Re-Accredited 'B++' 2.86 CGPA by NAAC
VEER NARMAD SOUTH GUJARAT UNIVERSITY
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વીર નર્મદ દક્ષિણ ગુજરાત યુનિવર્સિટી
યુનિવર્સિટી કેમ્પસ, ઉધના-મગદલ્લા રોડ, સુરત - ૩૯૫ ૦૦૭, ગુજરાત, ભારત.
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-: <u>પરિપત્ર</u> :-

વિજ્ઞાન વિદ્યાશાખા હેઠળની સંલગ્ન તમામ અનુસ્નાતક અભ્યાસક્રમ ચલાવતી કોલેજોનાં આચાર્યશ્રીઓને તથા ડિપાર્ટમેન્ટના વિભાગીય વડાશ્રીઓને જણાવવાનું કે, શૈક્ષણિક વર્ષ ૨૦૨૪–૨૫ થી અમલમાં આવનાર M.Sc. Physics Sem.-3 અને 4નો અભ્યાસ સમિતિ દ્વારા નિયુકત પેટાસમિતિ દ્વારા તૈયાર કરવામાં આવેલ અભ્યાસક્રમ ભૌતિકશાસ્ત્ર વિષયની અભ્યાસ સમિતિની તા.૧૧/૦૩/૨૦૨૪ની સભાના ઠરાવ ક્રમાંકઃ૨ અન્વયે વિજ્ઞાન વિદ્યાશાખાને કરેલ ભલામણ વિજ્ઞાન વિદ્યાશાખાની તા.૨૭/૦૩/૨૦૨૪ની સભાના ઠરાવ ક્રમાંક :૭ અન્વયે મંજૂર કરી એકેડેમિક કાઉન્સિલને કરેલ ભલામણ એકેડેમિક કાઉન્સિલની તા.૦૧/૦૩/૨૦૨૪ ની સભાના ઠરાવ ક્રમાંક :૧૦૪ અન્વયે માન.કુલપતિશ્રીને આપેલ સત્તા અંતર્ગત માનનીય કુલપતિશ્રી દ્વારા મંજૂર કરેલ છે.જેનો અમલ કરવા આથી જાણ કરવામાં આવે છે.

<u>ભૌતિકશાસ્ત્ર વિષયની અભ્યાસ સમિતિની તા.૧૧/૦૩/૨૦૨૪ ની સભાના ઠરાવ ક્રમાંકઃ૨</u>

:: આથી ઠરાવવામાં આવે છે કે, શૈક્ષણિક વર્ષ–૨૦૨૪–૨૫ થી અમલમાં આવનાર M.Sc. Physics Sem.- 3 & 4 નો પેટાસમિતિ દ્વારા તૈયાર કરવામાં આવેલ અભ્યાસક્રમ સર્વાનુમતે મંજૂર કરી વિજ્ઞાન વિદ્યાશાખાને ભલામણ કરવામાં આવે છે.

<u>વિજ્ઞાન વિદ્યાશાખાની તા.૨૭/૦૩/૨૦૨૪ની સભાનાં ઠરાવ ક્રમાંકઃ૦૭</u>

:: આથી ઠરાવવામાં આવે છે કે, ભૌતિકશાસ્ત્ર વિષયની અભ્યાસ સમિતિની તા.૧૧/૦૩/૨૦૨૪ ની સભાના ઠરાવ ક્રમાંક :૨ અન્વયે કરેલ ભલામણ સ્વીકારી શૈક્ષણિક વર્ષ ૨૦૨૪–૨૫ થી અમલમાં આવનાર M.Sc.Physics Sem.-3 & 4 નો અભ્યાસક્રમ મંજૂર કરવા એકેડેમિક કાઉન્સિલને ભલામણ કરવામાં આવે છે.

(બિડાણઃ ઉપર મુજબ)

ક્રમાંક : એસ./સાયન્સ/પરિપત્ર/૭૬૫૩/૨૦૨૪
તા.૦૪–૦૪–૨૦૨૪

કુલસચિવ

પ્રતિ,

૧) વિજ્ઞાન વિદ્યાશાખા હેઠળની સંલગ્ન તમામ અનુસ્નાતક અભ્યાસક્રમ ચલાવતી કોલેજોનાં આચાર્યશ્રીઓ. તથા વિભાગીય વડાશ્રી.

..... આપશ્રીની કોલેજના સંબંધિત શિક્ષકોને તથા વિદ્યાર્થીઓને જાણ કરી અમલ કરવા સારૂ.

૨) અધ્યક્ષશ્રી, વિજ્ઞાન વિદ્યાશાખા.

૩) પરીક્ષા નિયામકશ્રી, પરીક્ષા વિભાગ, વીર નર્મદ દ.ગુ.યુનિવર્સિટી, સુરત.

.....તરફ જાણ તેમજ અમલ સારૂ.

PROGRAMME STRUCTURE

Master of Science in Physics – M. Sc. - PHYSICS

Syllabus with effect from the Academic Year 2024-2025

Name of Programme	Master of Science in Physics
Abbreviation	M.Sc. - Physics
Duration	2 Years
Eligibility Criteria	B. Sc. Physics
Medium of Instruction	English
Objective of Program	The objective of the M.Sc. (Physics) program is to mold the students for building their carrier in research as well as in other allied fields.
Programme Specific Outcome (PSO)	(1) Enhancement of the student's knowledge in the subject. (2) Impartment of quality education to the students in the subject through well designed course of fundamental concept and technological importance. (3) Student's skill and capabilities building in the field of research and developments. (4) Students are trained for scientific approach and be able to work with quality, objectivity, ethical responsibilities, efficiency, accuracy and precision.

Syllabus with effect from the Academic Year 2024-2025

Structure for MSc Physics – Semester - III							
Course Type	Course Code	Course Name	Teaching hours/week	Credit	Internal Marks	External Marks	Total Marks
Core	PH-531	Quantum Mechanics-II	04	04	30	70	100
	PH-532	Basic Nuclear and Particle Physics	04	04	30	70	100
	PH-533	Laser Fundamentals and Applications	04	04	30	70	100
Elective (Any one course can be taken)	PH-534	Elective 1:Microcontrollers	04	04	30	70	100
		Elective 2:Advanced Materials Science	04	04	30	70	100
		Elective 3: Python Programming and Computational Physics	04	04	30	70	100
		Elective 4:Nuclear Reactions	04	04	30	70	100
	PH-535	Practical	12	06	50	100	150
Skill based course	PH-536	Microprocessors	02	02	20	30	50
		Total	30	24	190	410	600

Course Name	PH-531: Quantum Mechanics-II
Course Code	PH-531
Course Type	Core
Course Outcome (CO)	(1) By studying the course student will be able to explore applications of Quantum Mechanics to single and many particles in three dimensions extending to approximate methods. (2) Students will be able to solve the Schrödinger equation for spinless particles moving in three-dimensional potentials. (3) Students will be able to deal with rotations, the properties of addition of angular momenta, and the properties of tensor operators. (4) Students will be able to examine how to describe systems with many identical particles. (5) Students will get conceptual knowledge and application of approximation methods that deal with stationary states.

