AC – 07/07/2023
Item No. – 6.4 (N)

As Per NEP 2020

University of Mumbai

Title of the program

A-P.G. Diploma in Physics
B- M.Sc. (Physics) (Two Year) } -2023-24
C- M. Sc. (Physics) (One Year) -2027-28

Syllabus for

Semester – Sem I & II

Ref: GR dated 16th May, 2023 for Credit Structure of PG

Preamble

1. **Introduction:** Physics is the most of basic of sciences. It seeks to understand natural phenomena in a quantitative manner, and to answer some of the oldest and deepest questions ever asked by human beings: What are things made of? Is there a limit to the smallest things that we can think of? Did the world have a beginning? Will it have an end? At the same time, it provides the base of much of the technology that we take for granted in the 21st century: computers, artificial satellites, mobile phones, TV, microwave ovens... Indeed, it will not be an exaggeration to say that modern human life is shaped by technologies that are largely based on a foundation of physics. Physics as a discipline has existed for three hundred years and has a large 'core' body of knowledge. Our M.Sc. programme lays emphasis on the courses that constitute this core component, while providing students with a bouquet of optional papers covering almost all branches of physics. Those who wish to pursue higher studies in the subject are thereby well equipped to choose their branch of study. The programme also aims at equipping future teachers (at college as well school level) with a thorough grounding in the subject. Since physics is the base of much of modern technology, the programme also gives adequate hands-on experience to students who may go on to work in applied fields. Finally, viewing physics as a training ground for the mind the programme also aims to equip those who go into other fields of work with logical thinking and a critical attitude. During the current academic year 2023-24, University Department of Physics is following NEP-2020 program.

2:Aims and Objectives: Create the facilities and environment in all the educational institutions to consolidate the knowledge acquired at +2+3 level and to motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.•Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classroom.

3: Learning outcomes:

I. The students would be able to have strong foundation knowledge and comprehend the basic concepts and principles in Physics.

II. The students would be able to progress in their academic performance through structured curricula.

III. The students would be able take up competitive exams in different sectors, can be entrepreneurs and succeed in higher education in Physics.

IV. The students would be able to experience a well resourced environment for learning Physics

V. To motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.

4: Any other points:

I. During the course work students will be provided hands on training on highly sophisticated state of art equipments.

II. Students will be provided internship at the various government lab and nearby industries.

III. Collaborative activities with national and international institutes/industries to cater the need of regional development.

R:____________________

5. Credit Structure of the Program (Sem I, II, III & IV) (Table as per with sign of HOD and Dean)

PG Program as per NEP 2020 Structure

The University department of Physics has currently 1 PG degree program namely M.Sc Physics with 68 seats. The Structure of three PG Degree programs under NEP 2020 is enclosed herewith. Program Name: M.Sc Physics with 68 seats

Credit Distribution Structure for Two Years/ One Year PG

M.Sc (Physics)

Year	Level	Sem	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Elective					
1	6.0	Sem 1	3 x 4 + 2 x 1 = 14	4	4	--	--	22	
			Phys (501) Classical Mechanics	Phys-(505) Elective 1 (List attached)	Phys-(506) Research Methodology	--	--		
			Phys-(502) Quantum Mechanics 1						
			Phys-(503) Mathematical Physics						
			Phys-(504) Practical-1						
		Sem 2	3 x 4 + 2 x 1 = 14	4	4	--	--	22	
			Phys-(511) Introduction to Programming	Phys-(515) Elective 2 (List attached)	--	Phys-(516) Research Project--			
			Phys-(512) Quantum Mechanics 2						
			Phys-(513) Nuclear Physics						
			Phys-(514) Practical-2						
Cum. Cr. for PG Diploma			28	8	4	4	--	44	
Exit Option: 1 yr PG Diploma (44 credits) after Three Year UG Degree									

Year	Level	Sem	Major		RM	OJT / FP	RP	Cum. Cr.	Degree
			Mandatory	Elective					
2	6.5	Sem 3	3 x 4 + 2 x 1 = 14	4	--	--	4	22	
			Phys-(601) Electrodynamics	Phys-(605) Elective 3 (List attached)	--	--	Phys-(606) Research Project		
			Phys-(602) Electronics						
			Phys-(603) Solid State Physics						
			Phys-(604) Practical-3						
		Sem 4	3 x 4 = 12	4	--	--	6	22	
			Phys-(611) Introduction to Programming	Phys-(615) Elective 4 (List attached)	--	--	Phys-(616) Research Project		
			Phys-(612) Quantum Mechanics 2						
			Phys-(613) Nuclear Physics						
Cum. Cr. for 1 yr PG Degree			26	8	--	--	10	44	
Exit Option: 1 yr PG Degree (44 credits) after Four Year UG Degree									
Cum. Cr. for 2 yr PG Degree			54	16	4	--	14	88	
Exit Option: 2 yr PG Degree (88 credits) after Three Year UG Degree									

LIST OF ELECTIVES

	Elective 1 Phys-(505A-505H)	Elective 2 Phys-(515A-515H)	Elective 3 Phys-(605A-605H)	Elective 4 Phys-(615A-615H)
I	VLSI Design and Embedded Systems	VHDL, C++ and Python Programming	Microwave Electronics	Microprocessor and Microcontroller
J	Bio-medical Physics and Instrumentation	VLSI Design and Embedded Systems	Python Programming	Python Programming-Machine learning
J	Signal Modulation and Transmission Techniques	Embedded C and Interfacing	Digital Communication Systems and Python Programming	Radar and Optical Fiber Communication
K	Fundamental of Materials Science	Materials and Their Applications	Energy Studies	Polymers

VABambole
Sign of HOD
Prof. Vaishali A. Bambole
Department of Physics
Professor & Head
Department of Physics
University of Mumbai

Garje
Sign of Dean
Prof Shivram Garje
Science and Technology

PROGRAMME OUTCOMES OF M.Sc. (PHYSICS)

1. To navigate learners towards the frontiers of Physics
2. To establish a world-class academic programme, with dual emphasis on foundational teaching and active participation in frontier research
3. To establish the best in class infrastructure for facilitating the process of learning and research with core strengths of the Department
4. To nurture learning in various sub-disciplines of Physics viz Theoretical, Experimental and Computational, expanding into areas of High Energy Physics, Astronomy and Space Physics, Materials Science, Soft Matter Physics, Atomic and Nuclear Physics
5. To network with national and global academic institutions through vibrant exchange programmes and collaborations in teaching and research
6. To instill in the learners the spirit of inquiry and innovation
7. To create opportunity platforms for nucleation and incubation of entrepreneurs
8. To build synergistic channels for productive knowledge transfer and utilization through industry partners
9. To create value added linkages and career opportunities for faculty and students through effective networking both at national and international levels
10. To ensure the creation of responsible personnel through engagement in socially relevant outreach programmes

The Department has the M.Sc.(Physics) offered as
1. M.Sc.(Physics) by papers
2. M.Sc.(Physics) by research

The latter is a unique programme initiated by the founder head (Late) Prof M.C.Joshi, supported by the Department of Atomic Energy (DAE) through the scientists of the Bhabha Atomic Research Centre (BARC) and Tata Institute of Fundamental Research (TIFR). The programmes are designed with syllabi adhering to the proposed academic objectives.

