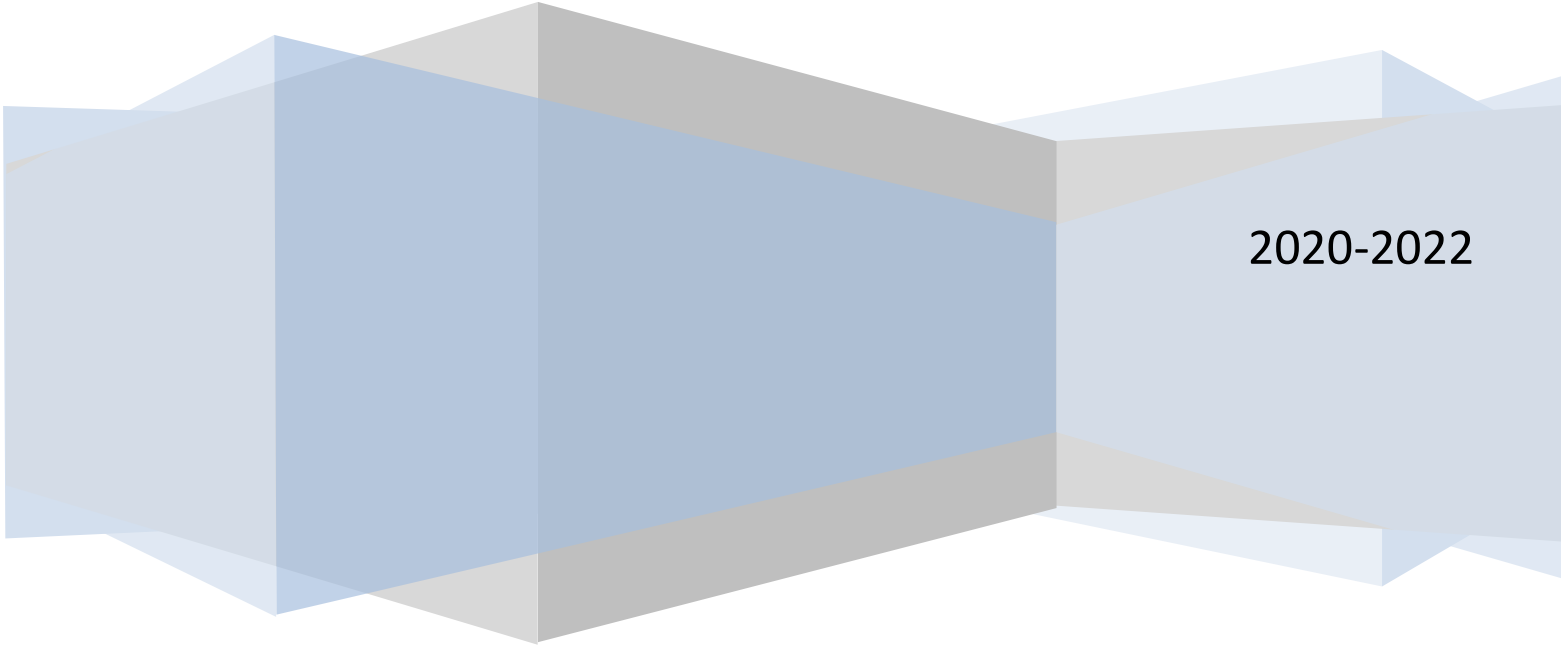


POST GRADUATION DEPARTMENT OF APPLIED PHYSICS AND  
BALLISTICS, F. M. UNIVERSITY, BALASORE

**SYLLABUS FOR THE COURSE M. SC. IN  
APPLIED PHYSICS & BALLISTICS**



2020-2022

**P.G. Department of Applied Physics and Ballistics****Syllabus structure (M. Sc. Applied Physics and Ballistics)****Approved by BOS on Dt. 13.11.2020****(Regular Mode)**

<b>M.Sc. in Applied Physics and Ballistics</b>		
Semester	Marks	Credit
1 <sup>st</sup> semester	500	24
2 <sup>nd</sup> semester	500*	24*
3 <sup>rd</sup> semester	500**	24
4 <sup>th</sup> semester	500	28
Total	2000	100

\*One MOOC/SWAYAM course of 4 credits is selected by the student of M.Sc. APAB. After successful completion of the course the secured credit will be added to the 2<sup>nd</sup> 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. Applied Physics & Ballistics****(REGULAR 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 (A)	Practical: Computational Physics	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 (A)	Internal Ballistics	100	04
APAB-205 (A)	Practical: Electronics	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 Applied Physics and Ballistics**

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

Special Paper-I	Ballistics
Special Paper-II	Electronics
Special Paper-III	Condensed matter physics

**Special Paper-I (Ballistics)**

Code	Name	Mark	Credit
APAB-401(A)	Terminal Ballistics	100	04
APAB-402(A)	External Ballistics	100	04
APAB-403(A)	Rocket Ballistics:	100	04
APAB-404 (A)	Ballistics Practical	100	08
APAB-405 (A)	Project & Grand viva:	100	08
	<b>Total</b>	<b>500</b>	<b>28</b>

**Special Paper-II (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
	<b>Total</b>	<b>500</b>	<b>28</b>

**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
	<b>Total</b>	<b>500</b>	<b>28</b>

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

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	General Newtonian mechanics, rotational and planetary motion, principle of relativity
<b>Teaching Scheme</b>	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	<p><b>Lagrangian and Hamiltonian Formalism:</b> Constraints-D'Alembert's principle and Lagrange's equations-velocity dependent potentials and the dissipation function, simple applications of the Lagrange formulation. <b>Variational Principle and Lagrange's Equations:</b> 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.</p> <p><b>(Self Study Portion: simple applications of the Lagrange formulation, conservation theorems and symmetry properties.)</b></p>	14
II	<p><b>Central force Problems:</b> 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.</p> <p><b>(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.)</b></p>	12
III	<p><b>The kinematics of Rigid Body Motion and Small Oscillations:</b> 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.</p> <p><b>(Self Study Portion: Orthogonal transformation-Formal properties of the transformation matrix)</b></p>	12

IV	<b>The Rigid Body Equations of Motion:</b> 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. <b>(Self Study Portion: Tensor and dyadics, Precession of the equinoxes and of satellite orbits-Precession of system of changes in a magnetic field.)</b>	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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To emphasize the mathematical formulation of mechanics problems and to physically interpret the solutions.</li> <li>➤ To apply the fundamental concepts of classical mechanics to the particle systems and rigid bodies.</li> <li>➤ To develop problem solving and critical thinking skills.</li> </ul>
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1 <sup>st</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-102	Mathematical Methods in Physics	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Basic vectors and matrices, functions and derivatives, sets, integral properties.
<b>Teaching Scheme</b>	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	<p><b>Functions of a Complex Variable:</b> 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.</p> <p><b>(Self Study Portion: Analytic functions, Cauchy's Integral Theorem)</b></p>	12
II	<p><b>Linear Vector Space:</b> Definition, Linear independence, basis and dimension, scalar product, dual vector, Cauchy-Schwarz inequality, orthonormal basis, Schmidt orthogonalisation process.</p> <p><b>Matrices:</b> Inverse of a matrix, orthogonal matrix, rotation, similarity transformation, Eigen-values and eigenvectors, secular equation, Cayley-Hamilton theorem, matrix diagonalisation.</p> <p><b>(Self Study Portion: Inverse of a matrix, orthogonal matrix, rotation, Cayley-Hamilton theorem)</b></p>	12
III	<p><b>Tensors:</b> 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.</p> <p><b>Group theory:</b> 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.</p> <p><b>(Self Study Portion: Lie group and Lie algebra, SO(3) groups and their representation)</b></p>	12

