BANKURA UNIVERSITY

(West Bengal Act XIX of 2013- Bankura University Act, 2013)

Main Campus, Bankura Block-II, P.O.: Purandarpur, Dist.: Bankura, Pin- 722155, West Bengal

Office of the Secretary

Faculty Council for Undergraduate Studies

Ref: BKU/FCUG/172/2026 Date: 25/06/2026

NOTIFICATION

As directed, the undersigned is pleased to inform all concerned that Bankura University has initiated the process to implement New Curriculum and Credit Framework for Undergraduate Programme, UGC 2022 (as per NEP 2020) for 4-years Undergraduate programme with Physics as Major, Minor etc. from the academic session 2023-2024. The syllabus as framed / drafted and partially implemented deserves to be analysed after receiving feedback from different stakeholders. As an important corollary to the process, a workshop will be organized on the date mentioned herewith to get the feedback from the stakeholders. Present Students, Alumni, Guardians, Academicians and other stakeholders related to the specific programme/course are requested for their kind participation in the workshop and to present their views/ observations, etc. The stakeholders may go through the draft syllabus attached herewith and convey their observations to the office of the undersigned on ugsecretaryoffice@bankurauniv.ac.in within seven days from the date of publication of this notice.

Date: 30.06.2026
Time: 11:30 AM
Google Meet joining link : https://meet.google.com/esv-hsbp-wrs

Sd/-
Dr. Arindam Chakraborty
Secretary
Faculty Council for Undergraduate Studies

Ref: BKU/FCUG/171(6)/2026 Date: 25/06/2026

1. Registrar (Addl. Charge), Bankura University.
2. Dean (Officiating), Faculty Council of P.G. Studies in Arts, Science etc. Bankura University.
3. Chairperson / Convenor, Undergraduate Board of Studies in Physics, Bankura University with request for necessary action.
4. System Administrator, Bankura University with request to upload this in website.
5. Secretary, Hon'ble Vice Chancellor, Bankura University.
6. Guard File.

Sd/-
Dr. Arindam Chakraborty
Secretary
Faculty Council for Undergraduate Studies

PROGRAMME AND COURSE STRUCTURE WITH CREDIT DISTRIBUTION

FOR

UG Degree Programmes with Single Major

IN

PHYSICS

(***w.e.f. 2023-2024***)

BANKURA UNIVERSITY
BANKURA
WEST BENGAL
PIN 722155

STRUCTURE IN PHYSICS
(UG Degree Programmes with Single Major)
SEMESTER –I

Category of Course				Marks			No. of Hours		
	Course Code	Course Title	Credit	I.A.	ESE	Total	Lec.	Tu.	Lab.
1. Major (MJ) :: DSC	S/PHS/101/MJC-1	Mechanics and General Properties of Matter	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
2. Minor Stream	S/PHS/102/MN-1	Mechanics and General Properties of Matter	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
3. Multidisciplinary	S/PHS/103/MD-1	Fundamentals of Physics-I	**3**	**10**	**40**	**50**			
4. Skill Enhancement Courses	S/PHS/104/SEC-1	Basics of Computer and Python Programming	**2 (Th) + 1 (Lab) = 3**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
5. Ability Enhancement Course	ACS/105/AEC-1	Compulsory English: Literature and Communication	**2**	**10**	**40**	**50**			
6. Value Added Course	ACS/106/VAC-1	Environmental Studies	**4**	**10**	**40**	**50**			
Total Credit = 4+4+3+3+2+4 = 20				**Total Number of Courses = 6**					

SEMESTER –II

Category of Course	Course Code			Course Title			Credit		
				I.A.	ESE	Total	Lec.	Tu.	Lab.

1. Major (MJ) :: DSC	S/PHS/201/MJC-2	Electricity and Magnetism	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
2. Minor Stream	S/PHS/202/MN-2	Electricity and Magnetism	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
3. Multidisciplinary	S/PHS/203/MD-2	Fundamentals of Physics-II	**3**	**10**	**40**	**50**			
4. Skill Enhancement Courses	S/PHS/204/SEC-2	Basic Instrumentation Skills	**2 (Th.) + 1 (Lab.) = 3**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
5. Ability Enhancement Course	ACS/205/AEC-2	MIL-1	**2**	**10**	**40**	**50**			
6. Value Added Course	ACS/206/VAC-2	Any one of the followings: 1. Understanding India: Indian Philosophical Traditions and Value Systems 2. Health and Wellness 3. Basics of	**4**	**10**	**40**	**50**			
Total Credit = 4+4+3+3+2+4 = 20				**Total Number of Courses = 6**					

