POST GRADUATION DEPARTMENT OF APPLIED PHYSICS AND BALLISTICS, F. M. UNIVERSITY, BALASORE

SYLLABUS FOR THE COURSE M. SC. IN PHYSICS (SFC MODE)

2020-2022

P.G. Department of Applied Physics and Ballistics

Syllabus structure (M. Sc. Physics)

Approved by BOS on Dt. 13.11.2020

(SFC Mode)

M.Sc. in Physics		
Semester	Marks	Credit
1st semester	500	24
2nd semester	500*	24*
3rd semester	500**	24
4th semester	500	28
Total	2000	100
*One MOOC/SWAYAM course of 4 credits is selected by the student of M.Sc. Physics. After successful completion of the course the secured credit will be added to the 2nd semester secured credit. In this case total credit and mark changes as per the transfer marks and credits. **choice based credit paper is selected by the student of other PG Depts.		

P.G. Department of Applied Physics and Ballistics

Syllabus structure of M. Sc. Physics

(SFC MODE)

First Semester

Code	Name	Mark	Credit
APAB-101	Classical Mechanics	100	04
APAB-102	Mathematical Methods in Physics	100	04
APAB-103	Electronics & Computer Programming	100	04
APAB-104	Weapon System & Experimental Methods	100	04
APAB-105 (B)	Practical: Electronics	100	08
	Total	500	24

Second Semester

Code	Name	Mark	Credit
APAB-201	Statistical Mechanics	100	04
APAB-202	Quantum Mechanics	100	04
APAB-203	Fluid Dynamics	100	04
APAB-204 (B)	Atomic and Molecular Physics	100	04
APAB-205 (B)	Practical: Computational Physics	100	08
	Total	500	24

One course/paper of 4 credits is selected from available SWAYAM platform to get extra credit in the second semester.

Third Semester

Code	Name	Mark	Credit
APAB-301	Solid State Physics	100	04
APAB-302	Electrodynamics	100	04
APAB-303	Nuclear & Particle Physics:	100	04
APAB-304	Modern Physics and Electronics (Choice based Credit paper for other subject P.G. students)	100	04
APAB-305	Practical: Modern Physics & Material Science	100	08
FMS	Fakir Mohan Studies	(Non Credit)	00 (Non credit paper)
	Total	500	24

M.Sc. in Physics

Fourth Semester (out of 3 special papers 1 special paper is mandatory)

Special Paper-I	Electronics
Special Paper-II	Nuclear & Particle Physics
Special Paper-III	Condensed matter physics

Special Paper-I (Electronics)

Code	Name		Mark	Credit
APAB-401(B)	Electrical circuit & Control:		100	04
APAB-402(B)	Optoelectronics & Optical Communication:		100	04
APAB-403(B)	Pulse & Digital circuit:		100	04
APAB-404 (B)	Advance Electronics Practical:		100	08
APAB-405 (B)	Project & Grand viva:		100	08
		Total	500	28

Special Paper-II (Nuclear and Particle Physics)

Code	Name		Mark	Credit
APAB-401(C)	Nuclear & Particle Physics-I		100	04
APAB-402(C)	Nuclear & Particle Physics-II		100	04
APAB-403(C)	Nuclear & Particle Physics-III		100	04
APAB-404 (C)	N&P Physics Practical		100	08
APAB-405 (C)	Project & Grand viva :		100	08
		Total	500	28

Special Paper-III (Condensed Matter Physics)

Code	Name		Mark	Credit
APAB-401(D)	Condensed Matter Physics-I		100	04
APAB-402(D)	Condensed Matter Physics-II		100	04
APAB-403(D)	Condensed Matter Physics-III		100	04
APAB-404 (D)	CMP Practical		100	08
APAB-405 (D)	Project & Grand viva :		100	08
		Total	500	28

1st SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-101	Classical Mechanics	4	20	80

Objectives	This core course is designed according to advanced learning of mechanics. The course aims to develop a comprehensive knowledge and mathematical skills to solve practical problems in physics. Special emphasis has been given to understand various basic principles of mechanics and their applications.
Pre-Requisites	General Newtonian mechanics, rotational and planetary motion, principle of relativity
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Lagrangian and Hamiltonian Formalism:** Constraints-D'Alembert's principle and Lagrange's equations-velocity dependent potentials and the dissipation function, simple applications of the Lagrange formulation. Variational Principle and Lagrange's Equations: calculus of variations-Derivations of Lagrange's equations-from Hamilton's principle-Extension of Hamilton's principle to nonholonomic systems- Advantages of variational principle formulation-conservation theorems and symmetry properties. Hamiltonian and Hamilton's equations of motion: Canonical transformations: Poisson brackets, Langrange Brackets, Action-angle variables, Hamilton-Jacobi equation. (Self Study Portion: simple applications of the Lagrange formulation, conservation theorems and symmetry properties.)	14
II	**Central force Problems:** Reduction to the equivalent one-body problem-The equations of motion and first integrals-The equivalent one-dimensional problems and classification of orbits-The virial theorem-The differential equation of orbit and integrable power-law potentials-conditions for closed orbits (Bertrand's theorem)-The Kepler Problem: Inverse square law of force-The motion in time in the Kepler problem-The Laplace-Runge-Lenz vector-Scattering in a central force field, Transformation of the scattering problem to the laboratory co-ordinates. (Self Study Portion: The differential equation of orbit and integrable power-law potentials-conditions for closed orbits (Bertrand's theorem)-The Kepler Problem: Inverse square law of force.)	12
III	**The kinematics of Rigid Body Motion and Small Oscillations:** The independent co-ordinates of a rigid body-Orthogonal transformation-Formal properties of the transformation matrix, The Euler Angles, Euler's theorem on the motion of a rigid body-Finite rotations-Infinitesimal rotations-Rate of change of vector-The Coriolis force. Small Oscillations: Coupled Oscillations, normal modes. (Self Study Portion: Orthogonal transformation-Formal properties of the transformation matrix)	12

IV	**The Rigid Body Equations of Motion:** Angular momentum and kinetic energy of motion about a point-Tensor and dyadics-The inertia tensor and the momentum of inertia-The eigen values of the inertia tensor and the principal axis transformation-Methods of solving rigid body problems and the Euler equations of motion Torque-Free motion of a rigid body-The heavy symmetrical top with one point fixed-Precession of the equinoxes and of satellite orbits-Precession of system of changes in a magnetic field. (Self Study Portion: Tensor and dyadics, Precession of the equinoxes and of satellite orbits-Precession of system of changes in a magnetic field.)	10
	Total	48

TEXT BOOKS:

1 . Classical Mechanics-Herbert Goldstein, Addison-Wesley/Narosa (Indian Student Edition)

2 . Classical Mechanics-Rana and Joag, Tata-McGraw-Hill

REFERENCE BOOKS:

1 Classical Mechanics of particles and Rigid body-Kiran C. Gupta, New age Publishers

2 Classical Mechanics-J.D. Uppadaya

3 Classical mechanics – S.L.Gupta, Meenakshi prakashan, 1970, New Delhi.

4 Introduction to classical mechanics – R.G.Takwall and P.S.Puranik, Tata – McGrawHill, 1980, New Delhi.

5 An Introduction to Continuum Mechanics-M. E. Gurtin, Academic Press

Course Outcome	At the end of this course the learner is expected: ➢ To emphasize the mathematical formulation of mechanics problems and to physically interpret the solutions. ➢ To apply the fundamental concepts of classical mechanics to the particle systems and rigid bodies. ➢ To develop problem solving and critical thinking skills.

1st SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-102	Mathematical Methods in Physics	4	20	80

Objectives	This course is designed to fill up the gaps at undergraduate level. It intends to develop competency in the applied mathematical skills required at higher-level physics. Students will be trained with the rigor required to solve a wide range of problems in the physical sciences.
Pre-Requisites	Basic vectors and matrices, functions and derivatives, sets, integral properties.
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Functions of a Complex Variable**: Analytic functions, Cauchy's Integral Theorem, Cauchy's Integral Formula, Taylor's Theorem, Laurent's Theorem, Singularities, Residues, Residue Theorem and Evaluation of Integrals, multi-valued function-branch point and branch cut, contour integration involving branch point. **(Self Study Portion: Analytic functions, Cauchy's Integral Theorem)**	12
II	**Linear Vector Space:** Definition, Linear independence, basis and dimension, scalar product, dual vector, Cauchy-Schwarz inequality, orthonarmal basis, Scmidt orthogonalisation process. **Matrices:** Inverse of a matrix, orthogonal matrix, rotation, similarity transformation, Eigen-values and eigenvectors, secular equation, Cayley-Hamilton theorem, matrix diagonalisation. **(Self Study Portion: Inverse of a matrix, orthogonal matrix, rotation, Cayley-Hamilton theorem)**	12
III	**Tensors:** Introduction, Cartesian tensor, algebra of Cartesian tensors, outer product theorem, quotient theorem, contraction theorem, tensor algebra, the Kronecker delta and Levi-Civita tensors, pseudo-tensors, tensor calculus, tensors in Skew Cartesian frames, contravariant and covariant representation, general tensors, algebra of general tensors, relative tensors, covariant derivative, calculus of general tensors, the Reimann-Christoffel symbols. **Group theory:** Basic concepts of groups, group representation, relevance to quantum mechanics, Lie group and Lie algebra, SU(2) groups and their representation, SO(3) groups and their representation. **(Self Study Portion: Lie group and Lie algebra, SO(3) groups and their representation)**	12

IV	**Special Functions:** Series solutions: Frobenius Method, Hermite Polynomials, Legendre polynomials, generating function, recurrence formulae, orthogonality properties, Bessel's function, generating function, recurrence formulae, orthogonality properties, Hypergeometic functions and their properties, Lagurее polynomial and their properties, Green Functions. **Integral Transform:** Fourier series, Fourier Integrals, Fourier transforms, Convolution theorem, Laplace transform- derivatives, properties and applications to solution of differential equations. **Elementary Probability Theory:** random variables, Binomial, Poissson and Normal distributions. **(Self Study Portion: Hermite Polynomials, Elementary Probability Theory, random variables, Binomial, Poissson and Normal distributions.)**	12
	Total	48

TEXT BOOKS:

1 Mathematical Methods for Physicist: G. B. Arfken, Hans. J. Weber,-Academic Press
2 Mathematical Physics: H. K. Dass, Rama Verma-S. Chand and Company Ltd.

REFERENCE BOOKS:

1 Matrices and tensors: A. W. Joshi
2 Numerical Methods using FORTRAN: C. Xavier-New Age International Publishers
3 Mathematical Physics: B. S. Rajput
4 Mathematical Physics: Satya Prakash
5 Introduction Mathematical Physics: Charlie Harper

Course Outcome	At the end of this course the learner is expected: ➢ To introduce advanced mathematical methods in physics and their applications. ➢ To enable students to use mathematical concepts required in physics. ➢ To develop expertise in solving the complex problems in physics. ➢ To prepare the students to formulate, interpret and draw inferences from complex physical concepts.