M.Sc.(Physics)

PROGRAMME SPECIFIC OUTCOMES (PSO)

The programme ensures that the learners

1. Acquire core competency in the areas of Basic and Applied Physics (PSO1)
2. Are exposed to the state-of-art facilities in the Department and collaborating institutions in the neighborhood (PSO2)
3. Are familiarized with current trends in a wide variety of sub-disciplines and emerging areas of Physics (PSO3)
4. Are able to apply their acquired skills in other interdisciplinary areas of science and technology(PSO4)
5. are equipped with knowledge to engage in teaching in academic institutions, research in National research laboratories and R&D based industries as also initiating technology based entrepreneurship (PSO5)

CLASSICAL MECHANICS

The course discusses in length, the two frameworks of analytical mechanics viz **Lagrangian** and **Hamiltonian**. The first unit reviews Newtonian Mechanics and compares it with Lagrangian mechanics that is discussed following the introduction of **d'Alembert's principle** and concepts of virtual work. This is followed by the **Conservation laws** in both formalisms and introduction of the Calculus of variations. The unit on **Central Force** introduces the concept of constants of motion, transformations and cyclic co-ordinates and emphasizes their use in solving real problems. The unit on Hamiltonian dynamics introduces the **Poisson bracket** and discusses the problems of canonical transformations and associated functions. The link between Classical and Quantum Mechanics is brought about by the concept of Poisson brackets.

Course outcomes:

At the end of the course, the learner is able to

1. Understand the principle of virtual work and the concepts of least action, the formalisms of Lagrange and Hamiltonian (CO1)
2. Describe the motion of a system in Lagrangian and Hamiltonian formalisms (CO2)
3. Understand the features of motion under central force, periodic motion, small oscillations as they appear in other areas of Physics (CO3)
4. Use the Poisson brackets in Hamiltonian dynamics and solve related problems (CO4)
5. Understand the linkages of the techniques of Classical Mechanics in solving problems in areas of Statistical Mechanics (Phase space), Molecular Physics (CO5)

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2		1	2
CO2	3	2		1	2
CO3	3	2		2	2
CO4	3	2		2	2
CO5	3	3		3	3

1: Low 2: Moderate 3: High

QUANTUM MECHANICS I

The course introduces the concepts and postulates of **wave mechanics** to the formulation of quantum mechanics, **the matrix formulation**, the development of Dirac notation, the operators for quantum angular momenta. The one-dimensional Schrodinger equation is discussed at length and the problems addressed are Particle in a box, harmonic oscillator, unbound states, potential well, two particle problem, radial equation and complete solution of the hydrogen atom problem using spherical harmonics and other special functions.

Course Outcomes:

At the end of the course, the learner is able to

1. Understand the basic principles of Quantum mechanics and the need for its formalism (CO1)
2. Understand the Uncertainty Principle and formulation of Schrodinger equation (CO2)
3. Understand the importance of Dirac formalism, vector spaces and apply the same in solving problems of potential barrier, square well potential (CO3)
4. Apply the techniques of solving differential equations using various special functions as they appear in the solution of Schrodinger equation for Hydrogen atom problem (CO4)
5. Solve the various boundary value and potential problems using the techniques of quantum mechanics (CO5)

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2			3
CO2	3	2			2
CO3	3	2		2	2
CO4	3	2		2	2
CO5	3	2		2	2

1: Low 2: Moderate 3: High

MATHEMATICAL METHODS IN PHYSICS

The course commences with a unit on **Matrices and Tensors**; the vector spaces are discussed in the light of matrices and tensors. The emphasis is on solving eigen value problems as they appear in Classical and Quantum Mechanics and other applied areas of Physics. The basics of tensor analysis are introduced to understand the formulation of Relativistic Electrodynamics and other advanced areas of theoretical Physics. The unit on **Functions of Complex Variables** has a review of complex numbers and the algebra and discusses the calculus of complex variables with Cauchy Riemann for analytic functions, Caucy Goursat theorem, Cauchy's integral formula and the Residue theorem and its application in solving complex and real integrals. The units on **Differential Equations** introduces the Frobenius method of series solution of linear differential equations and the associated polynomial solutions of Legendre, Laguerre, Hermite and Bessel functions. The **Integral Transforms** of Fourier and Laplace and their application in solving linear differential equations and **partial differential equations** are discussed. The Green's function method of solving differential equations is addressed.

Course Outcomes:

At the end of the course the learner will be able to

1. Solve eigenvalue problems using matrices as they appear in Classical and Quantum Mechanics (CO1)
2. Apply tensor analysis to understand the formulation of relativistic electrodynamics and other areas of Physics (CO2)
3. Apply residue theorem of complex variables to solve real and definite integrals (CO3)
4. Understand the emergence of special functions as solutions of differential equations and to solve problems in physics (CO4)
5. Solve partial differential equations using integral transforms in boundary value problems (CO5)

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2			2
CO2	3	2		2	2
CO3	3	2		2	2
CO4	3	2		2	2
CO5	3	2	2	3	3

1: Low 2: Moderate 3: High

Introduction to Programming

The advances in computer technology have brought the need to devise numerical algorithms to optimize their usage in problem solving. The implementation of a mathematical method with an appropriate convergence check in a programming language is termed as a numerical algorithm. The presently used programming languages for scientific computing are C, C++ as against the formerly used FORTRAN and PASCAL. The operating system used by computational scientists is generally UNIX or LINUX as against the DOS or WINDOWS. The present course discusses the Numerical methods of interpolation, curve-fitting, differentiation and integration using the various standard techniques of Difference table, Runge-Kutta, Newton-Raphson methods with programs in C/C++. Some of the emerging problems of Monte-Carlo methods for simulation and Random number generation are also discussed. The course is supported by hands-on problem solving.

Course Outcome:

At the end of the course, the learner can

1. Understand the use of programming language and write simple programs for mathematical problems (CO1)
2. Develop flowcharts for analyzing a given mathematical problem and solve them numerically (CO2)
3. Apply the techniques of numerical methods in interpolation to generate difference tables of a given data set (CO3)
4. Analyze a given data set and fit them to a suitable polynomial equation and present them graphically (CO4)
5. Simulate models for a given mathematical problem by techniques of Monte Carlo and other related techniques (CO5)

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3				2
CO2	3			2	2
CO3	3			3	
CO4	3	2			
CO5	3	2		3	2

1: Low   2: Moderate   3: High

QUANTUM MECHANICS II

The course focuses on the application of Quantum Mechanics to problems of **Angular momentum** of electrons viz addition of angular momenta, **Clebsch Gordon coeffiecients**; estimation of scattering amplitude in **scattering theory**. The time independent and time dependent perturbation theory is discussed with illustrative examples. The methods of Ritz **variational method, WKB method** are presented and applied to real problems.