Course Content	
Unit 1	**Three-Dimensional Problems** 3D Problems in Cartesian Coordinates: General Treatment: Separation of Variables, The Free Particle, The Box Potential, The Harmonic Oscillator, 3D Problems in Spherical Coordinates: Central Potential: General Treatment, The Free Particle in Spherical Coordinates, The Spherical Square Well Potential, The Isotropic Harmonic Oscillator, The Hydrogen Atom, Effect of Magnetic Fields on Central Potentials.
Unit 2	**Rotations and Addition of Angular Momenta** Rotations in Classical Physics, Rotations in Quantum Mechanics: Infinitesimal Rotations, Finite Rotations, Properties of the Rotation Operator, Euler Rotations, Representation of the Rotation Operator, Rotation Matrices and the Spherical Harmonics, Addition of Angular Momenta: Addition of Two Angular Momenta: General Formalism, Calculation of the Clebsch–Gordan Coefficients, Coupling of Orbital and Spin Angular Momenta, Addition of More Than Two Angular Momenta, Rotation Matrices for Coupling Two Angular Momenta, Isospin, Scalar, Vector, and Tensor Operators: Scalar Operators, Vector Operators, Tensor Operators: Reducible and Irreducible Tensors, Wigner–Eckart Theorem for Spherical Tensor Operators.
Unit 3	**Identical Particles** Many-Particle Systems: Schrödinger Equation, Interchange Symmetry, Systems of Distinguishable Non-interacting Particles, Systems of Identical Particles: Identical Particles in Classical and Quantum Mechanics, Exchange Degeneracy, Symmetrization Postulate, Constructing Symmetric and Anti-symmetric Functions, Systems of Identical Non-interacting Particles, The Pauli Exclusion Principle, The Exclusion Principle and the Periodic Table.
Unit 4	**Approximation Methods for Stationary States** Time-Independent Perturbation Theory: Non-degenerate Perturbation Theory, Degenerate Perturbation Theory, Fine Structure and the Anomalous Zeeman Effect, The Variational Method, The Wentzel–Kramers–Brillouin Method: General Formalism, Bound States for Potential Wells with No Rigid Walls, Bound States for Potential Wells with One Rigid Wall, Bound States for Potential Wells with Two Rigid Walls, Tunneling through a Potential Barrier.

Reference Books	
1.	Quantum Mechanics: Concepts and Applications: Nouredine Zettili, A John Wiley and Sons Ltd., Second Edition, (2004).
2.	A text book of Quantum Mechanics: P. M. Mathews and K. Venkatesan, Tata McGraw Hill Education Private Limited, Second Edition, (2011).
3.	Quantum Mechanics: L. I. Schiff, McGraw-Hill Inc., US, Third Edition, (1968).
4.	Introduction to Quantum Mechanics: David Griffiths, Pearson Education; Second Edition, (2015).
5.	Quantum Mechanics: A. K. Ghatak and S. Lokanathan Macmillan-India, Fifth Edition, (2004).
6.	Quantum Mechanics: Claude Cohen-Tannoudji, Bernard Diu, Franck Laloe Vol. I & II, Wiley-CH, (1997).

Course Name	PH-532:Basic Nuclear and Particle Physics
Course Code	PH-532
Course Type	Core
Course Outcome (CO)	(1) To understand basic properties of nucleus and study concepts such as isospin, parity etc. in context to nucleons. (2) To learn about the fundamental interactions and their comparative properties and study nuclear radioactivity and associated properties. (3) To learn about nuclear detectors and study various nuclear models. (4) To get introduction to Particle Physics and classify particles and learn their properties. (5) To learn various quantum numbers of the particles and their conservation laws.

Course Content	
Unit 1	**Basics of Nuclear Physics** History and overview, some introductory terminology, nuclear properties, units and dimensions, nuclear mass and binding energy, nuclear spin and parity, magnetic dipole moment, electric quadrupole moment, isospin, fundamental interactions and their properties.
Unit 2	**Nuclear Decay and Radioactivity** The radioactive decay law, production and decay of radioactivity, types of decays, natural radioactivity, interaction of radiation with matter, heavy charged particles, electrons, electromagnetic radiation, gas-filled counters, scintillation detectors, semiconductor detectors, magnetic spectrometers, counter telescopes, multiwire proportional counters, polarimeters.
Unit 3	**Nuclear Models** Nuclear models, the shell model, shell model poetical, spin-orbit potential, magnetic dipole moments, electric quadrupole moments, valence nucleons, even-Z even-N nuclei and collective structure, nuclear vibrations, nuclear reactions, more realistic nuclear models, many-particle shell model, single-particle states in the deformed nuclei
Unit 4	**Particle Physics** Introduction, productions of elementary particles, classification of particles, quanta of forces, matter particles, antiparticles, symmetries and conservation laws, energy and momentum, angular momentum, parity, baryon number, lepton number, isospin, strangeness and charm, the quark model, color quarks and gluons.

Reference Books	
1.	Introduction to Nuclear Physics: H. Enge
2.	Introductory Nuclear Physics: K. Krane, Wiley India Pvt. Ltd. (1988)
3.	Introduction to Elementary Particles: Griffiths
4.	Nuclear Physics: S. N. Ghoshal, S. Chand & Co. Pvt. Ltd., Revised enlarged Edition, (2014)
5.	Introduction to Nuclear and Particle Physics: Mittal, Gupta and Verma,PHI Learning Pvt. Ltd., Third Edition, (2017)
6.	Nuclear Physics: D. C. Tayal

Course Name	PH-533: Laser Fundamentals and Applications
Course Code	PH-533
Course Type	Core
Course Outcome (CO)	(1) The course provides all the important physical principles concerned in the laser devices and tried to offer a consistent treatment of each. (2) Throughout the course the dealing has been kept as easy as possible and understandable to students with variety of backgrounds. (3) Some awareness with elements of electromagnetic theory and of spectroscopy will be helpful. (4) By studying this course, students are aware of various applications of Laser and fiber optic communication system. (5) Post completion of the course, student would be able to understand how the laser physics related with molecular spectra.

Course Content	
Unit 1	**LASER I** Introduction, Einstein coefficients, Light amplification, Threshold conditions, Laser rate equations: Two level system, three level system and four level system, Variation of Laser power around threshold, Optimum output coupling. Neodymium lasers (Nd:YAG and Nd: Glass), Gas Lasers: Neutral Atom Gas Lasers: Helium-Neon Laser, CO_2 laser, Argon ion laser, Dye laser, Semiconductor lasers.
Unit 2	**LASER II** Introduction, Optical Resonators: Modes of a rectangular cavity and the open planar resonator, Quality factor, Ultimate line width of the laser, Mode selection: Transverse mode selection and longitudinal mode selection, Q-switching, Techniques for Q-switching, Mechanical Shutter, Electro-optic effect, Acoustooptic effect, Shutters using saturable absorber, Mode locking in lasers, Techniques for mode locking.
Unit 3	**Non-linear optics** Harmonic generation, Second harmonic generation, Phase matching, Third harmonic generation, Optical mixing, Parametric generation light, Self focusing of light, Multiphoton process: Multiquantum Photoelectric effect, Two photon processes, Experiments in two photon processes, Three photon processes, Parametric generation of light, Parametric light oscillator, Frequency up conversion, Phase conjugate optics, Laser Spectroscopy: Rayleigh and Raman scattering, Stimulated Raman effect, Hyper- Raman effect : Classical treatment, Coherent anti stokes Raman Scattering, Spin Flip Raman laser, Free- electron laser, Photo-acoustic Raman spectroscopy, Brillouin Scattering, Saturation Absorption spectroscopy, Doppler free two Photon spectroscopy.
Unit 4	**Light wave communications** Light information carrying-capacity of light waves, Introduction to fiber propagation using a ray model: Step index fiber: numerical aperture and multipath dispersion, Propagation and multipath dispersion in graded index fiber, Material dispersion, Refractive index of the bulk media: theory and experimental values, Time dispersion in Bulk media. The combined effect of Material dispersion and Multipath dispersion, Root- mean- square Pulse widths and Frequency response:

	RMS pulse widths, Frequency response, Total RMS pulse width.

Reference Books	
1.	Optical Electronics: A. K. Ghatak and K. Thyagarajan, Cambridge University press, (1990).
2.	Lasers and Non – linear Optics: B. B. Laud, Wiley Eastern Limited, (1993).
3.	Lasers Theory and Applications: K. Thyagarajan and A. K. Ghatak, Macmillan India Limited, (1981).
4.	Lasers Fundamentals: William T. Silfvast, (Second Edition), Cambridge University press, (2004).
5	Solid State Laser Engineering: Walter Koechner, (Sixth Revised Edition) Springer.
6	Optical Communication Systems: John Gowar, Prentice-Hall of India (1984).

