DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY

CIRCULAR NO.SU/Sci./Forensic Sci./67/2021

It is hereby inform to all concerned that, the syllabus prepared by the Ad-hoc Board in Forensic Science and recommended by the Dean, Faculty of Science & Technology the Hon'ble Vice-Chancellor has accepted the following syllabi in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith for University and Affiliated Colleges.

Sr.No.	Syllabus (under Choice Based Credit System)
1.	**M.Sc. Forensic Cyber semester Ist to IVth.**
2.	**M.Sc. Forensic Toxicology semester Ist to IVth.**
3.	**M.Sc. Applied Physics and Ballistics semester Ist to IVth.**
4.	**PG Diploma in Digital and Cyber Forensic & Related Law semester Ist and IInd**
5.	**PG Diploma in Forensic Science & Related Law semester Ist and IInd**
6.	**Service Course**

This shall be effective from the Academic Year 2021-22 and onwards.

All concerned are requested to note the contents of this circular and bring notice to the students, teachers and staff for their information and necessary action.

University Campus,
Aurangabad-431 004.
REF.NO. SU/SCI/2021/4692-700
Date:- 06-12-2021.

Deputy Registrar,
Academic Section.

Copy forwarded with compliments to :-

1] **The Principal of all affiliated concerned Colleges,**
Dr. Babasaheb Ambedkar Marathwada University,

2] **Head of the Department, Department of Forensic Science,**
Dr.Babasaheb Ambedkar Marathwada University, Aurangabad.

3] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

Copy to :-

1] The Director, Board of Examinations & Evaluation,Dr.BAMU,A'bad.
2] The Section Officer,[M.Sc.Unit] Examination Branch,Dr.BAMU,A'bad.
3] The Programmer [Computer Unit-1] Examinations, Dr.BAMU,A'bad.
4] The Programmer [Computer Unit-2] Examinations, Dr.BAMU,A'bad.
5] The In-charge,[E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.BAMU,A'bad.
6] The Public Relation Officer, Dr.BAMU,A'bad.

Dr. Babasaheb Ambedkar Marathwada University,

Aurangabad

STRUCTURE AND CURRICULAM
FOR

M.Sc. Applied Physics and Ballistics Programme
(Choice Based Credit System)

Academic Year ***2021-22*** onwards

Dean
Faculty of Science & Technology
Dr. Babasaheb Ambedkar Marathwada
University, Aurangabad

Structure and Curriculum for
M.Sc. Applied Physics and Ballistics
Programme (Choice Based Credit System)

The **M.Sc. Applied Physics and Ballistics** Programme is divided into four semesters having **100 credits.** There are **15 theory courses** of **60 credits** (04 credits each) with 1 **service course** of 04 credits. Besides there are **7 laboratory courses** of **28** credits (04 credits each) and a **research project of 12 credits**. Tutorial, assignments and seminar presentation are integral components of all theory courses.

Eligibility:

Those who have completed any Bachelor degree in any discipline of science from a recognized University/ Institution are eligible for admission as per the rules and regulations laid down by Dr. Babasaheb Ambedkar Marathwada University, Aurangabad.

Intake Capacity :- 30 Seats to be filled as per following criterion.

I) Eighty (80%) seats shall be reserved for the eligible candidates those have obtained degree from Dr. Babasaheb Ambedkar Marathwada University, Aurangabad.

II) Ten (10%) seats shall be reserved for the eligible candidate who has obtained the degree from the other University within the State of Maharashtra. One seat will be for open and the other seat will go for student having higher percentage from any reserved category.

III) Ten (10%) seats shall be reserved for the eligible candidate who has obtained the degree from the other State Universities and will be filled on the basis of merit.

Note:

1. ***If any seat remains vacant then it will be allotted to candidate pertaining to criteria I) above further vacant seat/s if any will be allocated to waitlist candidate belonging to criteria II or then to criteria III.***
2. ***Prevailing reservation policies of Maharashtra state and Dr. Babasaheb Ambedkar Marathwada University will be applicable.***

Choice Based Credit System (CBCS):-

The choice based credit system has been adopted. This provides flexibility to make the system more responsive to the changing needs of our students, the professionals and society. Students will have to earn respective credits for the award of the degree.

Choice Based Credit System (CBCS) :

The choice based credit system has been adopted for this program. This provides flexibility to make the system more responsive to the changing needs of our students, the professionals and society. It gives greater freedom to students to determine their own pace of study. The credit based system also facilitates the transfer of credits.

For the award of **M.Sc. Applied Physics and Ballistics**, students will have to earn 100 credits.

Credit-to- contact hour Mapping:

One contact hour per week is assigned 1 credit for theory and 0.5 credits for laboratory courses/ research project. Thus a 4 - credit theory course corresponds to 4 contact hours per week and same analogy will be applicable for laboratory courses / research project.

Attendance:-

Students must have minimum of 75 % attendance in each theory, practical paper for appearing examination otherwise he / she will not be strictly allowed for appearing the University examination.

However, students having 65 % attendance may request Head of the concerned Institution for the condonation of attendance on medical ground.