SEMESTER –III

Category of Course				**Marks**			**No. of Hours**		
	Course Code	**Course Title**	**Credit**	**I.A.**	**ESE**	**Total**	**Lec.**	**Tu.**	**Lab.**
1. Major (MJ) :: DSC	S/PHS/301/MJC-3	**Mathematical Physics-I**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
2. Major (MJ) :: DSC	S/PHS/302/MJC-4	**Waves and Oscillatio**	**3 (Th.) + 1 (Lab.) =**	**10**	**25 (Th.) 15 (Lab.)**	**50**			

		n	**4**						
3. Minor Stream	S/PHS/303/MN-3	**Waves and Oscillation**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
4. Multidisciplinary	S/PHS/304/MD-3	**Renewable Energy and Energy harvesting**	**3**	**10**	**40**	**50**			
5. Skill Enhancement Courses	S/PHS/305/SEC-3	**Introduction to LASER and Fibre Optics**	**2 (Th) + 1 (Lab) = 3**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
6. Ability Enhancement Course	ACS/306/AEC-3	MIL-II	**2**	**10**	**40**	**50**			
Total Credit = 4+4+4+3+3+2 = 20				**Total Number of Courses = 6**					

SEMESTER –IV

Category of Course	**Course Code**			**Course Title**			**Credit**		
				I.A.	**ESE**	**Total**	**Lec.**	**Tu.**	**Lab.**
1. Major (MJ) :: DSC	S/PHS/401/MJC-5	**Mathematical Physics-II**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
2. Major (MJ) :: DSC	S/PHS/402 /MJC-6	**Heat and Thermodynamics**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
3. Major (MJ) :: DSC	S/PHS/403 /MJC-7	**Classical mechanics**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
4. Major (MJ) :: DSC	S/PHS/404 /MJC-8	**Analog Electronics systems and Applications**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			

3. Minor Stream	S/PHS/405/MN-4	**Heat and Thermodynamics**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**				
6. Ability Enhancement Course	**ACS/406/AEC-4**	**Compulsory English: Literature and Communication**	**2**	**10**	**40**	**50**				
Total Credit = 4+4+4+4+4+2 = 22				**Total Number of Courses = 6**						

SEMESTER –V

Category of Course				**Marks**			**Teaching Hours/Week**		
	Course Code	**Course Title**	**Credit**	**I.A.**	**ESE**	**Total**	**Lec.**	**Tu.**	**Lab.**
1. Major (MJ) :: DSC	S/PHS/501 /MJC-9	**Mathematical Physics-III**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
2. Major (MJ) :: DSC	S/PHS/502 /MJC-10	**Quantum Mechanics-I**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
3. Major (MJ) :: DSC	S/PHS/503 /MJC-11	**Digital system and applications**	**3 (Th.) + 1 (Lab.) = 4**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
4. Major (MJ) :: DSC	S/PHS/504 /MJC-12	**Optics and EM Theory**	**3**	**10**	**40**	**50**			
5. Minor stream	S/PHS/505/ MN-5	**Digital system and applications**	**2 (Th) + 1 (Lab) = 3**	**10**	**25 (Th.) 15 (Lab.)**	**50**			
6. Internship	ACS/506/INT-3	Internship (Mendatory)	**2**			**50**			
Total Credit = 4+4+4+4+4+2 = 22				**Total Number of Courses = 6**					

SEMESTER –VI

Category of Course				Marks			Teaching Hours/Week		
	Course Code	Course Title	Credit	I.A.	ESE	Total	Lec.	Tu.	Lab.
1. Major (MJ) :: DSC	S/PHS/601 /MJC-13	**Statistical mechanics**	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
2. Major (MJ) :: DSC	S/PHS/602 /MJC-14	**Nuclear Physics**	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.); 15 (10+5) (Lab.)	50			
3. Major (MJ) :: DSC	S/PHS/603 /MJC-15	**Solid state physics**	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
4. Major (MJ) :: DSC	S/PHS/604 /MJC-16	**Quantum Mechanics-II**	3 (Th.) + 1 (Lab.) = 4	10	25 (Th.) 15 (Lab.)	50			
5. Minor Stream	S/PHS/605/MN-6	Classical Physics	2 (Th) + 1 (Lab) = 3	10	25 (Th.) 15 (Lab.)	50			
Total Credit = 4+4+4+4+4 = 20				**Total Number of Courses = 5**					

