gel-Ball milling ,Electrodeposition electro less deposition, spray pyrolysis, hydrothermal synthesis.	15
Unit IV	**Nanotechnology Applications:** Applications of nanoparticles, quantum dots, nanotubes and nanowires for nanodevice fabrication – Single electron transistors, coulomb blockade effects in ultra-small metallic tunnel junctions - nanoparticles based solar cells and quantum dots based white LEDs – CNT based transistors	15

Reference Books:

1	Hand book of Nanoscience, Engineering and Technology (The Electrical Engineering handbook series), Kluwer Publishers.
2	"Sol-Gel Science", C.J. Brinker and G.W. Scherrer, Academic Press, Boston
3	Nanoscale characterization of surfaces & interfaces, N John Dinardo, Weinheim Cambridge: Wiley-VCH.

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Learning Objectives

The objective of the course is to provide students with a comprehensive understanding of advanced Mathematical methods in Physics. The course aims to develop their knowledge and skills in analyzing and solving problems related to these topics, using appropriate mathematical formalism and physical concepts.

Learning Outcomes

On completion of the course the student will be able to understand the Coordination transformation, covariant differentiation, Group transformation with crystallographic point groups. It also helps them to understand about the concepts and usefulness of Laplace and Fourier transformation.

Course Title:	**Mathematical Physics**	**Course Code: 24MPH9206T**
Total Lecture hour 60		
Unit I	Coordinate transformation in N-dimensional space: Contravriant and covariant tensor, Jacobian. Relative tensor, pseudo tensors (Example: change density, angu1ar momentum) Algebra of tensors, Metric theorem,Covariant differentiation. Ricci's theorem, Divergence, Curl and Laplacian in tensor form. Stress-andStrain tensors. Hook's law in tensor form. Lorentz Covariance of Maxwell equation. Elements of complex analysis, Analytic functions, Residues and evaluation of integrals	**Hours** 15
Unit II	Group of transformations. (Example: symmetry transformation of square), Generators of a finite group, Normal subgroup, Direct product of groups.. Isomorphism and Homomorphism. Representation theory of finite groups, Invariant subspace and reducible representations, irreducible representation, Crystallo-graphic point groups. Irreducible representation of C4v Translation group and the reciprocal lattice	15
Unit III	Fourier Transforms: Development of the Fourier integral from the Fourier series, Fourier and inverse Fourier transform: Simple applications: Finite wave train, wave train with Gaussian amplitude, Fourier transform of Derivatives, Solution of wave equation as an application, Convolution theorem, intensity in term of spectral density for quasi-monochromatic EM waves, momentum representation. Application of Hydrogen Atom and Harmonic Oscillator problems. Application of Fourier Transform to Diffraction Theory; Diffraction pattern of one two slits	15
Unit IV	Laplace transforms, and their properties, Laplace transform of derivatives and integrals of Laplace transform, Laplace, Convolution theorem, Impulsive function Application of Laplace transform in solving liner differential equations with constant coefficient with variable coefficient and liner partial differential equation.	15

Reference Books:

1	Mathematical Methods for Physicists: George Arkfen (Academic Press).
2	Applied Mathematics for Engineers and Physicists: L. A. Pipe (McGraw Hill)
3	Mathematical Methods-Potter and Goldberg (Prentice Hall).
4	Elements of Group Theory for Physicists: A. W. Joshi (Wiley Eastern Ltd.)
5	Vector Analysis (Schaum Series) (Mc Graw Hill).

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Semester III

Solid State Physics

Course Objectives

The objective of the course solid state physics is to provide advance knowledge of crystal lattices and defects, band theory of solids, lattice vibrations, magnetism and superconductivity.

Course outcomes:

On completion of this course student will be able to understand about crystal systems, defects, band theory, and calculation of bands, tight binding approximations, lattice vibrations, magnetism and superconductivity. Students will be able to apply their knowledge and deep understanding about these topics in research.

Course Title:	**Solid State Physics**	**Corse Code: 24MPH9301T**
Total Lecture hours 60		
Unit I	**Crystallography:** Electron and neutron scattering by crystals, Surface crystallography, Graphene, Non crystalline solids, Monatomic amorphous materials, Correlation functions, Simple crystal structures, Diffraction of electromagnetic waves by crystals, reciprocal lattice, Brillouin zone, X-ray diffraction, Bragg's law, diffraction from non-crystalline systems, quasi crystals. **Defects:** Point defects: Frenkel defects and Schottky defects, Concentration of Schottky & Frenkel defects as function of temperature lattice vacancies, interstitials, colour centres, F-centres. Line defects or Dislocations: Edge dislocation, Screw dislocation, Burgers vector.	15
Unit II	**Band Theory**: Origin of energy bands and band gaps, effective mass, periodic potential and Bloch's theorem, Kronig-Penney model, weak potential approximation, nearly free electron model, HartreeFock theory of free electrons, tight-binding approximation and calculation of band-structures in simple cubic and body centered cubic lattices, pseudo potential method.	15
Unit III	**Lattice vibrations**: Lattice vibrations, optical phonons and dielectric constant, vibrations of crystals with monoatomic basis, two atoms per primitive basis, quantization of lattice vibrations, phonon momentum, and inelastic scattering by phonons. Specific heat of solids, phonon heat capacity, anharmonic crystal interactions, thermal conductivity, optical properties of metals, skin effect and anomalous skin effect.	15
Unit IV	**Magnetism** Langevin diamagnetism equation, quantum theory of diamagnetism of mononuclear systems, quantum theory of Para magnetism, Hund's rules. Ferromagnetic order, magnons, neutron magnetic scattering, Antiferromagnetic order, Ferromagnetic domains. **Superconductivity:** Experimental Results: Meissner effect, Type-I and Type-II superconductors heat capacity, microwave and infrared properties, isotope effect, flux quantization, ultrasonic attenuation, density of states, nuclear spin relaxation, Giaver and AC and DC Josephson tunneling. Cooper pairs and derivation of BCS Hamiltonian, results of BCS Theory (no derviation).SQUID	15

Reference and Reading Books:

1. Introduction to Solid State Physics by Charles Kittel (Seventh or higher Edition).
2. Solid State Physics by A.J. Dekker
3. Principles of solid state physics by Levy
4. Solid state physics by S.O. Pillai,
5. Solid State Physics by N.W. Ashcroft and N.D. Mermin, Cengage Learning
6. Principles of the Theory of Solids by J. M. Ziman, CUP- Vikas Students" Edition
7. Solid State Physics by R. L. Singhal, KedarNath Ram Nath Publications
8. Elements of Solid State Physics by J. P. Srivastava, Prentice Hall of India
9. Fundamentals of Solid State Physics by B.S. Saxena, R.C. Gupta, P N. Saxena, J.N. Mandal, Pragati Prakashan Meerut.