Evaluation Methods:-
The assessment will be based on continuous internal assessment (CIA) and semester end examination (SEE). There shall Continuous Internal Assessment for each theory paper. In all semester, 20% (i.e. 15) marks shall be for CIA and 80% (i.e. 60) marks for SEE. Marks obtained by the student in all heads viz. CIA and SEE shall be added while declaring the final result.

Continuous Internal Assessment (CIA):-
The internal marks shall be assigned on the basis of tutorials/ home assignment /seminar presentation and weekly tests/preliminary examination to be conducted by the concerned Institution. These marks shall be communicated to the University before commencement of semester end examination.

Semester End Examination (SEE) :
The semester end examination for each theory and practical paper shall be conducted by the University at the end of each semester.

Results Grievances / Redressal and ATKT rules :-
Result Grievances / redressal /revaluation and ATKT rules shall be as made applicable by the University from time to time.

Earning Credits:-
At the end of every semester, a letter grade will be awarded in each course for which a student had registered. A student's performance will be determined by the number of credits that he/she earned by the weighted Grade Point Average (GPA). The SGPA (Semester Grade Point Average) will be awarded after completion of respective semester and the CGPA (Cumulative Grade Point Average) will be awarded at the end of the 4th semester by the University.

Grading System:-

A ten point rating scale shall be used for the evaluation of the performance of the students to provide letter grade for each course and overall grade for the Master Programme. Grade points are based on the total number of marks obtained by him / her in all heads of the examination of the course. The grade points and their equivalent range of marks are shown in the following Table

Table : Ten point grade and grade description

Marks Obtained (%)	Grade Point	Letter Grade	Description
90-100	9.00- 10	O	Outstanding
80-89	8.00-8.90	A^{++}	Exceptional
70-79	7.00-7.90	A^{+}	Excellent
60-69	6.00-6.90	A	Very Good
55-59	5.50-5.90	B^{+}	Good
50-54	5.00-5.40	B	Fair
45-49	4.50-4.90	C^{++}	Average (Above)
41-44	4.1-4.49	C	Average
40	4.0	P	Pass
< 40	0.0	F	Fail (Unsatisfactory
	0.0	AB	Absent

- Non appearance in any examination / assessment shall be treated as the students have secured zero marks in that subject examination / assessment.
- Minimum P grade (4.00 grade points) shall be the limit to clear / pass the course / subject. A student with F grade will be considered as 'failed" in the concerned course and he / she has to clear the course by appearing in the next successive semester examinations.
- Every student shall be awarded grade points out of maximum 10 points in each subject (based on 10 point scale). Based on the grade points obtained in each subject, Semester Grade Point Average (SGPA) and then Cumulative Grade Point Average (CGPA) shall be computed. Results will be announced at the end of each semester and CGPA will be given on the completion of M. Sc. programme.

Computation of SGPA (Semester Grade Point Average) and CGPA (Cumulative Grade Point Average)

Grade in each subject / paper will be calculated based on the summation of marks obtained in internal and semester end examination.

The computation of SGPA and CGPA will be as below

- Semester Grade Point Average (SGPA) is the weighted average points obtained by the students in a semester and will be computed as follows

$$SGPA = \frac{\text{Sum (Course Credit X Number of Grade Points in concern Course Gained by the Student)}}{\text{Sum (Course Credit)}}$$

The SGPA will be mentioned on the mark sheet at the end of every semester.

- The Cumulative Grade Point Average (CGPA) will be used to describe the overall performance of a student in all semester of the course and will be computed as under.

$$CGPA = \frac{\text{Sum (All four Semester SGPA)}}{\text{Total Number of Semester}}$$

The SGPA and CGPA shall be rounded off to the second place of decimal.

Grade Card:-

Results will be declared and the grade card (containing the grades obtained by the student along with SGPA) will be issued by the university after completion of every semester. The grade card will be consisting of following details.

- Title of the courses along with code opted by the student.
- Credits associated with the course.
- Grades and grade points secured by the student.
- Total credits earned by the student in a particular semester.
- Total credits earned by the students till that semester.
- SGPA of the student.
- CGPA of the student (at the end of the 4th semester).

Cumulative Grade Card:-

The grade card sheet showing details grades secured by the student in each subject in all semester along with overall CGPA will be issued by the University at the end of 4th semester.