1st SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-103	Electronics and Computer Programming	4	20	80

Objectives	This Course has two parts. First part enables the students to comprehend the theory, concepts, characteristics and working principles of basic electronic devices and their activities in electronic circuits. The knowledge acquired by the students helps them to design, test, troubleshoot, and rectify faults in electronic circuits. Second part provides the skill of C programing for scientific computation so that student can use this knowledge for solving various mathematical and physical problems. It provides the knowledge of various numerical techniques used to solve mathematical problems which cannot be solved analytically.
Pre-Requisites	Fundamental knowledge of electronic components and circuit theorems, Fundamental knowledge of computers, basic mathematical skill
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Network Analysis:** Node & mesh analysis, Superposition theorem, Thevenin's theorem, Reciprocity theorem, Norton's theorem, Maximum power transfer theorem, Network Analysis using Laplace Transformation: Step response of series RL, RC, RLC, parallel RLC, Response of series RL, RC, RLC, and parallel RLC to exponential driving sources. **(Self Study Portion: Response of series RL, RC, RLC, and parallel RLC to exponential driving sources)**	12
II	**Semiconductor devices** : Semiconductors in equilibrium: electron and hole statistics in intrinsic and extrinsic semiconductors, metal-semiconductor junctions, Ohmic and rectifying contacts, P-N Junction Diode, Applications of Diodes: Rectifier circuits, Clipping and clamping circuits, Special purpose diodes: Zener Diode, Tunnel diode, LED, photo diode, etc, Transistors: BJT and FET, Transitor biasing, Positive feedback, Negative feedback, transistor as an amplifier, Oscillators, OP-AMP: Basics, Virtual Ground, The Ideal Op Amp, Inverting and Non – Inverting configurations, Equivalent Circuit model, Op-amp application in Integration, differentiation and Summing Circuits, Differential Amplifier, Voltage Buffer. **(Self Study Portion: Applications of Diodes: Rectifier circuits, Clipping and clamping circuits, Special purpose diodes: Zener Diode, Tunnel diode, LED, photo diode, etc)**	14
III	**Digital Electronics:** Number Systems, Binary Arithmetic, Boolean Algebra, Logic Gates, Simplification using Karnaugh map, Combinational Circuits: Adder, Subtractor, Multiplexer, decoder, comparator. Sequential Circuits: Flip Flops, Timers, Shift Registers, Counters and D/A and A/D Converters, Microprocessor and microcontroller basics. **(Self Study Portion: Flip Flops, Timers, Shift Registers, Counters, Microprocessor and microcontroller basics)**	10

IV	**<u>Numerical Computing:</u>** Programming in C: Constants, variables and data types, Operators and expressions, Input and Output, Decision making and branching, Looping, Arrays, sub-programming, Simple Programs using C: Characteristics of numerical computing, Trapezoidal Integration, Simpson's rules for Integration, Runge-Kutta Method, roots of functions, interpolation, extrapolation, Newton- Raphson Method, Finite difference and Solutions of Linear equations. **(Self Study: roots of functions, interpolation, extrapolation, Newton-Raphson Method, Finite difference and Solutions of Linear equations)**	12
	Total	48

TEXT AND REFERENCE BOOKS:

1 Network Analysis: M.E. Van Valkenburg
2 Network Analysis: G.K. Mithal
3 Digital Electronics and Computer Design: M. M. Mano (PHI)
4 Principles of Electronics: V.K. Mehta
5 Electronic Devices and Circuit Theory: Boylestad, Nashelsky
6 Let us C:- Yashavant Kanetkar (BPB Publications)
7 C Language and Numerical Mehods – C. Xavier
8 Numerical Techniques in C – E. Balguruswamy

Course Outcome	At the end of this course the learner is expected: ➢ To enhance comprehension capabilities of students through understanding of electronic devices. ➢ To understand the physical construction, working and operational characteristics of semiconductor devices. ➢ To understand the basics of computational physics. ➢ To study numerical algorithms and their implementation to solve problems.

1st SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-104	Weapon System and Experimental Methods	4	20	80

Objectives	This Course has two parts. First part enables the students to comprehend the theory, concepts, characteristics and working principles of various experimental methods used in Physical sciences. The knowledge acquired by the students helps them to design, test, troubleshoot, and rectify faults in various instruments. Second part provides basic knowledge regarding various weapon systems used in battle field and various DRDO labs for testing purpose.
Pre-Requisites	Fundamental knowledge of electronic components and basic mathematical skill.
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Experimental Methods:** Transducers (Strain Gauges, temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors), measurement and control; Signal conditioning and recovery, impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding; lock-in detector, box-car integrator, modulation techniques. **(Self Study Portion: lock-in detector, box-car integrator, modulation techniques)**	12
II	**Ordnance :** Introduction, Classification (Small Arms, Mortar as, Guns, Howitzers, Rocket Launchers, Missiles), Classification based on specific tactical roles, Basic structure, Superstructure, Saddle, Cradle, Requirements of an Ideal Field Gun, Basic components and functional requirements, Certain definitions related to a barrel, Rifling, Rifling design considerations (Forms of twist, Rifling profile), Breech mechanism (breech ring, breech block, thrust surfaces, breech screw, carrier), Extractor, Obturation, Firing mechanism, Chamber. **(Self Study Portion: Classification (Small Arms, Mortar as, Guns, Howitzers, Rocket Launchers, Missiles), Classification based on specific tactical roles, Gun Chamber, Firing Mechanism)**	12
III	**Gun Barrel and Design :** Desired characteristics of a barrel, Stresses on barrels (Radial stress, Circumferential stress, Longitudinal stress, Torsional stress and Girder stress), Barrel construction (Wire wound, Composite, Mono block), Use of plastic region of the material and its application to auto frettaged method of gun construction, Comparison of different methods of gun construction, Basic gun design rules, Theories of elastic failures, von Misses-Hencky theory of failure including its derivation, Barrel wear (erosion, fatigue, causes and their reduction). (Interior ballistics 3.3) (Part2-Balistics-1-14.2/3). **Recoil systems** (Functions, mechanism of recoil energy absorption), Buffer types (Valve key, Shallowing groove cylinder, Tapered rod, Rotating), Liquid for buffer, Cut off gear,	12

	Recuperator, Controls to run out, Soft recoil. Fume extractor, Muzzle brake, Advantages and disadvantages, Droop, Balancing gears, Elevating and traversing gears, Carriages and mountings, Articulation, Spades, Forces and their behavior during firings, Stability, Jump, (Part2-Balistics-1-15.2) **(Self Study Portion: Characteristics of a barrel, Stresses on barrels (Radial stress, circumferential stress, longitudinal stress, Barrel wear (erosion, fatigue), Function, recoil mechanism, run out, Fume extractor, muzzle brake, stability)**	
IV	**Ammunition :** Cartridge and make up of cartridges (BL, QF – fixed, separate), Cartridge cases (metallic & essential qualitative requirements, semi-combustible, combustible, relative merits & demerits), Means of ignition (ignition problem, percussion, electrical), classification and characteristics of projectile (ogive, nose, shoulder, body, driving band, base, boat tailing, bands, bourrelet) Driving band attachment to body and engraving process, Forces on the Driving band, Requirements of a projectile (ballistic efficiency, tactical efficiency, shape), crh (simple and compound), fuze, Components of fuzes, Arming and safety arrangements in fuzes. **(Self Study Portion: Cartridges (BL, QF - fixed, separate), Projectile (classification and characteristics), driving band (DB), forces on DB, fuze (components, arming and safety arrangements in fuzes))**	12
	Total	48

TEXT AND REFERENCE BOOKS:

1 A Course in Electrical and Electronic Measurements and Instrumentation – A.K. Sawhney, Dhanpat Rai & Co.
2 "Text Book of Ballistics and Gunnery", 1987 - War Office, UK.
3 "Element of Ordnance", 1982 – T.J Hayes, John Wiley, New York.
4 "Ballistics: Theory and Design of Guns and Ammunition", David E. Carlucci and Sidney S. Jacobson.
5 "Handbook of Artillery Weapons", 1987 - Royal College of Military Science, UK
6 "e-Ballistics" by Gunther Dyckmans (Freely available in the internet).
7 Gene Slover's US Navy Pages (freely available in the internet).
8 "Engineering Design Handbook, Guns Series, Muzzle Devices", US Army Material Command, May 1968
9 "Engineering Design Handbook, Guns Series, Guns General", US Army Material Command, August 1964
10 "Engineering Design Handbook, Guns Series, Gun Tubes", US Army Material Command, February 1964
11 "Design of Towed Artillery Weapon Systems", US Army Material Command, March 1990.

Course Outcome	At the end of this course the learner is expected: ➢ To enhance comprehension capabilities of students through understanding of Instruments. ➢ To understand the physical construction, working and operational characteristics of Experimental devices. ➢ To understand the basics of Ordnance, Gun and Ammunition. ➢

1st SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-105 (B)	Electronics Practical	8	---	100

Objectives	This practical course enables the students to realize physically the basic electronic devices and various electronics circuits. The knowledge acquired by the students helps them to design, test, troubleshoot, and rectify faults in electronic circuits.
Pre-Requisites	Fundamental knowledge of electronic components and electronics devices.
Teaching Scheme	It is totally based on Laboratory demonstrations and Laboratory realization.

LIST OF EXPERIMENTS	
1	Study of Kirchhoff's Law (Loop and Node Analysis)
2	Study of Superposition Theorem
3	Study of Thevenin's, Norton's and Maximum Power transfer Theorem
4	To study working of Wheatstone bridge
5	To study the diode as a half wave rectifier with and without filter
6	To study the diode as a full wave rectifier with and without filter
7	To set up and study a Zener diode shunt regulator and to plot its line and load regulation characteristics
8	To study the DC Amplifier using Bipolar Transistor
9	Study of half adder, full adder, half subtractor and full subtractor
10	To study the behavior of S-R, J-K, MS-JK, D and T flip flop
11	To study and design of ripple counter, synchronous binary using JK flip flop
12	To study and design of Ring and Junction counter
13	To measure OPAMP Parameters
14	To study OPAMP as inverting and non-inverting amplifier
15	To design and test integrator circuit using OPAMP and to find usual frequency range for integrator.
16	To study differential amplifier using single OPAMP.
17	To design and test differentiator circuit using OPAMP and to find usual frequency range for differentiator.