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Advance Physics Lab - I

Course objective:

The Objective of the course Advance Physics Laboratory is to provide comprehensive understanding of advance physics laboratory. The course aims to improve knowledge and skill of students in designing and developing advance experiments in physics.

Course Outcome:

After completion of this course students will be able to understand fundamental concepts and principles in physics laboratory. The laboratory experience foster critical thinking, problem solving abilities, analysis of experimental data and application of theoretical knowledge to real world scenarios

Course Title:	**Advance Physics Lab - I**	**Corse Code: 24MPH9301P**
	A total of eight experiments must be performed by the students to complete the laboratory course. Experiments of equal standard can be designed to satisfy the minimum condition. This should be intimated and approved by the Convener, Board of Studies before the start of the academic session.	
	1. To study temperature variation of resistivity with temperature and determine band gap of a semiconductor using four probe method. 2. To study Hall Effect and determine hall coefficient, type and concentration of charge carriers. 3. To study variation of rigidity of a given specimen as a function of temperature. 4. To determine the magnetic susceptibility of the given paramagnetic liquid using Quincke's method. 5. To determine the Lande's g-factor using Electron Spin Resonance of a given specimen. 6. To determine ultrasonic velocity and to obtain compressibility of given liquid. 7. Synthesis/Characterization of a crystalline solid/ Thin Film. 8. Synthesis/Characterization of a substance in Nano-particle form. 9. Determination of dielectric constant of given material using a Lecher wire system by comparing the wavelengths measured with and without the dielectric. 10. Study the dispersion relation for the monoatomic lattice and determination of cut-off frequency using lattice dynamic kit 11. Study the dispersion relation for the Diatomic lattice using lattice dynamic kit and compare results with theoretical prediction. 12. To determine the specific heat capacity of a given solid by the method of mixtures. 13. Design and study RC phase shift oscillator using OP-AMP. 14. Design and study Wein bridge oscillator using OP-AMP. 15. Design and study Astable and Mono stable multi-vibrator using IC555 timer.	

Exam Scheme

Student will have to perform one experiment in end semester examination and duration of exam will be 5 Hours.

Marks distribution

Experiment	Viva-voice	Record/File	Maximum Marks
60	20	20	100

Marking distribution in Experiment

Principle/ Formula	Figure/Circuit	Observations	Calculation	Results/ Discussion	Precaution
10	8	20	12	8	2

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Condensed Matter Physics

Course Objectives

The objective of the course condensed matter physics is to provide advance knowledge of phase transformation and alloys, disordered system, high temperature superconductors, Nano-materials, novel organic materials, polymers and structural characterization of materials

Course outcomes:

On completion of this course student will be able to understand about phase transformation, high temperature superconductors, disordered systems, novel organic materials like fullerenes, CNT, amorphous polymers and structural characterization of materials. Students will be able to apply their knowledge and deep understanding about these topics in research.

Course Title:	Condensed Matter Physics	Corse Code: 24MPH9302T
Total Lecture hours 60		
Unit I	**Phase transformation and alloys**: Equilibrium transformation of first and second order, equilibrium diagrams, phase rule, interpretation of phase diagrams, substitutional solid solutions, Vegard's law, intermediate phases, Hume-Rothery rules, interstitial phases (carbides, nitrides, hydrides, borides). **Disordered systems:** Substitutional, positional and topographical disorder, short and long range order, glass transition, glass forming ability, nucleation and growth processes. Point defects: shallow impurity states in semiconductors. Localized lattice vibrational states in solids. Vacancies, interstitials and colour centres in ionic crystals.	15
Unit II	**High temperature Superconductors:** Normal state properties (structural phase transition) of cuprates, phase separation and charge distribution into CuO2 planes, striped phase, phase diagram, pseudo gap, dependence of T_C on crystal structure, effect of impurities. **Nano-materials:** Free electron theory (qualitative idea), variation of density of states with energy, variation of density of state and band gap with size of crystal. Electron confinement in one and two dimension, idea of quantum dots and quantum wires. **Different methods of preparation of Nano-materials:** - Sol-gel and chemical co-precipitation method, effect of temperature on the size of the particles. Bottom up and top down approach of deposition.	15
Unit III	**Novel organic materials**: Formation and characterization of Special carbon solids, fullerenes and carbon nanotubes (CNT). Single wall and multi-wall CNT. Electronic properties of CNT and electronic devices based on CNT. **Amorphous polymers**- glass transition temperature, effect of molecular architecture on glass transition temperature, free volume theory for glass transition. **Conducting polymers**- optical band gap of polymers, electrical conduction in conducting polymers, mechanical and thermal properties of polymers, polymer blends and composites.	15
Unit IV	**Structural characterization and electron structure determination**: Basic theory of X-ray diffraction, indexing of Debye-Scherrer patterns from powder samples, examples from some cubic and noncubic symmetries. Basic principles of X-ray absorption spectroscopy, photo emission and positron annihilation techniques. Qualitative discussion of experimental arrangement. Electrical conductivity of thin films, difference in behaviour of thin films from bulk material, Boltzman transport equation for a thin film (for diffuse scattering), expression for electrical conductivity for thin film. Enhancement of magnetic anisotropy due to surface pinning.	15

Reference and Reading Books:

1. Introduction to Solid State Physics by Charles Kittel, Wiley India Pvt. Ltd
2. Solid State Physics by A. J. Dekker, Macmillan India Limited.