Course Structure:

MSCFAPBS- M.Sc. Forensic Applied Physics & Ballistics Semester, **P-**Paper, **L-**Lab, **D-** Dissertation

Semester I				
Course	**Course Title**	**Teaching time/week**	**Marks**	**Credits**
MSCFAPBSI P1	Classical Mechanics	4 hours	100	4
MSCFAPBSI P2	Mathematical Methods in Physics	4 hours	100	4
MSCFAPBSI P3	Electronics & Computer Programming	4 hours	100	4
MSCFAPBSI P4	Weapon System & Experimental Methods	4 hours	100	4
MSCFAPBSI L1	Lab course 1	8 hours	100	4
MSCFAPBSI L2	Lab course 2	8 hours	100	4
Total Credits for Semester I : 24 (Theory : 16 ; Laboratory : 08)				
Semester II				
MSCFAPBSII P1	Statistical Mechanics	4 hours	100	4
MSCFAPBSII P2	Quantum Mechanics	4 hours	100	4
MSCFAPBSII P3	Fluid Dynamics	4 hours	100	4
MSCFAPBSII P4	Internal Ballistics	4 hours	100	4
MSCFAPBSII L3	Lab course 3	8 hours	100	4
MSCFAPBSII L4	Lab course 4	8 hours	100	4
Total Credits for Semester II : 24 (Theory : 16 ; Laboratory : 08)				
Semester III				
MSCFAPBSIII P1	Solid State Physics	4 hours	100	4
MSCFAPBSIII P2	Nuclear & Particle Physics:	4 hours	100	4
MSCFAPBSIII P3	Research Methodology	4 hours	100	4
MSCFAPBSIII P4	Modern Physics and Electronics	4 hours	100	4
MSCFAPBSIII L5	Lab course 5	8 hours	100	4
MSCFAPBSIII L6	Lab course 6	8 hours	100	4
Total Credits for Semester III : 28 (Theory : 16 ; Laboratory : 08; Service course : 04)				
*****students have to opt a service course in this semester as per the prevailing norms of the university**				

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Semester IV				
MSCFAPBSIV P1	Terminal Ballistics	4 hours	100	4
MSCFAPBSIV P2	External Ballistics	4 hours	100	4
MSCFAPBSIV L7	Lab course 7	8 hours	100	4
MSCFAPBSIV D	Project/Dissertation	24 hours	100	12
Total Credits for Semester IV : 24 (Theory : 08 ; Laboratory : 04 ; Research Project : 12)				
Total Credits : 100 (Sem I : 24 + Sem II : 24 +Sem III : 28 + Sem IV : 24)				

Notes:

- Tutorial / assignments are integral components of all theory courses.
- Tutorials consist of conceptual as well as numerical problems / questions based the respective theory courses in the semester covering all four (04) units
- Each course / paper should be taught for 60 contact hours (48 lectures and 12 tutorials).
- Teaching duration for LAB COURSES in all semesters should be of 08 hours per week per batch.
- One batch of the students will be consisting students for laboratory courses as well as project.
- Each of the courses is divided into four units.
- The content of theory course / paper as well laboratory (practical) course may be modified time to time (with the approval DC) to keep pace with the recent developments and trends in the subject.

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Semester I

MSCFAPBSI P1: Classical Mechanics

Unit I. **Lagrangian and Hamiltonian Formalism:**

Constraints-D'Alembert's principle and Lagrange's equations-velocity dependent potentials and the dissipation function, simple applications of the Lagrange formulation. Variational Principle and Lagrange's Equations: calculus of variations-Derivations of Lagrange's equations-from Hamilton's principle-Extension of Hamilton's principle to nonholonomic systems- Advantages of variational principle formulation-conservation theorems and symmetry properties.

Hamiltonian and Hamilton's equations of motion: Canonical transformations: Poisson brackets, Langrange Brackets, Action-angle variables, Hamilton-Jacobi equation.

Unit II. **Central force Problems:**

Reduction to the equivalent one-body problem-The equations of motion and first integrals-The equivalent one-dimensional problems and classification of orbits-The virial theorem-The differential equation of orbit and integrable power-law potentials-conditions for closed orbits (Bertrand's theorem)-The Kepler Problem: Inverse square law of force-The motion in time in the Kepler problem-The Laplace-Runge-Lenz vector-Scattering in a central force field, Transformation of the scattering problem to the laboratory co-ordinates.

Unit III. **The kinematics of Rigid Body Motion and Small Oscillations:**

The independent co-ordinates of a rigid body-Orthogonal transformation-Formal properties of the transformation matrix, The Euler Angles, Euler's theorem on the motion of a rigid body-Finite rotations-Infinitesimal rotations-Rate of change of vector-The Coriolis force.

Small Oscillations: Coupled Oscillations, normal modes.

Unit IV. **The Rigid Body Equations of Motion**

Angular momentum and kinetic energy of motion about a point-Tensor and dyadics-The inertia tensor and the momentum of inertia-The eigen values of the inertia tensor and the principal axis transformation-Methods of solving rigid body problems and the Euler equations of motion Torque-Free motion of a rigid body-The heavy symmetrical top with one point fixed-Precession of the equinoxes and of satellite orbits-Precession of system of changes in a magnetic field.

TEXT BOOKS:

1 . Classical Mechanics-Herbert Goldstein, AddisonWesley/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
5. An Introduction to Continuum Mechanics-M. E. Gurtin, Academic Press

MSCFAPBSI P2: Mathematical Methods in Physics

Unit I. **Functions of a Complex Variable**: Analytic functions, Cauchy's Integral Theorem, Cauchy's Integral Formula, Taylor's Theorem, Laurent's Theorem, Singularities, Residues, Residue Theorem and Evaluation of Integrals, multi-valued function-branch point and branch cut, contour integration involving branch point.

