Dr. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, CHHATRAPATI SAMBHAJINAGAR.

CIRCULAR NO.SU/M.Sc./College/Physic/62/2024

It is hereby inform to all concerned that, the syllabus prepared by the Board of Studies and recommended by the Dean, Faculty of Science & Technology, the Hon'ble Vice-Chancellor has accepted **the syllabus of M.Sc. Physics IInd semester under the scheme of National Education Policy-2020 run to the Affiliated Colleges, Dr.Babasaheb Ambedkar Marathwada University** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

This is effective from the Academic Year 2023-24 and onwards.

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

University Campus,
Aurangabad-431 004.
REF.NO. SU/SCI/2024/21528-37
Date:- 30.01.2024.

Deputy Registrar,
Academic Section.

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

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DR.BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY

CHHATRAPATI SAMBHAJINAGAR-431 004, (M. S.), INDIA

FACULTY OF SCIENCE AND TECHNOLOGY

Master of Science in Physics

(M. Sc. in Physics)

(2 Years P.G. Program)

As Per

National Education Policy-2020

Course Structure and Curriculum

(Outcome-based Curriculum)

For Affiliated Colleges

DR.BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY

CHHATRAPATI SAMBHAJINAGAR-431 004, (M. S.), INDIA

Effective from the Academic Year 2023-24

INDEX

AS PER NEP 2020

SEMESTER – II

Course and Credit Distribution Structure for
Two Years Post Graduate Programme with Multiple Entry Exit Options

Class: M. Sc. First Year, Semester: Second Semester, Subject: Physics

Course Type	Course Code	Course Name	Teaching Scheme (Hrs./Week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Discipline Specific Core Course (DSC) Mandatory	PHYT/MJ/558	Quantum Mechanics-I	2	--	2	--	14
	PHYT/MJ/559	Mathematical Methods in Physics-I	2	--	2	--	
	PHYT/MJ/560	Statistical Mechanics-I	2	--	2	--	
	PHYT/MJ/561	Classical Mechanics-I	2	--	2	--	
	PHYP/MJ/583	Practical Based on PHYT/MJ/558	--	4	--	2	
	PHYP/MJ/584	Practical Based on PHYT/MJ/559	--	4	--	2	
	PHYP/MJ/585	Practical Based on PHYT/MJ/560	--	4	--	2	
DSE (Choose any one from pool of Course)	PHYT/DSE/562 PHYP/DSE/586	The 8051 Microcontroller Practical Based on PHYT/DSE/562	2	4	2	2	4
		OR					
	PHYT/DSE/563 PHYP/DSE/587	Molecular Spectroscopy Practical Based on PHYT/DSE/563	2	4	2	2	
		OR					
	PHYT/DSE/564 PHYP/DSE/588	Nuclear Reaction and Energy Practical Based on PHYT/DSE/564	2	4	2	2	
		OR					
	PHYT/DSE/565 PHYP/DSE/589	Thin Film and Vacuum Technology Practical Based on PHYT/DSE/565	2	4	2	2	
OJT/FILED PROJECT	PHYP/OJT/FP/597		--	8	--	4	4
			10	24	10	12	22

Course Name: Quantum Mechanics-I

Course Code: PHYT/MJ/558, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Course Objectives:

i. To introduce the Quantum Mechanical postulates for physical systems
ii. To introduce the Quantum Mechanical concepts of measurements for physical systems
iii. To introduce the role of Quantum Mechanics on evolution of the physical systems in our Universe
iv. To introduce the concept of Quantum Mechanics in simple microscopic systems and its connection to actual observable.

Course Outcomes:

On completion of the course, students will be able to describe:

- Failure of classical physics at the microscopic level
- Basic non-relativistic Quantum Mechanics
- Matrix representation of Quantum Mechanics

They will have skills to do the following:

- Apply principles of Quantum Mechanics to calculate observables for given wave functions
- Solve Schrodinger equation for simple systems like simple harmonic oscillator, hydrogen atom, particle in a box, etc.

Course Content:

Unit I: Quantum Mechanics in 1-D: (10 Hours)

Exact Solutions of Schrödinger's equation in one dimension. Free particle, The Potential step and potential barrier (E is less that and greater than V_o) Tunneling. Dirac notation, Harmonic Oscillator using Matrices of p, x, E. The Uncertainly relation in Harmonic oscillator.

Unit II: Quantum Mechanics in 3D: (10 Hours)

The Hydrogen atom, Spherical polar co-ordinates separation of angular and radial part (Details and Recursion formulae not expected), Calculation of wave function using standard formulae; Degeneracy, angular momentum, various commutation relations. J_+ and J_- operators, Ladder Operators with J and Jz etc. Eigenvalues. Metrics of $j=y_2$ and j=1. Pauli Spin Matrics.

Unit III: Approximate methods and Scattering: (10 Hours)

The Variational method-Application to Simpler problem – particle in a box, harmonic oscillator – H_2^+ ion, time independent cases; time dependent perturbation theory; Fermi's rule, Harmonic perturbation, scattering cross section, scattering cross section scattering amplitude, Partial wave analysis; first born approximation.