3. Room temperature superconductivity byA Mourachkine, Cambridge International Science Publishing, 2004.
4. Principles of Condensed Matter Physics by P.M. Chaikin and T.C. Lubensky, Cambridge University Press
5. Polymer Physics by Ulf W. Gedde, Chapmann& Hall, 2001.
6. Introduction to Polymer Physics by David. I. Bower.
7. Polymer Science by J.R. Fried.
8. Thin film physics by Heaven
9. Physics of thin films by K. L. Chopra
10. Quantum dot heterostructures: D. Bimerg, M. Grundmann and N.N. Ledenstov, John Wiley & Sons, 1998
11. Nano particles and Nano structured films – preparation, characterization and applications, Ed. J.H. Fendler, John Wiley & Sons, 1998.
12. Physics of low dimensional semiconductors: John H. Davies, Cambridge Univ. Press, 1997
13. Physics of semiconductor nano structures: K.P. Jain, Narosa, 1997
14. Nanostructures and nanomaterials: synthesis properties and applications by Guozhong Cao, Imperial College Press, 2004
15. Fundamentals of Nanoelectronics by George W. Hanson, Pearson Education, 2009.
16. Nanotechnology: Principles and practices by SulabhaKulkarni, Capital Publishing Company, 2009

Advance Quantum Mechanics

Course Objectives

The objective of the course advanced quantum mechanics is to provide advance knowledge of non-relativistic scattering, relativistic formulation, Dirac equation and its symmetries and quantum theory of radiation.

Course outcomes:

On completion of this course student will be able to understand about phase transformation, high temperature superconductors, disordered systems, novel organic materials, polymers and structural characterization of materials. Students will be able to apply their knowledge and deep understanding about these topics in research.

Course Title:	Advance Quantum Mechanics	Corse Code: 24MPH9303T
Total Lecture hours 60		
Unit I	**Scattering (Non-relativistic):** Differential and total scattering cross section, transformation from CM frame to Lab frame, Solution of scattering problem by the method of Partial wave analysis, Expansion of a Plane wave into a Spherical wave and scattering amplitude, The optical theorem, Applications-Scattering from a delta potential, Square well potential and the Hard sphere scattering of identical particles, Energy dependence and resonance scattering, Breit-Wigner formula, Quasi stationery States.	15
Unit II	The Lippman-Schwinger equation and the Green's functions approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering under first Born approximation in elastic scattering. **Relativistic formulation:** Attempt for relativistic formulation of Quantum theory, The Klein-Gordon equation, Probability density and probability current density, Solution for free particle K.G. equation in momentum representation, Interpretation of negative probability density and negative energy solutions.	15
Unit III	**Dirac equation and its Symmetries:** Dirac equation for a free particle, Matrix representation of Dirac equation, Properties of Dirac matrices and Algebra of Gamma matrices, Non-relativistic limit of Dirac equation (Inclusive of electromagnetic interaction solution of the free particle), Dirac equation in continuity form, Solution of Dirac equation for free particle, Lorentz covariance of Dirac equation, interpretation of negative energy solution and Hole theory, Parity (P), Charge conjugation (C), Time reversal (T), CPT and PCT operators for the Dirac spinner, Dirac spinner: their properties and	15

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	transformation behaviour under Lorentz transformation, Bilinear covariants and their transformation behaviour under Lorentz and Parity transformation, Zetterbewegung, Klein paradox.	
Unit IV	**Quantum Theory of Radiation:** Classical radiation field, Fourier decomposition and quantization of radiation oscillator, Quantization of radiation oscillator in terms of creation and annihilation operator, Photon States, Fluctuations and the uncertainty relation, Basic matrix elements for emission and absorption, Spontaneous emission in the dipole approximation, Rayleigh scattering, Thomson scattering and Raman effect, Radiation damping and resonance fluorescence.	15

Reference and Reading Books:

1. Quantum Mechanics – A Modern Approach by Ashok Das and A.C. Milissiones (Garde and Breach Science Publishers
2. Advanced Quantum Mechanics by J.J. Sakurai (John Wiley)
3. Relativistic Quantum Mechanics by Bjorken and Drell (McGraw Hill)
4. Quantum Mechanics, Second Edition by EugenMerzbacher (John Wiley and Sons)
5. David J. Griffiths: Introduction to Quantum Mechanics by David J. Griffiths (2nd Ed.,Pearson)
6. Quantum Mechanics: Concepts and Applications by N. Zettili
7. Quantum Mechanics by L. I. Schiff, 3rd Ed. (McGraw Hill)
8. Principles of Quantum Mechanics by R. Shankar

Experimental Techniques in Physics

Course Objectives

The objective of the course experimental techniques in physics is to provide advance knowledge of sample preparation, physical property measurements of solids, Interaction of radiation with matter, radiation detectors, microscopy and X-ray analysis.

Course outcomes:

On completion of this course student will be able to understand about various sample preparation techniques, physical property measurements of solids, radiation detectors and various microscopy techniques like SEM, AFM, FTIR, Raman spectroscopy and X-ray analysis of crystals. Students will be able to apply their knowledge and deep understanding about these topics in research.

Course Title:	**Experimental Techniques in Physics**	**Corse Code: 24MPH9304T**
Total Lecture hours 60		
Unit I	**Sample Preparation:** Standard methods for the preparation of different kind of materials, Surface preparation and cleaning procedure. Thin film preparation techniques: Thermal evaporation, sputtering, ion-beam, molecular epitaxial and chemical vapour methods. **Physical Property Measurements of Solids:** Experimental techniques for measurement of Heat capacity, Electrical resistance of metals, thermal conductivity and magnetic susceptibility (Principle, typical experimental setup).	15
Unit II	**Interaction of Radiation with matter**: Photo Electric Effect, Compton Scattering, Pair Production. Neutron activation analysis, Delayed and Prompt Gamma neutron activation analysis. **Radiation detectors:** GM counter, Scintillation, Semiconductor PIN detector, HPGe detector, NaI detector (Qualitative and comparative study)	15
Unit III	**Microscopy:** Electron Microscopy (SEM, TEM, HRTEM), Scanning probe microscopy (AFM, MFM, STM), UV-Vis, spectroscopy and its applications. FT-IR spectroscopy, Luminescence spectroscopy techniques- Fluorescence spectroscopy, Raman spectroscopy, Thermal analysis using DTA, TGA, DSC; Electronic transport analysis using Current vs Voltage characteristics – two probe and four probe techniques, various types of contacts, Dielectric and	15

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	impedance spectroscopy, spectrum analyser, fluorescence and Raman spectrometer, Interferometers for different analytical study.	
Unit IV	**X-ray analysis:** Origin of X-rays, X-ray generators. Scattering of X-ray, atomic scattering Factor, Diffraction of X-ray, various X-ray diffraction methods, X-ray powder diffraction method -indexing of powder lines, Laue's method, rotational method, X-ray diffractometer, determination of crystal, structure and lattice parameter, small angle x-ray diffraction and its applications. XPS, XRF and its applications.	15

Reference and Reading Books:

1. Vacuum Science and Technology by VV Rao, TB Ghosh and KL Chopra, APL, New Delhi.
2. Advanced Experimental techniques in Modern Physics by KM Varier, New Delhi.
3. Electronic Instrumentation - Kalsi H S.
4. X-Ray Crystallography – B.E. Warren.
5. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods by Y. Leng.
6. Materials Characterization Techniques by Sam Zhang, Lin Li, Ashok Kumar.