Course Name	PH-534: Elective 1 Microcontrollers
Course Code	PH-534
Course Type	Elective 1
Course Outcome (CO)	(1) After completion of the course, students shall acquire knowledge about the concepts and understanding of Microcontrollers and 8051 Architecture. (2) Students are familiar with different microcontrollers, numbering systems and binary codes. Students are acquired knowledge from conversion of one number system into another number system. (3) Students are to become familiar with internal hardware design, the architecture of the device and to determine the type, number and size of the registers and other circuitry. (4) Students learn the detailed study of the operational codes of the 8051 and understand the machine control concerns sensing the on-off states of external circuitry. (5) Students learn the operation of jump and call instructions that alter the flow of the program examining the results of the action codes.

Course Content	
Unit 1	**Microprocessors and Microcontrollers** Comparing Microprocessors and Microcontrollers, Four bit to thirty-two bit Microcontrollers. Numbering systems and Binary Arithmetic: Positional number systems, Integer binary numbers, Fractional binary numbers, Binary addition and Subtraction, Binary multiplication and Division. Binary Codes: Character code, Numeric code, Packed and unpacked BCD numbers, Gray codes, Error correction and detection codes.
Unit 2	**8051 Architecture** 8051 Microcontroller Hardware, 8051 Block diagram, 8051 Programming model, 8051 Oscillator and clock, Internal memory, Internal RAM, Stack and stack pointer, Special Function Registers, Input / Output pins ports and circuits, External memory, Counters and Timers, TCON-SFR, TMOD-SFR, Timer Counter Interrupts, Timing, Timer Modes of Operation, Counting, Serial data Input / Output, SCON-SFR, PCON-SFR, Serial Data interrupts, Data transmission, Data reception, Serial data transmission modes, Interrupts, IE-SFR, IP-SFR, Timer flag Interrupt, Serial Port Interrupt, External Interrupt, Reset, Interrupt control, Interrupt Priority, Interrupt Destinations, Software-Generated Interrupts,
Unit 3	**Moving data and Arithmetic operations:** Addressing modes, Immediate addressing mode, Register addressing mode, Direct addressing mode, Indirect addressing mode, External data moves, Code Memory Read-Only data moves, Push and Pop opcodes, Data exchanges, Example Programs. Flags, Instruction affecting flags, Incrementing and Decrementing, Unsigned addition, Signed addition, Unsigned subtraction, Signed subtraction, Multiplication, Division, Decimal arithmetic, Example Programs.
Unit 4	**Logical operation and Jump and Call instructions:** Byte level logical operations, Bit level logical operations: Internal RAM bit addresses, SFR bit addresses, Bit level Boolean operations, Rotate and Swap operations, Example

	Programs. Jump and Call program range: Relative range, Short absolute range, Long absolute range, Jumps: Bit jumps, Byte jumps, Unconditional jumps, Calls and Subroutine: Subroutine: Calls and the Stack, Calls and Returns, Example Programs.

Reference Books	
1.	The 8051 microcontroller, Architecture, Programming and Applications: Kenneth J. Ayala, West Publishing Company (1997).
2.	The 8051 Microcontroller and Embedded Systems: M.A. Mazidi, J. G. Mazidi, R. D. McKinlay.

Course Name	PH-534: Elective 2- Advanced Materials Science
Course Code	PH-534
Course Type	Elective 2
Course Outcome (CO)	(1) Students will learn brief classification of all Engineering materials varies from indigenous Metals to modern exotic materials with their distinguish properties and applications. (2) Student will learn most advance materials like Quantum Dot, Spintronics, Nitilon and nanomaterials with their synthesis and advance applications. (3) Course prepare students to be proficient and confident in all aspects of novel materials dicount, characterization and applications **(4)** Students are able to work in variety of industries such as medical devices, Automation industry, Electronic and Semiconductor devices, Advanced Ceramic, Composites, Polymer and their advance Classification.

Course Content	
Unit 1	**MATERIALS SCIENCE AND CIVILIZATION** Materials Science, Materials Science and their Ages, Classification of Engineering Materials, Stone age to Exotic Ages. Schematics of Materials Science and their elements, Structure, Properties and Performance Materials Science activities in India.
Unit 2	**STATE OF MATTERS** States of Matter and their classification, Theory of Liquid State, Plasma State and their Criterions, Crystalline, Amorphous Dendrities, spherulites, Gas, Bose Einstein Condensate, Fermi Dirac Condensate, Liquid Crystals and their applications, Colloidal States of matter, Types of Colloidal states, Gel, Emulsion, Emulsifier Agent and their role.
Unit 3	**POLYMER, CERAMICS AND COMPOSITES** Types of organic Materials, Polymer, Classification of Polymers, Polymerization and their types, Rubber, Ceramics, Classification of Ceramics. Applications of Ceramics, Composites Classification Matrix Phase PMC, CMC, MMC, Reinforcement, Types of Reinforcement, Composites, Application of Composites.
Unit 4	**ADVANCED MATERIALS** Advanced Materials, Quantum Dots, Spintronic, Biomaterials, Nano materials, Fullerene, History of Nano science, Seeing the Nano materials, Applications of Nano materials - In Cancer, Drug management, Cosmetics, Water purification, Textile, Future Lightning. Quantum Computers, Laboratory on Chip (LOC), Carbon Nano tubes, Types of Carbon nano tubes.

Reference Books	
1.	Elements of Materials Science and Engineering: Lawrence H. Van Vlack, Pearson Education, Sixth Edition, (2006).
2.	Materials Science and Metallurgy: U.C. Jindal, Atish Mozumder, Pearson Education, Third Edition, (2013).
3.	Engineering Materials (Polymers, Ceramics and Composites) : A. K. Bhargava

	PHI Learning Pvt. Ltd., Fourth Edition, (2010)
4.	Materials Science – An Intermediate Test: William F. Hosfold, Cambridge University Press, First Edition, (2007).
5.	Materials Science and Engineering: A First Course: V. Ragavan, Prentice – Hall of India Pvt. Ltd., Fifth Edition, (2005).
6.	Materials Science and Metallurgy: Parashivamurthy K. I., Pearson Education, First Edition, (2012).

Course Name	PH-534: Elective 3-Python Programming and Computational Physics
Course Code	PH-534
Course Type	Elective 3
Course Outcome (CO)	(1) This course provides the knowledge to simulate the physical systems using Python. (2) Students will be Proficient in the use of Python for scientific tasks, including data manipulation, scripting, and file operations. (3) Students will able to use conditional statements, loops and plotting for data analysis. (4) Students will acquire the knowledge of nonlinear dynamics, chaos theory, and their applications in modelling oscillatory motion, predator-prey systems, and chaotic phenomena. (5) Students will develop the skill of simulation of quantum wave packets and electromagnetic waves using numerical methods, including algorithm implementation, visualization, and results assessment.

Course Content	
Unit 1	**PYTHON Language** Introduction to Python for Science and Engineering, Interacting with Python, Installing Python on Your Computer, The Spyder Window, **The IPython Pane:** Magic commands, System shell commands, Tab completion, Recap of commands, **Interactive Python as a Calculator:** Binary arithmetic operations in Python, Types of numbers, Important note on integer division in Python, **Variables:** Names and the assignment operator, Legal and recommended variable names, Reserved words in Python, Script Files and Programs, **Python Modules:** Python modules and functions: A first look, Some NumPy functions, Different ways of importing modules, Getting Help: Documentation in IPython, Stand-alone IPython, Programming Errors, **Strings, Lists, Arrays, and Dictionaries** Strings, **Lists:** Slicing lists, The range function: Sequences of numbers, Tuples, Multidimensional lists and tuples, **NumPy Arrays:** Creating arrays (1-d), Mathematical operations with arrays, Slicing and addressing arrays, Fancy indexing: Boolean masks, Multi-dimensional arrays and matrices, Differences between lists and arrays, Dictionaries, Objects, **Input and Output** Keyboard Input, **Screen Output:** Formatting output with *str.format(),* Printing arrays, **File Input:** Reading data from a text file, Reading data from an Excel file: CSV files, **File Output:** Writing data to a text file, Writing data to a CSV file
Unit 2	**PYTHON Language** **Conditionals and Loops** **Conditionals:** *if, elif,* and *else* statements, Logical operators, **Loops:** for loops, while loops, Loops and array operations, List Comprehensions **Plotting** An Interactive Session with PyPlot, Basic Plotting, Specifying line and symbol types and colors, Error bars, Setting plotting limits and excluding data, Subplots, **Logarithmic Plots:** Semi-log plots, Log-log plots, **More Advanced Graphical Output:** An alternative syntax for a grid of plots, Plots with multiple axes,