IV	<p><b>Special Functions:</b> Series solutions: Frobenius Method, Hermite Polynomials, Legendre polynomials, generating function, recurrence formulae, orthogonality properties, Bessel's function, generating function, recurrence formulae, orthogonality properties, Hypergeometric functions and their properties, Laguerre polynomial and their properties, Green Functions.</p> <p><b>Integral Transform:</b> Fourier series, Fourier Integrals, Fourier transforms, Convolution theorem, Laplace transform- derivatives, properties and applications to solution of differential equations.</p> <p><b>Elementary Probability Theory:</b> random variables, Binomial, Poisson and Normal distributions.</p> <p><b>(Self Study Portion: Hermite Polynomials, Elementary Probability Theory, random variables, Binomial, Poisson and Normal distributions.)</b></p>	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

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To introduce advanced mathematical methods in physics and their applications.</li> <li>➤ To enable students to use mathematical concepts required in physics.</li> <li>➤ To develop expertise in solving the complex problems in physics.</li> <li>➤ To prepare the students to formulate, interpret and draw inferences from complex physical concepts.</li> </ul>
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1 <sup>st</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-103	Electronics and Computer Programming	4	20	80

<b>Objectives</b>	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 programming 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.
<b>Pre-Requisites</b>	Fundamental knowledge of electronic components and circuit theorems, Fundamental knowledge of computers, basic mathematical skill
<b>Teaching Scheme</b>	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	<b>Network Analysis:</b> 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. <b>(Self Study Portion: Response of series RL, RC, RLC, and parallel RLC to exponential driving sources)</b>	12
II	<b>Semiconductor devices :</b> 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, Transistor 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. <b>(Self Study Portion: Applications of Diodes: Rectifier circuits, Clipping and clamping circuits, Special purpose diodes: Zener Diode, Tunnel diode, LED, photo diode, etc)</b>	14
III	<b>Digital Electronics:</b> 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. <b>(Self Study Portion: Flip Flops, Timers, Shift Registers, Counters, Microprocessor and microcontroller basics)</b>	10

IV	<p><b>Numerical Computing:</b> 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.</p> <p><b>(Self Study: roots of functions, interpolation, extrapolation, Newton-Raphson Method, Finite difference and Solutions of Linear equations)</b></p>	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 Methods – C. Xavier
- 8 Numerical Techniques in C – E. Balguruswamy

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To enhance comprehension capabilities of students through understanding of electronic devices.</li> <li>➤ To understand the physical construction, working and operational characteristics of semiconductor devices.</li> <li>➤ To understand the basics of computational physics.</li> <li>➤ To study numerical algorithms and their implementation to solve problems.</li> </ul>
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1 <sup>st</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-104	Weapon System & Experimental Methods	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Fundamental knowledge of electronic components and basic mathematical skill.
<b>Teaching Scheme</b>	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	<b>Experimental Methods:</b> 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. <b>(Self Study Portion: lock-in detector, box-car integrator, modulation techniques)</b>	12
II	<b>Ordnance :</b> 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. <b>(Self Study Portion: Classification (Small Arms, Mortar as, Guns, Howitzers, Rocket Launchers, Missiles), Classification based on specific tactical roles, Gun Chamber, Firing Mechanism)</b>	12
III	<b>Gun Barrel and Design :</b> 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 frettagged 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). <b>Recoil systems</b> (Functions, mechanism of recoil energy absorption), Buffer types (Valve key, Shallowing groove cylinder, Tapered rod, Rotating), Liquid for buffer, Cut off gear,	12

	<p>Recuperator, Controls to run out, Soft recoil.</p> <p>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)</p> <p><b>(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)</b></p>	
IV	<p><b>Ammunition</b> : Cartridge and make up of cartridges (BL, QF – fixed, separate), Cartridge cases (metallic &amp; essential qualitative requirements, semi-combustible, combustible, relative merits &amp; demerits), Means of ignition (ignition problem, percussion, electrical), classification and characteristics of projectile (ogive, nose, shoulder, body, driving band, base, boat tailing, bands, bourrelet)</p> <p>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.</p> <p><b>(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))</b></p>	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.

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To enhance comprehension capabilities of students through understanding of Instruments.</li> <li>➤ To understand the physical construction, working and operational characteristics of Experimental devices.</li> <li>➤ To understand the basics of Ordnance, Gun and Ammunition.</li> </ul>
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<b>1<sup>st</sup> SEMESTER</b>				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-105 (A)	Computational Physics	8	---	100

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

<b><u>LIST OF EXPERIMENTS: (C/FORTRAN)</u></b>	
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.
<b><u>MATLAB/MATHEMATICA/MAPLE</u></b>	
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	