Course Outcome	At the end of this course the learner is expected: ➢ To familiarize the students with electronic instruments ➢ To impart hands-on experience on verification of circuit laws and theorems. ➢ To study experimentally the characteristics of diodes and BJT's ➢ To make the student understand the basic concepts in multivibrators and digital devices

2nd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-201	Statistical Mechanics	4	20	80

Objectives	This course offers an introduction to probability, statistical mechanics, thermodynamics and explores topics to modern statistical mechanics. Topics include: classical statistical mechanics, interacting systems, quantum statistical mechanics, and identical particles.
Pre-Requisites	Undergraduate thermodynamics and quantum physics, vibrations and waves, differential equations, elementary concepts of errors.
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Statistical Thermodynamics:** Macroscopic and microscopic states, connection between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox. Ensemble Theory: Phase space, Liouville's theorem, microcanonical ensemble, examples, quantum states and phase space. **Canonical Ensemble:** Equilibrium, partition function, energy fluctuation, equipartition and Virial theorem, harmonic oscillators, statistics of paramagnetism, Grand Canonical Ensemble: Equilibrium, partition function, density and energy fluctuation, correspondence with other ensembles, examples. **(Self Study Portion: Examples of microcanonical ensemble, harmonic oscillators in Canonical Ensemble, Examples of Grand Canonical Ensemble)**	14
II	**Formulation of Quantum Statistics:** Quantum mechanical ensemble theory, density Matrix, statistics of various ensembles, examples. Ideal gas in different quantum mechanical ensembles. Systems of: monatomic, diatomic and polyatomic molecules. **(Self Study Portion: Examples of Quantum mechanical ensembles, Systems of polyatomic molecules.)**	12
III	**Ideal Bose gas:** Photons and Planck's Law, Phonons, Bose-Einstein condensation, Thermodynamic description of phase transition, Phase transitions of second kind, Discontinuity of specific heat, Change in symmetry in a phase transition of second kind. **(Self Study Portion: Thermodynamic description of phase transition)**	11
IV	**Ideal Fermi Gas:** Thermodynamics, Pauli paramagnetism, Landau diamagnetism, DeHassVan Alphen Effect, thermionic and photoelectric emissions, white dwarfs. Ising Model: Ising model,: definition of Ising Model, ID-Ising model. **(Self Study Portion: DeHassVan Alphen Effect, thermionic and photoelectric emissions)**	11
	Total	48

TEXT BOOKS:

1. Statistical Mechanics-K: Huang
2. Statistical Mechanics- R. K. Patheria

REFERENCE BOOKS:

1 Elementary Statistical Physics- C Kittel
2 Statistical Mechanics-F: Mohling
3 Statistical Mechanics-Landau and Lifshitz.
4 Physics Transitions and Critical Phenomena-H.E. Stanley
5 Thermal Physics-C.Kittel
6 Fundamentals of Statistical and Thermal Physics-F.Reief

Course Outcome	At the end of this course the learner is expected: ➢ To develop an understanding of the statistical mechanics. ➢ To acquire the knowledge of various statistical distributions. ➢ To understand the applications of statistical mechanics in broad areas of modern physics.

2nd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-202	Quantum Mechanics	4	20	80

Objectives	This course will enable the students to apply the concept of quantum mechanics for problem solving at atomic and subatomic scale to describe the behavior of matter and energy through critical thinking in physical world.
Pre-Requisites	Matrix and linear algebra, In depth knowledge of calculus sequence, exposure to ordinary differential and partial differential equations.
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	Topics	Hours
I	**General Principles of Quantum Mechanics:** Linear vector space, ket and bra vectors, scalar product of vectors and their properties, Linear operator, Adjoint Operators, Unitary Operators and transformations, Expectation values of dynamical variables and physical interpretation, Hermitian operators, Probability interpretation, degeneracy, Schimdt method of orthogonalization. **Mathematical Basics**: Expansion Theorem, Completeness and Closure property of the basis set, Co-ordinate and Momentum representation, Compatible and incompatible observables, Commutator algebra, Uncertainty relation as a consequence of noncommutability, Minimum uncertainty wave packet. *(Self Study Portion: Linear operator, Adjoint Operators, Unitary Operators and transformations, Hermitian operators.)*	12
II	**Quantum Dynamics:** Time evolution of quantum states, time evolution operator and its properties, Schroedinger Picture, Heisenberg Picture, Interaction Picture, Equation of Motion, Operator Method of solution of Harmonic oscillator, Matrix representation and time evolution of creation and annihilation operator._ *(Self Study Portion: Time evolution of quantum states, time evolution operator and its properties.)*	10
III	**Rotation and Orbital Angular Momentum:** Rotation Matrix, Angular momentum operators as the generators of rotation. Lx, Ly, Lz and L^2 in spherical polar co-ordinates, Eigen values and Eigen functions of Lz and L^2 (OP method), Spherical Harmonics, Matrix representation of L+, L-and L^2. Spin ½ particles, Pauli spin matrices and their properties, Eigen values and Eigen functions, Spinor transformation under rotation. Total Angular momentum J, Eigen value problem of Jz and J2, Angular momentum matrices, Addition of angular momenta and C. G. Co-efficient, angular momentum states for composite systems in the angular momenta (1/2, ½) and (1,1/2). *(Self Study Portion: Lx, Ly, Lz and L2 in spherical polar co-ordinates, Matrix representation of L+, L-and L2)*	14

IV	**<u>Motion in Spherical Symmetric Field:</u>** Hydrogen atom, Reduction of two body problem to equivalent to one body problem, Radial equation, Energy eigenvaues and eigenfunctions, Degeneracy, radial probability distribution. Free particle problem incoming and outgoing spherical waves, Expansion of plane waves in terms of spherical waves, bound states of a 3-D square well, particle in a sphere. **<u>Approximation Methods:</u>** Time independent perturbation theory and application, variational method, WKB approximation, Time dependent perturbation theory, Fermi's Golden rule, selection rules. **<u>Scatterings:</u>** Elementary theory of scattering, Phase shifts, Partial waves, Born approximations ***(Self Study Portion: Radial probability distribution, Bound states of a 3-D square well, particle in a sphere)***	12
	Total	48

<u>TEXT BOOKS:</u>

1. Quantum Mechanics-Joichan

<u>REFERENCE BOOKS:</u>

1. Quantum Mechanics- Gasorowicz
2. Quantum Mechanics-Ghatak and Loknathan
3. D.J. Griffiths, Introduction to Quantum Mechanics, 2nd Ed., Pearson Publication, 2009.
4. P.M. Mathews, K. Venkatesan, A Textbook of Quantum Mechanics, 2nd Ed., McGraw Hill, 2010.
5. R.L. Liboff, Introductory Quantum Mechanics, 4th Ed., Pearson Education, 2003.
6. V.K.Thankappan, Quantum Mechanics, 4th Ed., New Academic Science, 2005.
7. R. Shankar, Principles of Quantum Mechanics, 2nd Ed., Plenum Press, 1994.

Course Outcome	At the end of this course the learner is expected: ➢ To learn the general formalism and the mathematical background of Schrodinger's quantum theory. ➢ To obtain analytical solutions of simple systems in one, two and three dimensions. ➢ To develop problem solving skills.

2nd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-203	Fluid Dynamics	4	20	80

Objectives	This course will enable the students to understand the basic laws, principles and phenomena in the area of fluid dynamics. Theoretical preparation enabling students to apply the acquired knowledge and skills in professional and specialist courses.
Pre-Requisites	Basic knowledge of classical mechanics and mathematical physics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Fluid Flow Concepts and Basic equations**: Velocity field, acceleration of a fluid element, continuity equation, conservation of momentum, stream line functions, rotation of fluid element, Euler's equation. Bernoulli's equation along a stream line and in rotational flow, Bernoulli's equation from thermodynamics ,static and dynamics pressure, Losses due to geometric changes:-Sudden expansion and contraction Venturimetre. **(Self Study Portions: Static and dynamics pressure, Losses due to geometric changes:-Sudden expansion and contraction, Venturimetre.)**	12
II	**Dimensional Analysis and Dynamic Similitude:** Buckingham's Π Theorem, Dimensionless parameters, Euler's number, Reynold's number, Froude's number, Weber number, Model studies and wind tunnel tests. **(Self Study Portions: Reynold's number, Froude's number, Weber number)**	10
III	**Viscous Effect**: Normal stress shear stress, Navier-Stokes theorem, Flow through a parallel channel, Flow past a sphere, Terminal velocity order of magnitude analysis, Approximation of the Navier-Stokes equations. Boundary layer concepts:-Momentum integral equation, velocity profile, Boundary layer thickness, SkinFriction effecter, Transverse component of velocity, Displacement thickness, momentum thickness. Drag: Bluff badles, Aerofoil, Boundary layer control, entrance region. **(Self Study Portions: Transverse component of velocity, Displacement thickness, momentum thickness. Drag: Bluff badles, Aerofoil, Boundary layer control, entrance region.)**	14
IV	**Compressible flow**: Perfection gas Relations:-Speed of propagation in gas, in isothermal and adiabatic condition, Mach number, Limits of incompressibility. Isentropic flow:-Laws of conservation, Static and stagnation values, flow through a duct of varying cross-section, mass flow rate, choking a converging passage, constant area adiabatic flow and Fanno like, constant area frictionless flow and Raleigh line. **Fluid Metrology**: Pressure measurement, Velocity measurement, Turbulence measurement, Viscosity measurement **(Self Study Portions: Pressure measurement, Velocity measurement, Turbulence measurement, Viscosity measurement)**	12
	Total	48

TEXT BOOKS:

1 Fluid Mechanics, A.K. Mohanty, PHI
2 Fluid Dynamics, R.V. Mises, Springer

REFERENCE BOOKS:

1 Foundation of Fluid Mechanics , S. W .Yuan, PHI
2 Text Book of Fluid Mechanics, R. S. Khurmi, S. Chand
3 Perspective in Fluid Dynamics, Batchelor, Cambridge

Course Outcome	At the end of this course the learner is expected: ➢ To define basic terms, values and laws in the areas of fluids properties, statics, kinematics and dynamics of fluids, and hydraulic design of pipes ➢ describe methods of implementing fluid mechanics laws and phenomena while analysing the operational parameters of hydraulic problems, systems and machines.