Course Outcomes:

At the end of the course, the learner can

1. Gain understanding of the mathematical foundations of the angular momenta of a system of particles (CO1)
2. Apply the concept of non-relativistic Hamiltonian for an electron with spin and perform calculation using angular momentum techniques (CO2)
3. Apply various approximation methods in the solution of time independent and time dependent Schrodinger equations (CO3)
4. Apply the perturbation theory to various forms of Schrodinger equation in scattering theory and partial wave analysis (CO4)
5. Apply the quantum mechanical principles to solve problems of wave propagation, scattering phenomena (CO5)

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2			2
CO2	3	2			2
CO3	3	2			2
CO4	3	2			2
CO5	3	2		3	3

1: Low 2: Moderate 3: High

NUCLEAR PHYSICS

The course in Nuclear Physics introduces not only the **nuclear structure** but also throws light on the **nuclear reactions**. Special emphasis is on gaining knowledge about the safety norms and the prevalent regulatory framework of nuclear safety in India.

An understanding of the **nuclear sizes and their estimation**, the constituent protons and neutrons and the formation of deuteron is gained by in-depth discussion with examples. The various nuclear models like the Shell model, Nilsson model etc. are introduced with its assumptions, predictions and limitations.

The **mechanisms of the decay schemes** of the charged particles (alpha and beta) with their energetics, the transition rules for gamma decay with the associated selection rules and the information obtained from Fermi-Curie plots are described. The interaction of charged particles and radiation with matter is discussed. The conservation laws associated with the various nuclear reactions are introduced. The study entails an in-depth discussion of the fission and fusion reactions with special thrust on the Nuclear Programme of India.

Particle Physics is introduced in close association with nuclear physics to understand the sub-atomic elementary particles, specially the quarks. The various concepts viz Quark Model, Standard model, Eight fold way are described. The ideas of Quantum Electrodynamics, Quantum Chromodynamics are introduced. The problem of Neutrino is addressed with regards to some of its properties. The concepts of helicity, parity, parity violation, some standard experiments are introduced. The current advances in the field are brought in appropriately to understand the importance of the accelerators, detectors and the significance of the High Energy Collider experiment of CERN.

Course Outcome:

At the end of the course, the learner

1. Gains knowledge about the nuclear properties such as mass, size, spin and the methods adopted for their estimation
2. Gains awareness of safety and regulatory norms adopted in the nuclear programme in the country
3. Understands the various nuclear models,
4. Understands the nuclear reactions with the ideas of decay mechanisms, interaction of radiation with matter and the experimental methods of analysis
5. Gains insight into the basics of Particle Physics with introductory ideas of the fields of Quantum Electrodynamics and Quantum Chromodynamics

Mapping of Course Outcomes with Programme Specific Outocmes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3			2	2
CO2	3	3	3		3
CO3	3				2
CO4	3	3	2	2	2
CO5	3	3	3	2	2

1: Low 2: Moderate 3: High

Core Subjects:

Classical Mechanics (60 lectures, 4 credits)

Unit-1

Review of Newton's laws, Mechanics of a particle, Mechanics of a system of particles, Frames of references, rotating frames, Centrifugal and Coriolis force, Constraints, D'Alembert's principle and Lagrange's equations, Velocity-dependent potentials and the dissipation function, Simple applications of the Lagrangian formulation. Hamilton's principle, Calculus of variations, Derivation of Lagrange's equations from Hamilton's principle, Lagrange Multipliers and constraint exterimization Problems, Extension of Hamilton's principle to nonholonomic systems, Advantages of a variational principle formulation

Unit-2

Conservation theorems and symmetry properties, Energy Function and the conservation of energy. The Two-Body Central Force Problem**:** Reduction to the equivalent one body problem, The equations of motion and first integrals, The equivalent one-dimensional problem and classification of orbits, The virial theorem, The differential equation for the orbit and integrable power-law potentials, The Kepler problem: Inverse square law of force, The motion in time in the Kepler problem, Scattering in a central force field, Transformation of the scattering problem to laboratory coordinates.

Unit-3

Small Oscillations: Formulation of the problem, The eigenvalue equation and the principal axis transformation, Frequencies of free vibration and normal coordinates, Forced and damped oscillations, Resonance and beats.

Legendre transformations and the Hamilton equations of motion, Cyclic coordinates and conservation theorems, Derivation of Hamilton's equations from a variational principle.

Unit-4

Canonical Transformations, Examples of canonical transformations, The symplectic approach to canonical transformations, Poisson brackets and other canonical invariants, Equations of motion, infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation, The angular momentum Poisson bracket relations.

Main Text: Classical Mechanics, H. Goldstein, Poole and Safco, 3 rd Edition, Narosa Publication (2001)

Additional References:

1. Classical Mechanics, N. C. Rana and P. S. Joag. Tata McGraw Hill Publication.
2. Classical Mechanics, S. N. Biswas, Allied Publishers (Calcutta).
3. Classical Mechanics, V. B. Bhatia, Narosa Publishing (1997).
4. Mechanics, Landau and Lifshitz, Butterworth, Heinemann.
5. The Action Principle in Physics, R. V. Kamat, New Age Intnl. (1995).
6. Classical Mechanics, Vol I and II, E. A. Deslougue, John Wiley (1982).
7. Theory and Problems of Lagrangian Dynamics, Schaum Series, McGraw (1967).
8. Classical Mechanics of Particles and Rigid Bodies, K. C. Gupta, Wiley Eastern (2001)

Quantum Mechanics-I (60 lectures, 4 credits)

Unit-1: Theory:

de Broglie hypothesis; Heisenberg's uncertainty principle; probability waves. Postulates of QM: Observables and operators; measurements; the state function and expectation values; the time-dependent Schrodinger equation; time development of state functions; solution to the initial value problem. Superposition and Commutation: The superposition principle; commutator relations; their connection to the uncertainty principle; degeneracy; complete sets of commuting observables.

Unit-2: Formalism:

Dirac notation; Hilbert space; Hermitian operators and their properties. Matrix mechanics: Basis and representations; matrix properties; unitary and similarity transformations; the energy representation. Schrodinger, Heisenberg and Interaction pictures.

Unit-3: Schrodinger equation solutions-1 Time development of state functions and expectation values; conservation of energy, linear momentum and angular momentum; parity.

General properties of one-dimensional Schrodinger equation. Particle in a box. Harmonic oscillator. Unbound states; one-dimensional barrier problems. Finite potential well.

Unit-4: Schrodinger equation solutions-2

Schrodinger equation in 2D and 3D and Examples, Its solution in spherical coordinate systems.

Texts:

1. Richard Liboff, Introductory Quantum Mechanics, 4^{th} ed., 2003. (RL)
2. DJ Griffiths, Introduction to Quantum Mechanics, 1995. (DG)
3. A Ghatak & S Lokanathan, Quantum Mechanics: Theory & Applications. 5^{th} ed., 2004. (GL)

Additional References:

1. W Greiner, Quantum Mechanics: An Introduction, 4^{th} ed., 2004.
2 R Shankar, Principles of Quantum Mechanics, 2^{nd} ed., 1994.
3 SN Biswas, Quantum Mechanics, 1998.

Mathematical Methods of Physics- No of credits: 4

Unit-I

Complex Variables, Limits, Continuity, Derivatives, Cauchy-Riemann Equations, Analytic functions, Harmonic functions, Elementary functions: Exponential and Trigonometric, Taylor and Laurent series, Residues, Residue theorem, Principal part of the functions, Residues at poles, zeroes and poles of order m, Contour Integrals, Evaluation of improper real integrals, improper integral involving Sines and Cosines, Definite integrals involving sine and cosine functions.