References:

1. Quantum Mechanics concept and application by M. Zettili, I K International Publishing.
2. Introduction Quantum Mechanics by Richard Liboff. Peasson Education.
3. Quantum Mechanics theory and application by Ajoy Ghatak and S. Lokhanthan, Mackmillam.
4. Quantum Physics by H. C. Verma, Surya Publication
5. Quantum Mechanics by G. Aruldhas, PHI learrrirs pvt limited.
6. Principle of Quantum Mechanics by R. Shankar Spriger Verlag New York Inc.

Course Name: Mathematical Methods in Physics-I

Course Code: PHYT/MJ/559, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To facilitate the students to understand -
   a) The basic elements of complex mathematical analysis, including the integral transform and Laplace transform.
   b) To expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion.
   c) To apply integral transform (Fourier and Laplace) to solve mathematical problems of interest in physics, use Fourier transforms as an aid for analyzing experimental data.
   d) To solve partial differential equations of second order by use of series expansion (Fourier series) and integral transforms.

Learning Outcomes:

1. After finishing the course the student should be able to:
   a) master the basic elements of complex mathematical analysis, including the integral theorems, obtain the residues of a complex function and to use the residue theorem to evaluate definite integrals
   b) Solve ordinary differential equations of second order that are common in the physical sciences.
   c) Expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion.
   d) Apply integral transform (Fourier and Laplace) to solve mathematical problems of interest in physics, use Fourier transforms as an aid for analyzing experimental data.
   e) Solve partial differential equations of second order by use of standard methods like separation of variables, series expansion (Fourier series) and integral transforms.
   f) Solve some simple classical variational problems.

Course Contents:

Unit I. Fourier series (10 Hours)

Definition, Periodic series, Dirichlet's conditions for a Fourier series, Evaluation of coefficient, Function defined in two or more sub ranges,Discontinu8os function,Fourier series representation of even and odd function General properties of Fourier series, simple applications, convergence, integration, differentiation, problems.

Unit II. Laplace Transforms (10 Hours)

Definition, Important formulae, Properties of Laplace Transform ,Laplacc transform of derivatives, LT of derivative of order n, LT of integral of f(t)LT of t(multiplication by t), problems LT of $\frac{1}{t}$ f(t) (division by t), unit step function,, impulse function, Periodic function. Inverse Laplace transforms, important formulae, ILT multiplication by s, ILT division by s, Shifting properties, ILT of derivatives, ILT of Integrals, ILT by partial fraction method.

Unit III: Integrals Transforms (10 Hours)

Integral transform, Fourier Integral theorem. Fourier sine and cosine Transform. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Fourier transform of derivatives, Inverse Fourier transform and problems

References:

1. Advance Engineering Mathematics H. K. Dass/ S. Chand co. / 978-93-52533-83-1/2018
2. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence,3rd ed., **2006,** Cambridge University Press /ISBN978052167918/2006
3. Mathematical Physics Fourth edition – B. D. Gupta/ **ISBN** 978-93-5453-506-2/ Vikas Publishing House, New Delhi/2008
4. Mathematical Physics- B.S. Rajput, Pragati Prakashan (Meerut). **ISBN** 10: 8175568712/23 edition/2005
5. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications/ ISBN-13: 978- 0486691930/1996
6. Complex Variables, A.S. Fokas & M.J. Ablowitz, Cambridge University Press, **ISBN**-13: 978-0521534291/2003.
7. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 8th Ed./ (**ISBN**: 978-0-07-333730-2/ 2004, Tata McGraw-Hill
8. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, Jones & Bartlett/ **ISBN**-13: 978-0763757724/2nd edition /1940.

Course Name: Statistical Mechanics-I

Course Code: PHYT/MJ/560, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Course Objectives:

1. To develop strong mathematical and statistical skills, including probability theory, probability distributions, and statistical methods, which are essential for analyzing complex systems.
2. To introduce students to different ensembles (e.g., microcanonical, canonical, grand canonical) and their applications in describing the behavior of systems in different thermodynamic conditions.
3. To study quantum statistical mechanics, including Fermi-Dirac and Bose-Einstein statistics, and their relevance in describing the behavior of particles with quantum properties.
4. To establish a connection between statistical mechanics and classical thermodynamics, showing how macroscopic properties emerge from microscopic interactions.
5. To Study phase transitions and critical phenomena in depth, including critical exponents, universality, and the Ising model, to understand abrupt changes in the properties of matter.

Course Outcomes:

1. After learning this course students analyze transport phenomena such as diffusion, heat conduction, and viscosity using statistical methods.
2. Explore the application of statistical mechanics in various fields such as condensed matter physics, biophysics, and materials science.
3. Encourage research skills and critical thinking, allowing students to apply statistical mechanics principles to solve real-world problems and conduct independent research.
4. Students equip with advanced theoretical and computational tools to analyze and understand the behavior of complex systems at the molecular and atomic level, making it applicable to research, academia, and industries such as materials science and biophysics.