Unit II. **Linear Vector Space:** Definition, Linear independence, basis and dimension, scalar product, dual vector, Cauchy-Schwarz inequality, orthonarmal basis, Scmidt orthogonalisation process.
Matrices: Inverse of a matrix, orthogonal matrix, rotation, similarity transformation, Eigen-values and eigenvectors, secular equation, Cayley-Hamilton theorem, matrix diagonalisation.

Unit III. **Tensors:** Introduction, Cartesian tensor, algebra of Cartesian tensors, outer product theorem, quotient theorem, contraction theorem, tensor algebra, the Kronecker delta and Levi-Civita tensors, pseudo-tensors, tensor calculus, tensors in Skew Cartesian frames, contravariant and covariant representation, general tensors, algebra of general tensors, relative tensors, covariant derivative, calculus of general tensors, the Reimann-Christoffel symbols.
Group theory: Basic concepts of groups, group representation, relevance to quantum mechanics, Lie group and Lie algebra, SU(2) groups and their representation, SO(3) groups and their representation.

Unit IV. **Special Functions:** Series solutions: Frobenius Method, Hermite Polynomials, Legendre polynomials, generating function, recurrence formulae, orthogonality properties, Bessel's function, generating function, recurrence formulae, orthogonality properties, Hypergeometic functions and their properties, Laguree polynomial and their properties, Green Functions.
Integral Transform: Fourier series, Fourier Integrals, Fourier transforms, Convolution theorem, Laplace transform- derivatives, properties and applications

to solution of differential equations.

Elementary Probability Theory: random variables, Binomial, Poissson and Normal distributions.

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

MSCFAPBSI P3: Electronics and Computer Programming

Unit I. **Network Analysis:** Node & mesh analysis, Superposition theorem, Thevenin's theorem, Reciprocity theorem, Norton's theorem, Maximum power transfer theorem, Network Analysis using Laplace Transformation: Step response of series RL, RC, RLC, parallel RLC, Response of series RL, RC, RLC, and parallel RLC to exponential driving sources.

Unit II. **Semiconductor devices :** Semiconductors in equilibrium: electron and hole statistics in intrinsic and extrinsic semiconductors, metal-semiconductor junctions, Ohmic and rectifying contacts, P-N Junction Diode, Applications of Diodes: Rectifier circuits, Clipping and clamping circuits, Special purpose diodes: Zener Diode, Tunnel diode, LED, photo diode, etc, Transistors: BJT and FET, Transitor biasing, Positive feedback, Negative feedback, transistor as an amplifier, Oscillators, OP-AMP: Basics, Virtual Ground, The Ideal Op Amp, Inverting and Non – Inverting configurations, Equivalent Circuit model, Op-amp application in Integration, differentiation and Summing Circuits, Differential Amplifier, Voltage Buffer.

Unit III. **Digital Electronics:** Number Systems, Binary Arithmetic, Boolean Algebra, Logic Gates, Simplification using Karnaugh map, Combinational Circuits: Adder, Subtractor, Multiplexer, decoder, comparator. Sequential Circuits: Flip Flops, Timers, Shift Registers, Counters and D/A and A/D Converters, Microprocessor and microcontroller basics.

Unit IV. **Numerical Computing:** 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.

TEXT AND REFERENCE BOOKS:

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

MSCFAPBSI P4: Weapon System & Experimental Methods

Unit I. **Experimental Methods:** Transducers (Strain Gauges, temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors), measurement and control; Signal conditioning and recovery, impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding; lock-in detector, box-car integrator, modulation techniques.

Unit II. **Ordnance :** Introduction, Classification (Small Arms, Mortar as, Guns, Howitzers, Rocket Launchers, Missiles), Classification based on specific tactical roles, Basic structure, Superstructure, Saddle, Cradle, Requirements of an Ideal Field Gun, Basic components and functional requirements, Certain definitions related to a barrel, Rifling, Rifling design considerations (Forms of twist, Rifling profile), Breech mechanism (breech ring, breech block, thrust surfaces, breech screw, carrier), Extractor, Obturation, Firing mechanism, Chamber.

Unit III. **Gun Barrel and Design :** Desired characteristics of a barrel, Stresses on barrels (Radial stress, Circumferential stress, Longitudinal stress, Torsional stress and Girder stress), Barrel construction (Wire wound, Composite, Mono block), Use of plastic region of the material and its application to auto frettaged method of gun construction, Comparison of different methods of gun construction, Basic gun design rules, Theories of elastic failures, von Misses-Hencky theory of failure including its derivation, Barrel wear (erosion, fatigue, causes and their reduction). (Interior ballistics 3.3) (Part2-Balistics-1-14.2/3).