SEMESTER –VII

Category of Course				Marks			Teaching hours/Week		
	Course code	Course Title	Credit	I.A.	ESE	Total	Lec	Tu	Lab
1. Major (MJ) ::DSC	S/PHS/701/MJC-17	**Advanced Quantum**	3 (Th)+ 1(Lab)=4	10	25 (Th) + 15 (Lab)	50			

		Mechanics							
2. Major (MJ) ::DSC	S/PHS/702/MJC-18	**Molecular Spectroscopy I**	**3 (Th)+ 1(Lab)=4**	**10**	**25 (Th) + 15 (Lab)**	**50**			
3. Major (MJ) ::DSC	S/PHS/703/MJC-19	**Advanced Classical Electrodynamics I**	**3 (Th)+ 1(Lab)=4**	**10**	**25 (Th) + 15 (Lab)**	**50**			
4. Major (MJ) ::DSC	S/PHS/704/MJC-20	**Advanced Classical Mechanics I**	**3 (Th)+ 1(Lab)=4**	**10**	**25 (Th) + 15 (Lab)**	**50**			
5. Minor Stream	S/PHS/705/MN-7	**Atomic and Molecular Spectroscopy**	**2 (Th)+ 1(Lab)=3**	**10**	**25 (Th) + 15 (Lab)**	**50**			
Total Credit= 4+4+4+4+3=19				**Total number of courses= 5**					

PROGRAMME OUTCOME

The Undergraduate (UG) programme of Physics is composed of major, minor and interdisciplinary subjects. The syllabus is based on the National education policy which covers almost all the fields of Physics. The students will be enriched with plenty of knowledge after the completion of the course. The complete syllabus is compatible with the competitive examination for higher studies and research. In this programme there are various multidisciplinary courses. The students will acquire multidisciplinary skills which will be of tremendous value to them.

Semester-VII
(Major)
Credit= 3+1=4

MJC-17: Advanced Quantum Mechanics (Theory) (Credit-3)

1. Approximation methods:

Time independent perturbation theory for non-degenerate anddegenerate states (derivation of first order corrections of energy eigenvalues and wave functions and derivation of Second order correction of energy eigenvalues), Application of timeindependent perturbation theory - Anharmonic oscillator, Stark effect in hydrogen atom, Groundstate energy of Helium atom. Variational method: Concept of method of variation and itsapplication for finding the ground state of Helium atom, WKB method: Connection formulae,Application.

Time-dependent perturbation theory: Schrodinger, Heisenberg, Interaction picture, Transition probability, Constant and Harmonic perturbation, Fermi's golden rule,adiabatic and Sudden approximation.

2. Generalized angular momentum:

Infinitesimal rotation, Generator of rotation, Commutationrules, Matrix representation of angular momentum operators, Spin, Pauli spin matrices, Rotation of spin states, Coupling of two angular momentum operators, Clebsch Gordon co-efficient, applications.

3. Symmetries:

Symmetries, Invariance principle and Conservation laws, Space translation, Time translation, Space rotation, Irreducible spherical tensor operators, Wigner-Eckert theorem and itsapplications, Space inversion, Time reversal.

4. Scattering theory:

Scattering of a particle by a fixed Centre of force, scattering amplitude, differential and total cross sections. Method of partial waves, phase shifts, optical theorem. Scattering by a hard sphere and potential well. Integral equation for potential scattering. Green's function. Born approximation. Yukawa and Coulomb potential.

Books Recommended:

1) 'Quantum Physics' by Robert Eisberg and Robert Resnick (John Wiley and sons).
2) 'Quantum Theory' by D. Bohm (Prentice-Hall).
3) 'Quantum Mechanics: Theory and Applications' by A. K. Ghatak and S. Lokanathan (Macmillan India Ltd.).
4) 'Quantum Mechanics' by L. I. Schiff (McGraw-Hill Book, New York).
5) 'Quantum Mechanics' by Cohen and Tanandji.
6) Prabir Ghosh, Quantum mechanics, Narosa Publication

MJC-17: Advanced Quantum Mechanics (Lab) (Credit-1)

1. The Zeeman Effect: Measure the splitting of spectral lines (e.g., Neon or Mercury) in a strong magnetic field. Students calculate the Bohr magneton and observe "normal" vs. "anomalous" splitting, which directly demonstrates electron spin and LS coupling.