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To familiarize the students with computational techniques</li> <li>➤ To study numerical algorithms and their implementation to solve problems.</li> </ul>
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2 <sup>nd</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-201	Statistical Mechanics	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Undergraduate thermodynamics and quantum physics, vibrations and waves, differential equations, elementary concepts of errors.
<b>Teaching Scheme</b>	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	<p><b>Statistical Thermodynamics:</b> 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.</p> <p><b>Canonical Ensemble:</b> 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.</p> <p><b>(Self Study Portion: Examples of microcanonical ensemble, harmonic oscillators in Canonical Ensemble, Examples of Grand Canonical Ensemble)</b></p>	14
II	<p><b>Formulation of Quantum Statistics:</b> 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.</p> <p><b>(Self Study Portion: Examples of Quantum mechanical ensembles, Systems of polyatomic molecules.)</b></p>	12
III	<p><b>Ideal Bose gas:</b> 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.</p> <p><b>(Self Study Portion: Thermodynamic description of phase transition)</b></p>	11
IV	<p><b>Ideal Fermi Gas:</b> 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.</p> <p><b>(Self Study Portion: DeHassVan Alphen Effect, thermionic and photoelectric emissions)</b></p>	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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"><li>➤ To develop an understanding of the statistical mechanics.</li><li>➤ To acquire the knowledge of various statistical distributions.</li><li>➤ To understand the applications of statistical mechanics in broad areas of modern physics.</li></ul>
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2 <sup>nd</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-202	Quantum Mechanics	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Matrix and linear algebra, In depth knowledge of calculus sequence, exposure to ordinary differential and partial differential equations.
<b>Teaching Scheme</b>	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	<p><b>General Principles of Quantum Mechanics:</b> 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.</p> <p><b>Mathematical Basics:</b> 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.</p> <p><i>(Self Study Portion: Linear operator, Adjoint Operators, Unitary Operators and transformations, Hermitian operators.)</i></p>	12
II	<p><b>Quantum Dynamics:</b> 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._</p> <p><i>(Self Study Portion: Time evolution of quantum states, time evolution operator and its properties.)</i></p>	10
III	<p><b>Rotation and Orbital Angular Momentum:</b> Rotation Matrix, Angular momentum operators as the generators of rotation. <math>L_x</math>, <math>L_y</math>, <math>L_z</math> and <math>L^2</math> in spherical polar co-ordinates, Eigen values and Eigen functions of <math>L_z</math> and <math>L^2</math> (OP method), Spherical Harmonics, Matrix representation of <math>L_+</math>, <math>L_-</math> and <math>L^2</math>.</p> <p>Spin <math>\frac{1}{2}</math> particles, Pauli spin matrices and their properties, Eigen values and Eigen functions, Spinor transformation under rotation.</p> <p>Total Angular momentum <math>J</math>, Eigen value problem of <math>J_z</math> and <math>J^2</math>, Angular momentum matrices, Addition of angular momenta and C. G. Co-efficient, angular momentum states for composite systems in the angular momenta <math>(\frac{1}{2}, \frac{1}{2})</math> and <math>(1, \frac{1}{2})</math>.</p> <p><i>(Self Study Portion: <math>L_x</math>, <math>L_y</math>, <math>L_z</math> and <math>L^2</math> in spherical polar co-ordinates, Matrix representation of <math>L_+</math>, <math>L_-</math> and <math>L^2</math>)</i></p>	14



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

**TEXT BOOKS:**

1. Quantum Mechanics-Joichan

**REFERENCE BOOKS:**

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.

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To learn the general formalism and the mathematical background of Schrodinger's quantum theory.</li> <li>➤ To obtain analytical solutions of simple systems in one, two and three dimensions.</li> <li>➤ To develop problem solving skills.</li> </ul>
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2 <sup>nd</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-203	Fluid Dynamics	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Basic knowledge of classical mechanics and mathematical physics
<b>Teaching Scheme</b>	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	<b>Fluid Flow Concepts and Basic equations:</b> 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 Venturimeter. <b>(Self Study Portions: Static and dynamics pressure, Losses due to geometric changes:-Sudden expansion and contraction, Venturimeter.)</b>	12
II	<b>Dimensional Analysis and Dynamic Similitude:</b> Buckingham's $\Pi$ Theorem, Dimensionless parameters, Euler's number, Reynold's number, Froude's number, Weber number, Model studies and wind tunnel tests. <b>(Self Study Portions: Reynold's number, Froude's number, Weber number)</b>	10
III	<b>Viscous Effect:</b> 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. <b>Boundary layer concepts:</b> -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. <b>(Self Study Portions: Transverse component of velocity, Displacement thickness, momentum thickness. Drag: Bluff badles, Aerofoil, Boundary layer control, entrance region.)</b>	14
IV	<b>Compressible flow:</b> 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. <b>Fluid Metrology:</b> Pressure measurement, Velocity measurement, Turbulence measurement, Viscosity measurement <b>(Self Study Portions: Pressure measurement, Velocity measurement, Turbulence measurement, Viscosity measurement)</b>	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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"><li>➤ To define basic terms, values and laws in the areas of fluids properties, statics, kinematics and dynamics of fluids, and hydraulic design of pipes</li><li>➤ describe methods of implementing fluid mechanics laws and phenomena while analysing the operational parameters of hydraulic problems, systems and machines.</li></ul>
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2 <sup>nd</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-204(A)	Internal Ballistics	4	20	80

<b>Objectives</b>	This core course intends to give a deep understanding about explosives, gun propellant, internal ballistics and intermediate ballistics.
<b>Pre-Requisites</b>	Idea of basic physics, chemistry and fluid mechanics
<b>Teaching Scheme</b>	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	<p><b>Explosives:</b> Combustion, Deflagration, Explosion, Detonation, Characteristics of an explosive (Criteria for a material to be designated as an explosive), Transition from burning to detonation, Propagation of detonation shockwave, Characteristics of military explosives, Sensitivity, power and brisance, Measurement of explosive parameters, Categorisation of explosives (low explosives – high explosives – primary, secondary, intermediary, tertiary), Explosive train, Gun powder and Pyrotechnic compositions.</p> <p><b>(Self Study Portion: Categorisation of explosives (low explosives – high explosives – primary, secondary, intermediary, tertiary), Explosive train, Gun powder and Pyrotechnic compositions.)</b></p>	12
II	<p><b>Gun propellant:</b> Key feature of propellant, Characteristics of an ideal propellant, explosive compounds and explosive mixtures, chemical composition of gun propellants. Single-, Double-, and Triple base propellants</p> <p><b>Thermo physics and Thermo chemistry of propellants:</b> Oxygen balance, Heat of formation and heat of explosion (or, combustion), Internal energy, Helmholtz free energy changes, Balancing combustion (explosion) equations, Composition of combustion products, Indicators to determine volume of combustion products, Thermal equilibrium, Equilibrium constant, Water-gas equilibrium. Determination of flame temperature.</p> <p><b>Corrections for deviations:</b> from Ideal gas laws, for water-gas equilibrium, for internal energy of products.</p> <p>Prediction of propellant performance, Force constant, Pressure of combustion.</p> <p><b>Efficiency of gun-ammunition system</b> (thermodynamic and piezometric) (Interior ballistics 2-6)</p> <p><b>(Self Study Portion: Corrections for deviations: from Ideal gas laws, for water-gas equilibrium, for internal energy of products. Prediction of propellant performance, Force constant, Pressure of combustion.)</b></p>	12
III	<p><b>Internal Ballistics:</b></p> <p>Propellant combustion, Laws of burning, Propellant vivacity, Form function, Ballistic size, Types of burning, Shape function and Z-f relationship, Burning characteristics of different shapes of propellants, Pressure-time, Travel-time, and Velocity-time curves, All burnt point and its importance.</p> <p>The main issues of internal ballistics, Approach to solution, The basic analytical model and the simplifying assumptions underneath it, Estimation of energy losses under various heads (gas inertia, heat transfer, friction, air resistance inside bore, recoil energy, rotational</p>	12