Recoil systems (Functions, mechanism of recoil energy absorption), Buffer types (Valve key, Shallowing groove cylinder, Tapered rod, Rotating), Liquid for buffer, Cut off gear,

Recuperator, Controls to run out, Soft recoil.
Fume extractor, Muzzle brake, Advantages and disadvantages, Droop, Balancing gears, Elevating and traversing gears, Carriages and mountings, Articulation, Spades, Forces and their behavior during firings, Stability, Jump, (Part2-Balistics-1-15.2)

Unit IV. **Ammunition** : Cartridge and make up of cartridges (BL, QF – fixed, separate), Cartridge cases (metallic & essential qualitative requirements, semi-combustible, combustible, relative merits & demerits), Means of ignition (ignition problem, percussion, electrical), classification and characteristics of projectile (ogive, nose, shoulder, body, driving band, base, boat tailing, bands, bourrelet)
Driving band attachment to body and engraving process, Forces on the Driving band, Requirements of a projectile (ballistic efficiency, tactical efficiency, shape), crh (simple and compound), fuze, Components of fuzes, Arming and safety arrangements in fuzes.

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.

MSCFAPBSI L1 Lab Course 1

LIST OF EXPERIMENTS	
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

MSCFAPBSI L2 Lab Course 2

LIST OF EXPERIMENTS	
1	Numerical Differentiations
2	Numerical Integration by Trapezoidal Method
3	Numerical Integration by Simpson Method
4	Evaluation of Gamma Function
5	Solution of Second order differential equation by Range-Kutta Method
6	Finding roots of an equation by Newton-Raphson Iteration method
7	Least Square fitting of linear equations
8	Solution of system of linear equations.

Semester II

MSCFAPBSII P1: Statistical Mechanics

Unit I. **Statistical Thermodynamics:** Macroscopic and microscopic states, connection between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox. Ensemble Theory: Phase space, Liouville's theorem, microcanonical ensemble, examples, quantum states and phase space.
Canonical Ensemble: Equilibrium, partition function, energy fluctuation, equipartition and Virial theorem, harmonic oscillators, statistics of paramagnetism, Grand Canonical Ensemble: Equilibrium, partition function, density and energy fluctuation, correspondence with other ensembles, examples.

Unit II. **Formulation of Quantum Statistics:** Quantum mechanical ensemble theory, density Matrix, statistics of various ensembles, examples. Ideal gas in different quantum mechanical ensembles. Systems of: monatomic, diatomic and polyatomic molecules.

Unit III. **Ideal Bose gas:** Photons and Planck's Law, Phonons, Bose-Einstein condensation, Thermodynamic description of phase transition, Phase transitions of second kind, Discontinuity of specific heat, Change in symmetry in a phase transition of second kind.

Unit IV.

Ideal Fermi Gas: Thermodynamics, Pauli paramagnetism, Landau diamagnetism, DeHassVan Alphen Effect, thermionic and photoelectric emissions, white dwarfs. Ising Model: Ising model,: definition of Ising Model, ID-Ising model.

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

MSCFAPBSII P2: Quantum Mechanics

Unit I. **General Principles of Quantum Mechanics:** Linear vector space, ket and bra vectors, scalar product of vectors and their properties, Linear operator, Adjoint Operators, Unitary Operators and transformations, Expectation values of dynamical variables and physical interpretation, Hermitian operators, Probability interpretation, degeneracy, Schimdt method of orthogonalization.

Mathematical Basics: Expansion Theorem, Completeness and Closure property of the basis set, Co-ordinate and Momentum representation, Compatible and incompatible observables, Commutator algebra, Uncertainty relation as a consequence of noncommutability, Minimum uncertainty wave packet.

Unit II. **Quantum Dynamics:** Time evolution of quantum states, time evolution operator and its properties, Schroedinger Picture, Heisenberg Picture, Interaction Picture, Equation of Motion, Operator Method of solution of Harmonic oscillator, Matrix representation and time evolution of creation and annihilation operator.

Unit III. **Rotation and Orbital Angular Momentum:** Rotation Matrix, Angular momentum operators as the generators of rotation. Lx, Ly, Lz and L^2 in spherical polar co-ordinates, Eigen values and Eigen functions of Lz and L^2 (OP method), Spherical Harmonics, Matrix representation of L+, L-and L^2.
Spin ½ particles, Pauli spin matrices and their properties, Eigen values and Eigen functions, Spinor transformation under rotation.
Total Angular momentum J, Eigen value problem of Jz and J2, Angular momentum matrices, Addition of angular momenta and C. G. Co-efficient, angular momentum

states for composite systems in the angular momenta (1/2, ½) and (1,1/2).

Unit IV. **Motion in Spherical Symmetric Field:** Hydrogen atom, Reduction of two body problem to equivalent to one body problem, Radial equation, Energy eigenvaues and eigenfunctions, Degeneracy, radial probability distribution.
Free particle problem incoming and outgoing spherical waves, Expansion of plane waves in terms of spherical waves, bound states of a 3-D square well, particle in a sphere.

Approximation Methods: Time independent perturbation theory and application, variational method, WKB approximation, Time dependent perturbation theory, Fermi's Golden rule, selection rules.