Unit-II

Matrices, Eigenvalues and Eigen vectors, orthogonal, unitary and hermitian matrices, Diagonalization of Matrices, Application to Physics problems. Introduction to Tensor Analysis, Addition and Subtraction of Tensors, summation convention, Contraction, Direct Product, Levi-Civita Symbol

Unit-III

General treatment of second order linear differential equations with non-constant coefficients, Power series solutions, Frobenius method, Legendre, Hermite and Laguerre polynomials, Bessel equations. Nonhomogeneous equation– Green's function, Sturm-Liouville theory.

Unit-IV

Integral transforms: three dimensional Fourier transforms and its applications to PDEs (Green function of Poisson's PDE), convolution theorem, Parseval's relation, Laplace transforms, Laplace transform of derivatives, Inverse Laplace transform and Convolution theorem, use of Laplace's transform in solving differential equations.

Main references:

1. S. D. Joglekar, Mathematical Physics: The Basics, Universities Press 2005
2. S. D. Joglekar, Mathematical Physics: Advanced Topics, CRC Press 2007
3. M. L. Boas, Mathematical methods in the Physical Sciences, Wiley India 2006
4. G. Arfken and H. J. Weber: Mathematical Methods for Physicists, Academic Press 2005

Additional references:

1. A. K. Ghatak, I. C. Goyal and S. J. Chua, Mathematical Physics, McMillan
2. A.C. Bajpai, L.R. Mustoe and D. Walker, Advanced Engineering Mathematics, John Wiley
3. E. Butkov, Mathematical Methods, Addison-Wesley
4. J. Mathews and R.L. Walker, Mathematical Methods of physics
5. P. Dennery and A. Krzywicki, Mathematics for physicists
6. T. Das and S.K. Sharma, Mathematical methods in Classical and Quantum Mechanics
7. R. V. Churchill and J.W. Brown, Complex variables and applications, V Ed. Mc Graw. Hill
8. A. W. Joshi, Matrices and Tensors in Physics, Wiley India

Sem-1, Laboratory-1

Experiment	**References**
Carrier lifetime by pulsed reverse method	Semiconductor electronics by Gibson
Resistivity by four probe method	Semiconductor measurements by Runyan
Temperature dependence of avalanche and Zener breakdown diodes	a) Solid state devices - W.D. Cooper b) Electronic text lab manual - PB Zbar c) Electronic devices & circuits - Millman and Halkias
DC Hall effect	a) Manual of experimental physics - E.V.Smith b) Semiconductor Measurements - Runyan c) Semiconductors and solid state physics -Mackelvy d) Handbook of semiconductors – Hunter
Determination of particle size of lycopodium particles by laser diffraction method	a). A course of experiments with Laser - Sirohi b). Elementary experiments with Laser- G. white
Magneto resistance of Bi specimen	Semiconductor measurements by Runyan
Microwave oscillator characteristics	a) Physics of Semiconductor Devices by S.M.Sze
Temperature on-off controller using. IC	a) Op-amps and linear integrated circuit technology by Gayakwad
Waveform Generator using ICs	a) Operational amplifiers and linear integrated circuits-— Coughlin & Driscoll b) Op-amps and linear integrated circuit technology — R. Gayakwad c) Opertional amplifiers : experimental manual C.B. Clayton
Instrumentation amplifier and its applications	*a)* Operational amplifiers and linear integrated circuits - Coughlin &. Driscoll *b)* Integrated Circuits - K. R. Botkar
Study of 8 bit DAC	a) Op-amps and linear integrated circuit technology — R. Gayakwad b) Digital principles and applications by Malvino and Leach
16 channel digital multiplexer	a) Digital principles and applications by Malvino and Leach b) Digital circuit practice by RP Jain
Study of elementary digital	Digital Electronics by Roger Tokheim
voltmeter	(5th Edition, page 371)

Note: Minimum number of experiments to be performed and reported in the journal = 06 with minimum 3 experiments from each Group. i.e. Group A: 03 and Group B: 03

Additional references:

[1] Digital theory and experimentation using integrated circuits - Morris E. Levine (Prentice Hall)

[2] Practical analysis of electronic circuits through experimentation - Lome Macronaid (Technical Education Press)

[3] Logic design projects using standard integrated circuits - John F. Waker (John Wiley & sons)

[4] Practical applications circuits handbook - Anne Fischer Lent & Stan Miastkowski (Academic Press)

[5] Digital logic design, a text lab manual - Anala Pandit (Nandu printers and publishers Pvt. Ltd.)

Numerical Techniques and Programming

(45 lectures+15 tutorials, 4 credits)

Unit – I: Python Programming

Introduction, data-types, variables and constant, typecasting, operators (assignment, logical, arithmetic etc), user input (console), conditional statements (if else, nested if else and elif), arrays (list, tuple, sets and dictionary), loops in python – for loop, while loop & nested loops, string manipulation, user defined functions, modules: math, numpy; basics of object oriented programming, creating class and object, constructors.

Unit – II: Numerical Methods: Roots of Equations, Interpolation, Curve fitting, and Derivatives

Roots of polynomial and transcendental equation, bisection method, false position method, Newton-Raphson method.

Linear interpolation, Lagrange's interpolation formula, Newton's forward and backward interpolation formula.

Least squares method principle, fitting a straight line, fitting an exponential curve, fitting curve of the form $y=ax^b$, fitting a parabola, fitting through a polynomial.

Numerical differentiation.

Unit – III: Numerical Integration and Solution to Simultaneous Equations

Newton cotes formula: Trapezoidal rule, Simpson's one third rule, Simpson's three eight rule, Gauss quadratics method.

Gaussian elimination method, Gaussian elimination with pivotal condensation method, Gauss-Jordan elimination method, Gauss—Seidal iteration method, Gauss-Jordan matrix inversion method.

Unit – IV: Solution of Differential Equation

Numerical solution of Ordinary differential equation: Taylor series method, Runge-Kutta method. Classification of 2nd order partial differential equation, Solution of partial differential equation: Difference equation method over a rectangular domain for solving elliptic, parabolic and hyperbolic partial differential equation

References:

1. *Scientific Computing in Python*, 2nd Edition, Abhijit Kar Gupta
2. https://www.iuac.res.in/phoenix/python4schools/Python-for-Education.pdf
3. Jain M.K., Iyengar SRK, Jain R. K.: *Numerical methods for scientific and Engineering Computation*, New Age International, 1992.
4. *Numerical Recipes in C++ (2nd ed.)*, W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P. Flannery
5. H. M. Antia: *Numerical methods for scientists and engineers*.
6. Babu Ram: *Numerical Methods*, Pearson Education India, 2009

Quantum Mechanics-II (60 lectures, 4 credits)

Unit-1: Angular Momentum:1

Orbital angular momentum operators in cartesian and spherical polar coordinates, commutation and uncertainty relations, spherical harmonics. Two-particle problem - coordinates relative to the centre of mass; radial equation for a spherically symmetric central potential. Hydrogen atom, eigenvalues and radial eigenfunctions, degeneracy, probability distribution. Ladder operators, eigenvalues and eigenfunctions of L2 and L_z using spherical harmonics, angular momentum and rotations.