Opto-electronics

Course Objectives

The objective of the course optoelectronics is to provide advance knowledge of special diodes and optoelectronic devices, basics of laser actions, optical detectors, optical fibers, and junction detectors.

Course outcomes:

After completion of course, students will able to understand of Injection luminescence, the internal quantum efficiency, the external quantum Efficiency, examining and comparing the condition for the laser action, types of laser, semiconductor lasers, Optical detectors, photoconductive detectors, Solar cell, Holography and its applications, Liquid crystal displays, The Optical Fiber , Semiconductors PIN diodes, Avalanche photodiodes detectors and phototransistors.

Course Title:	**Opto-electronics**	**Corse Code: 24MPH9305T**
Total Lecture hours 60		
Unit I	**Special Diodes & Optoelectronic Devices:** Varactor diode; Schottky diode; Tunnel diode; Liquid crystal diode (LCD); Light emitting diode (LED)-Construction, working, generation of light and external quantum efficiency, high frequency limit, effect of surface and indirect recombination current in LED; Solar cell- Construction, working, Open circuit voltage, short circuit current & fill factor; Photodetectors, Semiconductor controlled rectifier (SCR), Diac, and Triac.	15
Unit II	**Injection luminescence**: Recombination processes, the spectrum of recombination radiations, Direct and Indirect band gap Semiconductors, The Internal Quantum Efficiency, The External Quantum Efficiency. **The basic principles of laser actions:** spontaneous and stimulated emission and absorption, the condition for the laser action, Types of laser, Semiconductor lasers; Theory of Laser action in Semiconductors , condition for gain, The threshold conditions for oscillations, rates of spontaneous and stimulated emission , effect of refractive index , calculation of the gain coefficients , relation of the gain coefficient to current density.	15
Unit III	**Optical Detectors**: Introduction, Device types, Optical Detection. Principles, Absorption, quantum efficiency, Responsivity, Long wavelength cut off, Photoconductive Detectors, Characteristics of particular photoconductive materials. Solar cell, Holography and its applications, Liquid crystal displays **Optical fiber**: Introduction, Structure of optical fiber, Propagation of light through a numerical aperture, Pulse broadening, advantages and disadvantages of fiber optics.	15
Unit IV	**Junction Detectors**: Detectors performance parameters Semiconductors PIN diodes:- General Principle, quantum efficiency, Materials and design for PIN	15

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	photodiodes. Impulse & frequency response of PIN photodiodes. **Avalanche photodiodes detectors**: - The multiplication process. Avalanche photodiodes (APD) design, APD bandwidth, phototransistors.	

Reference and Reading Books:

1. Optical communication systems. John Gowar (Prentice Hall of India Pvt.Ltd.New Delhi1987.)
2. Optical fibre communications-Principles and practice John. M. Senior. Prentice Hall International (1985)
3. Optoelectronics-An Introduction(Second edition) J.Wilson. , J.F.B Hawkes Prentice Hall International (1989).
4. Physics of the semiconductor devices by S.M.Sze. 2nd edition(1983) Wiley Eastern Ltd.
5. Fiber Optics And Lasers -The Two Revolutions Ajoy Ghatak and K Thyagarajan

Plasma Physics

Course Objectives

The objective of the course Plasma physics is to provide advance knowledge of phase different type of plasma and their characteristics, magneto hydrodynamics kinetic description of plasma, production of plasma in laboratory and diagnostics

Course outcomes:

On completion of this course student will be able to understand different types of plasma and their characteristics, understand the motion of charge particles within the plasma with the influence of electric and magnetic field, understand plasma waves and their propagation, generation of plasma in laboratory and industry. Apply their knowledge in the production of plasma for semiconductor devices fabrication.

Course Title:	**Plasma Physics**	**Corse Code: 24MPH9306T**
Total Lecture hours 60		
Unit I	**Introduction to plasma:** Orbit theory of drift motions in plasma. Pinch effect. Bennett's relation, Plasma oscillations, Short wavelength of plasma oscillation. Debye shielding and different characteristic parameter of plasma. **Single particle motion:** Propagation of EM waves through plasma, Effect of external magnetic field on wave propagations: ordinary and extraordinary rays. Adiabatic invariants.	15
Unit II	**Waves in fluid plasma:** Fluid picture of plasma, Waves in cold unmagnetized plasma, Electrostatic wave, Electromagnetic waves. Effects of finite temperature on waves in fluid picture. Ion-acoustic wave. **Magneto hydrodynamics:** MHD equations, Magnetic Reynold's number, MHD waves-Alfven wave and magnetosonic wave.	15
Unit III	**Kinetic description of plasma**: Boltzmann-Vlasov equation, Derivation of fluid equations, Vlasov theory of electrostatic plasma waves, Landau damping, Fokker-Planck equation, Non-linear effects, **Non-linear effects:** Plasma sheath, Ponderomotive force, Non-linear wave propagation in plasma, KDV equation, NLS equation. Modulational instability.	15
Unit IV	**Plasma production and diagnostics**: Conduction and breakdown in gases. Townsend's current growth equation. Paschen's law.Capacitive and Inductive coupling of plasma. Production of plasma in the laboratory. DC andRF glow discharge plasma. Application of plasma for semiconductor device fabrication. RF plasma enhanced chemical vapour deposition method. **Plasma diagnostics**: Estimation of different plasma parameters by Langmuir single and doubleprobe methods, Optical emissions spectroscopy (OES), Mass Spectrometry, Inductively coupled plasma optical emission spectroscopy.	15

Reference and Reading Books:

1. Electromagnetic Theory and Electrodynamics: SatyaPrakash
2. Classical Electrodynamics: John David Jackson (Wiley India)

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3. Introduction to Electrodynamics: David J. Griffiths (Prentice-Hall of India, New Delhi)
4. Electromagnetic Field Theory for Engineers and Physicists: G. Lehner (Springer)
5. Modern Electrodynamics: A. Zangwill (Cambridge University Press)
6. Introduction to Plasma Physics and Controlled Fusion: Francis F. Chen
7. Plasma Physics: S.N. Sen.