1. **Classical Statistics** (12 Hours)
   Ensembles, types of ensembles, density of distribution in phase space, Liouville's theorem, postulates of equal priori probability, statistical equilibrium, thermal equilibrium, mechanical equilibrium, particle equilibrium, connection between statistical and thermodynamical quantities, microstate and macrostates, Stirlings approximation, general statistical distribution law, most probable distribution law and classical Maxwell-Boltzmann distribution law.

2. **Theory of Transport Phenomena** (8 Hours)
   Bose-Einstein statistics, Fermi- Dirac statistics, Maxwell–Boltzmann statistics, thermodynamic interpretation of the parameters α and β, black body radiation and the Planck's radiation law, Grand canonical ensembles and quantum statistics, phase transition in Ferromagnetic material.

3. **Theory of Diatomic Molecule** (10 Hours)

Einstein theory of specific heat of solids, Debye theory of specific heat of solids, Bose-Einstein condensation, Thermal properties of Bose-Einstein condensation , Landau theory, Electron gas, free electron model electronic emission, Pauli's theory of paramagnetism, Boltzmann transport equation for electron and Lorentz solution, Isothermal Hall effect, Phase transition of the second kind(Ising Model), Bragg-Williams approximation, One dimensional Ising Model.

Books :

1. Fundamentals of statistical mechanics-B B Laud New Age International Publishers ISBN 978-81-224-3278-7, 2016.
2. Elementary Statistical mechanics. Gupta & Kumar year: 2019 Publisher: Pragati Prakashan ISBN: 978-93-5006-943-1.
3. Statistical mechanics R. K. Pathria, Second Edition published by Elsevier ISBN 0-7506-2469-8
4. Statistical Mechanics-E Atlee Jackson Publisher Dover Publication ISBN 9780486149394
5. Statistical Mechanics – B. K. Agarwal New Age International Publishers ISBN 978-8122433548
6. Fundamental of Statistical and thermal Physics -Reif ISBN 9781577666127
7. Statistical Mechanics: The Principle of Statistical Mechanics. By Richard C. Tolman. Oxford University Press, 1939.

Course Name: Classical Mechanics-I

Course Code: PHYT/MJ/561, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. Classical mechanics is a course where it all started. Newton demonstrated that the same forces and laws of mechanics that apply to apples and everyday objects (the terrestrial) also govern the behavior of the moon and the planets (the celestial).
2. He showed that nature had a high degree of structure and order, and that we could hope to uncover it and so physics was born.
3. Newton's laws of motion, or mechanics, were not only universal, they proved to be useful. In a wide array of physical situations, classical mechanics is all you need to be able to predict the motion of apples,

Learning outcomes:

1. Classical mechanics is a hot area of active research once more.
2. Chaos has lead to significant advances in mathematics and physics (for example, it offers some explanation for the phenomenon of ergodicity in statistical mechanics) and fundamentally changes the way we look a predictability and solvability of dynamical systems.
3. And there's even more: while classical mechanics, by definition, does not include the 21st century advances of quantum mechanics and relativity, it is nevertheless an essential prerequisite for study of these topics. For example, the Hamiltonian in quantum mechanics originates from the classical mechanics Hamiltonian that we will encounter.

Course Contents:

Unit I: Mechanics of a particle and system of particles (10 Contact Hours)

Mechanics of a particle, conservation of linear momentum, conservation of angular momentum, conservation of energy, Mechanics of a systems of particles, conservation of linear momentum, conservation theorem for angular momentum, conservation of energy, Constrained motion, constrains, degree of freedom, generalized co-ordinates, generalized notations, limitations of Newton's laws.

Unit II: Variational Principle (10 Contact Hours)

Introduction to calculus of variations, some techniques of calculus of variations, examples, shortest distance between two points of a plane, minimum surface of revolution, the branchistochrone problem, Variational technique for many independent variables, Euler Lagragian differential equation.

Unit III: Hamilton's Principle (10 Contact Hours)

Hamilton's variational Principle, statement, deduction, Deduction of Lagrange's equation of motion from Hamilton's principle (for conservative system), Deduction of Lagrange's equation by differential method, D'Alembert's principle, Lagrange's equation from D'Alembert's principle, conservation system, Non-conservative system, Non-conservative forces, Lagrangian for charged particle in a electromagnetic field, Deduction of Hamilton's principle from D'Alembert's principle, Deduction of Lagrange's equation using variational principle, applications of Lagrange's equations of motion, Linear harmonic oscillator, simple pendulum, spherical pendulum, compound pendulum, Atwood's machine, conservation theorems, conservation of linear momentum, angular momentum and conservation of energy.