	<p>energy), Improved analytical model, estimation of velocity. Pressure gradient and prediction of pressure history, Empirical methods of computing muzzle velocity. Le Duc's formula for muzzle velocity (Part2-Balistics-1-11).</p> <p>Importance of pressure-space(shot travel) curve, Variations in loading conditions (propellant mass, propellant size, propellant shape, projectile mass, chamber capacity, bore area, shot-start pressure, shot travel).</p> <p>Attainment of higher velocities (Interior Ballistics 2.12)</p> <p><b>(Self Study Portion: Variations in loading conditions (propellant mass, propellant size, propellant shape, projectile mass, chamber capacity, bore area, shot-start pressure, shot travel). Attainment of higher velocities (Interior Ballistics 2.12))</b></p>	
IV	<p><b>Intermediate Ballistics:</b> Gas dynamics of the muzzle flow field, Flash, Blast, Flash and blast suppression, Sabot and sabot separation process.</p> <p>Rigid body motion of recoiling parts. Barrel vibration, Equations of motion of barrel. Current trends and future directions in gun propulsion</p> <p>Analytical &amp; computational Ballistics: Introduction, Lagrange gradient, Lagrangian approach</p> <p><b>Measurement of Ballistic Parameters:</b></p> <p>Dispersion of Fire, Yaw and Jump by photogrammetry or high speed photography.</p> <p>Barrel recoil and runout, Buffer pressure, Barrel vibration</p> <p><b>(Self Study Portion: Dispersion of Fire, Yaw and Jump by photogrammetry or high speed photography. Barrel recoil and runout, Buffer pressure, Barrel vibration)</b></p>	12
	Total	48

### TEXT AND REFERENCE BOOKS:

1. "Chemistry of Powder and Explosives", Tenney L. Davis
2. "The Chemistry of Explosives", Jacqueline Akavan
3. "Propellants and Explosives – Thermochemical Aspects of Combustion" Naminosuke Kubota, Wiley-VCH
4. "High Explosives and Propellants", S. Fordham, Pergamon Press
5. "Interior Ballistics", 1951 HMSO Publications, UK
6. "Theory of Interior Ballistics of Guns", J Corner, John Wiley and Sons Inc, USA, 1950
7. "Interior Ballistics of Guns", AMCP, US Army Materials Command, February 1965
8. "e-Ballistics" by Gunther Dyckmans (Freely available in the internet).
9. "Mathematical Treatise on Interior Ballistics of Guns", Dr. Himanshu Shekhar, Power Publishers, Kolkata
10. "Text Book of Ballistics and Gunnery", 1987 - War Office, UK.
11. "Ballistics: Theory and Design of Guns and Ammunition", David E. Carlucci and Sidney S. Jacobson.
12. "Elements of Armament Engineering Part II – Ballistics", AMCP, US Army Materials Command, September 1963
13. "Gene Slover's US Navy Pages Naval Ordnance 1937" (Freely available in the Internet)

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To realize the role and practical application of physics in Ballistics.</li> <li>➤ To provide the accomplishments necessary for advanced research in Defense Organizations.</li> </ul>
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<b>2<sup>nd</sup> SEMESTER</b>				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-205 (A)	Electronics Practical	8	---	100

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Fundamental knowledge of electronic components and electronics devices.
<b>Teaching Scheme</b>	It is totally based on Laboratory demonstrations and Laboratory realization.

<b><u>LIST OF EXPERIMENTS</u></b>	
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.

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To familiarize the students with electronic instruments</li> <li>➤ To impart hands-on experience on verification of circuit laws and theorems.</li> <li>➤ To study experimentally the characteristics of diodes and BJT's</li> <li>➤ To make the student understand the basic concepts in multivibrators and digital devices</li> </ul>
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3 <sup>rd</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-301	Solid State Physics	4	20	80

<b>Objectives</b>	This course deals with basic principles and techniques of solid state physics.
<b>Pre-Requisites</b>	Idea of quantum mechanics and atomic physics
<b>Teaching Scheme</b>	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	<p><b>Crystal Physics:</b> 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.</p> <p><b>Lattice vibration and thermal properties:</b> 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.</p> <p><i>(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)</i></p>	13
II	<p><b>Quantized free electron theory:</b> 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.</p> <p><b>Intrinsic and extrinsic semiconductors:</b> carrier concentration and Fermi levels of intrinsic and extrinsic semi-conductors Bandgap. Direct and indirect gap semiconductors. Hydrogenic model of impurity levels.</p> <p><b>Energy bands in solids:</b> 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).</p> <p><i>(Self Study Portion: Sommerfeld's model for metallic conduction. AC conductivity and optical properties, The tight binding model, Electron dynamics in an electric field.)</i></p>	13
III	<p><b>Dielectrics:</b> Polarizability; Clausius-Mossotti formula; Dielectric constant; ferroelectrics.</p> <p><b>Magnetic properties of solids:</b> 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.</p>	11

	(Self Study Portion: Heisenberg exchange interaction. Mean field theory. Antiferromagnetism. Neel point. Other kinds of magnetic order. Nuclear magnetic resonance.)	
IV	<p><b>Superconductivity:</b> 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..</p> <p>(Self Study Portion: Thermodynamics of superconducting transition, London equation, coherence length, BCS Theory)</p>	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

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To understand the basics of crystal structures and crystal systems.</li> <li>➤ To realize the nature of bonding and binding in all crystals.</li> <li>➤ To make students familiar with elastic waves and phonons.</li> <li>➤ To enhance the ability of students to understand electron and band theories.</li> </ul>
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3 <sup>rd</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-302	Electrodynamics	4	20	80

<b>Objectives</b>	Electrostatics 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.
<b>Pre-Requisites</b>	Vector algebra and tensor, calculus, classical mechanics, methods for solutions of differential equations, concepts of relativity, and concepts of fluid mechanics.
<b>Teaching Scheme</b>	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	<b>Maxwell's Equations:</b> 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-Kronig relations. <b>(Self Study Portion: Green function solution of Maxwell's equation, Plane waves in a non conducting medium)</b>	12
II	<b>Microwave Propagation:</b> 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. <b>(Self Study Portion: circular waveguides, Solutions for different terminations)</b>	12
III	<b>Radiation, Scattering and Diffraction:</b> 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 aperture. <b>(Self Study Portion: Rayleigh scattering, Thompson scattering)</b>	12
IV	<b>Covariant Formulation:</b> Four vector notation, Relativistic particle kinematics and dynamics, covariant form of Maxwell equations, Maxwell field tensor, Transformation of electromagnetic field components. <b>Radiation by a moving Charge:</b> 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. <b>(Self Study Portion: covariant form of Maxwell equations, Maxwell field tensor)</b>	12
	Total	48