2nd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-204(B)	Atomic and Molecular Physics	4	20	80

Objectives	This core course intends to give a deep understanding about constitution of atoms and molecules though different kinds of spectra produced by them.
Pre-Requisites	Idea of quantum mechanics – various perturbation techniques and Knowledge of solving differential equations
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**General discussion in Hydrogen spectra:** Atomic spectra, Bohr's postulates, Bohr's Model of one-electron atom, unquantised states and continuous spectra, Bohr's Model and absorption spectra, correction for finite nuclear mass, variation in Rydberg constant due to finite nuclear mass, discovery of heavy hydrogen, comparison of H and He+ spectra, Wilson-Sommerfeld quantisation rules, de-Broglie's Interpretation of Bohr's quantisation law, Bohr's correspondence principle, Sommerfeld's extension of Bohr's Model, Sommerfeld's relativistic correction, shortcomings. Orbital Magnetic Dipole moment: Bohr Magneton, Behaviour of Magnetic Dipole in External Magnetic Field, Lamour Precession, space quantisation, Electron spin, Vector model of atom, spectroscopic terms and their notations, Stern-Gerlach experiments, spin-orbit interaction , quantum mechanical relativity correction, hydrogen fine structure. **(Self Study Portion: Bohr's Model and absorption spectra, correction for finite nuclear mass, variation in Rydberg constant due to finite nuclear mass, discovery of heavy hydrogen, comparison of H and He+ spectra, Stern-Gerlach experiments.)**	12
II	Identical Particles, exchange symmetry of wave functions, Formulation of Pauli's exclusion principle, Symmetry character of various particles, Slater determinant, Exchange force, spectrum of Helium, Prohibition of Inter combinations. Multi-electron atoms in Schroedinger's Theory, Results of Hartree Theory, Atomic orbitals and Hund's rule, the periodic table. Atoms with several optically active electrons, L-S Coupling, Lande Interval Rule, Normal and Inverted Multiplets, Determination of spectral terms for L-S coupling, Order of terms and fine structure levels, selection rules, j-j coupling, selection rules. **(Self Study Portion: Multi-electron atoms in Schroedinger's Theory, Results of Hartree Theory, Atomic orbitals and Hund's rule, the periodic table)**	12

III	**<u>Spectra of Alkali Metals</u>**, Ritz combination principle, Explanation of the spectra, Absorption spectra, resonance line, fine structure in alkali spectra, calculation of level splitting due to spin orbit interaction, intensity ratio of doublets. Spectra of alkaline earth metals, vector model of two-valence electron atom, interaction energy, regularities in complex spectra. Normal and Anomalous Zeeman effects, Paschen-Back effect, Transition from weak to strong field, examples, The stark effect in Hydrogen, hyperfine structure of spectral lines, Zeeman effect in hyperfine structure, Back-Goudsmit effect in Hyperfine structure. ***(Self Study Portion: Spectra of alkaline earth metals, vector model of two-valence electron atom, interaction energy, regularities in complex spectra)***	12
IV	X-ray spectra, Kossel's explanation of characteristic X-ray spectra, X-ray emission spectra and the Moseley law, Fine structure in X-ray emission spectra, screening doublets, X-ray absorption spectra, Auger effect. Types of molecular spectra and molecular energy states, The Born-Oppenheimer approximation, Pure rotational spectra, Vibrational-rotational spectra, The Raman spectra: classical and quantum theory. **(Self Study Portion: Vibrational Spectra, The Raman Spectra: classical and quantum theory.)**	12
	Total	48

<u>TEXT BOOKS:</u>

1 Raj kumar, Atomic and Molecular Spectra:Laser
2 H. E. White, Introduction to Atomic Spectra, Tata McGraw Hill (1934).
3 G.Aruldhas 'Molecular Spectroscopy'.
4 C. L. Banwell and E. M. McCash. 'Fundamentals of Molecular Spectroscopy' Tata- McGraw-Hill.

<u>REFERENCES:</u>

1 G. Herzberg. 'Molecular Spectroscopy (Diatomic Molecules)' Van-Nostrand.
2 G. M. Barrow. 'Molecular Spectroscopy'. McGraw-Hill.
3 J.Michael Hollas. ' Modern spectroscopy'. John-Wiley & sons.
4 Bransden and Joachin. 'Atoms and Molecules'
5 G. K. Woodgate, Elementary Atomic Structure, Clarendon Press (1989).
6 F. L. Pilar, Elemntary Quantum Chemistry, McGraw Hill (1990).

Course Outcome	At the end of this course the learner is expected: ➢ To develop the skills to solve real physical problems using quantum mechanics. ➢ To provide the accomplishments necessary for advanced courses such as optics, astrophysics, condensed matter physics and nuclear physics. ➢ To emphasize the modern developments in experimental techniques especially spectroscopy. ➢ To realize the role and practical application of physics of atoms and molecules in the modern world.

2nd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-205 (B)	Computational Physics	8	---	100

Objectives	This practical course enables the students to develop mathematical models and use computer programming for simulating real world physical problems.
Pre-Requisites	Fundamental knowledge of computers, basic mathematical skill.
Teaching Scheme	It is totally based on Laboratory demonstrations and Laboratory realization.

LIST OF EXPERIMENTS: (C/FORTRAN)	
1	To find largest or smallest of a given set of numbers
2	To generate and print first hundred prime numbers
3	To find sum of AP and GP
4	To find transpose of Matrix
5	Matrix Algebra
6	Evaluation of Log and exponential
7	Solution of Quadratic Equation
8	Numerical Differentiations
9	Numerical Integration by Trapezoidal Method
10	Numerical Integration by Simpson Method
11	Evaluation of Gamma Function
12	Solution of Second order differential equation by Range-Kutta Method
13	Finding roots of an equation by Newton-Raphson Iteration method
14	Least Square fitting of linear equations
15	Solution of system of linear equations.
MATLAB/MATHEMATICA/MAPLE MATLAB Fundamentals, MATLAB's opening window features, Getting started with MATLAB, M – file, control statements of M – file programming, Matrix manipulation, creating a function file	

Course Outcome	At the end of this course the learner is expected: ➢ To familiarize the students with computational techniques ➢ To study numerical algorithms and their implementation to solve problems.

3rd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-301	Solid State Physics	4	20	80

Objectives	This course deals with basic principles and techniques of solid state physics.
Pre-Requisites	Idea of quantum mechanics and atomic physics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Crystal Physics:** Types of lattices, Miller indices, simple crystal structures, crystal diffraction, Bragg's law, Reciprocal lattice (sc, bcc, fcc), Laue equations, structure factor, Atomic form factor, Types of crystal binding, cohesive energy of ionic crystals, Madelung constant, Inert gas crystals, Vander Waal, London equation, Metal crystals, Hydrogen bonded crystals. Defects in crystals; Point and line defects. **Lattice vibration and thermal properties:** Einstein and Debye models; continuous solid; linear lattice; acoustic and optical modes; dispersion relation; attenuation; density of states; phonons and quantization; Brillouin zones; thermal conductivity of metals and insulators. *(Self Study Portion: Types of crystal binding, cohesive energy of ionic crystals, Madelung constant, Inert gas crystals, Vander Waal, London equation, Metal crystals, Hydrogen bonded crystals)*	13
II	**Quantized free electron theory:** Fermi energy, wave vector, velocity and temperature, density of states. Electronic specific heats. Pauli spin paramagnetism. Sommerfeld's model for metallic conduction. AC conductivity and optical properties, plasma oscillations. Hall effects. **Intrinsic and extrinsic semiconductors:** carrier concentration and Fermi levels of intrinsic and extrinsic semi-conductors Bandgap. Direct and indirect gap semiconductors. Hydrogenic model of impurity levels. **Energy bands in solids:** The Bloch theorem. Bloch functions. Review of the Kroning-penney model. Brillouin zones. Number of states in the band. Band gap in the nearly free electron model. The tight binding model. The fermi surface. Electron dynamics in an electric field. The effective mass. Concept of hole. (elementary treatment). *(Self Study Portion: Sommerfeld's model for metallic conduction. AC conductivity and optical properties, The tight binding model, Electron dynamics in an electric field.)*	13
III	**Dielectrics:** Polarizability; Clausius-Mossotti formula; Dielectric constant; ferroelectrics. **Magnetic properties of solids:** Diamagnetism, Langevin equation. Quantum theory of paramagnetism. Curie law. Hund's rules. Paramagnetism in rare earth and iron group ions. Elementary idea of crystal field effects. Ferromagnetism. Curie-Weiss law. Heisenberg exchange interaction. Mean field theory. Antiferromagnetism. Neel point. Other kinds of magnetic order. Nuclear magnetic resonance.	11

	(Self Study Portion: Heisenberg exchange interaction. Mean field theory. Antiferromagnetism. Neel point. Other kinds of magnetic order. Nuclear magnetic resonance.)	
IV	**Superconductivity:** Experimental facts, occurrence, effect of magnetic fields, Meissner effect, entropy and heat capacity, energy gap, microwave and infrared properties, type-I and type-II superconductor, theoretical explanation, thermodynamics of superconducting transition, London equation, coherence length, BCS Theory, flux quantization, single particle Tunneling, Josephson Tunneling, DC and AC Josephson effects, High temperature super conductors-SQUIDS.. (Self Study Portion: Thermodynamics of superconducting transition, London equation, coherence length, BCS Theory)	11
	Total	48

TEXT BOOKS:

1. H. P. Myers, Introduction to Solid State Physics, Viva books (1998).
2. M.A. Omar, Elementary Solid State Physics, Addison-Wesley (1975).
3. C. Kittel, Introduction to Solid State Physics, John Wiley (1996).

REFERENCES:

1. A. J. Dekker, Solid State Physics, Macmillan (1986).
2. N. W. Ashcroft and N. D. Mermin, Solid State Physics, HBC Publ., (1976).
3. F.C.Phillips: An introduction to crystallography (wiley)(3rd edition)
4. Charles A Wert and Robb M Thonson: Physics of Solids
5. J. P. Srivastava: Elements of solid state physics (Prentice Hall India; 2nd edition).
6. Christmaan-solid state physics (academic press)
7. John Singleton: Band theory and Electronic properties of Solids (Oxford University Press; Oxford Master Series in Condensed Matter Physics).
8. Ibach & Luth: Solid State Physics

Course Outcome	At the end of this course the learner is expected: ➢ To understand the basics of crystal structures and crystal systems. ➢ To realize the nature of bonding and binding in all crystals. ➢ To make students familiar with elastic waves and phonons. ➢ To enhance the ability of students to understand electron and band theories.

3rd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-302	Electrodynamics	4	20	80

Objectives	Electrostatistics and magnetostatics are introduced so as to link from the undergraduate levels to advanced levels on electromagnetic theory. Electromagnetic Theory covers the basic principles of electromagnetism so as to enable students for understanding physical phenomena and principles in postgraduate and research levels.
Pre-Requisites	Vector algebra and tensor, calculus, classical mechanics, methods for solutions of differential equations, concepts of relativity, and concepts of fluid mechanics.
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Maxwell's Equations:** Green function solution of Maxwell's equation, Lorentz and Coulomb Gauge, Gauge invariance, Plane waves in a non conducting medium, Linear and circular polarization, Stoke's parameters, frequency dispersion characteristics of dielectrics, conductors and plasma, waves in dispersive medium, Kramer-Kroning relations. *(Self Study Portion: Green function solution of Maxwell's equation, Plane waves in a non conducting medium)*	12
II	**Microwave Propagation**: Classification of guided wave solutions-TE, TM and TEM waves. Rectangular and circular waveguides. Excitation of waveguides. Rectangular and cylindrical cavity resonators. Transmission line equations. Voltage and current waves. Solutions for different terminations. *(Self Study Portion: circular waveguides, Solutions for different terminations)*	12
III	**Radiation, Scattering and Diffraction:** Fields and radiation of localized oscillating source, Electric dipole, Magnetic dipole and electric quadrupole, Field radiation, Center-fed linear antenna with sinusoidal current, scattering by small dielectric sphere in long wave length limit, Rayleigh scattering, Thompson scattering, Kirchhoff's formulation of diffraction by a circular aperature. *(Self Study Portion: Rayleigh scattering, Thompson scattering)*	12
IV	**Covariant Formulation:**Four vector notation, Relativistic particle kinematics and dynamics, covariant form of Maxwell equations, Maxwell field tensor, Transformation of electromagnetic field components. **Radiation by a moving Charge:** Lienard-Weichert potential and field for a point charge, Total power radiated by an accelerated charge, Lamour's formula, angular distribution of radiation from an accelerated charge. *(Self Study Portion: covariant form of Maxwell equations, Maxwell field tensor)*	12
	Total	48

TEXT BOOKS:

1 Classical Electrdynamics-J.D Jackson
2 Introduction to Electrodynamics- Griffith

REFERENCE BOOKS:

1. Introduction to Electrodynamics-A.Z. Capri and P.V. Panat
2. Principles of Optics- M. Born and E. Wolf

Course Outcome	At the end of this course the learner is expected: ➢ To develop theoretical knowledge in electrodynamics. ➢ To develop skills on solving analytical problems in electrodynamics. ➢ To understand the electrodynamics of radiating and relativistic systems. ➢ To give basics of defining the complete electromagnetic response of complex systems.