Microwave Electronics and Communication

Course Objectives

The fundamental objectives of this course are to enable students to understand the basic concepts of circuits found in analog communication systems, to impart in depth knowledge of different devices used in microwave electronics, to interpret and analyze the characteristics of the main components of different radars, to be able to design the simplest devices and transmitting and receiving systems of radiofrequency series, to introduce the various types of modulation and demodulation used in analog signal transmission, to give a thorough understanding about satellite communication.

Course outcomes:

On completion of this course student will be able toanalyzeanalog communication signals in time domain and frequency domain, distinguish between differentanalog modulation techniques, understand different devices used in microwave electronics and develop understanding about satellite communication and its theory.

Course Title:	**Microwave Electronics and Communication**	**Corse Code: 24MPH9307T**
Total Lecture hours 60		
I	**Klystrons**: Velocity modulation and bunching, Output powers, Reflex klystron, multicavity klystron (qualitative). Travelling Wave Tube: Slow wave structures, Amplification process, Axial electric field, wave modes , gain consideration, Coupled cavity TWT. **Magnetron :** Cylindrical magnetron, linear magnetron, coaxial magnetron, Voltage tunable magnetron, Inverted coaxial magnetron, Forward cross field and backward cross field magnetron.	15
II	**Gunn diode:** Gunn effect, Differential negative resistance, High field domain, Gunn oscillation mode, LSA mode, stable amplification mode. **Tunnel diode:** Principle of operation, microwave characteristics. Qualitative discussion on Read diode, IMPATT diodes, Parametric devices, Microwave frequency, Difficulties of conventional devices at microwave frequencies, Microwave devices and systems, Ground wave, sky wave, Line of sight propagation. Applications of microwaves.	15
III	**Analog Signal Transmission:** Amplitude, Frequency & Phase modulation, AM, FM, Modulating and Demodulating circuits, AM, FM Receivers functioning (BLOCK diagram) and Characteristics Features, PAM, PWM and PPM modulation and demodulation, Quantization processes, Compounding and Quantization noise, PCM, Differential PCM and Delta Modulation systems, Comparison of PCM and DM, Time division multiplexing.	15
IV	**Satellite Communication:** Principle of Satellite Communication, Satellite frequency allocation and band spectrum, Satellite orbit, trajectory and its stability, Satellite link design, Elements of Digital Satellite Communication, Multiple Access technique, Antenna system, Transponder, Satellite Applications.	15

Reference and Reading Books:

1. Hand Book of Electronics: S. L. Gupta & V. Kumar, Pragati Prakashan
2. Modern Electronic Communication: Gary M. Miller, 6th edition
3. Communication System: Simon Haykin
4. Electronics Communication: Roddy and Coolen
5. Microwave and Radar Engineering: M. Kulkarni
6. Digital and Analog Communication Systems: K. San Shanmugam
7. Satellite Communication: Pratt and Bostian
8. Microwave: K.C. Gupta
9. Electronic Communication Systems: George Kennedy & Bernard Davis.

Semester IV
Nuclear and Particle Physics

Course Objectives

The fundamental objectives of this course are to enable studentsto impart knowledge to pursue research in experimental and theoretical nuclear physics. To understand about two nucleon systems and nuclear forces, nuclear shell model, beta decay, gamma decay, detectors and accelerators.

Course outcomes:

On completion of this course student will be able to understand about nature of nuclear forces, two nucleon systems, nuclear shell model, beta decay and gamma decay, detectors and accelerators.

Course Title:	Nuclear and Particle Physics	Corse Code: 24MPH9401T
Total Lecture hours 60		
Unit I	**Nuclear forces and two nucleon systems:** General nature of force between two nucleons, saturation of nuclear forces, charge independence and spin dependence. General forms of two nucleon interaction, Central, non-central and velocity dependent potential, Analysis of the ground state (3S1) of deuteron using a square well potential. range-depth relationship, excited states of deuteron, Discussion of the ground state of deuteron under non-central force, calculation of the electric quadrupole and magnetic dipole moments and the D-state admixture.	15
Unit II	**Nuclear Shell Model**: Single particle and collective motions in nuclei : Assumptions and justification of the shell model, average shell potential, spin orbit coupling; single particle wave functions and level sequence; magic numbers; shell model predictions for ground state parity; angular momentum, magnetic dipole and electric quadrupole moments; and their comparison with experimental data; configuration mixing; single particle transition probability according to the shell model; selection rules; approximate estimates for the transition probability and Weisskopf units; Nuclear isomerism. Brief discussion of Nuclear Collective model.	15
Unit III	**Beta Decay:** Beta particles experimental information, neutrino hypothesis, Fermi theory of beta decay, Fermi Kurieplot, Brief survey of ft values, allowed and forbidden transitions, Non-conservation of parity in beta decay, Experimental verification of parity violation, Helicity of Neutrino. **Gamma Decay:** Electromagnetic transitions in nuclei, Electric and Magnetic multipole moments and Gamma ray transition probabilities in nuclear system (no derivation), Internal conversion zero-zero transition of gamma rays. **Detectors:** Gas filled counters, Scintillation counter, Cerenkov counters, Solid state detectors, Electronic circuits used with typical nuclear detector.	15
Unit IV	**Particle Physics:-** Basic interactions and their mediating quanta, types of particles and its families, Fermions and Bosons, Leptons and Hadrons, particles and antiparticles, idea of resonances, conservation rules in fundamental interactions. Determination of spins and parity of pions, spins of particles, associated production, strangeness and decay mode, charge kaons, Isospin and its conservation, Concept of Quark model: Quarks their quantum numbers. Quark model of hadrons, quark flavours, confinement and QCD potential. Isospin and Gell-Mann-Nishijima relation. Baryon decuplet and octet. Colour degree of freedom. Magnetic moments of baryons, Mass relations and splittings. Mesons built of light and heavy quarks.	15

Reference and Reading Books:

1. Nuclear Physics by R.R. Roy and B.P. Nigam (Wiley-Eastern-1979)
2. The Atomic Nucleus by R.D. Evans (McGraw Hill – 1955)
3. Element of Nuclear Physics by W.E. Burchema (El.B.S. Longman – 1988)
4. Structure of Nucleus by M.A. Preston and R.K. Bhaduri (Addision Wesley – 1975)
5. Introductory Experimental Nuclear Physics by R.M. Singru
6. Concept of Nuclear Physics by B.L. Cohen (Tata McGraw Hills – 1988)

7. Nuclear Physics by B.K. Agarwal (Lokbharti Publication, Allahbad -1989)
8. Nuclear Radiation Detectors by S. S.Kapoor, & V. S Ramamurthy.
9. Radiation Detectors by G. F. Knoll.
10. Ideas of Particles Physics J. E. Dodd (Cambridge Univ. Press.)
11. Particle Physics by B. R. Martin, & G. Shaw.