**TEXT BOOKS:**

- 1 Classical Electrodynamics-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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"><li>➤ To develop theoretical knowledge in electrodynamics.</li><li>➤ To develop skills on solving analytical problems in electrodynamics.</li><li>➤ To understand the electrodynamics of radiating and relativistic systems.</li><li>➤ To give basics of defining the complete electromagnetic response of complex systems.</li></ul>
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3 <sup>rd</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-303	Nuclear and Particle Physics	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Calculus, tensors, basic concepts of Atomic Physics and Quantum Mechanics.
<b>Teaching Scheme</b>	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	<p><b>Nuclear size and shape:</b> Nuclear radii and charge distributions, nuclear binding energy, electric and magnetic moments.</p> <p><b>Nuclear Models:</b> 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.</p> <p><b>(Self Study Portion: Semi-empirical mass formula, Mass Parabolas, Bohr-Wheeler theory of fission, Collective model of Bohr and Mottelson.)</b></p>	12
II	<p><b>The Two-Nucleon Problem:</b> 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.</p> <p><b>Nuclear Force:</b> Central and non-central forces, Force dependent on Isospin, Exchange force, charge dependence and charge symmetry of Nuclear force, Mirror Nuclei.</p> <p><b>(Self Study Portion: n-n scattering, p-p scattering at low energies, Mirror nuclei)</b></p>	12
III	<p><b>Nuclear Reaction:</b> 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.</p> <p><b>(Self Study Portion: Selection Rules for allowed transition, Parity violation.)</b></p>	12
IV	<p><b>Particle Physics:</b> 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.</p> <p>Elementary ideas on quantum field theory, Klein-Gordon equation, Dirac Equation, Dirac Matrices.</p> <p>Particle Accelerators and detectors.</p> <p><b>(Self Study Portion: Particle Accelerators and detectors)</b></p>	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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"><li>➤ To introduce students to the fundamental principles and concepts governing nuclear and particle physics.</li><li>➤ To know about nuclear physics' scientific and technological applications as well as their social, economic and environmental implications.</li><li>➤ To understand the concept of elementary particles.</li></ul>
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3 <sup>rd</sup> SEMESTER				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-304 (For Non Physics students)	Modern Physics & Electronics	4	20	80

<b>Objectives</b>	This course designed to explore the fundamental modern physics and basic electronics for non physics students.
<b>Pre-Requisites</b>	Vector Calculus, Differential Equation and basics of chemistry
<b>Teaching Scheme</b>	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	<b>Quantum Mechanics:</b> 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 <b>(Self Study Portion: Harmonic oscillator)</b>	12
II	<b>Nuclear Structure:</b> Nuclear Composition, some nuclear properties, stable nuclei, binding energy, liquid drop model, Shell model, Meson theory of nuclear forces <b>Nuclear Transformations:</b> 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 <b>(Self Study Portion: Nuclear reactors, nuclear fusion in stars, fusion reactors)</b>	12
III	<b>Solid State Physics :</b> 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. <b>(Self Study Portion: Superconductivity - Fundamentals. Type -I and Type-II superconductors, Flux quantization, Bound electron pairs)</b>	12
IV	<b>Electronics :</b> 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. <b>(Self Study Portion: Thevenin's Theorem, Norton's Theorem, and Maximum Power Transfer Theorem)</b>	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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To know about basics of Quantum Mechanics</li> <li>➤ To know about basics of Nuclear Physics</li> <li>➤ To know about basics of Solid State Physics</li> <li>➤ To know about basics of Electronics</li> </ul>
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<b>3<sup>rd</sup> SEMESTER</b>				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-305	Modern Physics And Material Science Laboratory	8	---	100

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Fundamental knowledge of Modern Physics and Material Science
<b>Teaching Scheme</b>	It is totally based on Laboratory demonstrations and Laboratory realization.

<b><u>LIST OF EXPERIMENTS: (C/FORTRAN)</u></b>	
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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To understand the basic principles of Modern Physics</li> <li>➤ To study the various characteristics of know and unknwn materials.</li> </ul>
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4 <sup>th</sup> SEMESTER (SP-BALLISTICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-401-A	Terminal Ballistics	4	20	80

<b>Objectives</b>	This course deals with Terminal Ballistics mainly classification of projectiles, properties of materials, warheads, design of armours and Forensic Ballistics
<b>Pre-Requisites</b>	Weapon system, internal Ballistics, basics of material science and fluid mechanics
<b>Teaching Scheme</b>	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	<p><b>Terminal Ballistics:</b> General introduction, definition, classification of projectiles, phase diagram and ballistics limit, failure mechanism</p> <p><b>Properties of materials:</b> Introduction, stress in solids, anisotropy of real materials, metallic and non-metallic materials, stress-strain relationships-elastic and plastic deformation, fracture, fragmentation, fatigue, waves in rods, propagation of elastic and plastic waves in rods, shock wave, reflection of elastic waves, bending waves.</p> <p><b>(Self Study Portion: Terminal Ballistics- definition, classification of projectiles, phase diagram)</b></p>	12
II	<p><b>Munitions and the defeat of armour:</b> fragmentation warheads, introduction, natural fragmentation, theoretical estimation of maximum fragmentation size, distribution of the number of fragments and of fragmentation masses, fragmentation initial velocity in a static detonation, direction of projection of fragments, effect of air resistance on fragmentation velocity, fragmentation efficiency, controlled fragmentation.</p> <p><b>Shape charge warheads:</b> estimation of the radii of jet and slug, equation of jet, effect of compressibility, effect of spinning a linear during jet formation, jet breakup, jet stability, break-up time, cut-off velocity, penetration by shaped charge jets.</p> <p><b>Kinetic energy projectiles:</b> introduction, empirical formulae for the prediction of penetration, an application of one dimensional analysis, impact velocity regime, analytical model of failure modes, modeling of penetration/perforation process for high velocity impact of long rod, high explosive squash head, plate charge.</p> <p><b>(Self Study Portion: Munitions and the defeat of armour: Fragmentation, fragmentation warheads, natural fragmentation, controlled fragmentation, Shape charge warheads: Introduction, Penetration by SCW, Kinetic energy projectiles: High Explosive Squash Head)</b></p>	12
III	<p><b>Design and Defeat of Armour:</b> Introduction, Mechanical property requirements, Armour material characteristics, Armour structure, Defeat of armour, Failure mechanism, Ballistics limit.</p> <p><b>Penetration:</b> Penetration Theory, penetration and perforation of metals (aluminum), penetration and perforation of composites.</p> <p><b>(Self Study Portion: Design and Defeat of Armour: Failure mechanism, Ballistics limit.)</b></p>	12



IV	<p><b>Forensic Ballistics:</b> Internal and External Ballistics-Introduction, direction, time and range of fire-projectile velocity, Recoil, Trajectory-effect of projectile on hitting a target, Function of bullet shape, Striking velocity and angel, Tumbling bullets-Cavitations-Ricochet.</p> <p><b>Dispersion:</b> Measure of dispersion, analysis of dispersion, consistency, statistical treatment of consistency, the chance of a round falling within a zone, practical determination of consistency, accuracy, precision-Probability error of delivery, circular probability areas, Ricochet, Safety Zones</p> <p><b>(Self Study Portion: Forensic Ballistics: direction, time and range of fire, velocity, angle of projectile, recoil, trajectory on hitting a target, cavitations.)</b></p>	12
	Total	48

### TEXT BOOKS:

1. Text Book of Ballistics and Gunnery, 1987, War Office, UK.
2. Ballistics: Theory and Design of Gun and Ammunition – DE Carlucci and SS Jacobson, CRC Press

### REFERENCE BOOKS:

1. T.B.B.G. pamphlet No.9
2. Terminal Ballistics- Text Book and atlas of gunshot wounds, Malcom J Dodd, CRC Press, Taylor & Francis publications
3. Firearms in Criminal Investigation and Trials, Dr. BR Sharma, 3rd Edition, Universal Law Publishing Co. Pvt Ltd.
4. Gunshot Wounds – Practical aspects of Firearms, ballistics and Forensic Techniques, Vincent JM DiMaio, Elsevier Science Publishing Co. Inc.
5. Wound Ballistics and the Scientific Background, Karl G Sellier & Beat P Kneubuehl, Elsevier Science Publishing Co. Inc.