Unit-2 Angular Momentum:2

Total angular momentum J; L.S coupling; eigenvalues of J2 and J_z.

Addition of angular momentum, Clebsch Gordon coefficients for $j_1=j_2=1/2$ and $j_1=1$, $j_2=1/2$, coupled and uncoupled representation of eigenfunctions. Angular momentum matrices; Pauli spin matrices; spin eigenfunctions; free particle wave functions including spin, addition of two spins. Identical particles: symmetric / antisymmetric wavefunctions.

Unit-3: Perturbation Theory and Variational Methods:

1. Time-independent perturbation theory: First-order and second-order corrections to non-degenerate perturbation theory. Degenerate perturbation theory - First order energies and secular equation. Time- dependent perturbation theory and applications.

Ritz variational method: basic principles, illustration by simple examples.

Unit-4: Scattering theory:

Scattering cross section and scattering amplitude; partial wave phase shift -- optical theorem, S-wave scattering from a finite spherical attractive and repulsive potential wells; centre of mass frame; Born approximation.

Texts:

1. Richard Liboff, *Introductory Quantum Mechanics*, 4th ed., 2004. (RL)

2. DJ Griffiths, *Introduction to Quantum Mechanics*, 1995. (DG)

3. A Ghatak & S Lokanathan, *Quantum Mechanics: Theory & Applications.* 5th ed., 2004. (GL)

Additional References:

1. W Greiner, *Quantum Mechanics: An Introduction*, 4th. ed., 2004.
2. R Shankar, Principles of Quantum Mechanics, 2nd ed., 1994.
3. SN Biswas, *Quantum Mechanics*, 1998.

Electrodynamics

Unit-1:

- Units in Electrodynamics, Maxwell's equations, The Pointing vector, The Maxwellian stress tensor
- Electromagnetic waves in vacuum, Polarization of plane waves. Electromagnetic waves in matter, frequency dependence of conductivity, frequency dependence of polarizability, frequency dependence of refractive index.

Unit-2:

- Wave guides, boundary conditions, classification of fields in wave guides, phase velocity and group velocity, resonant cavities.
- Introduction to plasmas, quasi-neutrality, particle motions in EM fields in a plasma, adiabatic invariants, magnetic confinement.

Unit-3:

- Lorentz Transformations, Four Vectors and Four Tensors, The field equations and the field tensor, Maxwell equations in covariant notation.
- Relativistic covariant Lagrangian formalism: Covariant Lagrangian formalism for relativistic point charges, the energy-momentum tensor, Conservation laws.

Unit-4:

- Moving charges in vacuum, gauge transformation, the time dependent Green function, The Lienard-Wiechert potentials, Leinard-Wiechert fields, application to fields-radiation from a charged particle
- Antennas, Radiation by multipole moments, Electric dipole radiation, Complete fields of a time dependent electric dipole, Magnetic dipole radiation

Main References:

- W. Greiner, Classical Electrodynamics (Springer- Verlag, 2000) (WG).
- M. A. Heald and J. B. Marion, Classical Electromagnetic Radiation, 3rd edition (Saunders, 1983) (HM)
- J. D. Jackson, Classical Electrodynamics, 4Th edition, (John Wiley & sons) 2005 (JDJ)

Additional references:

- D.J. Griffiths, Introduction to Electrodynamics, 2nd Ed., Prentice Hall, India,1989.
- J.R. Reitz ,E.J. Milford and R.W. Christy, Foundation of Electromagnetic Theory, 4th ed., Addison -Wesley, 1993
- Andrew Zangwill, Modern Electrodynamics, Cambridge Univ. Press, 2013

Sem-2 Laboratory-2

Experiment	**References**
Zeeman Effect using Fabry-Perot etalon / Lummer — Gehrecke plate	a). Advance practical physics - Worsnop and Flint b). Experiments in modern physics - Mellissinos
Characteristics of a Geiger Muller counter and measurement of dead time	a). Experiments in modern physics- Mellissions b). Manual of experimental physics --EV-Smith c). Experimental physics for students - Whittle &. Yarwood
Ultrasonic Interferometry- Velocity measurements in different Fluids	Medical Electronics- Khandpur
Measurement of Refractive Index of Liquids using Laser	Sirohi- A course of experiments with He-Ne Laser; Wiley Eastern Ltd.
I-V/ C-V measurement on semiconductor Specimen	Semiconductor measurements - Runyan
Double slit- Fraunhofer diffraction (missing order etc.)	Advance practical physics - Worsnop and Flint
Determination of Young's modulus of metal rod by interference method	Advance practical physics - Worsnop and Flint (page 338)
Adder-subtractor circuits using ICs	a) Digital principles and applications -- Malvino and Leach b) Digital circuits practice - R.P. Jain
Study of Presettable counters - 74190 and 74193	a) Digital circuit practice - Jain & Anand b) Digital principles and applications -- Malvino and Leach c) Experiments in digital practice -Jain & Anand
TTL characteristics of totem pole, open collector and tristate devices	a) Digital circuits practice - Jain & Anand b) Digital principles and applications -- Malvino and Leach
Pulse width modulation for speed control of dc toy motor	Electronic Instrumentation - H. S. Kalsi
Study of sample and hold circuit	Integrated Circuits - K. R. Botkar
Switching Voltage Regulator	Integrated Circuits - K. R. Botkar

Fundamentals of Materials Science, (60 lectures, 4 credits)

Unit 1:

Introduction to Materials Science and Engineering, Types of Materials, Competition among Materials, Future trends In Materials Usage, Atomic Structure and Bonding, Types of Atomic and Molecular Bonds, Ionic Bonding, Covalent Bonding, Metallic Bonding, Secondary Bonding, Mixed Bonding, Crystal Structures and Crystal Geometry, The Space Lattice and Unit Cells, Crystal Systems and Bravais Lattices, Principal Metallic Crystal Structures, Atom Positions in Cubic Unit Cells, Directions in Cubic Unit Cells, Miller Indices For Crystallographic Planes In Cubic Unit Cells, Crystallographic Planes and Directions In Hexagonal Unit Cells, Comparison of FCC, HCP, and BCC Crystal Structures, Volume, Planar, and Linear Density Unit Cell Calculations, Polymorphism or Allotropy, Crystal Structure Analysis

Unit 2 :

Solidification, Crystalline Imperfections, and Diffusion In Solids, Solidification of Metals, Solidification of Single Crystals, Metallic Solid Solutions, Crystalline Imperfections, Rate Processes In Solids, Atomic Diffusion In Solids, Industrial Applications of Diffusion Processes, Effect of Temperature on Diffusion In Solids.

Unit 3:

Mechanical Properties of Metals, The Processing of Metals and Alloys, Stress and Strain In Metals, The Tensile Test and The Engineering Stress-Strain Diagram, Hardness and Hardness Testing, Plastic Deformation of Metal Single Crystals, Plastic Deformation of Polycrystalline Metals, Solid-Solution Strengthening of Metals, Recovery and Recrystallization of Plastically Deformed. Metals, Fracture of Metals, Fatigue of Metals, Creep and Stress Rupture of Metals.