Scatterings: Elementary theory of scattering, Phase shifts, Partial waves, Born approximation

TEXT BOOKS:

1. Quantum Mechanics-Joichan

REFERENCE BOOKS:

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

MSCFAPBSII P3: Fluid Dynamics

Unit I. **Fluid Flow Concepts and Basic equations**: Velocity field, acceleration of a fluid element, continuity equation, conservation of momentum, stream line functions, rotation of fluid element, Euler's equation.
Bernoulli's equation along a stream line and in rotational flow, Bernoulli's equation from thermodynamics ,static and dynamics pressure, Losses due to geometric changes:-Sudden expansion and contraction Venturimetre.

Unit II. **Dimensional Analysis and Dynamic Similitude:** Buckingham's Π Theorem, Dimensionless parameters, Euler's number, Reynold's number, Froude's number, Weber number, Model studies and wind tunnel tests.

Unit III. **Viscous Effect**: Normal stress shear stress, Navier-Stokes theorem, Flow through a parallel

channel, Flow past a sphere, Terminal velocity order of magnitude analysis, Approximation of the Navier-Stokes equations.

Boundary layer concepts:-Momentum integral equation, velocity profile, Boundary layer thickness, SkinFriction effecter, Transverse component of velocity, Displacement thickness, momentum thickness. Drag: Bluff badles, Aerofoil, Boundary layer control, entrance region.

Unit IV. **Compressible flow**: Perfection gas Relations:-Speed of propagation in gas, in isothermal and adiabatic condition, Mach number, Limits of incompressibility. Isentropic flow:-Laws of conservation, Static and stagnation values, flow through a duct of varying cross-section, mass flow rate, choking a converging passage, constant area adiabatic flow and Fanno like, constant area frictionless flow and Raleigh line.

Fluid Metrology: Pressure measurement, Velocity measurement, Turbulence measurement, Viscosity measurement.

TEXT BOOKS:

1. Fluid Mechanics, A.K. Mohanty, PHI
2. Fluid Dynamics, R.V. Mises, Springer
3.

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

MSCFAPBSII P4: Internal Ballistics

Unit I. **Explosives:** 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, Caterigorisation of explosives (low explosives – high explosives – primary, secondary, intermediary, tertiary), Explosive train, Gun powder and Pyrotechnic compositions.

Unit II. **Gun propellant:** 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

Thermo physics and Thermo chemistry of propellants: 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. **Corrections for deviations:** from Ideal gas laws, for water-gas equilibrium, for internal energy of products.
opellant performance, Force constant, Pressure of combustion.
Efficiency of gun-ammunition system (thermodynamic and piezometric) (Interior ballistics 2-6)

Unit III. **Internal Ballistics:**

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.

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 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).

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).

Attainment of higher velocities (Interior Ballistics 2.12)

Unit IV. **Intermediate Ballistics:** Gas dynamics of the muzzle flow field, Flash, Blast, Flash and blast suppression, Sabot and sabot separation process.

Rigid body motion of recoiling parts. Barrel vibration, Equations of motion of barrel. Current trends and future directions in gun propulsion

Analytical & computational Ballistics: Introduction, Lagrange gradient, Lagrangian approach

Measurement of Ballistic Parameters:

Dispersion of Fire, Yaw and Jump by photogrammetry or high speed photography.

Barrel recoil and runout, Buffer pressure, Barrel vibration

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)

MSCFAPBSII L3 Lab Course 3

LIST OF EXPERIMENTS	
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

MSCFAPBSII L4 Lab Course 4

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

Semester III

MSCFAPBSIII P1: Solid State Physics

Unit I. **Crystal Physics:** Types of lattices, Miller indices, simple crystal structures, crystal diffraction, Bragg's law, Reciprocal lattice (sc, bcc, fcc), Laue equations, structure factor, Atomic form factor, Types of crystal binding, cohesive energy of ionic crystals, Madelung constant, Inert gas crystals, Vander Waal, London equation, Metal crystals, Hydrogen bonded crystals. Defects in crystals; Point and line defects.

Lattice vibration and thermal properties: Einstein and Debye models; continuous solid; linear lattice; acoustic and optical modes; dispersion relation; attenuation; density of states; phonons and quantization; Brillouin zones; thermal conductivity of metals and insulators.

Unit II. **Quantized free electron theory:** Fermi energy, wave vector, velocity and temperature, density of states. Electronic specific heats. Pauli spin paramagnetism. Sommerfeld's model for metallic conduction. AC conductivity and optical properties, plasma oscillations. Hall effects.
Intrinsic and extrinsic semiconductors: carrier concentration and Fermi levels of intrinsic and extrinsic semi-conductors Bandgap. Direct and indirect gap semiconductors. Hydrogenic model of impurity levels.

Energy bands in solids: The Bloch theorem. Bloch functions. Review of the Kroning-penney model. Brillouin zones. Number of states in the band. Band gap in the nearly free electron model. The tight binding model. The

fermi surface. Electron dynamics in an electric field. The effective mass. Concept of hole. (elementary treatment).