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To understand the concept and applications of Terminal Ballistics.</li> </ul>
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4 <sup>th</sup> SEMESTER (SP-BALLISTICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-402-A	External Ballistics	4	20	80

<b>Objectives</b>	This course deals with External Ballistics mainly various aerodynamic forces and moments on a projectile, various projectile trajectories and aeroballistics
<b>Pre-Requisites</b>	Weapon system, internal Ballistics, classical mechanics, fluid dynamics
<b>Teaching Scheme</b>	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	<p><b>Aerodynamic Forces &amp; Moments Acting on Projectiles:</b></p> <p>Elements of trajectory, definition of projectile coordinates, generalised yaw of a projectile, drag force, spin-damping moment, rolling moment, lift and normal force, center of gravity (CG) and center of pressure (CP), overturning moment, Magnus effect, Magnus force and moment, pitch damping force and moment.</p> <p><i>(Self Study Portion: Elements of trajectory, definition of projectile coordinates)</i></p>	12
II	<p><b>Dynamic review:</b> Kinematics of particle, hodograph, kinematics of rigid body, kinematics equations for plane motion of a rigid body using translating and rotating system</p> <p><b>Trajectories:</b> Vacuum trajectory, simple air trajectory (Flat Fire), wind effects on a simple air trajectory, generalized point mass trajectory, effect of earth's rotation on a flat fire and vacuum trajectory six degree of freedom (6-DOF) trajectory, modified point mass trajectory</p> <p><i>(Self Study Portion: Kinematics of particle, hodograph, kinematics of rigid body, Vacuum trajectory)</i></p>	12
III	<p><b>Mass asymmetries:</b> Mass asymmetries, lateral throw-off, aerodynamic jump, static imbalance and dynamic imbalance, <b>Linearized Aeroballistics:</b> Linearized theory, linearized pitching and yawing motions, Gyroscopic and dynamic stability, epicyclic motion, yaw response, roll response, effect of slight mass asymmetry on the initial pitching and yawing motion of a spinning projectile, swerve motion</p> <p><i>(Self Study Portion: Mass asymmetries, lateral throw-off, static imbalance and dynamic imbalance)</i></p>	12
IV	<p><b>Aeroballistic Design:</b> Introduction-Artillery shell-Design criteria-Low drag design for artillery shell-stability of artillery shell, <b>Direct Fire Projectiles:</b> Direct fire projectiles-spin-stabilized K.E. penetrators-statically stable K.E. penetrator and long rods-Aircraft fired projectiles-Bombs and sub-munitions.</p> <p><b>Wind tunnel methods:</b> Examples of supersonic wind tunnel measurement, advantages and disadvantages of wind tunnels for projectile aeroballistics testing.</p> <p><i>(Self Study Portion: Examples of supersonic wind tunnel measurement, advantages and disadvantages of wind tunnels for projectile aeroballistics testing.)</i></p>	12
	Total	48

**TEXT AND REFERENCE BOOKS:**

1. Text Book of Ballistics and Gunnery, 1987, War Office, UK.
2. Military Ballistics: A Basic Manual – GM Moss et al, Brassey Series-unit-1 (ch 1, ch 4), unit-4 (ch-3)
3. Introduction to air craft flight mechanics, Thomas R. Yechout. (freely available on google books)(unit-2)
4. Ballistics: Theory and Design of Gun and Ammunition – DE Carlucci and SS Jacobson, CRC Press: unit-2 (ch-6, 7), unit-3 (ch-8), unit-4 (chap-4)
5. Modern Exterior Ballistics , 1999, Robert L McCoy – Schiffer Publishing Ltd. Unit-V(ch-14)
6. Proximity Fuzes : Theory and Techniques – VK Arora, DRDO, Ministry of Defence. Unit-V(ch1, 2, 3)
7. Ammunition For The Land Battle- PR Courtney-Green, Brassey Series unit-V (ch-13)

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To understand the concept and applications of External Ballistics.</li> <li>➤ To implement this knowledge to design various aeroballistics weapons.</li> </ul>
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4 <sup>th</sup> SEMESTER (SP-BALLISTICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-403-A	Rocket Ballistics	4	20	80

<b>Objectives</b>	This course deals with Rocket Ballistics mainly propulsion system, liquid propellant and solid propellant rocket and Guided Missile systems.
<b>Pre-Requisites</b>	Weapon system, internal Ballistics, external ballistics, fluid mechanics, chemistry and control system
<b>Teaching Scheme</b>	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	<p><b>Classification:</b> Duct jet Propulsion, Rocket Propulsion, Applications of Rocket Propulsion;  <b>Definitions and Fundamentals :</b> Thrust, Exhaust Velocity, Energy and Efficiencies, Typical Performance Values;  <b>Nozzle Theory and Thermodynamic Relations :</b> Summary of Thermodynamic Relations, Isentropic Flow Through Nozzles, Nozzle Configurations.  <b>(Self Study Portion: Summary of Thermodynamic Relations, Isentropic Flow Through Nozzles)</b></p>	12
II	<p><b>Flight Performance :</b> Effect of Propulsion System on Vehicle Performance, Flight Vehicles, Military Missiles; <b>Chemical Rocket Propellant Performance Analysis :</b> Background and Fundamentals, Analysis of Nozzle Expansion Processes, Computer – Assisted Analysis;  <b>Liquid Propellant Rocket Engine Fundamentals :</b> Types of Propellants, Propellant Tanks, Propellant Feed Systems, Gas Pressure Feed Systems, Tank Pressurization, Turbo-pump Feed Systems and Engine Cycles; <b>Liquid Propellants :</b> Propellant Properties, Liquid Oxidizers, Liquid Fuels, Liquid Monopropellants, Gelled Propellant, Gaseous Propellants, Safety and Environmental Concerns; <b>Thrust Chambers :</b> Combustion Chamber and Nozzle, Materials and Fabrication, Starting and Ignition; <b>Liquid Propellant Combustion and Its Stability :</b> Combustion Process, Combustion  <b>(Self Study Portion: Thrust Chambers : Combustion Chamber and Nozzle, Materials and Fabrication, Starting and Ignition; Liquid Propellant Combustion and Its Stability : Combustion Process, Combustion)</b></p>	12
III	<p><b>Engine system, Controls and Integration :</b> Engine Design; <b>Solid Propellant Rocket Fundamentals :</b> Basic Relations and propellant Burning Rate, Propellant Grain and grain Configuration, Propellant Grain Stress and Strain, Attitude Control and Side Maneuvers with Solid Propellant Rocket Motors; <b>Solid propellants :</b> Classification, Propellant Characteristics, Propellant Ingredients, Liners, Insulators, and Inhibitors, Propellant Processing and Manufacture; <b>Solid Propellant Combustion and Its Stability :</b> Ignition Process, Combustion Instability; <b>Solid Rocket Components and Motor Design :</b> Motor Case, Nozzles, Igniter Hardware.  <b>Thrust Vector Control :</b> TVC Mechanisms with a Single Nozzle, TVC with Multiple Thrust Chambers or Nozzles, Testing, Integration with Vehicle; <b>Selection of rocket Propulsion Systems :</b> Selection Process, Criteria for selection; <b>Rocket Exhaust Plumes :</b> Plume Appearance and Flow Behavior, Plume Effects; <b>Rocket Testing :</b> Types of Tests, Test facilities and Safeguards, Instrumentation and Data Management, Flight Testing.</p>	12