2. Electron Spin Resonance (ESR): Use a sample like DPPH to find the g-factor of an electron. This is a perfect application of the interaction of spin with a magnetic field and transition probability.

3. Analysis of the Stark Effect (via Spectroscopy): While a full Stark setup is difficult for UGs, students can analyze high-resolution discharge tube data to observe how external electric fields shift energy levels in Hydrogen-like atoms.

4. The Franck-Hertz Experiment: Demonstrate the existence of discrete energy levels in atoms through inelastic electron scattering. This serves as a foundational "scattering" experiment.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1: Master Approximation Techniques

Apply time-independent perturbation theory, the Variational method, and the WKB approximation to calculate energy eigenvalues and wavefunctions for complex systems, such as the Stark effect in hydrogen and the ground state of Helium.

2: Analyze Time-Dependent Phenomena

Formulate and solve problems involving time-dependent perturbations, transition probabilities, and Fermi's Golden Rule, while distinguishing between the Schrödinger, Heisenberg, and Interaction pictures of quantum dynamics.

3: Execute Angular Momentum Algebra

Evaluate generalized angular momentum operators, construct matrix representations, and implement the coupling of angular momenta using Clebsch-Gordan coefficients for multi-particle systems.

4: Synthesize Symmetries and Conservation Laws

Relate physical symmetries (space/time translation, rotation, and inversion) to fundamental conservation laws and utilize the Wigner-Eckert theorem to simplify the calculation of matrix elements for spherical tensor operators.

5: Formulate Scattering Solutions

Develop mathematical models for particle scattering using partial wave analysis and the Born approximation to determine differential and total cross-sections for various potential fields, including Yukawa and Coulomb potentials.

MJC-18: Molecular Spectroscopy -I (Theory) (Credit-3)

Born-Oppenheimer approximation and separation of electronic and nuclear motions in molecules. Band structures of molecular spectra. Breakdown of the Born-Oppenheimer approximation.

Introduction of quantization of energy. Regions of the spectrum. The intensities of spectral lines.

Microwave spectroscopy: Energy levels of diatomic molecules under rigid rotator and non-rigid rotator models. Selection rules. Spectral structure.

Infrared spectra: Energy levels of diatomic molecules under simple harmonic and anharmonic (no deduction necessary for this one) models. Selection rules and spectral structures. Morse potential energy curves. Dissociation energies. Isotope effect. Rotational – vibrational coupling. Parallel and perpendicular modes.

Raman spectroscopy. Rotational, Vibrational, Rotational-Vibrational Raman spectra. Stokes and anti-stokes Raman lines. Selection Rules. Spectral structures. Nuclear spin and its effect on Raman spectra.

Vibrational spectra of poly atomic molecules. Normal modes. Selection rules for Raman and infrared spectra. Complementarity of Raman and infrared spectra.

Electronic spectra of diatomic molecules: Vibrational band structure. Progressions and sequences. Isotope shifts.

Reference Books:

1. G. Herzberg. 'Molecular Spectroscopy (Diatomic Molecules)' Van-Nostrand.
2. G. M. Barrow. 'Molecular Spectroscopy'. McGraw-Hill.
3. J. Michael Hollas. 'Modern spectroscopy'. John-Wiley & sons.
4. C. L. Banwell and E. M. McCash. 'Fundamentals of Molecular Spectroscopy' Tata-McGraw-Hill.
5. G.Aruldhas, 'Molecular Spectroscopy'.
6. Bransden and Joachin. 'Atoms and Molecules'
7. M. Hammermesh, 'Group Theory'. Addison-Wesley
8. A. W. Joshi. 'Group Theory'. Wiley Eastern Ltd.

MJC-18: Molecular Spectroscopy -I (Lab) (Credit-1)

1. To determine the different wavelengths of Helium spectrum.
2. Analysis of rotation-vibration spectrum of diatomic molecule (HBr).
3. Analysis of rotational Raman Spectra of N2 molecule.
4. To determine the Bohr magneton value by Zeeman Effect set up.
5. To verify Raman effect.