	Mathematics and Greek symbols, **The Structure of matplotlib: OOP and All That:** The backend layer, The artist layer, The PyPlot (scripting) layer, **Contour and Vector Field Plots:** Making a 2D grid of points, Contour plots, Streamline plots, Three-Dimensional Plots **Functions** **User-Defined Functions:** Looping over arrays in user-defined functions, Fast array processing for user-defined functions, Functions with more than one input or output, Positional and keyword arguments, Variable number of arguments, Passing function names and parameters as arguments, **Passing data (objects) to and from functions:** Variables and arrays created entirely within a function, Passing lists and arrays to functions: Mutable and immutable objects, Anonymous Functions: lambda Expressions, NumPy Object Attributes: Methods and Instance Variables.
Unit 3	**Oscillatory Motion and Chaos** Free nonlinear oscillation, Nonlinear Oscillators, Bug Population Dynamics, The Logistic Map (Model), Properties of Nonlinear Maps (Theory and Exercise),Fixed Points, Period Doubling, Attractors, Mapping Implementation, Bifurcation Diagram (Assessment), Bifurcation Diagram Implementation, Visualization Algorithm: Binning, Feigenbaum Constants (Exploration), Logistic Map Random Numbers (Exploration), Other Maps (Exploration), Signals of Chaos: Lyapunov Coefficient and Shannon Entropy, Coupled Predator–Prey Models, Lotka–Volterra Model, Lotka–Volterra Assessment, Predator–Prey Chaos, Exercises, LVM with Prey Limit, LVM with Predation Efficiency, LVM Implementation and Assessment, Two Predators, One Prey (Exploration), Chaotic Pendulum, Free Pendulum Oscillations, Solution as Elliptic Integrals, Implementation and Test: Free Pendulum, Visualization: Phase-Space Orbits, Chaos in Phase Space, Assessment in Phase Space, Exploration: Bifurcations of Chaotic Pendulums, Alternate Problem: The Double Pendulum, Assessment: Fourier/Wavelet Analysis of Chaos, Exploration: Alternate Phase-Space Plots, Further Explorations.
Unit 4	**Quantum Packets and Electromagnetic** Quantum Wave Packets, Time-Dependent Schrödinger Equation (Theory), Finite-Difference Algorithm, Wave Packet Implementation, Animation, Wave Packets in Other Wells (Exploration), Algorithm for the 2D Schrödinger Equation, Exploration: Bound and Diffracted 2D Packet, Wave Packet–Wave Packet Scattering, Algorithm, Implementation, Results and Visualization, E&M Waves via Finite-Difference Time Domain, Maxwell's Equations, FDTD Algorithm, Implementation, Assessment, Extension: Circularly Polarized Waves, Application: Wave Plates, Algorithm, FDTD Exercise and Assessment.

Reference Books	
1.	Introduction to Python for Science and Engineering: David J. Pine, CRC Press Taylor and Francis Group, (2019).
2.	Computational Physics With Python: Dr. Eric Ayars, California State University, (2013).
3.	Computational Physics Problem solving with Python: R. H. Landau, Manuel J. Páze, and Cristian C. Bordeianu, Third Edition, Wiley-VCH, (2015).
4.	Computational Physics: Nicholas Giordano, Hisao Nakanishi, Second Edition, Pearson Prentice Hall, (2006).
5.	An Introduction to Computational Physics: T. Pang, Second Edition, Cambridge University Press (2006).

Course Name	PH-534: Elective 4-Particle Accelerators and Detectors
Course Code	PH-534
Course Type	Elective 4
Course Outcome (CO)	(1) The students will learn basic nuclear properties and different methods of their measurements (2) The students will be introduced to the phenomenon radioactivity, types of radioactive radiations and their properties. They will also learn various applications of radioactivity. (3) The students will have in depth study of α-decay and β- decay processes and theories giving explanation of these decay processes. They will also learn forbidden decays and comparative half-lives. (4) The students will learn the process of γ-emission and basic conservation laws, internal conversion process, γ-ray spectroscopy and Mossbauer effect.

Course Content	
Unit 1	**Particle Accelerators** Introduction, classification and performance characteristics of accelerators, electrostatic accelerators, Cockroft-Walton generator, Van de Graaff generator, pelletron accelerator, tandem accelerator, cyclotron, synchrocyclotron, betatron, electron synchrotron, microtron, linear accelerator.
Unit 2	**Nuclear Detectors I** Introduction, methods for the detection of free charge carriers, ionization chamber, mode of operation, integrating type of ion chambers, pulse, chambers, proportional counter, neutron counting, Giger-Muller Counter, counter characteristic, quenching of the discharge, dead-time of the G. M. Counter, efficiency of counting, semiconductor detectors, diffused junction detectors, surface barrier detectors, Si (Li) detector, Ge (Li) detector, HPGe detectors, use of semiconductor detectors.
Unit 3	**Nuclear Detectors II** Methods based on light sensing, scintillation detector, photomultiplier tubes, scintillation counting arrangement, electrical pulse formation, Cherenkov detector, methods of visualization of the tracks of ionizing radiation, Wilson cloud chamber, diffusion cloud chamber, bubble chamber, spark chamber, nuclear emulsion technique, applications of nuclear emulsions, nuclear emulsions in auto-radiography, solid state nuclear state detectors.
Unit 4	**Nuclear Electronics** Introduction, general considerations of electronics for energy spectroscopy, pre-amplifiers, charge sensitive pre-amplifiers, pulse shaping methods, RC pulse shaping circuits, bipolar pulse shaping and zero crossover timing, base-line restorer, electronics for timing with detectors, pulse amplitude analysis (ADC), SCA, MCA.

Reference Books	
1.	Introductory Nuclear Physics: K. Krane, Wiley India Pvt. Ltd. (1988).
2.	Nuclear Physics: S. N. Ghoshal ,S. Chand & Co. Pvt. Ltd., Revised enlarged Edition (2014).
3.	Introduction to Nuclear and Particle Physics by Mittal, Gupta and Verma, PHI Learning Pvt. Ltd., Third Edition (2017).

4.	Nuclear Physics: D. C. Tayal, Himalaya Publishing House (2017).
5.	Radiation Detection and Measurement: G. F. Knoll.
6.	Nuclear Radiation Detectors: S. S. Kapoor and V. S. Ramamurthy.

Course Name	PH-535: Practical
Course Code	PH-535
Course Type	Core
Course Outcome (CO)	(1) Attain proficiency in modern physics experiments, mastering techniques for observation, analysis, and interpretation of phenomena in experimental settings. (2) Develop expertise in radiation experiments, mastering GM tube characteristics, gamma source activity determination, inverse square law verification, energy determination, and spectrometry. (3) Attain proficiency in optical experiments, mastering Michelson's Interferometer, optical fiber characterization, numerical aperture calculations, polarized light intensity measurement, and Kerr effect demonstration.