	(Self Study Portion: Rocket Exhaust Plumes : Plume Appearance and Flow Behavior, Plume Effects; Rocket Testing : Types of Tests, Test facilities and Safeguards, Instrumentation and Date Management, Flight Testing.)	
IV	<p><b>Guided Missile Systems:</b> Introduction, Strategic vs Tactical Missiles, Guided Missile Sub systems (AirFrame, Propulsion, Guidance, Control system etc); <b>Basics of Aerodynamics:</b> Flow around a supersonic Missiles, Aerodynamic Forces and Moments acting on a missile; <b>Missile Control Methods and Technology:</b> Introduction, Types and Configuration (Pneumatic, Hydraulic and Electric Controls); <b>Generalised Equations of Motion:</b> System of Axes, Earth axes , Euler angles and attitudes, Axes Transformations, Equations of motions of a symmetric rigid body; <b>Missile Guidance Systems:</b> Introduction, Command LOS guidance, Homing Guidance (Active Homing, Semi-active and Passive), Proportional Navigation Guidance System</p> <p>(Self Study Portion: Missile Guidance Systems: Introduction, Command LOS guidance, Homing Guidance (Active Homing, Semi-active and Passive ), Proportional Navigation Guidance System)</p>	12
		Total 48

#### TEXT AND REFERENCE BOOKS:

1. Rocket Propulsion Elements, George P. Sutton, Oscar Biblarz, John Wiley & Sons Inc., 8<sup>th</sup> Edition, 2010.
2. Missile Guidance & Control Systems, George M. Siouris, 2004 Springer-Verlag, New York, Inc.
3. Tactical and Strategic Missile Guidance by Paul Zarchan

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To understand the concept and applications of Rocket Ballistics.</li> </ul>
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4 <sup>th</sup> SEMESTER- SP- BALLISTICS- PRACTICAL				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-404-A	Ballistics Practical	8	---	100

<b>Objectives</b>	This practical course enables the students to calculate various ballistics parameters by using instruments.
<b>Pre-Requisites</b>	Fundamental knowledge of mechanics, electronics and ballistics
<b>Teaching Scheme</b>	It is totally based on Laboratory demonstrations and Laboratory realization.

<u>LIST OF EXPERIMENTS</u>	
1	To predict and verify the range of the projectile launched at an angle. The initial speed of the projectile is determined by shooting it horizontally.
2	To predict and verify the range of the projectile launched at an angle. Photogates are used to determine the initial speed
3	To determine how the range of the projectile depends on the launch angle.
4	To determine how the vertical distance of a projectile drops is related to the horizontal distance the projectile travels when it is launched.
5	To show that the initial KE of a projectile shot straight up is transformed into an equal amount of gravitational potential energy
6	To show that momentum is conserved for elastic collisions in two dimensions
7	To find the launch angle that will maximize the height on a vertical wall for a projectile launched at a fixed horizontal distance from the wall
8	To show that the path of a projectile is parabolic
9	To measure the precession rate of a Gyroscope and compare it to theoretical value
10	To show that two disks spinning in opposite directions at the same angular speed will not precess when a torque is applied
11	To show three different types of nutations
12	To determine the value of gamma and work done for an adiabatic compressed system
13	Measurement of fluid velocities and confirm the Continuity Equation
14	Determination of pressure difference by using Bernoulli's Equation
15	Measurement of tensile strength, yield strength, compressive strength, ductility and modulus of elasticity of a material
16	To study Ideal gas law and adiabatic process and determine ratio of specific heat capacities for air using Ruchhardt's method
17	Measurements of static, total pressure, and velocity of the fluid stream using Pitot tube
18	Surveying of distance (range) and height measurements by Total Station

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To understand the operation of Ballistics instruments.</li> <li>➤ To calculate various Ballistic parameters to understand the design behavior of projectiles.</li> </ul>
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<b>4<sup>th</sup> SEMESTER- SP- BALLISTICS</b>				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-405-A	Project & Grand-Viva	8	---	100

<b>Objectives</b>	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/Applied Physics/Ballistics as project work.
<b>Pre-Requisites</b>	Fundamental knowledge of Physics .

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To know the research methodology of Physics</li> <li>➤ To know the process to take up research activities from a known topic.</li> </ul>
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4 <sup>th</sup> SEMESTER (SP-ELECTRONICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-401-B	Electrical Circuits and Control	4	20	80

<b>Objectives</b>	This course deals with advanced electrical circuit and Control system analysis
<b>Pre-Requisites</b>	Laplace Transform, basics of Electronics
<b>Teaching Scheme</b>	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. <b>(Self Study Portion: Milliman's theorem, Maximum Power Transfer Theorem.)</b>	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. <b>(Self Study Portion: Parallel resonance, bandwidth, Q-factor)</b>	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. <b>(Self Study Portion: Mason's gain formula - Examples)</b>	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. <b>(Self Study Portion: concepts of stability - Routh-Hurwitz stability.)</b>	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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"><li>➤ To introduce students to the basics of electrical circuits to advance circuits.</li><li>➤ To understand the concept of control system.</li></ul>
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4 <sup>th</sup> SEMESTER (SP-ELECTRONICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-402-B	Optoelectronics and Optical Communication	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Semiconductor devices, transmission devices, electrodynamics
<b>Teaching Scheme</b>	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	<b>Optical Processes in Semiconductors:</b> 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	<b>Semiconductor Junctions :</b> The hetrojunction- LED structure - heterojunction LED - Edge emitting LED- I-VCharacteristics -Spectral and frequency response. <b>Photodetectors:</b> 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	<b>Switching Devices and Opto-electronic ICs:</b> 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	<b>Fiber Optic Communication Optical fiber</b> - 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.