Unit 4:

Phase Diagrams, Phase Diagrams of Pure Substances, Gibbs Phase Rule, Binary Isomorphous Alloy Systems, The Lever Rule, Nonequilibrium Solidification of Alloys, Binary Eutectic Alloy

Systems, Binary Peritectic Alloy Systems, Binary Monotectic Systems, Invariant Reactions, Phase Diagrams With Intermediate Phases and Compounds, Ternary Phase Diagrams.

Reference:

1. William F Smith, Javad Hashemi, Ravi Prakash, Materials Science and Engineering, Tata-McGraw Hill, 4th Edition.

VLSI Design and Embedded Systems: (60 lectures, 4 credits)

Unit I:

Introduction to VLSI Design: Physics of Field Effect Transistors (FETs): General physical considerations, MOSFET Threshold voltage, flat band conditions, threshold adjustment, linear and saturated operation, FET capacitance mobility saturation and thermal variations, short channel effect and hot electron effects, Electromigration, Aluminum spikes and contact resistance.

Processing, Scaling and Reliability: Silicon Gate NMOS processes, Silicon Patterining,Mask Generation, Active Area definition, Transistor Formation Contacts, Metallization, Chip Scaling tact, Functional limitations of scaling, Scaling of wires and interconnections,Latch up in scaled CMOS circuits, Device reliabilitry, Soft erreor, Noise margins, Lead inductance, Gate oxide reliability, Polysilicon resistance and Input protection.

Design Rules and Layout: NMOS rules, CMOS design rules, passive load NMOS inverter, active load NMOS inverter, NMOS NAND & NOR gates, CMOS inverter, CMOS NAND & NOR gates, interlayer contacts, butting and buried contacts.

MOS Inverters: MOSFET aspect and inverter ratio, enhancement & depletion mode pull ups, enhancement Vs depletion mode pull ups, standard CMOS inverter, NMOS threshold voltage and inverter ratio transit and switching speed of NMOS & CMOS inverter.

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Unit II

CMOS Digital Gates and Sequential Circuits: NMOS and CMOS Super Buffer, Tri-State buffer and PAD Drivers, CMOS Gates, Dynamic CMOS Design, Charge Sharing, Pseudo- NMOS PMOS, Flip-Flops, Setup and Hold Time, Race Around Condition, Sequential Digital Circuits, Power Analysis and Estimation, Different Process Corners, Slow and Fast Transistors, High and Low Threshold Voltage Transistors

VLSI Computer Aided Design **(CAD) Tools and Methodology:** Full-Custom CMOS Design Flow, Semi- Custom Design Flow, Application Specific Integrated Circuit (ASIC) CMOS Design Flow. Resistor transfer level (RTL) simulation, Conformal Mapping and Equivalence Check, Physical Design Verification (DRC/LVS).

RTL-To-GDSII Flow: Floorplanning, Placement, Clock-Tree Synthesis, I/O Pads and I/O Rings, RC extraction, Wire load Models, Routing, Design Rule Checking(DRC), Static Timing Analysis, Dynamic Timing Analysis, Timing Report Generation and Analysis.

Packaging and Testing: Packaging of ICs. Different types of packages. Design for Testability – requirement & cost of testing, test pattern generation, fault models, test generation and methodology.

Unit III:

Introduction to Embedded Systems: Introduction to Embedded Systems, Architecture of Embedded System, Design Methodology, Design Metrics, General Purpose Processor, System On chip.

Embedded System Design and Development: Embedded system design, Life-Cycle Models, Problem solving, The design process, Requirement identification, Formulation of requirements specification. Development tools.

System Design Specifications: System specifications versus system requirements, Partitioning and decomposing a system, Functional design, Architectural design, Functional model versus architectural model, Prototyping, Other considerations, Archiving the project.

Unit IV:

Real-Time Operating System (RTOS) based Embedded System Design: Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS.

Android Operating System: Introduction to Android Technology, Strusture of Android Applications, Working with activities, Datad Stores, Network services and APIs, Intents, Content Propviders and Services, Advance Operations with android, Telephony, SMS, Audio, vidio using the Camera.

References:

1. Introduction to VLSI Design, E.D.Fabricius
2. Introduction to VLSI Systems, Carver Mead and Lynn Conway, Addison-Wesley.
3. Neil Weste and David Harris, CMOS VLSI Design: A Circuits and Systems Perspective, fourth edition, Addison Wesley, 2011.
4. Principles of CMOS VLSI Design a System Perspective, Neil H.E.Weste, Kamran Eshraghian, Addison-Wesley.
5. Basic VLSI Design, D. A. Pucknell, Kamran Eshraghian, Prentice Hall.
6. Introduction to embedded systems, by Shibu K. V.; Sixth Reprint 2012, Tata McGraw Hill
7. James K Peckol, "Embedded Systems – A contemporary Design Tool", John Weily, 2008.
8. Steve Furber, "ARM System-on-Chip Architecture", Second Edition, Pearson Education Publication.
9. James K. Peckol, "Embedded Systems: A Contemporary Design Tool", WILEY Student Edition Publication.
10. Tammy Noergaard, "Embedded Systems Architecture", Elsevier Publication

Additional References:

2. VHDL programming by example by Douglas L. Perry, Fourth edition, Tata McGraw-Hill
3. Starting Out with C++ Early Objects Tony Gaddis Judy Walters Godfrey Muganda Seventh Edition Addison-Wesley.
4. Object Oriented Programming with C++ by Balagurusamy, McGraw Hill Education (India) Private Limited, Sixth Edition.
5. A Byte of Python by C. H. Swaroop.

VHDL, C++ and Python Programming: (60 lectures, 4 credits)

Unit I:

VHDL I: ***Introduction to VHDL:*** VHDL Terms, Describing Hardware in VHDL, Entity, Architectures , Concurrent Signal Assignment , Event Scheduling, Statement concurrency, Structural Designs, Sequential Behavior, Process Statements, Process Declarative Region, Process Statement Part, Process Execution, Sequential Statements, Architecture Selection, Configuration Statements, Power of Configurations.

Behavioral Modeling: Introduction to Behavioral Modeling, Transport Versus Inertial Delay, Inertial Delay, Transport Delay, Inertial Delay Model, Transport Delay Model, Simulation Deltas, Drivers, Driver Creation, Bad Multiple Driver Model, Generics, Block Statements, Guarded Blocks.

Sequential Processing: Process Statement, Sensitivity List, Process Example, Signal Assignment Versus Variable Assignment, Incorrect Mux Example, Correct Mux Example, Sequential Statements, IF Statements, CASE Statements, LOOP statements, NEXT Statement, EXIT Statement, ASSERT Statement, Assertion BNF, WAIT Statements, WAIT ON Signal, WAIT UNTIL Expression, WAIT FOR time_expression, Multiple WAIT Conditions, WAIT Time-Out, Sensitivity List Versus WAIT Statement, Concurrent Assignment Problem, Passive Processes.

Unit-II:

VHDL II: Data Types*:* Object Types, Signal, Variables, Constants, Data Types, Scalar Types, Composite Types, Incomplete Types, File Types, File Type Caveats, Subtypes.