Course Content	
	Group A
1.	Qualitative observation of Compton effect.
2.	To observe the neon spectral bands formation in Frank-Hertz tube.
3.	Study of Zeeman effect
4.	To determine Brewster's Angle using LASER.
5.	To study Beer- Lambert (law) : concentration of chemical solution
	Group B
6.	To study characteristics of a GM tube and determination of its operating voltage, plateau length / slope etc.
7.	To determine activity of a gamma source (Relative Method)
8.	To verify inverse square law for γ – rays.
9.	To determine the Unknown energy of a radioactive isotope.
10.	To study Cs-137 spectrum and calculation of FWHM and resolution for a given scintillation detector.
	Group C
11.	Michelson's Interferometer.
12.	To measure the losses in dB of two optical fibers patch cords and the coefficient of attenuation.
13.	Calculate the numerical aperture and study the losses in optical fiber cable.
14.	To measure the light intensity of plane polarized light as a function of the analyzer position.
15.	To demonstrate the Kerr effect.
	Group D (Elective Paper 1)
16.	To design, build and test Binary to Gray code converter.
17.	To design, build and test a BCD to 7-Segnment ROM.
18.	To design, build and test a BCD to 9'S complement circuit.
19.	To design, build and test a 7 bit hamming code with even and odd parity.
20.	Microcontroller Programming
	Group D (Elective Paper 2)

16.	Study on Diffraction of X-Ray by (i) Brag's law and (2) Laue's Method.
17.	Measuring the diameters of the two diffraction rings for different accelerator voltages.
18.	Determining the wavelength of the electrons for different accelerator voltages by applying the Bragg condition.
19.	Find the permeability and permittivity of free space and air using current balance method.
20.	Determine the Dielectric Constant of different materials.
Group D (Elective Paper 3)	
16.	Write a PYTHON program to perform the simulation of nonlinear oscillators.
17.	Write a PYTHON program to perform the simulation of Logistic Map.
18.	Write a PYTHON program to perform the simulation of simple pendulum.
19.	Write a PYTHON program to perform the simulation of wave packet.
20.	Write a PYTHON program to perform the simulation of time dependent Schrödinger Equation.
Group D (Elective Paper 4)	
16.	To do spectrum analysis of Cs-137 & Co-60 and to explain some of the features of Compton edge and backscatter peak.
17.	To study variation of energy resolution with gamma energy.
18.	To study beta particle range and maximum energy (Feather Analysis).
19.	To determine linear and mass absorption coefficient using GM counter.
20.	To measure short half-life.

Course Name	PH-536:Skill based course-Microprocessors
Course Code	PH-536
Course Type	Skill based course
Course Outcome (CO)	(1) Students learn about conversion of number system and will acquire basic understanding and concept of Microprocessors. (2) Student would know the usage of Intel 8085 instruction set and to learn writing of assembly language programs for beginners. (3) This course is very helpful to work on microprocessor based project.

Course Content	
Unit 1	**Microprocessor Architecture** Review of number systems, Binary Addition, Binary subtraction, Representation of negative number: 9's Complement, 10's Complement and 1's Complement Conversion of Decimal number to Hexadecimal number and vice versa, Conversion of Decimal number to Octal number and vice versa, Conversion of binary number to Hexadecimal number, Introduction: Intel 8085, ALU, Timing and control unit, Registers, Data and Address bus, Pin configuration, Intel 8085 instructions, Opcode and Operands, Instruction word size, Timing and control signals, Fetch operation, Execute operation, Machine cycle and state, Instruction and data flow, System timing diagram, Memory read, I/O Read and I/O write.
Unit 2	**Instruction set for Intel 8085** Instruction and data formats, Addressing modes: Direct addressing, Register addressing, Register Indirect addressing, Immediate addressing, Status flags, Intel 8085 instructions: Data transfer group, Arithmetic group, Logical group, Branch group, Stack, I/O and machine control group. Examples of assembly language programs: Addition and subtraction of two 8-bit and 16-bit numbers, 1's Complement and 2's Complement of 16-bit number, Mask off least significant 4-bits of 8-bit number, Mask off most significant 4- bits of 8-bit number Shifting of a 16-bit number left by two bits, Find the largest and smallest number from a seriesof numbers.

Reference Books	
1.	Fundamentals of Microprocessors and Microcomputers: B. Ram, Dhanpat Rai Publications (1992).
2.	Microprocessor Architecture, Programming and applications: Ramesh S. Gaonkar, Wiley Eastern Limited.

Re-Accredited 'B++' 2.86 CGPA by NAAC
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PROGRAMME STRUCTURE

Master of Science in Physics – M. Sc. - PHYSICS

Syllabus with effect from the Academic Year 2024-2025

Name of Programme	Master of Science in Physics
Abbreviation	M.Sc. - Physics
Duration	2 Years
Eligibility Criteria	B. Sc. Physics
Medium of Instruction	English
Objective of Program	The objective of the M.Sc. (Physics) program is to mold the students for building their carrier in research as well as in other allied fields.
Programme Specific Outcome (PSO)	(1) Enhancement of the student's knowledge in the subject. (2) Impartment of quality education to the students in the subject through well designed course of fundamental concept and technological importance. (3) Student's skill and capabilities building in the field of research and developments. (4) Students are trained for scientific approach and be able to work with quality, objectivity, ethical responsibilities, efficiency, accuracy and precision.

Syllabus with effect from the Academic Year 2024-2025

Structure for MSc Physics – Semester - IV							
Course Type	Course Code	Course Name	Teaching hours/week	Credit	Internal Marks	External Marks	Total Marks
Core	PH-541	Advanced Quantum Mechanics	04	04	30	70	100
	PH-542	Atomic and Molecular Physics	04	04	30	70	100
	PH-543	Statistical Mechanics	04	04	30	70	100
Elective (Any one course can be taken)	PH-544	Elective 1: Micro and Nano Electronics	04	04	30	70	100
		Elective 2: Properties of Materials	04	04	30	70	100
		Elective 3: Simulation Techniques for computational Physics	04	04	30	70	100
		Elective 4: Nuclear Reactions	04	04	30	70	100
	PH-545	Practical	12	06	50	100	150
Skill based course	PH-546	Remote Sensors	02	02	20	30	50
		Total	30	24	190	410	600

Course Name	PH-541:Advanced Quantum Mechanics
Course Code	PH-541
Course Type	Core
Course Outcome (CO)	(1) By studying the course student will be able to deal time dependent perturbation and relativistic theory. (2) Students will study the approximation methods treating Hamiltonians that depend explicitly on time. (3) Students will study the quantum mechanical treatment of the scattering of a particle by a potential. (4) Students will train to solve the relativistic wave equations. (5) Students will study the Dirac Particle in different potentials.

Course Content	
Unit 1	**Time-Dependent Perturbation Theory** The Pictures of Quantum Mechanics: The Schrödinger Picture, The Heisenberg Picture, The Interaction Picture; Time-Dependent Perturbation Theory: Transition Probability, Transition Probability for a Constant Perturbation, Transition Probability for a Harmonic Perturbation; Adiabatic and Sudden Approximations: Adiabatic Approximation, Sudden Approximation; Interaction of Atoms with Radiation: Classical Treatment of the Incident Radiation, Quantization of the Electromagnetic Field, Transition Rates for Absorption and Emission of Radiation, Transition Rates within the Dipole Approximation, The Electric Dipole Selection Rules, Spontaneous Emission.
Unit 2	**Scattering Theory** Scattering and Cross Section: Connecting the Angles in the Lab and CM frames, Connecting the Lab and CM Cross Sections; Scattering Amplitude of Spinless Particles: Scattering Amplitude and Differential Cross Section, Scattering Amplitude; The Born Approximation: The First Born Approximation, Validity of the First Born Approximation; Partial Wave Analysis: Partial Wave Analysis for Elastic Scattering, Partial Wave Analysis for Inelastic Scattering; Scattering of Identical Particles.
Unit 3	**Relativistic Wave Equations** Generalization of the Schrödinger Equation, The Klein-Gordon Equation: Plane Wave Solutions; Charge and Current Densities, Interaction with Electromagnetic Fields; Hydrogen-Like Atom, Non-relativistic Limit; The Dirac Equation: Dirac's Relativistic Hamiltonian, Position Probability Density; Expectation Values, Dirac Matrices, Plane Wave Solutions of the Dirac Equation; Energy Spectrum
Unit 4	**The Dirac Equation** The Spin of the Dirac Particle, Significance of Negative Energy States; Dirac Particle in Electromagnetic Fields, Relativistic Electron in a Central Potential: Total Angular Momentum, Radial Wave Equations in Coulomb Potential, Series Solutions of the Radial Equations: Asymptotic Behaviour, Determination of the Energy Levels, Exact Radial Wave Functions; Comparison to Non-Relativistic Case, Electron in a Magnetic Field—Spin Magnetic Moment, The Spin Orbit Energy.