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"><li>➤ To understand the concept of optical processes in various semiconductor devices</li><li>➤ To get a clear idea regarding Solar cells and Optical Fiber communication.</li></ul>
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4 <sup>th</sup> SEMESTER (SP-ELECTRONICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-403-B	Pulse and Digital Circuits	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Basics of Electronics and electrical components, Laplace transform
<b>Teaching Scheme</b>	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	<p><b>Linear Wave shaping :</b> 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.</p> <p><b>Non-Linear Wave shaping:</b> 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.</p> <p><i>(Self Study Portion: High pass, low pass RC circuits, Ringing circuit, Emitter coupled clipper, Comparators, applications of voltage comparators )</i></p>	14
II	<p><b>Switching Characteristics of Devices:</b> 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.</p> <p><i>(Self Study Portion: Diode as a switch, piecewise linear diode characteristics.)</i></p>	10
III	<p><b>Multivibrators:</b> Analysis and Design of Bistable, Monostable, Astable Multivibrators and Schmitt trigger using transistors</p> <p><b>Time base Generators:</b> 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.</p> <p><i>(Self Study Portion: Transistor Bootstrap time base generator, Current time base generators)</i></p>	12
IV	<p><b>Combinational Digital Circuits:</b> 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</p> <p><b>Sequential Digital Circuits:</b> 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.</p> <p><i>(Self Study Portion: Number systems and codes, De-Morgan laws, Boolean Algebra)</i></p>	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

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"><li>➤ To understand the concept of Wave shaping circuits, multivibrators and time base generators</li><li>➤ To understand the design of sequential circuits and combinational circuits.</li><li>➤ To apply the knowledge to develop various memory units.</li></ul>
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<b>4<sup>th</sup> SEMESTER- SP- ELECTRONICS- PRACTICAL</b>				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-404-B	Advanced Electronics	8	---	100

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

<b><u>LIST OF EXPERIMENTS: (C/FORTRAN)</u></b>	
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.

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To understand the operation of advance electronics devices</li> <li>➤ To assemble various electronics circuit with help of electronic components.</li> </ul>
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<b>4<sup>th</sup> SEMESTER- SP- ELECTRONICS</b>				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-405-B	Project & Grand-Viva	8	---	100

<b>Objectives</b>	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/Ballistics as project work.
<b>Pre-Requisites</b>	Fundamental knowledge of Physics.

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To know the research methodology of Physics</li> <li>➤ To know the process to take up research activities from a known topic.</li> </ul>
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4 <sup>th</sup> SEMESTER (SP-CONDENSED MATTER PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-401-D	Condensed Matter Physics-I	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Basics of quantum mechanics, solid state physics and atomic physics
<b>Teaching Scheme</b>	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	<b>X-ray Diffraction and Crystallography</b> : 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 <b>(Self Study Portion: Identification of Bravais lattice, Calculation of lattice parameter, Powder diffractometric techniques)</b>	12
II	<b>Imperfection in Crystals</b> : 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. <b>(Self Study Portion: Plane defects- stacking faults , grain boundaries, Role of dislocations in crystal growth.)</b>	12
III	<b>Lattice vibrations and Phonons</b> : 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 <b>(Self Study Portion: Phonons, properties of phonons, Momentum of phonons)</b>	12
IV	<b>Thermal properties and Diffusion</b> : 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 and sphere; Diffusion couple, application based on second law of diffusion, Electrical conductivity in ionic crystal, Einstien relation of diffusion. <b>(Self Study Portion: Diffusion couple, application based on second law of diffusion, Electrical conductivity in ionic crystal, Einstien relation of diffusion.)</b>	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

<b>Course Outcome</b>	At the end of this course the learner is expected: ➤ To implement the course knowledge to pursue in condensed matter research.
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4 <sup>th</sup> SEMESTER (SP-CONDENSED MATTER PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-402-D	Condensed Matter Physics-II	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Basics of quantum mechanics, solid state physics and atomic physics
<b>Teaching Scheme</b>	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	<p><b>Semiconductor and Semiconductor Crystals</b> : . 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. Semiconductor 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</p> <p><b>(Self Study Portion: Effective mass of electron and its physical interpretation, electron diffraction experiment, Effective masses in Semiconductor )</b></p>	12
II	<p><b>Fermi Surfaces and Metals</b> ; 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</p> <p><b>(Self Study Portion: Experimental determination of Fermi surface, Quantization of orbits in a magnetic field, De Hass-Van Alphen effect)</b></p>	12
III	<p><b>Optical properties of Solids</b> : Dielectric function of free electron gas, Plasma optics, Dispersion relation for electromagnetic waves, 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.</p> <p><b>(Self Study Portion: Excitons- Frenkel and Mott-Wannier excitons; Raman effect in crystal, Electron spectroscopy with X-rays.)</b></p>	12

IV	<p><b>Exotic Solids and Nanotubes</b> : Quasi crystals, Liquid crystals, Polymers-basics and classification, Graphite structure, Fullerenes , 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.</p> <p><b>(Self Study Portion: Application of Schrodinger equation in Nanometric world –three dimension, two dimension, one dimension)</b></p>	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

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To implement the course knowledge to pursue in condensed matter and nano technology research</li> </ul>
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4 <sup>th</sup> SEMESTER (SP-CONDENSED MATTER PHYSICS)				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-403-D	Condensed Matter Physics-III	4	20	80

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Basics of quantum mechanics, solid state physics and atomic physics
<b>Teaching Scheme</b>	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	<p><b>Electron Transport Phenomenon:</b> 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.</p> <p><i>(Self Study Portion: Thermoelectric effects, Thermopower, Seebeck effect, Peltier effect, The Wiedemann-Franz law)</i></p>	12
II	<p><b>Nanostructures and Nano-scale characterisation techniques:</b> 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</p> <p><i>(Self Study Portion: Quantum Mechanics of Low-Dimensional systems: Density of states and quantum confinement, super lattice and Band offsets)</i></p>	12
III	<p><b>Electron Transport in Nanostructures:</b> 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</p> <p><i>(Self Study Portion: Semiconductor and metallic dots, Optical spectra, Discrete charge states and charging energy; Electrical transport in 0D-Coulomb blockade phenomenon.)</i></p>	12

IV	<p><b>Beyond the independent electron approximation:</b> 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).</p> <p>(Self Study Portion: Lindhard theory of screening, Friedel oscillations, Frequency dependent Lindhard screening)</p>	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

<b>Course Outcome</b>	<p>At the end of this course the learner is expected:</p> <ul style="list-style-type: none"> <li>➤ To implement the course knowledge to pursue in condensed matter and nano technology research</li> </ul>
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<b>4<sup>th</sup> SEMESTER (SP-CONDENSED MATTER PHYSICS)-PRACTICAL</b>				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-404-D	Advanced Practicals	8	---	100

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

<b><u>LIST OF EXPERIMENTS:</u></b>	
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 (Seebeck effect).

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To understand the characteristics of various materials for application purpose.</li> </ul>
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<b>4<sup>th</sup> SEMESTER- SP- CONDENSED MATTER PHYSICS</b>				
Sub. Code	Subject Name	Credit	Int. Marks	Ext. Marks
APAB-405-D	Project & Grand-Viva	8	---	100

<b>Objectives</b>	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.
<b>Pre-Requisites</b>	Fundamental knowledge of Physics.

<b>Course Outcome</b>	At the end of this course the learner is expected: <ul style="list-style-type: none"> <li>➤ To know the research methodology of Physics</li> <li>➤ To know the process to take up research activities from a known topic.</li> </ul>
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