Advance Physics Lab- II

Course objective:
The Objective of the course Advance Physics Laboratory is to provide comprehensive understanding of advance physics laboratory. The course aims to improve knowledge and skill of students in designing and developing advance experiments in physics.

Course Outcome:
After completion of this course students will be able to understand fundamental concepts and principles in physics laboratory. The laboratory experience foster critical thinking, problem solving abilities, analysis of experimental data and application of theoretical knowledge to real world scenarios

Exam Scheme
Student will have to perform one experiment in end semester examination and duration of exam will be 5 Hours

Marks distribution

Experiment	Viva-voice	Record/File	Maximum Marks
60	20	20	100

Marking distribution in Experiment

Principle/ Formula	Figure/Circuit	Observations	Calculation	Results/ Discussion	Precaution
10	8	20	12	8	2

Course Title:	**Advance Physics Lab- II**	**Corse Code: 24MPH9401P**
	A total of eight experiments must be performed by the students to complete the laboratory course. Experiments of equal standard can be designed to satisfy the minimum condition. This should be intimated and approved by the Convener, Board of Studies before the start of the academic session.	
	1. To determine half- life of radio isotope using GM Counter 2. To study the relationship between radiation intensity and factors like absorber thickness and distance. 3. To investigate the characteristics of the GM tube, including its efficiency and resolving time 4. To study spectrum of beta particles using Gamma ray spectrometer 5. To study Compton scattering of gamma rays and verify energy shift formula 6. To calibrate a scintillation spectrometer and determine energy of gamma rays from an unknown source 7. To study the characteristics of the reflex klystron tube and to determine its electronic tuning range. 8. To determine the Standing-Wave Ratio and Reflection Coefficient. 9. Find the dielectric constant of a given solid (Teflon) for three different lengths by using slotted section 10. Find the dielectric constant of a given liquid (organic) by using slotted section of K- band 11. Verification of Bragg's law using microwaves 12. Study the radiation pattern of a given pyramidal horn antenna by plotting it on polar graph paper. Find half power beam width (HPBW) and calculate its gain 13. Study the simulated LCR transmission line (audio frequency) and find out the value for characteristic impedance (Z_0) experimentally from graph 14. e/m of electron using Thomson's method. 15. To Determine thickness of a thin wire by diffraction using laser	

Statistical Physics

Course Objectives

Aim of this course is to develop an understanding of how the physics laws of statistical systems are formulated from scratch at the classical as well as quantum level with the aid of statistical distributions, and thereby partition function and entropy of the system. In addition the learners also get acquainted with some exotic phenomenon of the nature which are based upon the phase-transitions of various types, random walk, Heisenberg and Ising model for Magnetic materials.

Course outcomes:

On completion of the course, students will be able to understand, derive and apply the classical and quantum statistical distribution function from scratch for different statistical systems, formulate statistical models and derive the associated thermo-dynamical properties such as entropy, temperature, pressure and chemical potentials, differentiate between Bosonic and Fermionic systems and understand the allied phenomenon such as black-body radiation, Bose-Einstein condensations, learn and apply the ideas of phase-transitions of first and second order, ferromagnetism using Ising and Heisenberg models, formulate random walk problem and should be able to apply it to realistic systems in nature.

Course Title:	**Statistical Physics**	**Corse Code: 24MPH9402T**
Total Lecture hours 60		
Unit I	**Classical ensemble theory:** Phase space, Microcanonical Ensemble, Liouville's equation, connection between thermodynamic and statistical quantities, equation of states, Canonical Ensemble and Grand canonical Ensemble, Energy fluctuations, Density fluctuations in the Grand Canonical Ensemble, The Chemical potential, Equivalence of the various ensembles.	15
Unit II	The General Properties of Partition function, Classical Limit of Partition functions, Singularities and Phase transitions, Classical cluster expansion, quantum cluster expansion, Virial coefficient, variational Principles, imperfect gases at Low temperatures, Identical particles and symmetry requirement, difficulties with Maxwell-Boltzmann statistics, quantum distribution functions, Bose Einstein and Fermi-Dirac statistics and Planck's formula.	15
Unit III	Bose Einstein condensation, liquid He4 as a Boson system, quantization of harmonic oscillator and creation and annihilation of phonon operators, quantization of fermion operators. The Ising Model: Definition of Ising model, Spontaneous Magnetization, The Bragg-Williams Approximation, The One-dimensional Ising Model, Landau theory of Phase transition, critical indices, scale transformation and dimensional analysis.	15
Unit IV	Ferromagnetism – First and second order phase transition, the Bragg-Williams approximation, Heisenberg and Ising model in one dimension; an idea in two dimensions. Fluctuations: The Gaussian distribution for one and more than one variable. Fluctuations in thermodynamic qualities. Fluctuations in ideal gas. Poisson's formula. Energy fluctuations in canonical and concentration fluctuations in grand canonical ensemble – application to perfect classical/quantum gas. Random Walk and Brownian motion, introduction to non-equilibrium process.	15

Reference and Reading Books:

1. Statistical Mechanics by Haug
2. Fundamentals of Statistical and Thermodynamical Physics by Reif.
3. Statistical mechanics and Thermal Physics by Rice.
4. Kubo: Statistical Mechanics by Kubo
5. Statistical mechanics by Landau and Lifshitz
6. Statistical mechanicsbyS. N. Biswas

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Astronomy and Astrophysics

Course Objectives

The fundamental objectives of this course are to enable students to understand fundamentals of astronomy, major contents of universe, dark matter and black hole observation

Course outcomes:

On completion of the course, students will be able to understand about fundamentals of astronomy and dark matter. Student will be aware about contents of universe and black hole observation.