3rd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-303	Nuclear and Particle Physics	4	20	80

Objectives	This core course explores the fundamental physics about the structure of matter at the subatomic level which will enable students to follow up recent progress of nuclear and particle physics.
Pre-Requisites	Calculus, tensors, basic concepts of Atomic Physics and Quantum Mechanics.
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Nuclear size and shape:** Nuclear radii and charge distributions, nuclear binding energy, electric andmagnetic moments. **Nuclear Nuclear Models:** Liquid drop model, semi-empirical mass formula, Mass Parabolas, Bohr-Wheeler theory of fission, Experimental evidences for shell effects, Shell model, Spin-orbit coupling, Magic numbers, Angular momenta and parities of nuclear ground states, magnetic moments and Schmidt lines, Collective model of Bohr and Mottelson. (Self Study Portion: Semi-empirical mass formula, Mass Parabolas, Bohr-Wheeler theory of fission, Collective model of Bohr and Mottelson.)	12
II	**The Two-Nucleon Problem:** The Ground state of deuteron, excited state of deuteron, n-p scattering at low energies, tensor forces and deuteron problem, n-n scattering, p-p scattering at low energies. **Nuclear Force**: Central and non-central forces, Force dependent on Isospin, Exchange force, charge dependence and charge symmetry of Nuclear force, Mirror Nuclei. (Self Study Portion: n-n scattering, p-p scattering at low energies, Mirror nuclei)	12
III	**Nuclear Reaction:** Energetic of Nuclear reaction, Compound nuclear theory, Resonance scattering, Brit-Wigner formula, Nuclear Fusion, Alpha decay, Fermi's theory of Beta decay, Selection Rules for allowed transition, Parity violation. (Self Study Portion: Selection Rules for allowed transition, Parity violation.)	12
IV	**Particle Physics:** Basic forces, Classification of Elementary particles, Spin and Parity, Determination of Isospin, Strangeness, Lepton and Baryon Number, Conservation Laws, Gellmann-Nishijima Scheme, Meson and Baryon Octet, Elementary Ideas of SU(3), Symmetry Quark Model, CPT theorem. Elementary ideas on quantum field theory, Klein-Gordon equation, Dirac Equation, Dirac Matrices. Particle Accelerators and detectors. (Self Study Portion: Particle Accelerators and detectors)	12
	Total	48

TEXT BOOKS:

1 Nuclear Physics: R.R.Roy and B.P Nigam
2 Introductory Nuclear Theory: L. R. B. Elton
3 Elementary Particle Physics: M.J.Longo
4 Nuclear Physics Experiments: J. Verma

REFERENCE BOOKS:

1 Theoretical Nuclear Physics: Blatt and Weisskopf
2 Nuclear Physics: D. C. Tayal
3 Particle Physics: R. Omens
4 Nuclear Physics: Pandey and Yadav
5 Nuclear Physics: I. Kaplan
6 Concepts of Nuclear Physics: L. Cohen
7 Introduction to Nuclear and Particle Physics: R. C. Verma

Course Outcome	At the end of this course the learner is expected: ➢ To introduce students to the fundamental principles and concepts governing nuclear and particle physics. ➢ To know about nuclear physics' scientific and technological applications as well as their social, economic and environmental implications. ➢ To understand the concept of elementary particles.

3rd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-304 (For Non Physics students)	Modern Physics & Electronics	4	20	80

Objectives	This course designed to explore the fundamental modern physics and basic electronics for non physics students.
Pre-Requisites	Vector Calculus, Differential Equation and basics of chemistry
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Quantum Mechanics:** Wave properties of Particles, Heisenberg uncertainty relation, group velocity, phase velocity, wave function, the wave equation, Schrodinger equation, Operators, Dynamical Variables, Expectation Values, Particle in a box, finite Potential well, Tunnel effect, harmonic oscillator **(Self Study Portion: Harmonic oscillator)**	12
II	**Nuclear Structure:** Nuclear Composition, some nuclear properties, stable nuclei, binding energy, liquid drop model, Shell model, Meson theory of nuclear forces **Nuclear Transformations:** Radioactive Decay, half life, radioactive series, alpha decay, beta decay, gamma decay, cross section, nuclear reactions, nuclear fission, nuclear reactors, nuclear fusion in stars, fusion reactors **(Self Study Portion: Nuclear reactors, nuclear fusion in stars, fusion reactors)**	12
III	**Solid State Physics** : Materials, Crystalline and Amorphous Solids Crystallography, Crystal structure- Lattice, Basis, Unit cell, Primitive cell, Crystal systems – Bravais Lattice in 3D , Binding of atoms in solids, Type of Crystals - Ionic crystals, Covalent crystals, Metallic crystals, Molecular crystals, Hydrogen-bonded crystals, Band theory of solids, semiconductor Superconductivity – Fundamentals. Type –I and Type-II superconductors, Flux quantization, Bound electron pairs. **(Self Study Portion: Superconductivity - Fundamentals. Type -I and Type-II superconductors, Flux quantization, Bound electron pairs)**	12
IV	**Electronics :** Network – Fundamentals, Voltage and Current sources, Resistance, Inductance, Capacitance, Thevenin’s Theorem, Norton’s Theorem, and Maximum Power Transfer Theorem, Semiconductors –Basics , Intrinsic, Extrinsic- P-type and N-type, Semiconductor Devices – PN Junction Diode, Transistor , Digital Electronics- Binary Number System, Conversion of decimal to binary and vice versa , Binary Operations, Boolean Laws, Logic Gates- OR, AND, NOT and their combinations. **(Self Study Portion: Thevenin’s Theorem, Norton’s Theorem, and Maximum Power Transfer Theorem)**	12
	Total	48

TEXT & REFERENCE BOOKS:

1. Ghoshal S.N., Atomic and Nuclear physics, Vol.2., S. Chand and Company, Delhi.
2. Evans R.D., Atomic nucleus, Tata Mc Grow Hill, New Delhi.
3. Penrose R., Road to Reality, Vintage Books, 2007.
4. Ladd M.F.C. and Palmer R.A., Structure determination by X-ray crystallography, Plenum Press, USA, 2003.
5. Arthur Beiser, Concepts of modern physics, 5th Edn., McGraw-Hill, New York.
6. Chattopadhyay D, Rakhit P. C, Quantum Mechanics, Statistical Mechanics & Solid State Physics, S. Chand & Company Pvt. Ltd., New Delhi.
7. Kittel C. , Solid State Physics
8. Edminister J. And Nahvi M. , Electrical Circuits – Schaum's Outlines
9. Mehta V.K. , Principle of Electronics

Course Outcome	At the end of this course the learner is expected: ➢ To know about basics of Quantum Mechanics ➢ To know about basics of Nuclear Physics ➢ To know about basics of Solid State Physics ➢ To know about basics of Electronics

3rd SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-305	Modern Physics And Material Science Laboratory	8	---	100

Objectives	This practical course enables the students to realize various modern Physics experiments. It also helps to determine various characteristics of materials by using experimental set up.
Pre-Requisites	Fundamental knowledge of Modern Physics and Material Science
Teaching Scheme	It is totally based on Laboratory demonstrations and Laboratory realization.

LIST OF EXPERIMENTS: (C/FORTRAN)	
1	Study of thermal properties of solid using HEAT CAPACITY KIT.
2	Study of B-H loop of a ferromagnetic specimen by using B-H Curve UNIT.
3	Determine the Curie temperature of a ferroelectric/ferromagnetic material by using
4	CURIE TEMPERATURE KIT.
5	Measurement of ultrasonic velocity in solids and Young's Modulus of those solids in
6	YOUNG'S MODULUS KIT.
7	Study of Lattice Dynamic KIT.
8	Study of particle size by using LASER Apparatus
9	Measurement of Acoustic signal using data acquisition system .
10	Forbidden gap calculation.
11	Plank's constant measurement

Course Outcome	At the end of this course the learner is expected: ➢ To understand the basic principles of Modern Physics ➢ To study the various characteristics of know and unkown materials.

4th SEMESTER (SP-ELECTRONICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-401-B	Electrical Circuits and Control	4	20	80

Objectives	This course deals with advanced electrical circuit and Control system analysis
Pre-Requisites	Laplace Transform, basics of Electronics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	Circuit components, KCL, KVL, Circuit analysis methods: nodal analysis, mesh analysis, basic network theorems, Superposition theorem, Thevenin's Theorem, Norton's theorem, Reciprocity theorem, Milliman's theorem, Maximum Power Transfer Theorem. **(Self Study Portion: Milliman's theorem, Maximum Power Transfer Theorem.)**	12
II	Laplace transforms of unit step, shifted unit step, ramp and impulse functions. Response of RL, RC, RLC series circuits, series and parallel resonance, bandwidth, Q-factor. Low pass, High pass, R –C filters.Low, high, bandpass and band elimination filters. **(Self Study Portion: Parallel resonance, bandwidth, Q-factor)**	12
III	Open loop and closed loop control systems, Mathematical modeling of physical systems, Block diagram representation of systems – Block diagram reduction methods – Closed loop transfer function, and determination of signal flow graph. Mason's gain formula – Examples. **(Self Study Portion: Mason's gain formula - Examples)**	12
IV	Test signals – time response of first order and second order systems – time domain specifications – types and order of systems – generalized error co-efficient – steady state errors – concepts of stability – Routh-Hurwitz stability. Bode plot, Root locus technique, Elementary state variable formulation, state transition matrix and response for linear time invariant systems. **(Self Study Portion: concepts of stability - Routh-Hurwitz stability.)**	12
	Total	48

TEXT BOOKS:

1. A course in Electrical Circuit Analysis – Soni and Gupta, Dhanpat Rai
2. Control System Engineering, 3rd Edition, New Age International Edition, 2002- Nagrath & Gopal,
3. Network and systems – D Roy Choudhury

REFERENCE BOOKS:

1. Network analysis – M.E Van Valkenberg, PHI

2. Network analysis – G.K. Mittal

3. Automatic Control Systems, 7th Edition – Prentice Hall of India, 2002, Benjamin.C.Kuo,

4. Modern Control Engineering, Prentice Hall of India, 4th Edition, 2003, Ogata.K

Course Outcome	At the end of this course the learner is expected: ➢ To introduce students to the basics of electrical circuits. ➢ To understand the concept of control system.