Subprograms and Packages*:* Subprograms Function, Conversion Functions, Resolution Functions, Procedures, Packages, Package Declaration, Deferred Constants, Subprogram Declaration, Package Body.

Predefined Attributes: Value Kind Attributes, Value Type Attributes, Value Array Attributes, Value Block Attributes, Function Kind Attributes, Function Type Attributes, Function Array Attributes, Function Signal Attributes, Attributes ‘EVENT and ,LAST- VALUE Attribute ‘LAST-EVENT Attribute, ‘ACTIVE and ‘LAST-ACTIVE Signal Kind Attributes, Attribute ‘DELAYED, Attribute ‘STABLE, Attribute ‘QUIET, Attribute TRANSACTION, Type Kind Attributes, Range Kind Attributes.

Configurations: Default Configurations, Component Configurations, Lower-Level Configurations, Entity-Architecture Pair Configuration, Port Maps, Mapping Library Entities, Generics in Configurations, Generic Value Specification in Architecture, Generic Specifications in Configurations, Board-Socket-Chip Analogy, Block Configurations, Architecture configurations.

Unit III

Overview of Programming Using C++: Introduction to Computers and programming , Introduction to C++, Expressions and interactivity , Making decisions, Looping , Functions , Arrays , Sorting arrays, Pointers,

Object-Oriented Programming: Introduction to Classes and Object-Oriented Programming, Searching, Sorting, and Algorithm Analysis, Characters, Strings, and the string Class, Recursion, Polymorphism and Virtual Functions.

Unit IV:

Python Programming language: Introduction and Installing Python, Operators and Expressions, Looping, Control Statements, String Manipulation, Lists, Tuple, Dictionaries, Functions, Modules, Input-Output, Exception Handling. Introduction to Advance Python**:** OOPs concept, Regular expressions, CGI, Database, Networking, Multithreading, GUI Programming, Sending email

References:

3. VHDL programming by example by Douglas L. Perry, Fourth edition, Tata McGraw-Hil
4. Starting Out with C++ Early Objects Tony Gaddis Judy Walters Godfrey Muganda Seventh Edition Addison-Wesley.
5. Object Oriented Programming with C++ by Balagurusamy, McGraw Hill Education (India) Private Limited, Sixth Edition.
6. A Byte of Python by C. H. Swaroop.

Additional References:

a. Introduction to VLSI Design, E.D.Fabricius
b. Introduction to VLSI Systems, Carver Mead and Lynn Conway, Addison-Wesley.
c. Neil Weste and David Harris, CMOS VLSI Design: A Circuits and Systems Perspective, fourth edition, Addison Wesley, 2011.
d. Principles of CMOS VLSI Design a System Perspective, Neil H.E.Weste, Kamran Eshraghian, Addison-Wesley.
e. Basic VLSI Design, D. A. Pucknell, Kamran Eshraghian, Prentice Hall.
f. Introduction to embedded systems, by Shibu K. V.; Sixth Reprint 2012, Tata McGraw Hill
g. James K Peckol, “Embedded Systems – A contemporary Design Tool”, John Weily, 2008. Steve Furber, “ARM System-on-Chip Architecture”, Second Edition, Pearson Education Publication.
h. James K. Peckol, “Embedded Systems: A Contemporary Design Tool”, WILEY Student Edition Publication.
i. Tammy Noergaard, “Embedded Systems Architecture”, Elsevier Publication
j. VHDL programming by example by Douglas L. Perry, Fourth edition, Tata McGraw-Hill
k. Starting Out with C++ Early Objects Tony Gaddis Judy Walters Godfrey Muganda Seventh Edition Addison-Wesley

Embedded C, ARM and Interfacing: (60 lectures, 4 credits)

Unit I

Fundamentals of Embedded Operating System, Embedded Linux, GNU Tools, Dynamic memory allocation, Introduction to Operating System services, Process, memory and I/O management, Embedded C Programming, Review of data types, Introduction to Embedded C, Embedded programming issues, Modeling Language for Embedded Systems,

Unit II

Embedded Applications using Data structures, Linear data structures– Stacks and Queues, Nonlinear structures – Trees and Graphs, Socket programming, Creating a linked list, linked stack and queue, double and circular linked list, sparse matrices, binary tree, Interrupt handling in C, Code optimization issues in Embedded C, Object Oriented programming basics,

Unit III

ARM ((Advanced RISC Machine) **Architecture**: Overview of ARM processors, ARM architectural ((LPC2148 and LPC2378) support for high level language, ARM architectural support for system development, ARM architectural support for operating System, Memory subsystem architecture, Designing a cache system, Memory allocation, Communication protocols.

Unit IV

Communication Interface: Inter Integrated Circuit (I2C), Serial Peripheral Interface (SPI), Universal Asynchronous Receiver Transmitter (UART), Wire Interface, Parallel Interface

External Communication Interfaces: RS-232 & RS-485, USB, IEEE 1394 (Firewire), Infrared (IrDA), Bluetooth, Wi-Fi, ZigBee, GPRS.

References:

1. C Programming language, Kernighan, Brian W, Ritchie, Dennis M
2. “Embedded C”,Michael J. Pont, Addison Wesley
3. “Exploring C for Microcontrollers- A Hands on Approach”,Jivan S. Parab, Vinod G. Shelake, Rajanish K.Kamot, and Gourish M.Naik, Springer.
4. Daniel W. Lewis, “Fundamentals of embedded software where C and assembly meet”, Pearson Education, 2002.
5. Bruce Powel Douglas, “Real time UML, second edition: Developing efficient objects for embedded systems”, 3rd Edition 1999, Pearson Education.
6. Steve Heath, “Embedded system design”, Elsevier, 2003.
7. David E. Simon, “An Embedded Software Primer”, Pearson Education, 2003.

6. The Complete Reference C++, Herbert Schildt, TMH

8. GNU C++ For Linux, Tom Swan, Prentice Hall India
9. . Introduction to embedded systems, by Shibu K. V., Sixth Reprint 2012, Tata McGraw Hill

10.. Embedded Systems” Architecture, Programming and Design, by Raj Kamal, 2nd Second Edition, The McGraw-Hill Companies.