Course Title:	**Astronomy and Astrophysics**	**Corse Code: 24MPH9403T**
Total Lecture hours 60		
Unit I	Astronomy fundamentals, Black body radiation, Radiation mechanism, flux density and luminosity, Basics of Radiative transfer and Radiative processes, Magnitudes, Motions and Distance of Stars: Absolute Stellar magnitude and distance modulus, Bolometric and Radiometric magnitudes, Colour-index and luminosity of star.	15
Unit II	Overview of the major contents of the Universe, Sun and Stars, Stellar interiors, Stellar evolution, Basics of Stellar dynamics, HR diagram, Nuclear energy generation, Neutrino astronomy, White dwarfs and neutron stars, Compact objects, shape, size and contents of our Galaxy, normal and active Galaxy	15
Unit III	Dark Matter: Evidences of dark matter – Dark matter components in our galaxy, in Halos of the spiral galaxy, in clusters of candidates in dark matter. Baryonic and non-Baryonic candidates in dark matter. Spectral Energy Distribution (in optical Bands) in Stars, Rotation of stars, Study of Binary Stars, Gaseous Nebulae, Extinction curve of interstellar matter, dust-Rotation, Curve of galaxies, Spectral Energy Distribution.	15
Unit IV	Black hole Observation, Gravitational lens, Schwarzschild radius, Singularity, X-rays and Gamma rays bursts through cosmic flux detection using photo-multiplier tubes. Hubble's law and Hubble's constant (Red shift, distance, age of the Universe Measurements) – Galactic Structure – Rotation and spiral (Optical, radio, X-rays, Gamma radiation observation).	15

Reference and Reading Books:

1. Solar Astrophysics by Peter V. Foukal.
2. Galaxy Formation (second edition) by Malcolm S. Longair.
3. Fundamentals of solar Astronomy by ArvindBhattnagar and William livingston.
4. The Fundamentals of Stellar Astrophysics by George W. Collins,II.
5. Stellar Astrophysics by R.Q. Haung , K. N. yu.
6. Advanced Stellar Astrophysics by William Kenneth Rose.
7. Introduction to Stellar Astrophysics by Erika Bohm- Vitense.
8. Quasars and Active Galactic Nuclei by Ajit K. Kembhavi and Jayant Vishnu Narlikar.
9. Astrophysics Stars and Galaxies by K.D. Abhyankar.
10. The Sun by Michael Stix.
11. Spectropolarimetry by Jean Stein Flow.
12. Stellar Atmospheres by D. Mihafas
13. An Introduction to the Study of Stellar Structures by S. Chandrasekhar

High Energy Physics

Course Objectives

The fundamental objective of the course high energy and particle physics is to study the physics of elementary particles through the collisions of particles and nuclei at relativistic energies, production and detection of particles and concept of origin of the Universe.

Course outcomes:

On completion of the course, students will be able to apply concept of relativistic kinematics in solving related problems, explain the mechanism and features of particle production in hadronic and ion collisions, describe validity and failure of models of particle production, discuss the design of detectors in Mega Experiments like CMS, ALICE, PHENIX, CBM, etc.

Course Title:	High Energy Physics	Corse Code: 24MPH9404T
Total Lecture hours 60		
Unit I	Relativistic Kinematics Review of Lorentz transformations for energy and momentum, four-vectors and invariants, Laboratory and Centre-of-momentum systems, calculation of energy, momentum and angle of particles produced in nuclear reactions in Lab. and centre-of-momentum frames and their transformations and calculation of threshold energies for particle production. Mandelstam variables, Fermi Golden Rule, differential and total scattering cross sections, Lorentz invariant phase space, calculation of decay rates and phase space for two- and threebody decays, Dalitz plots and their applications to three-body decays.	15
Unit II	High Energy Hadron-Nucleon and Hadron-Nucleus Interactions High energy hadron-nucleon collisions: Features of relativistic hadron-nucleon collisions upto very high energy, behaviour of elastic, inelastic and total cross-sections as a function of incident energy, multiplicity distribution, Negative Binomial Distribution, KNO scaling and Feynman scaling. Relativistic hadron-nucleus and ion-ion collisions: Rapidity and pseudorapidity variables. Lab. and CM-rapidity, Maximum and minimum rapidities, Pseudorapidity distribution in projectile, target and central fragmentation regions.. Fluctuations and correlations: Two-particle correlations, short- and long-range multiplicity correlations, particle correlation and clusterization, Multiplicity fluctuations, Entropy and its generalization; Shanon and Renyi entropies. Features of non-statistical fluctuations: Intermittency and beyond-; erraticity, Multifractality and multifractal specific heat.	15
Unit III	Ultra-relativistic Nucleus-Nucleus Collisions, QGP formation and its Signatures. Ultra-relativistic nucleus-nucleus collisions: Glauber model of nucleus-nucleus collision, participant-spectator model, Bjorken estimate of the initial energy density, hadron structure and quark confinement, hydrodynamics of Quark-Gluon Plasma and phase diagram, deconfinement phase transition, global observables at RHIC and LHC energies, possible signatures of Quark-Gluon Plasma formation, dilepon production, Drell-Yan Process in nucleus-nucleus collision, direct photon production, De-bye screening in the QGP, J/Ψ suppression in the QGP, strangeness enhancement, correlation and event-by-event fluctuations, Handbury-Brown-Twiss effect, transverse mass, transverse energy, an isotropic flow and jet quenching.	15
Unit IV	Detectors in High Energy Physics Experiments General characteristics of detectors: Sensitivity, energy resolution and fano factor, detector efficiency and dead time. Multiwire and Drift Chambers: Ionization, drift and diffusion of charges in gases, pulse formation and its shape in proportional counters, Multiwire proportional counter:-basic principle of working, construction and readout method, The drift chamber:-principle of working, drift gases and spatial resoulution, Di-Muon Spectrometer of ALICE and MuCh of CBM, Cerenkov counter and its applications. Calorimetry in High-Energy Physics: Idea of radiation length and critical energy, electromagnetic shower and hadronic shower detectors. Review of some Major High Energy Physics Experiments: Neutrino Flavour Oscillation experiments and Physics Scenarios at RHIC and LHC energies.	15

Reference and Reading Books:

1. Pilkuhn, H. : The Interactions of Hadrons
2. Martin, L.P. : High Energy Hadron Physics (John Willey)
3. Collins, P.D.B. & Martin, A.D.: Hadron Interactions (Adam Hingler)
4. Hagedorn, R. : Relativistics Kinematics (Benjamin)
5. Perkins, D.H. : Introduction to High Energy Physics (Addison Wesley)
6. Halzen, F. and Martin, A. : Quarks and Leptons (John-Wiley)