4th SEMESTER (SP-ELECTRONICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-402-B	Optoelectronics and Optical Communication	4	20	80

Objectives	This course explores the basic optical processes in semiconductor and various optical devices which will enable students to follow up recent progress of Fiber optic communications.
Pre-Requisites	Semiconductor devices, transmission devices, electrodynamics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Optical Processes in Semiconductors:** Electron- hole Pair formation and recombination-band to band recombination- absorption in semiconductors- exciton absorption - donor-acceptor and impurity band absorption- absorption in quantum wells - radiation in semiconductors-Luminescence from quantum wells- time resolved photo luminescence. (Self Study Portion: absorption in quantum wells - radiation in semiconductors-Luminescence from quantum wells- time resolved photo luminescence)	12
II	**Semiconductor Junctions :** The hetrojunction- LED structure - heterojunction LED - Edge emitting LED- I-VCharacteristics -Spectral and frequency response. **Photodetectors:** Junction photo diodes- PTN-APD- Photo transistor- modulated barrier photo diode – Schottky barrier - MSM photo diode- multicavity Photo diodes - Basic Principles of Solar cells. (Self Study Portion: Schottky barrier - MSM photo diode- multicavity Photo diodes - Basic Principles of Solar cells.)	12
III	**Switching Devices and Opto-electronic ICs:** Electro optic modulators - Optical switching and logic devices - application of OEIC' S- materials and processing for OEIC'S - Integrated transmitters and receivers – guided wave devices (Self Study Portion: Integrated transmitters and receivers – guided wave devices)	12
IV	**Fiber Optic Communication Optical fiber** - Characteristics and fundamental parameters - Propagating modes -low loss fibres - transmission distance with optical fibers - examples of optical transmission techniques - instrumentation and control with optical fibers. (Self Study Portion: Examples of optical transmission techniques - instrumentation and control with optical fibers)	12
	Total	48

TEXT BOOKS:

1. Semiconductor Opto electronic devices-Pallab Bhattacharya PHI, 1995.
2. Opto Electronics - Wilson and Hawker
3. Optical Fiber Communication - Snematsu and Toa (John Wiley and sons)

REFERENCE BOOKS:

1. Opto Electronics - Texas Instruments.
2. Opto Electronics - Jasprit Singh
3. Fiber Optic Communication - R.L.Keiser.

Course Outcome	At the end of this course the learner is expected: ➢ To understand the concept of optical processes in various semiconductor devices ➢ To get a clear idea regarding Solar cells and Optical Fiber communication.

4th SEMESTER (SP-ELECTRONICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-403-B	Pulse and Digital Circuits	4	20	80

Objectives	This course explores the various wave shaping circuits, circuit components, multivibrators, time base generators, combinational and sequential circuits which will enable students to follow up recent progress of advance in pulse and digital circuits as well as design of memory components in various applications.
Pre-Requisites	Basics of Electronics and electrical components, Laplace transform
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Linear Wave shaping :** High pass, low pass RC circuits, their response for sinusoidal, step, pulse, square and ramp inputs. RC network as differentiator and integrator, RL and RLC circuits and their response for step input, Ringing circuit. **Non-Linear Wave shaping**: Diode clippers, Transistor clippers, clipping at two independent levels, Transfer characteristics of clippers, Emitter coupled clipper, Comparators, applications of voltage comparators, clamping operation, clamping circuits using diode with different inputs. (Self Study Portion: High pass, low pass RC circuits, Ringing circuit, Emitter coupled clipper, Comparators, applications of voltage comparators)	14
II	**Switching Characteristics of Devices:** Diode as a switch, piecewise linear diode characteristics, Transistor as a switch, Break down voltage consideration of transistor, saturation parameters of Transistor and their variation with temperature, Design of transistor switch, transistor-switching times. (Self Study Portion: Diode as a switch, piecewise linear diode characteristics.)	10
III	**Multivibrators**: Analysis and Design of Bistable, Monostable, Astable Multivibrators and Schmitt trigger using transistors **Time base Generators**: General features of a time base signal, methods of generating time base waveform, Miller and Bootstrap time base generators – basic principles, Transistor miller time base generator, Transistor Bootstrap time base generator, Current time base generators. (Self Study Portion: Transistor Bootstrap time base generator, Current time base generators)	12
IV	**Combinational Digital Circuits**: Number systems and codes, De-Morgan laws, Boolean Algebra, K-map and simplification of Boolean functions using K-map, Implementation of various Boolean functions. Design of Adders, Multiplexers, Decoders, BCD to 7 segment Decoder **Sequential Digital Circuits**: Clocked S-R Flip-Flop, J-K Flip-Flop, Master Slave J-K Flip-Flops, T and D Flip-Flops, Shift registers, Synchronous and Asynchronous Counters, Ring and Johnson Counters. (Self Study Portion: Number systems and codes, De-Morgan laws, Boolean Algebra)	12
	Total	48

TEXT BOOKS:

1 Pulse, Digital and Switching Circuits, J Millman and Taub, TMH, 2003.
2 Solid State Pulse Circuits,David A Bell, 4th Ed, PHI,
3 Digital Electronics and Computer Design – M.M. Mano, PHI

REFERENCE BOOKS:

1 Pulse and Digital Circuits, MS Prakash Rao,TMH, 2006.
2 Pulse & Digital Circuits, Anand Kumar, PHI
3 Pulse, Digital circuits and Computer fundamentals, R Venkataraman

Course Outcome	At the end of this course the learner is expected: ➢ To understand the concept of Wave shaping circuits, multivibrators and time base generators ➢ To understand the design of sequential circuits and combinational circuits. ➢ To apply the knowledge to develop various memory units.

4th SEMESTER- SP- ELECTRONICS- PRACTICAL				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-404-B	Advanced Electronics	8	---	100

Objectives	This practical course enables the students to realize and assemble various advance electronics devices.
Pre-Requisites	Fundamental knowledge of Electronics and electronics devices
Teaching Scheme	It is totally based on Laboratory demonstrations and Laboratory realization.

LIST OF EXPERIMENTS: (C/FORTRAN)	
1	Study of the V-I characteristics of the solar cell and to determine the fill factor.
2	Study the characteristics of two stages RC coupled Amplifier.
3	Study of the characteristics of UJT.
4	Study of the characteristics of LED.
5	Study of frequency response of the Opto-coupler.
6	Study of the basic parameters of OPAMP.
7	Study of the Integrator circuit using OPAMP.
8	Study of the differentiator circuit using OPAMP.
9	Study of OP-AMP as inverting and non-inverting Amplifier.
10	Study of dynamic characteristic of PID Controller.
11	Study of Binary Phase shifting keying modulation and demodulation.
12	Study of differential phase shift keying modulation and demodulation.
13	Study of Pulse width modulation and demodulation.

Course Outcome	At the end of this course the learner is expected: ➢ To understand the operation of advance electronics devices ➢ To assemble various electronics circuit with help of electronic components.

4th SEMESTER- SP- ELECTRONICS				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-405-B	Project & Grand-Viva	8	---	100

Objectives	In this type of course the student can engaged with one supervisor to perform project work which can be experimental or theoretical. The student can take up in depth and detailed study of specific topic in Electronics/Physics/Applied Physics as project work.
Pre-Requisites	Fundamental knowledge of Physics.

Course Outcome	At the end of this course the learner is expected: ➢ To know the research methodology of Physics ➢ To know the process to take up research activities from a known topic.

4th SEMESTER (SP-NUCLEAR AND PARTICLE PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-401-C	Nuclear Radiation Detectors and Accelerators	4	20	80

Objectives	This course explores the principles and working of Nuclear detectors and accelerators which will enable students to follow up recent progress in high energy detector physics and also Accelerator Physics.
Pre-Requisites	Basics of Electronics, Nuclear Physics and electrodynamics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Ionizing Radiations:** Ionization and transport Phenomena in gases-avalanche multiplication **Detector properties**: Detection, Energy measurement, position measurement, time measurement **Gas Counters:** Ionization chambers, Proportional counters, Multiwire proportional counters, Geiger-Muller Counters, Neutron Detectors **Solid State Detectors:** Semiconductor detectors, integrating solid state devices, surface barrier detectors (Self Study Portion: Ionization chambers, Proportional counters, integrating solid state devices, surface barrier detectors)	12
II	**Scintillation Counters**: Organic and inorganic scintillators- theory, characteristics and detection efficiency **High Energy Particle Detectors:** General Principles, Nuclear Emulsions, Cloud chambers, Bubble Chamber, Cerenkov Counter **Nuclear Electronics:** Analog and Digital Pulses, Signal Pulses, Transient effects in an R-C circuit, Pulse shaping, Linear Amplifiers, Pulse Height discriminators, Single channel analyzer, multi channel analyser. (Self Study Portion: Pulse shaping, Linear Amplifiers, Pulse Height discriminators, Single channel analyzer, multi channel analyser.)	12
III	**Historical Developments of accelerators,** Different types of accelerators, Layout and components of accelerators, accelerator applications. **Transverse motion:** Hamiltonian for particle motion in accelerators, Hamiltonian in Fernet-Serret co-ordinate system, Magnetic field in Frenet-Serret co-ordinate system, Equation of betatron motion, particle motion in dipole and quadrupole magnets, linear betatron motion: transfer matrix and stability of betatron motion, sympletic condition, effect of space, charge force on betatron motion **Synchrotron Motion**: Longitudinal equation of motion, the synchrotron Hamiltonian, the synchrotron mapping equation, evolution of synchrotron phase space ellipse (Self Study Portion: Longitudinal equation of motion, the synchrotron Hamiltonian, the synchrotron mapping equation, evolution of synchrotron phase space ellipse)	12

IV	**Linear Accelerators:** Historical milestones, fundamental properties of accelerating structures, particle acceleration by EM waves, longitudinal particle dynamics in Linac, transverse beam dynamic in a Linac **Principle and design details of accelerators:** Basic principle and design details of accelerators viz electrostatic, electrodynamic, resonant with special emphasis on microtron, pelletron and cyclotron, synchrotron radiation sources, spectrum of the emitted radiation and their applications **(Self Study Portion: microtron, pelletron and cyclotron, synchrotron radiation sources, spectrum of the emitted radiation and their applications)**	12
	Total	48

TEXT AND REFERENCE BOOKS:

1. Nuclear Radiation Detectors, S S Kapoor and V S Ramamurthy, Wiley-Eastern, New-Delhi, 1986
2. Radiation Detection, W H Tait, Butterworths, London, 1980
3. Nuclear Radiation Detection, W J Price, McGraw Hill, New York, 1964
4. Accelerator Physics, S. Y. Lee: World Scientific, Singapore, 1999.
5. Principles of Cyclic particle accelerators, J. J. Livingood: D. Van Nostrand co., 1961.
6. Particle Accelerator, J P Blewett : McGraw-Hill Book Co.
7. The Microtron, S P Kapitza and V N Melekhin, Harwood Academic Publishers
8. Particle Accelerators and their uses, W Scharf, Harwood Academic Publishers
9. Theory of Resonance Linear Accelerators, I M Kapchinsky, Harwood Academic Publishers
10. Linear Accelerator, P Lapostle and A Septier, North Holland

Course Outcome	At the end of this course the learner is expected: ➢ To understand the working of recent detectors and accelerators available for research. ➢ To implement the course knowledge to add few changes in the exiting detectors and accelerators in various research Laboratories.