Unit III. **Dielectrics:** Polarizability; Clausius-Mossotti formula; Dielectric constant; ferroelectrics. **Magnetic properties of solids:** Diamagnetism, Langevin equation. Quantum theory of paramagnetism. Curie law. Hund's rules. Paramagnetism in rare earth and iron group ions. Elementary idea of crystal field effects.Ferromagnetism. Curie-Weiss law. Heisenberg exchange interaction. Mean field theory. Antiferromagnetism. Neel point. Other kinds of magnetic order. Nuclear magnetic resonance.

Unit IV. **Superconductivity:** Experimental facts, occurrence, effect of magnetic fields, Meissner effect, entropy and heat capacity, energy gap, microwave and infrared properties, type-I and type-II superconductor, theoretical explanation, thermodynamics of superconducting transition, London equation, coherence length, BCS Theory, flux quantization, single particle Tunneling, Josephson Tunneling, DC and AC Josephson effects, High temperature super conductors-SQUIDS.

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

MSCFAPBSIII P2: Nuclear and Particle Physics

Unit I. **Nuclear size and shape:** Nuclear radii and charge distributions, nuclear binding energy, electric andmagnetic moments.
Nuclear Nuclear Models: Liquid drop model, semi-empirical mass formula, Mass Parabolas, Bohr-Wheeler theory of fission, Experimental evidences for shell effects, Shell model, Spin-orbit coupling, Magic numbers, Angular momenta and parities of nuclear ground states, magnetic moments and Schmidt lines, Collective model of Bohr and Mottelson.

Unit II. **The Two-Nucleon Problem:** The Ground state of deuteron, excited state of deuteron, n-p scattering at low energies, tensor forces and deuteron problem, n-n scattering, p-p scattering at low energies.
Nuclear Force: Central and non-central forces, Force dependent on Isospin, Exchange force, charge dependence and charge symmetry of Nuclear force, Mirror Nuclei.

Unit III. **Nuclear Reaction:** Energetic of Nuclear reaction, Compound nuclear theory, Resonance scattering, Brit-Wigner formula, Nuclear Fusion, Alpha decay, Fermi's theory of Beta decay, Selection Rules for allowed transition, Parity violation.

Unit IV. **Particle Physics:** Basic forces, Classification of Elementary particles, Spin and Parity, Determination of Isospin, Strangeness, Lepton and Baryon Number, Conservation Laws, Gellmann-Nishijima Scheme, Meson and Baryon Octet, Elementary Ideas of SU(3), Symmetry Quark Model, CPT theorem.
Elementary ideas on quantum field theory, Klein-Gordon equation, Dirac Equation, Dirac Matrices.
Particle Accelerators and detectors.

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
8

MSCFAPBSIII P3: Research Methodology

Unit I: Fundamentals of research

Introduction to research methodology, definition and basic concepts of research, objectives of research, motivation behind a research, types of research, research process: defining research problem, review the literature, formulation of hypothesis, research design, collection and analysis of data, interpretation and writing a report. Criteria for a good research, measuring research impact and quality: JCR report, impact factor and citation index, ethics and scientific conduct, Ethics in human and animal studies.

Unit II: Writing and presenting research

Components of research paper the IMRAD system, title, authors and addresses, abstract, acknowledgements, references, tables and illustration; preparation for publication, submission of manuscript, publication processes; presentation of research: oral and poster presentations, presentation in conferences and symposia; presentation and submission of research proposals to the funding agencies.

A brief idea about government research agencies including DBT, DFSS, DST, ICMR, CSIR, UGC, BPR&D, and DRDO.

Plagiarism: definition, forms, consequences, unintentional plagiarism, copyright infringement, collaborative work.

Unit III: Basic concepts of Statistics and data analysis

Basic definitions and applications of statistics, sampling: Representative sample, sample size, sampling bias and sampling techniques. Data collection and presentation: Types of data, methods of collection of primary and secondary data. Methods of data presentation-graphical representation by histogram, polygon, ogive curves and pie diagram. Measures of central tendency: mean, median and mode; measures of dispersion: range, mean deviation, standard deviation, variance, quartile, standard error and coefficient of variation; correlation and regression: positive and negative correlation and calculation of Karl-Pearsons coefficient of correlation, skewness and kurtosis.

Unit IV: Probability and Test of hypothesis

Introduction to probability theory, various definitions of probability, Basic terms: random experiments, event, trial, sample space, independent and mutually exclusive events; conditional probability, Addition and multiplication theorem, Baye's theorem, likelihood ratio and discriminating power. Distribution of data: normal, binomial and Poisson distribution.

Test of hypothesis: introduction and concepts; test for small and large sample: Z-test, t-test, chi square test, F-test and ANOVA.

Software related to statistical analysis: MS-Excel, SPSS etc.