Reference Books

1. Molecular Spectroscopy—Experiment and Theory: From Molecules to Functional Materials: 26 (Challenges and Advances in Computational Chemistry and Physics) by Andrzej Koleżyński (Editor), Magdalena Król (Editor), Springer
2. Spectroscopy Principles and Instrumentation by Mark F. Vitha, Wiley
3. Introduction to Experimental Infrared Spectroscopy: Fundamentals and Practical Methods, Wiley

Course Outcomes:

Upon successful completion of this course, students will be able to:

1: Appraise Molecular Approximations

Explain the physical significance and limitations of the **Born-Oppenheimer approximation** and describe how the separation of electronic, vibrational, and rotational motions leads to the observed band structures in molecular spectra.

2: Analyze Rotational Dynamics

Determine molecular parameters (such as bond lengths and moments of inertia) by analyzing **Microwave spectra** using both rigid and non-rigid rotator models and applying appropriate selection rules.

3: Evaluate Vibrational Transitions Model molecular vibrations using harmonic and anharmonic (Morse potential) oscillators to interpret **Infrared (IR) spectra**, calculate dissociation energies, and explain the impact of isotope substitution on vibrational frequencies.

4: Interpret Raman Scattering Apply the principles of **Raman spectroscopy** to identify rotational and vibrational modes, distinguish between Stokes and anti-Stokes lines, and evaluate the effect of nuclear spin on spectral intensities.

5: Characterize Polyatomic and Electronic States

Differentiate between IR and Raman activity using the **principle of complementarity**, identify normal modes of vibration in polyatomic molecules, and interpret electronic transitions including vibrational progressions and sequences.

6: Demonstrate Experimental Proficiency Acquire hands-on skills in calibrating spectrometers, analyzing complex rotation-vibration data (e.g., for **HBr** or N_2), and verifying fundamental quantum phenomena like the **Zeeman Effect** and **Raman scattering**.

MJC-19: Advanced Classical Electrodynamics (Theory) (Credit-3)

Electromagnetic (EM) Wave Propagation: Plane wave propagation in general directions. Wave propagation in dispersive media. EM wave propagation through dilute plasma. Plasma frequency. Orbit theory of drift motions in a plasma. Pinch effect. Instability in pinched plasma column. Plasma oscillations, short wavelength of plasma oscillation and Debye screening length, Effect of external magnetic field on wave propagations, Reflection of uniform plane waves at normal incidence. [10 Lectures]

Electromagnetic (EM) Radiation: Concept of retarded potentials, Solution of inhomogeneous wave equations. Liénard–Wiechert potential, Fields of a uniformly moving charge, Fields of an accelerated charge: Fields, radiation (power) and angular distribution from a charge at low velocity (non-relativistic), radiation (power) from a charge at linear motion and circular motion or orbit, angular distribution of power for linearly accelerated charges, relativistic correction, Bremsstrahlung and Cerenkov radiation, Basic radiation principles and the Hertzian dipole, Antenna specifications, Different types of antenna, Electric dipole radiation, Magnetic dipole radiation, Power radiated by a point charge. [15 Lectures]

Transmission Lines: Transmission lines and wave propagation. Transmission line equation. Lossless propagation. Condition for Distortion less Transmission and Minimum Attenuation, Transmission lines of finite length.

[5 Lectures]

Wave guides and resonant cavities: Basic concept of wave guides, TE & TM modes, Rectangular waveguide, circular waveguide, resonant cavities, rectangular cavity resonator-TE, TM modes. Power loss in a cavity-Q of a cavity.

[5 Lectures]

Relativistic Electrodynamics: Lagrangian and Hamiltonian of a relativistic charged particle in EM fields, Magnetism as a relativistic phenomenon. Field transformation equations. The electromagnetic field tensor. Electrodynamics in tensor form. Relativistic potentials. Current density 4-vectors. Invariance of Maxwell's equations. [10 Lectures]

Reference Books:

1. Classical Electrodynamics- J. D. Jackson.

2. Classical Electromagnetic Radiation- J. Marion
3. Introduction to Electrodynamics- D. J. Griffiths.
4. Classical Electricity and Magnetism- W. K. H. Panofsky and M. Phillips.
5. Electricity and Magnetism- E. M. Purcell and D. J. Morin
6. Introduction to Plasma Physics and Controlled Fusion- Francis F. Chen
7. Introduction to Special Relativity- R. Resnick.

Couse Outcome:

On completion of this course, students will be able to

(i) Understand basics of Maxwell's equations in different forms, EM wave propagation in dispersive media

(ii) Grow the concept of the physics of transmission lines, wave guides and resonant cavities

(iii) Comprehend the concept of retarded potentials and the origin of radiation as well as the theory of antenna.