4th SEMESTER (SP-NUCLEAR AND PARTICLE PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-402-C	Nuclear Reactor Theory and Nuclear Models	4	20	80

Objectives	This course explores the principles and working of Nuclear reactors which will enable students to follow up recent progress in Nuclear reactor physics. It also explores the advance nuclear structure model to enable the students for recent nuclear physics research.
Pre-Requisites	Basics of Electronics, Nuclear Physics and electrodynamics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Introduction:** Fundamentals of nuclear fission, fission fuels, neutron chain reaction, multiplication factor, condition for criticality, breeding phenomena, different types of reactors **The Diffusion of Neutrons:** Neutron Current density, the equation of continuity, Fick's law, the diffusion equation, boundary conditions, measurements of diffusion parameters **Neutron Moderation:** Moderation without absorption, Energy loss in elastic collisions, collision and slowing, Down densities, moderation, space dependent slowing down, Fermi's age theory, Moderation with absorption, NR and NRIM approximations, temperature effects on resonance absorption. (Self Study Portion: Fermi's age theory, Moderation with absorption, NR and NRIM approximations, temperature effects on resonance absorption)	12
II	**Criticality:** Criticality of an infinite homogeneous reactor, the one region finite thermal reactor, the critical equation, optimum reactor shapes, multi-region reactors, One group and two group methods of calculation of criticality, reflector savings, critical reactor parameters and their experimental determination. **Reactor Kinematics**: Infinite reactor with and without delayed neutrons, the stable period, reactivity and its determination, the prompt jump and prompt critical condition, changes in reactivity, temperature co-efficient, fuel depletion effects. **Reactor Control**: Control rod worth, One control rod, modified one group and two group theories. (Self Study Portion: Control rod worth, One control rod, modified one group and two group theories.)	12
III	**Single Particle Shell Model**: Determinate wave functions of the nucleus, single particle operator and their expectation values **Extended Single Particle Model**: Classification of Shells-Seniority and reduced i-spin, Configuration mixing, pairing force theory, Gap equation and ground state properties, idea of quasi particles and simple description of two, particle shell model spectroscopy (Self Study Portion: Idea of quasi particles and simple description of two, particle shell model spectroscopy)	12

IV	**Collective Model of Nucleus**: Deformable liquid drop and nuclear fission, shell effects on liquid drop energy, collective vibrations and excited states, permanent deformation and collective rotations, energy levels, electromagnetic properties of even-even, odd-A deformed nuclei, Nilsson model and equilibrium deformation, Behaviour of nuclei at high spin, Back bending_ (Self Study Portion: Nilsson model and equilibrium deformation, Behaviour of nuclei at high spin, Back bending)	12
	Total	48

TEXT AND REFERENCE BOOKS:

1. Introduction to Nuclear Reactor Theory: J R Lamarsh, Addison Wesley, 1966
2. Reactor Physics: P. F. Zweifel, Mc-Graw Hill Kogakusha Ltd. Tokyo, 1973
3. The elements of Nuclear Reactor Theory: S Glasstone and M C Mdiund, Van Nostrand Co., 1953
4. Physics of Nuclear Reactors: S. Garg, F. Ahmed, L S Kothari
5. Structure of the Nucleus, M. A. Preston and R. K. Bhaduri: Addn. Wesley, 1975.
6. Theoretical Nuclear Physics, M. Blatt and V. F. Weisskopf: John Wiley, 1952.
7. Nuclear Physics- Theory and Experiments, R. R. Roy and B. P. Nigam: John Wiley, 1967.
8. Nuclear Models, G. Maruhn: Springer
9. Elementary Pile Theory, S. Glasstone and M. C. Edlund: John Wiley, 1950.

Course Outcome	At the end of this course the learner is expected: ➢ To understand the working of recent nuclear reactors. ➢ To implement the course knowledge to add few changes in the exiting nuclear reactors. ➢ To understand the advance nuclear models and implement the knowledge in future Nuclear Physics research.

4^{th} SEMESTER (SP-NUCLEAR AND PARTICLE PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-403-C	High Energy Physics	4	20	80

Objectives	This course explores the theory of various interactions and symmetries in High energy Physics to enable the students for recent particle physics research.
Pre-Requisites	Basics of advance quantum mechanics, group theory, elementary particle physics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Particle Phenomenology:** Invariance and conservation laws in relation to particle reactions and decays. Translation and rotation operators, Lepton and Baryon conservation, Iso-spin, strangeness and hypercharge, Parity, Charge conjugation and Time reversal symmetries. CPT theorem and its consequences. Isospin symmetry in Two nucleon and Pion-Nucleon systems. **Relativistic Kinematics**: Lorentz transformations, Four Vectors, Energy and Momentum, Collisions, Examples and Applications, Mandelstam variables, Phase space, Decay of one particle into three particles, Dalitz Plot. (Self Study Portion: Mandelstam variables, Phase space, Decay of one particle into three particles, Dalitz Plot)	12
II	**Strong Interactions and Physics of Quarks and Gluons:** Uses of Symmetry, space, time and internal symmetries, Lie groups generators and Lie algebra, Casimir operators, SU(2) generators, SU(3) generators, U and V spin, Raising and Lowering operators, Root diagram, Weight diagram, Baryons and meson multiplets. Symmetry breaking and Gell-Mann-Okubo mass formula for baryon and mesons, Coleman-Glashow relation, Quarks and Gluons, Color hypothesis, Decays in terms of Quark Model. Charm, bottom and top quarks and higher symmetry. Quark-Gluon interaction, Experimental tests of Quantum Chromodynamics. Elementary idea on Quark Gluon Plasma (Self Study Portion: Experimental tests of Quantum Chromodynamics. Elementary idea on Quark Gluon Plasma)	12
III	**Weak Interactions:** Leptonic, semi-leptonic and non-leptonic weak decays. Fermi theory of Nuclear Beta decay, Fermi and G-T selection rules, Parity violation in weak interaction, Cobalt Sixty Experiment, Helicity of Neutrino, V-A interaction, Conservation of weak currents, Decay of Pions and Muons, Weak decay of quarks: The GIM model, CKM matrix, Strangeness Oscillations, Regeneration and CP-Violation in Kaon Decay. (Self Study Portion: The GIM model, CKM matrix, Strangeness Oscillations, Regeneration and CP-Violation in Kaon Decay)	12

IV	**Electro-Weak Unification:** Feynman Diagram, Electromagnetic interactions, Renormalization and Gauge invariance, Divergences in the weak interactions, Introduction to neutral currents, General idea of electro-weak unification, Experimental Evidence of Electro-Weak Unification, Non-Abelian Gauge Field Theory, Spontaneous Symmetry Breaking, Higgs Mechanism, Goldstone Theorem, A Brief Review of Salam-Weinberg-Glashow Model, Neutrino Oscillation and Mixing. **(Self Study Portion: A Brief Review of Salam-Weinberg-Glashow Model, Neutrino Oscillation and Mixing.)**	12
	Total	48

TEXT AND REFERENCE BOOKS:

1. Nuclear and Particle Physics : W. Burcham and M. Jobes.
2. Quarks and Leptons : Halzen and Martin.
3. Unitary symmetry and Elementary Particles : D.B.Lichtenberg.
4. Symmetry Principles in particle Physics : Emmerson.
5. Introduction to High Energy Physics : D. H. Perkins.
6. Particles and Nuclei : B. Povh, K. Rith, C. Scholz and F. Zetsche.
7. Introduction to Elementary particles: D. Griffiths

Course Outcome	At the end of this course the learner is expected: ➢ To understand the various interactions in high energy Physics. ➢ To implement the course knowledge in High energy/Particle Physics research.

4th SEMESTER- SP- NUCLEAR AND PARTICLE PHYSICS- PRACTICAL				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-404-C	Advanced Practical	8	---	100

Objectives	This practical course enables the students to realize and assemble various advance nuclear devices.
Pre-Requisites	Fundamental knowledge of nuclear Physics and devices
Teaching Scheme	It is totally based on Laboratory demonstrations and Laboratory realization.

LIST OF EXPERIMENTS:	
1	Study of effect of radiations of various radioactive sources by using G.M. Counter-Radiation Counter
2	Analysis of Gamma sources by using Gamma ray Spectroscopy & Compton scattering experiment
3	Study of e/m ratio by using Millikan Oil drop apparatus.
4	Spectrum analysis by using Franck Hertz Experiment with NEON Tube.
5	Study of Zeeman Effect in energy eigen values of given sample.
6	Calculation and observation of NMR /ESR with various samples.

Course Outcome	At the end of this course the learner is expected: ➢ To understand the operation of advance Nuclear devices

4th SEMESTER- SP- NUCLEAR AND PARTICLE PHYSICS				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-405-C	Project & Grand-Viva	8	---	100

Objectives	In this type of course the student can engaged with one supervisor to perform project work which can be experimental or theoretical. The student can take up in depth and detailed study of specific topic in Physics as project work.
Pre-Requisites	Fundamental knowledge of Physics.

Course Outcome	At the end of this course the learner is expected: ➢ To know the research methodology of Physics ➢ To know the process to take up research activities from a known topic.