11. Wireless Communications and Networks, by William Stallings, 2nd edition Pearson.

Additional References:

1. C Programming language, Kernighan, Brian W, Ritchie, Dennis M
2. “Embedded C”, Michael J. Pont, Addison Wesley
3. “Exploring C for Microcontrollers- A Hands on Approach”,Jivan S. Parab, Vinod

G. Shelake, Rajanish K.Kamot, and Gourish M.Naik, Springer.
4. Daniel W. Lewis, “Fundamentals of embedded software where C and assembly meet”, Pearson Education, 2002.
5. Bruce Powel Douglas, “Real time UML, second edition: Developing efficient objects for embedded systems”, 3rd Edition 1999, Pearson Education.
6. Steve Heath, “Embedded system design”, Elsevier, 2003.
7. David E. Simon, “An Embedded Software Primer”, Pearson Education, 2003.
6. The Complete Reference C++, Herbert Schildt, TMH
8. GNU C++ For Linux, Tom Swan , Prentice Hall India
9. Object_Oriented programming in C++, Robert Lafore , Galgotia publications
10. Operating System Concepts, Peter B. Galvin, Abraham Silberschatz, Gerg Gagne, Wiley Publishers
11. GNU/LINUX Application Programming, Jones, M Tims
12. Introduction to embedded systems, by Shibu K. V., Sixth Reprint 2012, Tata McGraw Hill
13. Embedded Systems” Architecture, Programming and Design, by Raj Kamal, 2nd Second Edition, The McGraw-Hill Companies.
14. Wireless Communications and Networks, by William Stallings, 2nd edition Pearson.
15. Biomedical Instrumentation S. Chatterjee and Aubert Miller Cengage Learning
16. Biomedical Instrumentation and Measurements Lesli Cromwell, F J Weibell, Erich Pfeiffer PHI
17. Handbook of Biomedical Instrumentation R S Khandpur TMH
18. Biomedical Digital Signal Processing Willis J Tompkins PHI

Biomedical Physics and Instrumentations: (60 lectures, 4 credits)

Unit I

Introduction to Biomedical Instrumentation System: Overview of Bioinstrumentation, Biomedical Simulators, Biomedical organizations and Standards; Sources of Bioelectric Potential and Electrodes- Resting and Action potential, Propagation of action potential, The bioelectric potentials: ECG, EEG, EMG, ERG, EOG, EGG; Digital Biosignals, Types of Noise.
Biomedical Electrodes, Sensors and Transducers: Electrode Theory, Goldman and Nernst Equations, Ag-AgCl Reference Electrode; Surface electrodes, Needle electrodes, microelectrodes; Classifications and Characteristics of Sensors and Transducers, Pressure, Flow, Temperature and Optical transducers.

Unit II

Instrumentation in Diagnostic Cardiology: The Heart and cardiovascular system, The Electrocardiogram (ECG), ECG leads, Vectorcardiography, Normal and abnormal ECGs, Block diagram of ECG machine (Electrocardiograph); Blood pressure, Heart sounds, Defibrillators and Pacemakers – Theory and circuits, Types of defibrillators and pacemakers

Electroencephalography and EMG Instrumentation: The Anatomy of the Nervous system, The organization of the Brain and its measurement, The Electroencephalogram (EEG) - EEG electrodes, machines and measurements; EMG Machines and Neuromuscular measurements

Unit III

Artifacts and Noise in Medical Instrumentation: Examples of noise in medical instrumentation and biomedical signals – baseline wander, powerline interference, electrode motion artifacts etc, Noise reduction with digital signal processing; QRS complex detection in ECG- Pan Tompkins Algorithm.

Unit IV

Modern Medical Imaging and Instrumentation Systems: Ultrasound and Ultrasonic imaging system – Ultrasound Doppler and flow detector, Echocardiogram; Physics of X-rays and X-ray machines, X-ray images and data, Computer Tomography (CT) – Principles and scans; Magnetic resonance imaging (MRI) Positron Emission Tomography (PET).

References:

1. Biomedical Instrumentation S. Chatterjee and Aubert Miller Cengage Learning
2. Biomedical Instrumentation and Measurements Lesli Cromwell, F J Weibell, Erich Pfeiffer PHI
3. Handbook of Biomedical Instrumentation R S Khandpur TMH
4. Biomedical Digital Signal Processing Willis J Tompkins PHI

Signal Modulation and Transmission Techniques

(60 lectures, 4 credits)

Unit 1:

Radio wave propagation; Electromagnetic waves, free space propagation, reflection, refraction, and diffraction, ground wave propagation, ionospheric propagation, line of sight propagation, propagation in mobile/portable environment, repeaters and cellular systems, other propagation modes.

Unit 2

Transmission Line Theory: Fundamental of transmission lines, Different types of transmission lines; Telephone lines and cables, Radio frequency lines, Micro strip transmission lines. Definition of characteristics impedance, Losses in transmission lines, Standing waves, Quarter and Half wavelength lines, Reactance properties of transmission lines, Fundamental of the Smith charts and its applications.

Unit 3:

Elements of communication system, time and frequency domains, noise in communications, Amplitude modulation, full carrier AM: time and frequency domain, quadrature AM, AM stereo, suppressed carrier AM. Angle modulation, frequency modulation, phase modulation, FM and noise, FM stereo.

Unit 4:

Satellite communication

Satellite orbits, geostationary satellites, applications of geostationary satellites, satellites in low and medium earth orbits, satellite telephone systems using LEO and MEO satellites.

Antennas: Basic considerations, Wire radiators in space, Terms and definitions, Effects of ground on antennas, Antenna Coupling at medium frequencies, Directional high frequency antennas, UHF and Microwave antennas, Wideband and special purpose antennas.

References:

11. Electronic Communications Systems by Blake, 2nd ed. Thomson India.
12. Electronic Communication Systems by George Kennedy and Bernard Davis, 4th ed., Tata McGraw-Hill Publishing Company Ltd., New Delhi.
13. Electronic Communication Systems-*Fundamentals through Advanced* by Wayne Tomasi; 4th Edition, Pearson education Singapore.

14. Additional References:

6. Electronic Communications by Dennis Roddy & John Coolen, (4th ed., Pearson Ed.)
7. Modern Electronic Communication by Gary M. Miller, (6th ed., Prentice Hall International Inc.)

Letter Grades and Grade Points

Semester GPA/Program CGPA	% Marks	Letter Grade Results
9.00-10.00	90-100	O(Outstanding)
8.00≤ 9.00	80.0≤ 90.0	A+(Excellent)
7.00≤ 8.00	70.0≤ 80.0	A(Very Good)
6.00≤ 7.00	60.0≤ 70.0	B+(Good)
5.50≤ 6.00	55.0≤ 60.0	B(Above Average)
5.00≤ 5.50	50.0≤ 55.0	C (Average)
4.00 ≤ 5.00	40.0 ≤ 50.0	P (pass)
Below 4.00		F (Fail)
Ab(Absent		Ab(Absent)

Syllabus

M.Sc.(Physics)

(Sem. I & II)

Team for Creation of Syllabus

Name	College Name	Sign
Prof Vaishali Bambole	University Department of Physics	
Prof Balasaheb J. Nagare	University Department of Physics	
Mr. Nitin Bijewar	University Department of Physics	

Sign of ~~HOD~~

Prof. Vaishali A. Bambole

Department of Physics

Professor & Head
Department of Physics
University of Mumbai

Sign of Dean

Prof Shivram Garje

Science and Technology

Appendix B

Justification for M.Sc.(Physics)

1.	Necessity for starting the course:	It is basic science program to understand the physical nature.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	Yes
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	Aided Yes
5.	To give details regarding the duration of the Course and is it possible to compress the course?:	PG Diploma in Physics:1 year M.Sc. (Physics): 2 Year
6.	The intake capacity of each course and no. of admissions given in the current academic year:	Intake- As per the requirement of Affiliated colleges
7.	Opportunities of Employability / Employment available after undertaking these courses:	Government sector, Industry and self employments, semiconductor and electronics industry.

Sign of HOD
Prof. Vaishali A. Bambole
Department of Physics

Professor & Head
Department of Physics
University of Mumbai

Sign of Dean
Prof Shivram Garje
Science and Technology