References:

1. Classical Mechanics, by Gupta, Kumar and Sharma, Pragati Prakashan, Meerut (2012). ISBN : 978-93-5006-380-4
2. Classical Mechanics, by H. Goldstein, 2nd Edition (Published by Narosa Publishing House Pvt. Ltd., New Delhi (2001) ISBN 10:8185015538 / ISBN 13:9788185015538
3.. Classical Mechanics, by H. Goldstein, Charles Poole, John Safco, 3 rd Edition (Published by Pearson Education Asia (2014)) ISBN 10:8131758915 / ISBN 13:9788131758915
4. Classical Mechanics, by N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991) ISBN 10: 0074603159 ISBN 13: 9780074603154
5. Classical Mechanics, P. V. Panat (Narosa Pub. House Pvt. Ltd.) 2008 ISBN: 9788173196317 / 8173196311

Course Name: The 8051 Microcontroller

Course Code: PHYT/DSE/562, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning objectives:

- Provide an overview of difference between microprocessor and microcontroller.
- Impart knowledge of concepts and architecture of 8051 microcontroller.
- Provide background knowledge and core expertise in 8 bit microcontroller.
- Convey basic knowledge of various registers, ports, memory organization and addressing modes in 8051 microcontroller.
- Give knowledge about arithmetic operations and jump ranges and instructions.
- Impart knowledge about assembly language programming of 8051 microcontroller.
- Help understand the importance of various peripheral devices & their interfacing with 8051 microcontroller.

Learning Outcomes:

- The students would learn the basic difference between the microprocessors and microcontroller.
- The students will learn the architecture and basic functional blocks from microcontroller.
- The students will learn the programming tools which is useful for the programming with 8051-microcontroller.
- The students will learn assembly language programming logic for 8051 microcontroller.
- The students will learn interfacing with 8051- microcontroller.

Course contents:

Unit I: 8051 Microcontroller: **(10 Contact Hours)**

An Introduction: Microprocessors and Microcontrollers, comparing microprocessors and Microcontrollers, a Microcontrollers survey, development system for Microcontrollers, 8051 Microcontroller hardware: Block diagram, Programming model, pin configuration, the 8051 oscillator and clock, program counter and data pointer, A and B CPU registers, flags and program status word, internal memory, internal RAM, the stack and the stack pointer, special function registers, internal ROM; Input / output pins, ports and circuits: port pin circuits, port 0, port 1, port 2, port 3; memory organization, counters and timers, serial data input / outputs, interrupts.

Unit II: Moving data and logical operations: **(10 Contact Hours)**

Move Operations: Introduction, addressing modes, external data moves, code memory read only data moves, push and pop op-codes, data exchange, simple programs, Logical operations: Introduction, byte level logical operations, bit level logical operation, rotate and swap operations, examples programs.

Unit III: Arithmetic, Jump and Call Operations: **(10 Contact Hours)**

Arithmetic operations: Introduction, flags, instructions affecting flags, incrementing and decrementing, addition: unsigned and signed, multiple byte signed arithmetic, subtraction: Unsigned and signed subtraction, multiplication and division, decimal arithmetic, examples programs. Jump and call operations:

Introduction, the jump and call program range, relative range, Short absolute range, long absolute range. Jumps, bit jumps, byte jumps, unconditional jumps, Calls and subroutine, subroutines, Calls and the stacks, Calls and returns. Interrupts and returns, Simple programmes using 8051 Microcontroller and applications.

References:

1. The 8051 Micorcontroller, Architecture, Programming and applications by Kenneth J Ayala ; Second Edition, ISBN 0-314—20188-2 (hard Copy) 1991; ISBN 0-314-77278-2(Soft) 2014.
2. Microprocessors and Interfacing : Programming and Hardware by Douglas V Hall : II Edition ; Tata McGraw-Hill Edition.
3. The 8051 Microcontroller and embedded Systems by Muhammad Ali Mazidi and Janice Gillspie Mazidi; Pearson Education.

Course Name: Molecular Spectroscopy

Course Code: PHYT/DSE/563, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

a) Introduction to electronic spectroscopy of diatomic molecules
b) Study of vibrational course structure of electronic spectra of diatomic molecules; analysis of vibrational spectra of diatomic molecules and estimation of vibrational constants, moment of inertia, force constant etc.
c) To understand the electronic structure, course and fine structure of energies of electronic states, of diatomic molecules
d) To understand the vibrational, rotational motions and coupling of these motions by evaluating the vibrational and rotational constants of the electronic states
e) To understand various coupling schemes
f) Determination of term manifold of homonuclear and heteronuclear diatomic molecules
g) To understand the symmetry properties of the electronic wave functions, the selection rules and allowed electronic transitions
h) To understand the basic physics of Raman scattering of diatomic/polyatomic molecules; experimental techniques of Raman spectroscopy; analysis of Raman spectra for investigating the molecular structure

Learning Outcomes:

CO1 arrange the wavenumbers of band heads and band origin in the Deslandres table; identify various sequences and progressions in the band spectrum; analyze the electronic spectra of diatomic molecules, and estimate vibrational constants and vibrational energies; able to calculate: harmonicity and anharmonicity constants of the upper and lower electronic states.