4th SEMESTER (SP-CONDENSED MATTER PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-401-D	Condensed Matter Physics-I	4	20	80

Objectives	This course explores the principles X-ray diffraction, crystallography, Imperfections in crystals, Lattice vibrations, phonons and thermal properties of various matters which will enable students to follow up recent progress in Condensed matter physics.
Pre-Requisites	Basics of quantum mechanics, solid state physics and atomic physics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**X-ray Diffraction and Crystallography** : Choice of x-rays , electrons, neutrons for crystallography, Atomic scattering factor, Geometrical structure factor, X-ray diffraction by Laue method, Rotating crystal method, Powder method; Scattering by a unit cell, Crystallographic zone axis ; Debye-Scherrer technique , Analysis of powder photographs, Determination of lattice type and space group, Crystal structure determination- Indexing of diffraction pattern, Identification of Bravais lattice, Calculation of lattice parameter, Powder diffractometric techniques (Self Study Portion: Identification of Bravais lattice, Calculation of lattice parameter, Powder diffractometric techniques)	12
II	**Imperfection in Crystals** : Classification of imperfections, Crystallographic imperfections, Point defects-concentrations of Schotky and Frenkel defects ; Line defects-edge dislocations, screw dislocations, Burger vectors, Dislocation motion, Stress fields around dislocations, Observations of dislocations; Plane defects- stacking faults , grain boundaries, Role of dislocations in crystal growth. (Self Study Portion: Plane defects- stacking faults , grain boundaries, Role of dislocations in crystal growth.)	12
III	**Lattice vibrations and Phonons** : Elastic vibrations of continuous media, Group velocity of harmonic wave trains, Wave motion of one dimensional atomic lattice, Lattice with two atoms with primitive cell- optical branch and acoustic branch, Some facts about diatomic lattice, Number of possible modes of vibrations in a band ; Phonons, properties of phonons, Momentum of phonons (Self Study Portion: Phonons, properties of phonons, Momentum of phonons)	12
IV	**Thermal properties and Diffusion** : Anharmonic crystal interactions , Thermal expansions – expansion coefficient , Lattice thermal conductivity of solids, , Umklapp process; Diffusion in solids- Ficks first law and second law, Diffusion coefficient through plane surface, cylinder andsphere; Diffusion couple, application based on second law of diffusion, Electrical conductivity in ionic crystal, Einstien relation of diffusion. (Self Study Portion: Diffusion couple, application based on second law of diffusion, Electrical conductivity in ionic crystal, Einstien relation of diffusion.)	12
	Total	48

TEXT AND REFERENCE BOOKS:

1. X-ray Crystallography by Azaroff
2. Crystallography for Solid State Physics by Verma and Srivastava
3. Introduction to Solid State Physics(7th edition) by C Kittel
4. Solid State Physics by W. Ashcroft and N. David Mermin
5. Solid State Physics by A.K. Saxena
6. Solid State Physics by Gupta and Kumar
7. Solid State Physics by M.A. Waheb

Course Outcome	At the end of this course the learner is expected: ➢ To implement the course knowledge to purse in condensed matter research.

4th SEMESTER (SP-CONDENSED MATTER PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-402-D	Condensed Matter Physics-II	4	20	80

Objectives	This course explores the principles semiconductor, semiconductor crystals, Fermi surfaces, metals, Optical properties of solids, exotic solids and nano tubes will enable students to follow up recent progress in Condensed matter physics and Nano Physics.
Pre-Requisites	Basics of quantum mechanics, solid state physics and atomic physics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Semiconductor and Semiconductor Crystals** : . Semiconductor- its carrier concentration in general ; Intrinsic semiconductor-its carrier concentration, fermi level and conductivity; Extrinsic Semiconductor –n type and p type and their carrier concentration and Fermi level. Semicoductor crystals- energy band gap, Direct and indirect absorption processes, Equation of motion of electron and its physical derivation , Hole-its characteristics, Effective mass of electron and its physical interpretation, electron diffraction experiment, Effective masses in Semiconductor (Self Study Portion: Effective mass of electron and its physical interpretation, electron diffraction experiment, Effective masses in Semiconductor)	12
II	**Fermi Surfaces and Metals** ; Various zone schemes , Fermi surface and its construction for square lattice by free electrons and by nearly free electrons , Brillouin zone and Fermi surface- its characteristics, Electron orbits, Hole orbits, Closed orbit, Open orbits, Wigner-Seitz method for energy calculation, Cohesive energy, Experimental determination of Fermi surface, Quantization of orbits in a magnetic field, De Hass-Van Alphen effect (Self Study Portion: Experimental determination of Fermi surface, Quantization of orbits in a magnetic field, De Hass-Van Alphen effect)	12
III	**Optical properties of Solids :** Dielectric function of free electron gas, Plasma optics, Dispersion relation for electromagnetic wavs, Transverse optical modes in a plasma, Longitudinal plasma oscillations, Plasmons and their measurement; Electrostatic screening, Screened Coulomb Potential, Mott Metal-Insulator transition, screening and phonon in metals, Optical reflectance, Kramers-Kronig relations,; Excitons- Frenkel and Mott-Wannier excitons; Raman effect in crystal, Electron spectroscopy with X-rays. (Self Study Portion: Excitons- Frenkel and Mott-Wannier excitons; Raman effect in crystal, Electron spectroscopy with X-rays.)	12

IV	**Exotic Solids and Nanotubes** : Quasi crystals, Liquid crystals, Polymers-basics and classification, Graphite structure, Fullerens , Carbon clusters, Carbon Nanotubes (CNT)-types, single wall and multi wall, structure and properties of CNT, Quantum mechanics for Nanoscale- size effects-due to Response time, Thermal time constant, Friction; Application of Schrodinger equation in Nanometric world –three dimension, two dimension, one dimension. (Self Study Portion: Application of Schrodinger equation in Nanometric world -three dimension, two dimension, one dimension)	12
	Total	48

TEXT AND REFERENCE BOOKS:

1. Introduction to Solid State Theory by Madelung
2. Quantum Theory of Solid State by Callaway
3. Introduction to Solid State Physics(7th edition) by C Kittel
4. Solid State Physics by A.J. Dekker
5. Elementary Solid State Physics by M.A. Omar
6. Solid State Physics by S.O. Pillai
7. Solid State Physics by M.A. Waheb

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Course Outcome	At the end of this course the learner is expected: ➢ To implement the course knowledge to purse in condensed matter and nano technology reseach

4th SEMESTER (SP-CONDENSED MATTER PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-403-D	Condensed Matter Physics-III	4	20	80

Objectives	This course explores the principles electron transport phenomena, nanostructure characterization and various which will enable students to follow up recent progress in Condensed matter physics and Nano Physics.
Pre-Requisites	Basics of quantum mechanics, solid state physics and atomic physics
Teaching Scheme	Regular class room lectures with/without use of ICT tools, sessions are planned to be interactive with focus on problem solving activities.

Detailed Syllabus		
Unit	**Topics**	Hours
I	**Electron Transport Phenomenon:** Motion of electrons in bands and the effective mass tensor (semi-classical treatment), Currents in bands and holes, Scattering of electrons in bands (elastic, inelastic and electron-electron scatterings), The Boltzmann equation, Relaxation time ansatz and linearized Boltzmann equation; Electrical conductivity of metals, Temperature dependence of resistivity and Matthiesen's rule; Thermoelectric effects, Thermopower, Seebeck effect, Peltier effect, The Wiedemann-Franz law. (Self Study Portion: Thermoelectric effects, Thermopower, Seebeck effect, Peltier effect, The Wiedemann-Franz law)	12
II	**Nanostructures and Nano-scale characterisation techniques:** Different type of Nanostructures; synthesis of nanomaterial: polycrystalline; single crystal; Bottom up approach; Top-Down approach; Imaging techniques (principle): Electron microscopy (TEM, SEM), Optical microscopy, Scanning tunnelling microscopy, Atomic force microscopy; Quantum Mechanics of Low-Dimensional systems: Density of states and quantum confinement, super lattice and Band offsets (Self Study Portion: Quantum Mechanics of Low-Dimensional systems: Density of states and quantum confinement, super lattice and Band offsets)	12
III	**Electron Transport in Nanostructures**: Electronic structure of 1D systems: 1D sub-bands, Van Hove singularities; 1D metals- Coulomb interactions and lattice couplings; Electrical transport in 1D: Conductance quantization and the Landau formula, Two barriers in series-Resonant tunnelling, Incoherent addition and Ohm's law, Coherence-Localization; Electronic structure of 0D systems (Quantum dots): Quantized energy levels, Semiconductor and metallic dots, Optical spectra, Discrete charge states and charging energy; Electrical transport in 0D- Coulomb blockade phenomenon (Self Study Portion: Semiconductor and metallic dots, Optical spectra, Discrete charge states and charging energy; Electrical transport in 0D-Coulomb blockade phenomenon.)	12

IV	**<u>Beyond the independent electron approximation</u>**: The basic Hamiltonian in a solid: Electronic and ionic parts, One-electron model, The adiabatic approximation; The Hartree equations, Exchange: The Hartree-Fock approximation, Hartree-Fock theory of free electrons- Ground state energy, exchange energy, correlation energy (only concept); Screening in a free electron gas: The Dielectric function, Thomas-Fermi theory of screening, Calculation of Lindhard response function, Lindhard theory of screening, Friedel oscillations, Frequency dependent Lindhard screening (no derivation). **(Self Study Portion: Lindhard theory of screening, Friedel oscillations, Frequency dependent Lindhard screening)**	12
	Total	48

TEXT AND REFERENCE BOOKS:

1. Solid State Physics: An Introduction to Principles of Materials Science (4 th Ed.) by H. Ibach and H. Luth
2. Introduction to Solid State Physics (8 th Ed.) by Charles Kittel
3. Solid State Physics by Neil W. Ashcroft and N. David Mermin
4. The Wave Mechanics of Electrons in Metals by Stanley Raimes

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Course Outcome	At the end of this course the learner is expected: ➢ To implement the course knowledge to purse in condensed matter and nano technology research

4th SEMESTER (SP-CONDENSED MATTER PHYSICS)-PRACTICAL				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-404-D	Advanced Practical	8	---	100

Objectives	This practical course enables the students to calculate various characteristics of material by using available instruments.
Pre-Requisites	Fundamental knowledge of Condensed matter physics
Teaching Scheme	It is totally based on Laboratory demonstrations and Laboratory realization.

LIST OF EXPERIMENTS:	
1	Study of effect of Hall effect in the given samples by using Hall Apparatus
2	Study of superconductivity and Meissner effect in the given samples.
3	Calculation of Susceptibility of paramagnetic samples by using quinck's method.
4	Study of various parameters of photoconductivity.
5	Study of energy band gap of various samples by using four probe methods.
6	Study of Faraday effect using He-Ne LASER
7	Study of B-H curve with deep set up.
8	Study of thermoelectric effect (Seeback effect).

Course Outcome	At the end of this course the learner is expected: ➢ To understand the characteristics of various materials for application purpose.

4th SEMESTER- SP- CONDENSED MATTER PHYSICS				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-405-D	Project & Grand-Viva	8	---	100

Objectives	In this type of course the student can engaged with one supervisor to perform project work which can be experimental or theoretical. The student can take up in depth and detailed study of specific topic in Physics as project work.
Pre-Requisites	Fundamental knowledge of Physics.

Course Outcome	At the end of this course the learner is expected: ➢ To know the research methodology of Physics ➢ To know the process to take up research activities from a known topic.