Reference Books	
1.	Quantum Mechanics: Concepts and Applications: Nouredine Zettili, A John Wiley and Sons Ltd.,Second Edition, (2004).
2.	A text book of Quantum Mechanics: P. M. Mathews and K. Venkatesan, Tata McGraw Hill Education Private Limited, Second Edition, (2011).
3.	Quantum Mechanics: L. I. Schiff, McGraw-Hill Inc., US, Third Edition, (1968).
4.	Introduction to Quantum Mechanics: David Griffiths, Pearson Education; Second Edition, (2015).
5.	Quantum Mechanics: A. K. Ghatak and S. Lokanathan Macmillan-India, Fifth Edition, (2004).
6.	Quantum Mechanics: Claude Cohen-Tannoudji, Bernard Diu, Franck Laloe Vol. I & II, Wiley-CH, (1997).

Course Name	PH-542:Atomic and Molecular Physics
Course Code	PH-542
Course Type	Core
Course Outcome (CO)	(1)The objective of the course is to provide requisite intellectual understanding in the field of atomic and molecular physics. (2) To learn the fine structure of hydrogenic atom and small corrections involved in it. (3) The students will understand the basic idea of central field approximation and general properties of central potential and conclude by considering corrections. (4) To study the general nature of molecular structure showing how the rotational, vibrational and electronic motions can be treated independently. (5) To understand the analysis of rotational spectra of diatomic molecules and how electric dipole transitions are modified when spin dependent interactions are considered.

Course Content	
Unit 1	**One-electron atoms: fine structure and hyperfine structure** Fine structure of hydrogenic atoms, Energy shifts, Fine structure splitting, Fine structure of spectral lines, Intensities of fine structure lines, The Lamb shift, Hyperfine structure and isotopic shifts, Magnetic dipole hyperfine structure, Electric quadrupole hyperfine structure, Isotope shifts.
Unit 2	**Two-electron atoms and many-electron atoms** Schrödinger equation for Two-electron atoms: Para and ortho states, Spin wave functions and the role of the Pauli exclusion principle, Level Scheme of two-electron atom, Independent particle model. The Zeeman Effect, The Stark effect, Quantum mechanical explanation of normal Zeeman effect, Anomalous Zeeman effect, Paschen Back effect, Stark effect. Many electron atoms: The central field Approximation, Spin and the Pauli exclusion principle, Spin-orbitals and Slater determinants, Slater determinants, Electron state in a central field: Configurations, shells and subshells, Degeneracies.
Unit 3	**Molecular structure** The Thomas-Fermi model of the atom: Fermi electron gas, The Hatree-Fock method and the self-consistent field: The Hatree-Fock equations, Physical interpretation of the Hartree-Fock equations, Koopmans' theorem, Corrections to the central field approximation: Correlation effects. Born-Oppenheimer separation for diatomic molecules, The rotation and vibration of diatomic molecules, The electronic spin and Hund's cases, Hund's cases (a), (b), (c), (d) and (e), Spin uncoupling, Λ-doubling, The structure of polyatomic molecules: Rotational structure, Vibrational structure and Electronic structure, Water molecule, Methane, ethylene and acetylene molecules, Benzene molecule and non-locallised orbitals.
Unit 4	**Molecular spectra and applications of atomic and molecular physics** Molecular spectra, Rotational spectra of diatomic molecules, Vibrational-rotational spectra of diatomic molecules, Electronic spectra of diatomic molecules: Vibrational structure of electronic spectra, Rotational structure of electronic spectra, Frank-Condon

	principle, Dissociation and Predissociation, Fluorescence and phosphorescence, Spin-dependent interactions and electric dipole transitions, Nuclear spin, Inversion spectrum of ammonia. Nuclear magnetic resonance, Rabi molecular beam apparatus, Ramsey's method of separated oscillatory fields, Paramagnetic resonance in bulk samples, Nuclear magnetic resonance in bulk samples, Chemical shifts, Atom optics: Focusing of atomic beams, focusing using static electromagnetic fields, Focusing by using light forces, Focusing by using a Fresnel zone plate. Atom mirrors: Reflection from surfaces, Reflection from an evanescent light wave, Atomic beam splitters: Diffraction from micro-fabricated structures, Photon recoil beam splitter, Sudden transition due to field gradients, Atoms in cavities and ions in traps: one-atom maser, one-atom laser, Ion in traps: Paul trap or radio-frequency trap, Penning trap, Quantum jumps of single ion, Crystallisation of laser-cooled ions in a trap.

Reference Books	
1.	Physics of Atoms and Molecules: B. H. Bransden and C.J. Joachain, Second Edition, Pearson, (2003).
2.	Modern Physics: R. Murugeshan, Seventeenth Edition, S. Chand & Company Pvt. Ltd (2014).
3.	Concepts of Modern Physics: Arthur Beiser, Sixth Edition, McGraw Hill, (2003).

Course Name	PH-543: Statistical Mechanics
Course Code	PH-543
Course Type	Core
Course Outcome (CO)	(1) Students will comprehend the unique properties of ideal Bose and Fermi gases. (2) Students will gain proficiency in the Ising model, exchange interaction, and Heisenberg Hamiltonian. They will apply these concepts to precisely analyze one-dimensional lattice systems. (3) Students will grasp the fundamentals of phase transitions, critical phenomena, and the dynamics involved. They will apply Mayer's theory and understand critical indices and Lee-Yang's theory. (4) Students will acquire a deep understanding of thermodynamic fluctuations, spatial correlations in fluids, and Brownian motion. They will apply theoretical models to explain diverse physical phenomena. (5) After completion of this course, students will possess a comprehensive understanding of ideal quantum systems, strongly interacting models, phase transitions, and fluctuations, applying these concepts to real-world phenomena.

Course Content	
Unit 1	**Ideal quantum systems:** a. Properties of ideal Bose gas: Bose-Einstein condensation: Transition in liquid He4, Superfluidity in He4. Photon gas: Planck's radiation law. Phonon gas: Debye's theory of specific heat of solids. b. Properties of ideal Fermi gas: Review of the thermal and electrical properties of an ideal electron gas. Landau levels, Landau diamagnetism. White dwarf and Neutron stars.
Unit 2	**Strongly interacting systems:** Ising model. Idea of exchange interaction and Heisenberg Hamiltonian. Ising Hamiltonian, zeroth and first order approximations, Exact treatment of one dimensional lattice.
Unit 3	**Phase transition** General remarks. Phase transition and critical phenomena. Critical indices. Mayer's theory of condensation, The theory of Lee and Yang, dynamical model of phase transitions.
Unit 4	**Fluctuations** Thermodynamic fluctuations. Spatial correlations in a fluid. Brownian motion: Einstein-Smoluchowski's theory, Langevan theory of Brownian motion, Fokker-Planck equation.

Reference Books	
1.	Statistical Mechanics: R.K. Pathria and P.D. Beale, Butterworth-Heinemann,Oxford, Third Edition, (2011).
2.	Statistical Mechanics: K. Huang, Wiley Eastern, New Delhi, (1987).
3.	Statistical Mechanics by F. Schwabl, Springer-Verlag, Berlin, (2006).
4.	Statistical Mechanics: B.K. Agarwal and M. Eisner, Wiley Eastern, New Delhi,Second Edition, (2011).

5	Elementary Statistical Physics: C. Kittel, Wiley, New York, (2004).
6	Statistical Mechanics: S.K. Sinha, Tata McGraw Hill, New Delhi, (1990)

Course Name	PH-544: Elective 1: Micro and Nano Electronics
Course Code	PH-544
Course Type	Elective 1
Course Outcome (CO)	(1) Student will learn Micro and Nano-electronics as a field of energy which deals with study and manufacturing of small (Micro and Nano electronics design and components. (2) Student will learn most advance Micro and Nano technologies like NMOS, CMOS, BIFET-BIMOS- BICMOS, ECL and I^2L technologies. (3) Student will learn modern architectures for PROM, EPROM, PAL, PLA and CCD memories. (4) Student can shape up their carrier in Integrated circuit (VLSI) design and manufacturing sector. This is an emerging sector for Gujarat as well as for our country.