CO2 explain various coupling schemes and uncoupling phenomena
CO3 calculate the term manifold of homonuclear and heteronuclear diatomic molecules
CO4 explain the symmetry properties of rotational levels of upper and lower electronic state
CO5 explain the symmetry properties of rotational levels of lower electronic state
CO6 explain the selection rules for electronic transitions; draw the allowed electronic transitions
CO7 describe the role of various parts of Raman spectrometer, analyze the Raman spectra of molecules, and determine their structure

Course Contents

Unit-I: Electronic Spectra of Diatomic Molecules: **(10 Contact Hours)**

Electronic energy and total energy, electronic energy and potential curves; stable and unstable molecular states, Vibrational structure of electronic transitions: general formulae, examples; graphical representation, Deslandres table, progressions and sequences, evaluation of vibrational constants, Rotational structure of electronic bands. Combination relation and evaluation of rotational constant for bands without and with Q branches.

Unit-II: Coupling of rotation and electronic motion and determination of term: **(10 Contact Hours)**

Classification of electronic states; multiplet structure, orbital angular momentum, spin, total angular momentum of the electrons; multiplets, symmetry properties of the electronic eigen functions, Hund's coupling cases a, b and c. Symmetry properties of rotational levels. Types of electronic transitions, selection rules, Study of 1 Σ- 1 Σ, 2 Σ - 2 Σ and 1 □- 1 Σ transitions, Determination of term manifold: Separated atoms (like and unlike atoms), Term manifold from electronic configuration, Pauli principle, Molecular configurations of CO, C2, N2, BeO, BeH etc molecules.

Unit-III: Raman Spectroscopy: **(10 Contact Hours)**

Classical theory and quantum theory of Raman Effect, Pure rotational Raman Spectra, Raman spectra of linear, symmetric top and asymmetric top molecules. Raman activity of vibrations, vibrational Raman Spectra, Rotational fine structure, polarization of light and Raman effect, Structure determination from Raman and IR spectra, Instrumentation: Raman spectrometer

Books:

1. Spectra of Diatomic Molecules by G. Herzberg, Krieger Malbar Florida, 1950, ISBN-10: 1406738530, ISBN-13: 978-1406738537.
2. Molecular Structure and Spectroscopy, by Aruldhas, G., Second Edition, 2004; ISBN: 978-81-203-3215-7, PHI Learning

Course Name: Nuclear Reaction and Nuclear Energy

Course Code: PHYT/DSE/564, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Course objective: The themes dealt with in this paper:

- This course gives basic foundation to specialization in nuclear physics and applications, including power production through fission and fusion reactors.
- The course is an advanced course and requires special efforts. So, it can be taught as an elective course only.
- The course will help the student for preparation of NET/SET and other competitive examinations.

Course outcomes (COs): The present unit attempts to achieve the following learning outcomes:

- After completing this course the student will be to prepare to understand the scope and possibilities of studies in nuclear physics for research career as well as in industry.
- This course is prerequisite to the second elective course.

Unit I: General Features of Nuclear Reaction and Mechanism **(10 hours)**

Introduction, Conservation laws in nuclear reactions, Energetics and Q-Value of nuclear reaction, nuclear transmutation, Nuclear reaction cross-section, Partial cross-section, Determination of cross-section, partial wave analysis for reaction cross-section, Breit-Wigner dispersion formula, Level width. Types of nuclear reaction, Compound Nucleus, Theory of nuclear reaction, Direct reaction, Continuum and statistical theories of nuclear reaction.

Unit II: Nuclear Fission **(10 hours)**

Nuclear fission, Types of fission, Emission of nuclear fission, fission of fertile material, Distribution of mass of fission products, Energy released in fission, Distribution of energy of fragments, Neutrons released in fission, Prompt and delayed neutrons, Spontaneous fission, Liquid drop model, Nuclear chain reaction, Classification of Nuclear Reactor.

Unit III: Nuclear Fusion **(10 hours)**

Introduction, The plasma, Fusion reaction in the plasma, Conditions for maintain fusion reaction, Stellar energy, Sources of stellar energy, Carbon-Nitrogen cycle, Controlled thermal nuclear reactions, The eight synthesizing processes.

References:

1. **Nuclear Physics,** D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).

2. **Nuclear Physics,** R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN- EBK0036746).
3. **Fundamentals of Nuclear Physics,** Jahan Singh, 1st edition, Pragati Prakashan, Meerut- (2012) (ISBN-978-93-5006-593-8)
4. **Nuclear Physics,** S. B. Patil, 1st edition, New Age International Publishers, New Delhi- (1991) (ISBN-978-81-224-0125-7).
5. **Nuclear Measurement Techniques,** K. Sri Ram, 1st edition, Affiliated East-West Press, Madras(1986) (ISBN-81-85095-56-6).
6. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
7. **Nuclear Physics,** Satya Prakash, 2nd edition, Pragati Prakashan, Meerut (2011) (ISBN- 81-7556-915-8).
8. **Nuclear Physics,** K. P. Das, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-517-3).
9. **Radioactive Materials,** Dr. B. M. Rao, 1st edition, Himalaya Publishing House, Mumbai- (2002).
10. **Nuclear Energy,** R. K. Taneja, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-516-6).