7. Wong, C.Y. : Introduction to High Energy Heavy Ion Collisions (World Scientific)
8. Ferbel, T. : Experimental Techniques in High Energy Physics (Addison Wesley)
9. Leo, W.R. : Techniques for Nuclear and Particle Physics Experiments (Narosa)
10. Kleinknecht, W.: Detectors for Particle Radiation (Cambridge)

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Seminar

Course Title:	Seminar	Corse Code: 24MPH9401S

Guideline for Seminar

- Select a latest topic relevant to stream of study with content suitable for master of Physics.
- Topic of presentation should be approved by head of the department/seminar coordinator well in advance.
- Know the topic very well and message of presentation should be clear.
- Presentation should consist of minimum 15 slides and maximum of 25 slides.
- In slides mention key point only and fonts should be readable
- For presentation select simple themes and avoid unnecessary animations.
- Give title for each slide and slide number
- Seminar should be 15 to 20 minutes duration and another 5 minutes for question answers.
- Organization of slides should be as follows
  1. First slide will be title page showing title of seminar, name of student, roll number and class of student.
  2. Second page will contain overview of seminar
  3. Body of seminar includes principle, methodology, graph, charts, block diagram, application, case study, advantages and disadvantages arranged in logical sequence depending on the topic.
  4. Conclusion
  5. Last slide should contain references and bibliography.
- **Seminar must be evaluated by two examiners: one will be internal and one external will be appointed by PDUSU.**
- **Maximum 15 students should be evaluated per day by the examiners.**
- Submit handout of presentation to Coordinator of seminar.

Distribution of marks:

Relevance of Title	Content of Seminar	Presentation in slides	Knowledge of topic	Message of presentation	Maximum marks
12	12	13	50	13	100

Project

Course Outcomes:

After completion of course, students will have hand on experience of

1. Literature survey on advanced research topics in Materials Science, Nuclear physics, High Energy Physics and Condensed Matter Physics
2. Planning and designing the experiment and theoretical modelling of the research problem
3. Analysis and evaluation of the experimental data/ theoretical & computational modeling
4. Deduction and systematic presentation of the results
5. Compilation of the results / information to produce written document
6. Defending the results of the project in an open viva–voice through power point Presentation

Course Title:	Project	Corse Code: 24MPH9401V

Guidelines

Project will be a supervised collaborative work in Theoretical Physics (Condensed Matter Physics, Nuclear Physics, Particle Physics), Experimental Physics, Computational Physics. The project will aim to introduce student to the basics and methodology of research in physics, which is done via theory, computation and experiments either all together or separately by one of these approaches.

Following will be the modalities:

(i) Since lot of ground work including purchase of components/ equipments may be involved depending on the choice of the project, a strict schedule will be drawn and followed, to meet the deadline for submitting the project.

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(ii) Students are required to consult and discuss with the potential supervisor and/or co-supervisor on the proposed project and apply to take on the project till mid of third Semester i.e. 30th September. The application is to be approved by the Head of Department/Principal.

(iii) The students will be allotted M.Sc. IV Semester project in consultation with their supervisors well in advance till 31st October, to give students ample time to work on the allotted topics in consultation with their supervisors.

(iv) To develop team spirit and group learning, students will be allotted projects in groups of three to four students but not more than four students in any case.

(v) Groups will be formed by inviting applications from the students who want to work together as a group in the office of Physics Department, after due recommendation from the supervisor under whose supervision they wish to work along with a tentative title/topic by 30th September.

(vi) Students can choose topics from the following major fields or any other field decided from time to time for which department has the faculty and facilities

1. Particle Physics/ Nuclear Physics
2. Condensed Matter Physics/ Material Sciences
3. Computational Physics
4. Electronics
5. Experimental Physics

(vii) Students will discuss the topic with the supervisors and submit a one page typed abstract giving the plan of the project by 31st November along with the list of components etc.

The plan of work should include information about.

a) Gathering resource material
b) Setting up of the experiment if any
c) Understanding of the theoretical frame work.
d) Writing of the program for computation if any
e) References

(viii) Group of students working on a particular topic will be required to give a presentation in the beginning of the IV semester i.e. February/ March about the progress made during vacations. The presentation should be preferably in the forms of a power point presentation.

(ix) 2ndpresentation of the progress of the work will be held in April.

(x) A complete seminar on the project will be held in the month of June before submission of the project report.

(xi) Three copies of the project will be required to be submitted in the office of the Physics department for final evaluation.

(xii) Final evaluation will be done by at least two examiners including one examiner outside department/Institute.

(xiii) The project dissertation should consist of minimum 50 pages (up to 80 pages) including text and figures. Other extended data sheets and programs can be placed under Appendix.

(xiv) Project report must include following

a) Title Page
b) Certificate from supervisor
c) Acknowledgement
d) Preface
e) Contents
f) List of abbreviations
g) List of tables
h) List of graphs and figures
i) Introducton
j) Chapter 1
k) Chapter 2
l) ………..
m) Concluding remarks
n) Appendices
o) Bibliography/references

(xv) **General Formatting:**

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- **Title Page**: The title page should indicate i) M.Sc. Coursework Project Title, ii) Student Name & Student Roll Number and iii) Project Supervisor(s) Name
- **Page Size:** A4 size page (8.27" x 11.69") paper with white background and black colour font for the text
- **Margins:** The left and right margins should be 1½ inches. The top & bottom margins should not be less than 1 inch each
- **Font:** The font size for the main text should be 12. The same font type and size should be used for the entire dissertation
- **Line Spacing:** The text should be in double-spacing
- **Page Numbering:** All pages except the title page must be paginated. The page numbers should appear at the bottom center of the page

A format of the Title page and certificate from supervisor given below:

<u>Title Page</u>

A project report submitted in partial satisfaction of the requirements for the degree of Master of Science in Physics

On

"Title of the Project"

Supervised by:
"(Name of the Supervisor)"

Submitted by:
"Name 1"
"Name 2"
"Name 3"
"Name of Department"
"Name of Institution"
Session

Page 2

Certificate

This is to certify that the project entitled "Title of Project" aimed at "Project purpose" was worked upon by the following students under my supervision at Physics Laboratory in Department of Physics "Name of Institution/ College",

Name 1 with signatures
Name 2 with signatures
Name 3 with signatures

It is certified that work done by the team in this project is original and has not been submitted for any degree.

Head of the Department

Name of Supervisor with Sign

Last Date for Submission of Project Report: Final project report shall be submitted within 15 days after the last theory paper examination of Semester IV.

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