Course Content	
Unit 1	**Micro Electronic Devices** Electronics and Microelectronics, Classification of Semiconductor Devices. Depletion and Enhancement MOSFET, NMOS, Physical behaviour of NMOS, Volt-Ampere Characteristics, Comparison of NMOS, for NMOS, Small Signal model of NMOS, NMOS amplifier with small signal analysis, NMOS as analog Switch, CMOS devices, CMOS small signal model, BIFET-BIMOS and BICMOS circuits.
Unit 2	**Micro electronic Technologies** NMOS Inverter, NMOS-NAND, NOR Gates, their architecture and Truth Tables, Propagation Delay of an NMOS, CMOS Inverter, CMOS – NAND, NOR and Transmission Gate with their architectures and operation, Emitter Coupled Logic (ECL) circuits, ECL advantages and limitations, Integrated Injection Logic (I^2L). Comparison of Logic families.
Unit 3	**Solid State Memories** Classification of memory, Limitations of ROM, Programmable ROM (PROM) and their architecture, Limitations of PROM, Erasable ROM (EPROM), FAMOS, Limitations of EPROM, Electrical Erasable PROM (EEPROM), Programmable Array Logic (PAL), Programmable Logic Array (PLA), Flash Memory Devices, Manufactures of Memory Devices, Charge Coupled Device (CCD) and their charge transfer, CCD structures, CCD organisations (Serpentine and LARAM).
Unit 4	**Nano Electronics** Challenges going to sub 100 nm MOSFETS, Nano MOS based Devices-Multiple Gate MOSFETS, FIN FETS, Verticals MOSFETS, Carbon Nano tube based Devices – CNFET, Characteristics. Spintronics, spin based Devices – Spin FET, Quantum Dots, Single Electron Devices, Flexible Devices.

Reference Books	
1.	Microelectronics: J. Millmann and A. Grable, Sixteenth Reprint, Mc Graw Hill, (2005).
2.	Microelectronics–Circuits Theory and Application: A. S. Sedra and K.C. Smith, Oxford University Press, Sixth Edition, (2013).
3.	Microelectronics–An Integrated Approach: Roger T Howe, Charles G. Sodini, Pearson Education, First Edition, (2006).
4.	Microelectronic Devices: Dipankar Nagchoudhuri, Pearson Education,

	Second Edition (2002).
5.	Technology of Quantum Devices: Manjieh Razeghi, Springer
6.	Physics of Quantum Well Devices: B. R. Nag, Springer, (2002)
7.	SWAYAM–Microelectronics: Devices to Circuits: Prof. S. Dasgupta 60 Lectures – 12 week (NPTEL).
8.	Nano electronics and Nano systems–From Transistors to Molecular: J. Dienstuhi, Springer, International Edition, Second Edition, (2008).
9.	Fundamentals of Nano electronics: George W. Hanson, Pearson Education, First Edition, (2009).

Course Name	PH-544: Elective 2: Properties of Materials
Course Code	PH-544
Course Type	Elective 2
Course Outcome (CO)	(1) Students will learn the general and distinguished properties of modern materials. (2) Students will learn the fundamental properties of materials like Dielectric, Mechanical, Electrical and Nonlinear optical properties with modern experimental aspects for these properties (3) Students can correlate the data available through different modern characterization tools with theories and interpret them for new structures or performances of new materials. (4) Students are able to work in variety of industries such as Automation industry, ceramic, Composite, Polymer and optoelectronic related industries.

Course Content	
Unit 1	**Dielectric Properties** Dielectric Behaviour, Dipole moment and Polarization, Polarization of an Electric Field, Frequency Dependence of Dielectric Constant, Effect of Temperature on Dielectric Constant, Dielectric Losses, Dielectric Breakdown, Dielectric Materials Practical Dielectrics.
Unit 2	**Mechanical Properties** Common terms, Atomic Model of Elastic Behaviour, Fundamental Mechanical Properties, Factors affecting Mechanical Properties, Mechanical tests – Brine" Hardness Test, Vicker's Hardness Test Rock well Hardness Test, Knoop's Hardness Test, Rebound Hardness Test, MOG's Hardness Test, Comparison of Various Tests, Deformation of Materials.
Unit 3	**Electrical Semiconductor Properties** Commonly used Conducting Materials, High resistivity Materials, Different Types of Bond structures, Electron Mobility, Electronic and Ionic Conduction, Insulation. Properties of Insulation Materials, Semiconductor, Intrinsic and Extrinsic Semiconductors, Semiconductor Devices, Application of semiconductors.
Unit 4	**Non Linear Optical Properties** Non linearity in Physics, Light Propagation in anisotropic media, The linear susceptibility, Second Harmonic Generation in KDP and in LBO. Third order nonlinear Process, High harmonic generation. The DC Kerr effect and Kerr Cell. The Optical Kerr Effect.

Reference Books	
1.	Elements of Materials Science and Engineering: Lawrence H. Van Vlack, Pearson Education, Sixth Edition, (2006).
2.	Materials Science and Metallurgy: U.C. Jindal, Atish Mozumder, Pearson Education, Third Edition, (2013).
3.	Engineering Materials (Polymers, Ceramics and Composites) : A. K. Bhargava, PHI

	Learning Private Ltd., Fourth Edition, (2010)
4.	Materials Science – An Intermediate Test: William F. Hosfold, Cambridge University Press, First Edition, (2007.)
5.	Materials Science and Engineering: A First Course: V. Ragavan, Prentice– Hall of India Private Ltd., Fifth Edition, (2005).
6.	Materials Science and Metallurgy: Parashivamurthy K. I., Pearson Education, First Edition (2012).
7.	Introduction to Nonlinear optics: Geoffrey, New Cambridge University Press, First Edition, (2011).

Course Name	PH-544: Elective 3: Simulation Techniques for computational Physics
Course Code	PH-544
Course Type	Elective 3
Course Outcome (CO)	(1) Students will master computational materials science, employing diverse techniques for modelling, simulation, and analysis in materials research. (2) Students will understand and apply computational materials science concepts, including random-walk simulations and modelling materials with long-range potentials. (3) Learners will grasp inter-atomic potentials and electronic structure methods, enabling them to simulate various materials and systems accurately using density functional theory. (4) Participants will master molecular dynamics fundamentals, including numerical integration, initial conditions, and analysis techniques for simulating atomic systems and materials research. (5) Students will proficiently utilize the Monte Carlo method to simulate materials, understand ensemble averages, and apply it to various systems in materials research.

Course Content	
Unit 1	**Random walk and Simulation of finite systems** Modelling and simulation, What is meant by computational materials science and engineering?, Scales in materials structure and behaviour, How to develop models, Random-walk model of diffusion, Connection to the diffusion coefficient, Bulk diffusion, A random-walk simulation, random walk models for materials, Sums of interacting pairs of objects, Perfect crystals, cutoffs, periodic boundary conditions, Implementations, Long-ranged Potentials.
Unit 2	**Inter-atomic Potentials and Electronic Structure Methods** The cohesive energy, Inter-atomic Potentials, Pair Potentials, Ionic materials, Metals, Covalent solids, System with mixed bonding, what we can simulate, Determining parameters in potentials, Quantum mechanics of multi-electron systems, Early density functional theories, The Hohenberg-Kohn theorem, Kohn-sham method, The exchange correlation functional pseudo-potentials, Use of density functional theory, Ab initio molecular dynamics, Car-Parinello simulation scheme.
Unit 3	**Molecular dynamics** Basics of molecular dynamics for atomic systems, Numerical Integration of Newton's equations, Conservation laws, examining the reliability of a simulation, Connection to thermodynamics, Initial conditions, Steps in an MD simulation, An example calculation, Potential cutoffs, Analysis of molecular dynamics simulations, "Lennard-Jonesium" as a model for materials, Spatial correlation functions, Time correlational Functionals, Molecular dynamics in other ensembles, velocity rescaling, Accelerated dynamics, Limitation of molecular dynamics, Molecular dynamics in materials research.
Unit 4	**The Monte Carlo method** Introduction, Ensemble averages, The Metropolis Algorithm (MA), Sampling in MA, Updating the energy in MA, The Ising model, metropolis Monte Carlo simulations of Ising model, Example simulation of Ising model, other sampling

	methods for the Ising model, Monte Carlo for atomic Systems, simulations of atoms in the canonical (NVT) ensemble other ensembles, Time in Monte Carlo simulations, Assessment of the Monte Carlo method, Uses of Monte Carlo method in materials research.