Course Name: Thin Film and Vacuum Technology

Course Code: PHYT/DSE/565, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

- This program will help to the students to work as technocrats in industries that rely on vacuum-based processes to create and manufacture products.
- Students will be able to elaborate the Physical Vapor Deposition Techniques.
- Students will be able to apply Chemical and Hybrid Methods for Thin Film Deposition.

Learning Outcome:

- Employment opportunities span a variety of industries such as semiconductors, microelectromechanical systems (MEMS), glass, optics, light-emitting diodes (LEDs), solar cells, vacuum-based equipment, and other industries that use thin film coating processes.
- The duties of a technician include building, validating, operating, maintaining, and troubleshooting vacuum-based equipment as well as providing advice on the use of this equipment and processes supported by this technology.
- The Vacuum and Thin Film Technology program prepares a student to work as a technician in industries that rely on vacuum-based processes to create and manufacture products.
- Employment opportunities span a variety of industries such as: Semiconductor, Microelectromechanical systems (MEMS), Glass, Optics, Light-emitting diodes (LEDS), Solar cells, Vacuum-based equipment, Other industries which use thin film coating processes

Course contents:

Unit I: Thin Film Deposition Mechanics: **10 Hours**

Thermodynamics and Thin Film Growth, Vacuum Technology: Gas Laws, Kinetic Theory of Gases, Gas Sources in a Vacuum Chamber, Vacuum Pumps.

Unit II: Physical Thin Film Deposition Techniques: **10 Hours**

Physical Vapor Deposition, Sputtering: DC, rf sputtering, Magnetron sputtering, ECR plasma deposition, Ball Milling, Dr. Blade method, Spin Coating method, Sputtering Mechanisms, and Evaporation.

Unit III: Chemical and Hybrid Methods for Thin Film Deposition: **10 Hours**

Chemical Vapor Deposition: Mechanisms, Materials, Chemistries, Systems, Chemical Bath Deposition, SILAR, Spray Pyrolysis technique, Electrophoretic technique. Thin Film Characterization: Structural, optical, electrical and magnetic, morphological.

References

1. R. K. Waits, Thin Film Deposition and Patterning, American Vacuum Society, 1998. M. Ohring, ISBN 10: 156396872X ISBN 13: 9781563968723
2. The Materials Science of Thin Films, Academic Press, Boston, 1991. Ludmila Eckertova, Physics of Thin Films, 2nd Plenum Press New York, 1986 (QC 176.83. E2613 1986) ISBN 10: 0123418240 ISBN 13: 9780123418241
3. Kasturi L. Chopra, Thin Film Phenomena (McGraw-Hill, 1969). ISBN 10: 0070107998 ISBN 13: 9780070107991
4. Handbook of Thin Film: Maissel and Glang (1970). ISBN 10: 0070397422 ISBN 13: 9780070397422

Course Name: Practical Based on PHYT/MJ/558

(Quantum Mechanics-I)

Course Code: PHYP/MJ/583, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objective

1. To understand and apply experimental techniques used in quantum mechanics, such as measurements, data acquisition and instrumentation.
2. To investigate measurement processes and uncertainties in quantum mechanics, eigen states and the Heisenberg uncertainty principle.
3. To study and demonstrate the phenomenon of quantum entanglement through experiments, emphasizing its implications for quantum information and communication.

Learning outcomes

1. Students gains hands on experience with experimental setups used in quantum mechanics, including apparatus for measuring quantum phenomena.
2. Students learn techniques for making quantum measurements and grasp the implification of the measurement process on quantum systems.
3. Outcomes collectively aim to ensure that the students grasp theoretical concept but also acquire practical skill and a deep understanding of how to apply quantum principles in experimental settings.

Course contents:

1. Study of Gaussian Type Orbital (GTOs) and Slater type orbital (STOs).
2. Comparison of Gaussian Type Orbital (GTOs) and Slater type orbital (STOs).
3. Plotting the hydrogen atom ground state 1s and 2s wave functions.
4. Plotting the hydrogen atom ground state 2p wave function.
5. Determination of normalization constant for 1s wave function of hydrogen atom.
6. Solution of Schrodinger equation for square/harmonic oscillator potential.
7. Solution of Schrodinger equation for triangular potential.

Course Name: Practical Based on PHYT/MJ/559

(Mathematical Methods In Physics-I)

Course Code: PHYP/MJ/584, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning objective

1. To develop problem solving skills by applying mathematical techniques to solve complex physical problems.
2. To acquiring skills in analyzing experimental or simulated data using statistical methods and mathematical techniques.
3. To learn effectively visualize and interpret mathematical results and data through graphical representations and plots.

Learning outcomes

1. Student can perform numerical simulations effectively, demonstrating an understanding of numerical methods and their application to physical scenarios.
2. Students can analyze experimental or simulated data using statistical methods and mathematical techniques, drawing meaningful conclusions from the results.
3. Students can present results through clear and effective visualization techniques, including graphical representations and plots.