Suggested readings:-

1. Statistics in Biology, (1967) Vol. 1: Bliss, C.I.K. McGraw Hill, NewYork.
2. Practical Statistics for experimental biologist (1985): Wardlaw, A.C.
3. Statistical Methods in Biology (2000): Bailey, N.T. J. English Univ. Press.
4. Biostatistics - 7th Edition : Daniel
5. Fundamental of Biostatistics : Khan
6. Bio-statistical Methods : Lachin
7. Statistics for Biologist (1974):Campbell R.C. Cambridge
8. Research Methodology Tools And Techniques : H.C Purohit
9. Research Methodology: An Introduction : Wayne Dean Goddard, Stuart Melville
10. Research Methodology in the Medical and Biological Sciences: PetterLaake Haakon Breien Benestad (Author) Bjorn Reino Olsen (Editor)
11. Research Methodology For Biological Science : Gurumani N Gurumani
12. Research Methodology- G.R. Basotia and K.K. Sharma.
13. Research Methodology- C.H. Chaudhary, RBSA Publication
14. Research Methodology: An Introduction - Wayne Goddard & Stuart Melville
15. Research Methodology - Ranjit Kumar
16. Research Methodology: Methods & Techniques - Kothari, C.R.

MSCFAPBSIII P4: Modern Physics and Electronics

Unit I. **Quantum Mechanics:** Wave properties of Particles, Heisenberg uncertainty relation, group velocity, phase velocity, wave function, the wave equation, Schrodinger equation, Operators, Dynamical Variables, Expectation Values, Particle in a box, finite Potential well, Tunnel effect, harmonic oscillator

Unit II. **Nuclear Structure:** Nuclear Composition, some nuclear properties, stable nuclei, binding energy, liquid drop model, Shell model, Meson theory of nuclear forces
Nuclear Transformations: Radioactive Decay, half life, radioactive series, alpha decay, beta decay, gamma decay, cross section, nuclear reactions, nuclear fission, nuclear reactors, nuclear fusion in stars, fusion reactors

Unit III. **Solid State Physics** : Materials, Crystalline and Amorphous Solids Crystallography, Crystal structure- Lattice, Basis, Unit cell, Primitive cell, Crystal systems – Bravais Lattice in 3D , Binding of atoms in solids, Type of Crystals - Ionic crystals, Covalent crystals, Metallic crystals, Molecular crystals, Hydrogen-bonded crystals, Band theory of solids, semiconductor Superconductivity – Fundamentals. Type –I and Type-II superconductors, Flux quantization, Bound electron pairs.

Unit IV. **Electronics :** Network – Fundamentals, Voltage and Current sources, Resistance, Inductance, Capacitance, Thevenin's Theorem, Norton's Theorem, and Maximum Power Transfer Theorem, Semiconductors –Basics , Intrinsic, Extrinsic- P-type and N-type, Semiconductor Devices – PN Junction Diode, Transistor , Digital Electronics- Binary Number System, Conversion of decimal to binary and vice versa , Binary Operations, Boolean Laws, Logic Gates- OR, AND, NOT and their combinations.

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

MSCFAPBSIII L5 Lab Course 5

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

17	To design and test differentiator circuit using OPAMP and to find usual frequency range for differentiator.

MSCFAPBSIII L6 Lab Course 6

Sr. No	List of experiments
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.

Semester IV

MSCFAPBSIV P1: Terminal Ballistics

Unit I. **Terminal Ballistics:** General introduction, definition, classification of projectiles, phase diagram and ballistics limit, failure mechanism

Properties of materials: 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.

Unit II. **Munitions and the defeat of armour:** 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.

Shape charge warheads: 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.

Kinetic energy projectiles: 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.

Unit III. **Design and Defeat of Armour:** Introduction, Mechanical property requirements, Armour material characteristics, Armour structure, Defeat of armour, Failure mechanism, Ballistics limit.

Penetration: Penetration Theory, penetration and perforation of metals (aluminum), penetration and perforation of composites.

Unit IV. **Forensic Ballistics:** 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.

Dispersion: 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

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, Elseviour Science Publishing Co. Inc.

5. Wound Ballistics and the Scientific Background, Karl G Sellier & Beat P Kneubuehl, Elsevior Science Publishing Co. Inc.

MSCFAPBSIV P2: External Ballistics

Unit I. **Aerodynamic Forces & Moments Acting on Projectiles:**

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.

Unit II. **Dynamic review:** Kinematics of particle, hodograph, kinematics of rigid body, kinematics equations for plane motion of a rigid body using translating and rotating system **Trajectories:** 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

Unit III. **Mass asymmetries:** Mass asymmetries, lateral throw-off, aerodynamic jump, static imbalance and dynamic imbalance, **Linearized Aeroballistics:** Lineraized 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

Unit IV. **Aeroballistic Design:** Introduction-Artillery shell-Design criteria-Low drag design for artillery shell-stability of artillery shell, **Direct Fire Projectiles**: Direct fire projectiles-spin-stabilized K.E. penetrators-statically stable K.E. penetrator and long rods-Aircraft fired projectiles-Bombs and sub-munitions.
Wind tunnel methods: Examples of supersonic wind tunnel measurement, advantages and disadvantages of wind tunnels for projectile aeroballistics testing.

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)

MSCFAPBSIV L7 Lab Course 7

LIST OF EXPERIMENTS	
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

24/11/24

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