Reference Books	
1.	Introduction to Computational Materials Science: Fundamentals to Applications: R. Lesar, Cambridge University Press, (2013).
2.	An Introduction to Computational Physics: T. Pang, Cambridge University Press, Second Edition, (2006).
3.	Computational Physics Problem solving with Python: R. H. Landau, Manuel J. Páze, and Cristian C. Bordeianu, Third edition, Wiley-VCH, (2015).
4.	Computational Problems for Physics: With Guided Solutions Using Python: R. H. Landau, M. J. Páez, CRC Press, Taylor & Francis Group,(2018).
5.	Computational Physics: Nicholas Giordano, Hisao Nakanishi, Second Edition, Pearson Prentice Hall, (2006).

Course Name	PH-544: Elective 4-Nuclear Reactions
Course Code	PH-544
Course Type	Elective 4
Course Outcome (CO)	(1) At the end of the course, the students will be able to study different types of nuclear reactions and apply conservation laws to get the reaction cross-sections during them (2) The students will learn the detail study of Neutron Physics. (3) The students will understand nuclear fission, fission reactors and related Parameters (4) The students will learn nuclear fusion. (5) The student will be able to learn about thermonuclear weapons.

Course Content	
Unit 1	**Nuclear Reactions I** Introduction, types of reactions and conservation laws, observables, conservation laws, energetics of nuclear reactions, isospin, reaction cross-sections, experimental techniques, Coulomb scattering, nuclear scattering, scattering and reaction cross-sections.
Unit 2	**Nuclear Reactions II** Ghoshal experiment, Compound nucleus reactions, Resonance Reactions, Direct reaction, Heavy-Ion Reactions, Super heavy elements, Pre-equilibrium reaction mechanism, Complete and incomplete fusion reactions, Optical Model.
Unit 3	**Neutron Physics** Introduction, neutron sources, absorption and moderation of neutrons, neutron detectors, neutron reactions and cross-sections, neutron capture, interference and diffraction with neutrons.
Unit 4	**Nuclear Fission and Nuclear Fusion** Nuclear Fission: Introduction, Why nuclei fission, Characteristics of Fission, mass distribution of fragments, number of emitted neutrons, radioactive decay processes, fission cross-sections, Energy in fission, controlled fission reactions, fission reactors, a natural fission reactor, fission explosives. Nuclear Fusion: Basic fusion processes, characteristics of fusion, solar fusion, controlled fusion reactors, thermonuclear weapons.

Reference Books	
1.	Introductory Nuclear Physics: K. Krane, Wiley India Pvt. Ltd. (1988).
2.	Nuclear Physics: S. N. Ghoshal ,S. Chand and Co. Pvt. Ltd., Revised enlarged edition (2014).
3.	Introduction to Nuclear and Particle Physics by Mittal, Gupta and Verma, PHI Learning Pvt. Ltd., 3rd edition (2017).
4.	Nuclear Physics: D. C. Tayal, Himalaya Publishing House (2017).
5.	Radiation Detection and Measurement: G. F. Knoll.
6.	Nuclear Radiation Detectors: S. S. Kapoor and V. S. Ramamurthy.

Course Name	PH-545: Practical
Course Code	PH-545
Course Type	Core
Course Outcome (CO)	(1) Students will develop proficiency in a range of experimental techniques encompassing multiple beam interferometry, particle size analysis, spectroscopy, and electronic properties (2) Students will acquire versatile experimental skills while studying solar cells, electron spin resonance, ultrasonic interferometer etc. (3) Students will be trained to learn thermal properties of materials, determine g-factor of proton.

Course Content	
Group A	
1.	To study two beam interference using Mach-Zehnder Interferometer.
2.	To determine the particle size of lycopodium powder.
3.	To determine the refractive indices for the O-ray and the E-ray using quartz/calcite.
4.	To confirm the de Broglie equation for wavelength.
5.	Experiment using Quantum Efficiency Apparatus.
Group B	
6.	To measure ‘h’ by Solar Cell.
7.	To determine the wavelength of Balmer series in the visible region from hydrogen emission.
8.	To study Electron Spin Resonance.
9.	To study ultrasonic Interferometer.
10.	To study Frank-Hertz experiment.
Group C	
11.	To study damping effect in various media.
12.	To find coefficient of thermal expansion of Copper, Aluminium and Brass using their pipes.
13.	Study of black body radiation.
14.	Determination of proton spin and nuclear g-factor using NMR.
15.	To study the I-V characteristics of CdS photo-resistor at constant irradiance.
Group D (Elective Paper 1)	
16.	Characteristics of SCR, MOSFET, IGBT and power transistors (1 PE)
17.	Determination of NMOS and PMOS characteristics.
18.	Design of a Voltage reference and Simple Cascade Current mirror.
19.	Determination of NMOS Device parameters (V_{TO}, K, λ).
20.	Design of CMOS inverter and measure its delay, Noise Margin and power.

Group D (Elective Paper 2)	
16.	To investigate the elastic and plastic extension of metal wires.
17.	Measurement of Vicker's and Mho hardness using micro hardness tester.
18.	To study thermal conductivity of aluminium and copper at a constant temperature gradient.
19.	To determine the electrical conductivity of aluminium and copper by plotting a current-voltage characteristic curve.
20.	To measure the transition temperature of a high temperature superconductor.
Group D (Elective Paper 3)	
16.	Write a PYTHON program to perform the simulation of Random walk.
17.	Write a PYTHON program to perform the simulation of Radioactive decay.
18.	Write a PYTHON program to perform the simulation of Molecular dynamics.
19.	Write a PYTHON program to perform the simulation of Scattering by central potential.
20.	Write a PYTHON program for integration using Monte Carlo Method.
Group D (Elective Paper 4)	
16.	To estimate efficiency of the G. M. detector for (a) gamma source and (b) beta source.
17.	To study backscattering of beta particles.
18.	To study activity of a gamma source (Absolute Method).
19.	To study production and attenuation of bremsstrahlung.
20.	To determine the resolving time.

Course Name	PH-536:Skill based course- Remote Sensors
Course Code	PH-536
Course Type	Skill based course
Course Outcome (CO)	(1) At the end of the course, the students will be able to learn classification of Sensors. (2) To study various sensor parameters. (3) To understand the optical IR sensors in detail

Course Content	
Unit 1	**Remote Sensors- An Overview** Classification of Remote Sensors, Selection of Sensor Parameter, Spatial Resolution, Spectral Resolution, Location of spectral band, Radiometric Resolution, Radiometric Quality, Temporal Resolution, Performance Specification.
Unit 2	**Optical Infrared Sensors** Quality of Image in Optical Systems, Imaging mode, Photographic Camera, Photographic films, Characterizing film, Distortion in Photographs, Television cameras, Opto-mechanical scanner, Scanning Systems, Collecting Optics, Spectral Dispersion System, Detectors.

Reference Books	
1.	Fundamentals of Remote Sensing : George Joseph and C. Jeganathan, Third Edition, Universities Press
2.	Comprehensive remote sensing: Sunling Liang, Volume I, Missions and Sensors, Elsevier.
3.	Fundamentals of Remote Sensing : S C Bhatia, Atlantic Publishers and Distributors (P) Ltd.
4.	Introduction to Remote Sensing, James B. Campbell, Randolph H. Wynne, and Valerie A. Thomas, Floyd, F. Sabins Jr.: Sixth Edition.
5.	Remote Sensing Principles and Interpretation: Wavel and PrInc, (2020).
6.	Remote Sensing and Image interpretation: Lillesand and Kiefer, John Wiley (2015).
7.	Manual of Remote Sensing Vol. I&II, American Society of Photogrammetry, Second Edition.
8.	Introduction to modern photogrammetry: E. Mikhail, J. Bethel, J. McGlone, India: Wiley(2001).