Course contents:

1. Determine the roots of Given Equation/ expression by bisection method.
2. Evaluation of given integrals using Simpson's 1/3 rd rule.
3. Evaluation of given integrals using Trapezoidal rule.
4. Find Cube roots of given function.
5. Determine Fourier series of given function.
6. To fit curve by Least square fit method.
7. Curve fitting by graphical method.

Course Name: Practical Based on PHYT/MJ/560

(Statistical Mechanics-I)

Course Code: PHYP/MJ/585, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objective

1. To understand and articulate foundational concepts such as ensemble theory, probability distributions and thermodynamic properties.
2. To develop computational skills for simulating and solving statistical mechanics problems.
3. To extend knowledge to quantum statistical mechanics, incorporating principles from quantum mechanics into statistical mechanics.
4. To apply statistical methods to analyze and interpret experimental data using techniques.
5. To explore applications of statistical mechanics in diverse fields including condensed matter physics, chemistry, biology and material science.

Learning outcomes

1. Students gain proficiency in experimental techniques relevant to statistical mechanics including data collection and analysis.
2. Students apply statistical model to real world systems using acquired theoretical knowledge to interpret and predict experimental results.
3. Students can develop skills in conducting computational simulations using software tools to simulate and analyze statistical mechanical systems.
4. Students can demonstrate the ability to critically to critically analyze experimental data, identifying sources of error and uncertainties in measurements.

Course contents

1. To determine Boltzmann constant.
2. Determination of Planck's constants.
3. Determination of thickness of thin wire (Photon as wave).
4. Study of statistical behavior of gas particle in a box.
5. To derive and calculate the canonical partition function for a system.
6. To understand and apply the Boltzmann distribution.
7. Study of Fermi- Dirac and Bose – Einstein statistics.
8. Determination of Hall Coefficient(free electron)
9. Determination of Magnetic Susceptibility (ESR , NMR).

Course Name: Practical Based on PHYT/DSE/562

(The 8051 Microcontroller)

Course Code: PHYP/DSE/586, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning objectives

- Provide knowledge and expertise in 8- bit microcontroller.
- Impart knowledge about assembly and machine language programming.
- Help to understand the importance of different interfacing to 8051 microcontroller.
- Impart knowledge of different types of external interfaces.

Learning outcomes:

- Understand the fundamentals of microcontroller systems, assembly language Programming, interfaces, and have an ability to apply them.
- Understand and apply the fundamentals of assembly and machine language Programming of 8051-microcontrollers.
- Design and formulate interfacing experiments for microcontroller.
- Solve problems by using the concepts of microcontroller systems.

Course content:

1. Assembly language Programs for addition using 8051 microcontroller 8 and 16 bit.
2. Assembly language Programs for subtraction using 8051 microcontroller 8 and 16 bit.
3. Assembly language Program for multiplication using 8051 microcontroller.
4. Assembly language Program for division using 8051 microcontroller.
5. Assembly language Programs for data transfer.
6. Assembly language Programs for ones, twos complements of 8 and 16 bits.
7. Assembly language Program for Ascending and descending numbers using 8051 microcontroller.
8. Assembly language Program to find square and square root of given number using 8051 microcontroller.
9. Assembly language Program to find Maximum and minimum numbers form given array using 8051 microcontroller.
10. Assembly language Program for analog to digital converter (ADC) using 8051 microcontroller.
11. Assembly language Program to generate ramp, triangular and square waves using DAC through 8255 of 8051 microcontroller.
12. Assembly language Program for stepper motor interface using 8051 microcontroller.

Note: Students must perform at least eight experiments from above list.

Course Name: Practical Based on PHYT/DSE/563

(Molecular Spectroscopy)

Course Code: PHYP/DSE/587, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Course Objectives:

- Thermal and DC electric field excitation of molecular spectra
- Recording the molecular spectra using latest computer interfaced instruments
- Vibrational analysis of the recorded molecular spectra and calculation of vibrational constants of upper and lower electronic states and estimation of force constants
- Rotational analysis of the recorded molecular spectra and calculation of rotational constants of upper and lower electronic states and estimation of bond lengths
- Understanding of Morse potentials of diatomic molecules
- Estimation of dissociation energy of I_2.
- Understanding the fundamentals and instrumentation of NMR spectrometer; analysis of NMR spectrum

Course Outcomes:

The student will be able to:

CO1	Record the molecular spectrum using HR4000 spectrometer by DC arc excitation
CO2	identify various sequences in the band spectrum and arrange the wavenumbers of band heads in the Deslandres table
CO3	Perform vibrational analysis and calculate vibrational constants of the upper and lower electronic states. Calculate force constants the upper and lower electronic states
CO4	Perform rotational analysis and calculate rotational constants of the upper and lower electronic states. Estimate bond lengths in upper and lower electronic states.
CO5	able to explain the role of Morse parameter an to plot Morse potential curve for a given diatomic molecule
CO6	Able to explain various parts and their role in recording NMR spectrum using NMR spectrometer
CO7	Able to record and analyze the NMR spectrum

Course contents:

Experiments based on Molecular Spectroscopy

1. Record the spectrum of Al arc in air using HR4000 spectrometer. Construct the Deslandre's table by using known wavelengths and calculate the vibrational constants and force constants of upper and lower electronic states
2. Vibrational analysis C_2 Swan system: Record the spectrum of gas flame (C_2 Swan system) in air using high resolution monochromator. Construct the Deslandre's table by using known wavelengths and calculate vibrational constants and force constants of upper and lower electronic states

3. Recording the high resolution spectra of BeO using high resolution spectrometer with CCD camera and calculate vibrational constants and force constants of upper and lower electronic states
4. Rotational analysis of spectra of diatomic molecules (High resolution spectroscopy) for bands with Q-branches
5. Rotational analysis of spectra of diatomic molecules (High resolution spectroscopy) for bands without Q-branches
6. Studies of IR spectra of organic molecules (Liquids) containing various functional groups using IR/FTIR spectrometers.
7. Studies of IR spectra of organic molecules (Solids) containing various functional groups using IR/FTIR spectrometers.
8. Spectroscopic investigations of molecules using Raman Spectrometer.
9. Record the spectrum of Iodine and determine dissociation energy of I_2 molecule by Brige-Spooner method
10. Calculation of Morse potential energy curves for molecular X and B states of AlO, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states
11. Calculation of Morse potential energy curves for molecular states of Swan system of C_2, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states.
12. Calculation of Morse potential energy curves for molecular states of visible system of BeO, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states.

Course Name: Practical Based on PHYT/DSE/564

(Nuclear Reaction and Nuclear Energy)

Course Code: PHYP/DSE/588, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Course Objectives:

a) Recording the pulse height spectra using latest gamma ray spectroscopy system.
b) Analysis of recorded pulse height spectra.
c) Study of various types of gamma ray sources.
d) Study the NaI(Tl) detector..

Course Outcomes:

e) The student will get a training for using state of the art data acquisition system in Nuclear Physics laboratory
f) The student will get training for analysis of recorded pulse height spectra.
g) The student will be able to perform various kinds of experiments using GM and Scintillation counter.

<u>Experiments based on Nuclear Physics</u>

1. Study of gamma ray spectrum using scintillation counter using single channel analyzer.
2. Absorption of gamma rays in lead.
3. Absorption of gamma rays in aluminum.
4. Alpha spectroscopy with surface barrier detector- energy analysis of an unknown gamma source.
5. Determination of range of beta particles in aluminum.
6. Determination of range of beta particles from unknown source by feather analysis.
7. Determination of resolution of NaI(Tl) detector.
8. Determining the activity of gamma a source.
9. To determine the absorption coefficient as function of gamma ray energy.
10. Measurements of linier attenuation coefficient of metals.
11. To determine the half –value layer of various samples.(e.g lead, aluminum)
12. To determine the tenth –value layer of various samples. .(e.g lead, aluminum)
13. To determine the Mean free path of various samples. .(e.g lead, aluminum)

Course Name: Practical Based on PHYT/DSE/565

(Thin Film and Vacuum Technology)

Course Code: PHYP/DSE/589, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Course Objectives:

i. Synthesis the thin film by CBD method.
ii. Develop thin films of different materials using different substrates by SILAR technique.
iii. Estimate the thickness of deposited materials on the substrate.
iv. Impart knowledge of thin film synthesis

Course Outcomes:

i. Understand the importance of the thin film deposition by CBD
ii. Apply the thin film deposition technique to synthesis the other materials
iii. Verify the electrical properties of the thin films.
iv. Design the thickness of the thin films.
v. Demonstrate importance of the Spin Coating Method.
vi. Able to determine the energy band gap of the nanomaterials.

1. Deposition of ZnO thin Film by a chemical bath deposition method and calculate the thickness of thin films.
2. Thin Film deposition of Zinc Oxide
3. Thin film deposition of CdS by Electrochemical Method/CBD
4. Deposition of ZnS thin film by Spin Coating method/Electrochemical Method
5. Deposition of CuS thin film by Hydrothermal Method/SILAR
6. Estimation of thickness of NiO thin film
7. Synthesis ZnO thin film using Dr. Blade method.
8. Deposition of thin films by Spin Coating method.
9. To study the optical properties of ZnO thin film using UV-Vis spectroscopy.
10. To study the optical properties of ZnS thin film using UV-Vis spectroscopy.
11. To study the optical properties of CdS thin film using UV-Vis spectroscopy.
12. To study the optical properties of CuS thin film using UV-Vis spectroscopy.
13. To study the Chemical species of ZnO thin film using FT-IR Spectroscopy.
14. To study the electrical properties of ZnO thin films using I-V characteristics.
15. Study the electrical properties of ZnS thin films using I-V characteristics.

Note: Students must perform at least <u>eight</u> experiments from above list.

Course Name: On-The Job Training/ Field Project

Course Code: PHYP/OJT/FP/597, Course Type: MJ,

Contact Hours: 120, Credits: 04, Hours/Week: 04, Max. Marks: 100