(iv) Learn the dynamics of relativistic particles and four vector representation of relativistic mechanics. They will able to express Maxwell's equations in terms of field tensor and dual tensor, calculate relativistic potentials and solve related problems.

MJC-19: Advanced Classical Electrodynamics (Lab) (Credit-1)

(1) To obtain the ABCD parameters of 220KV transmission line model using transmission line kit.

(2) To measure the earth resistance by earth tester.

(3) To determine experimentally flash over voltage of given sample of transformer oil and hence determine the dielectric strength.

(4) To study the characteristics of a Helmholtz coil.

(5) To study Faraday's law of induction.

Couse Outcome:

On completion of this course, students will be able to gather hand on knowledge of some of the topics that are taught in the theory of this course.

MJC-19: Advanced Classical Electrodynamics (Theory) (Credit-3)

1. Variational calculus in Physics

Basic ideas of functionals; Variational principle and Lagrangian Formulation; Euler's equations of motion for simple systems: harmonics oscillators, simple pendulum, spherical pendulum, coupled oscillators; Cyclic coordinates: Symmetries and conservation laws; Legendre transformations and the Hamiltonian formulation of mechanics; Hamilton's canonical equations and their applications; Lagrangian and Hamiltonian for relativistic particles; Principle of least action.

2. Canonical Transformation

Equations of point; generating functions and examples; Lagrange and Poisson brackets and their applications; Invariance of Poisson bracket under canonical transformation; Equations of motion in Poisson Bracket; infinitesimal canonical transformation; constants of motion and symmetry principles; generators of infinitesimal symmetry transformation; Noether's theorem; integral invariant of Poincare; Conservation theorems and angular momentum relation in Poisson brackets; Liouville's theorem.

3. Hamilton-Jacobi equation

Hamilton-Jacobi equation for Hamilton's principle and characteristics functions; Physical significance of these functions; Application of Hamilton-Jacobi equation in linear harmonic oscillator, particle falling under gravity etc.; Action angle variables & applications; Path from classical to quantum mechanics.

4. Rigid body dynamics:

Lagrange's equations of motion for a rigid body; Euler's theorem on the motion of a rigid body; infinitesimal rotations. Euler's equations of motion. Force free motion of a rigid body; heavy symmetrical top with one point fixed; precession and nutation; Larmor precession; gyroscope and asymmetrical top, condition for Fast and sleeping top.

Reference Books

1. Goldstein, Poole and Safko: Classical Mechanics – Addison Wesley / Narosa.
2. Landau and Lifshitz: Mechanics – Pergamon.
3. Rana and Joag: Classical Mechanics – Tata-McGraw Hill.
4. Whittaker: Analytical Dynamics of Particles and Rigid Bodies – Cambridge.

5. Fetter and Walecka: Theoretical Mechanics of Particles and Continua – McGraw Hill.
6. Raychaudhuri A. K: Classical Mechanics – Oxford.
7. Bhatia: Classical Mechanics – Narosa.
8. K.C. Gupta: Classical mechanics of particles and rigid bodies-New Age International.

MJC-19: Advanced Classical Electrodynamics (Lab)(Credit-1)

1. Derive and numerically verify the Euler-Lagrange equations from Hamilton's action principle using Scilab for harmonic oscillator and linear potential.
2. Lagrangian formulation and coupled normal modes analysis for simple pendulum Using Scilab Simulations.
3. Legendre transformation to Hamiltonian mechanics and phase-space trajectories using Scilab for a relativistic particle.
4. Canonical transformations verification using Generating Functions and Poisson Brackets computation in Scilab.
5. Noether's theorem demonstration, symmetries and Liouville's Phase-Volume conservation Using Scilab ensemble simulations.
6. Hamilton-Jacobi equation solution and Action-Angle variables extraction using Scilab quadrature and visualization.
7. Rigid body Euler equations integration and symmetric top precession/nutation analysis using Scilab.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1: Master Variational Formalisms Apply variational calculus and the Principle of Least Action to derive Euler-Lagrange equations for diverse physical systems, including relativistic particles and coupled oscillators.

2: Execute Hamiltonian Dynamics Perform Legendre transformations to transition between Lagrangian and Hamiltonian formalisms and solve Hamilton's canonical equations for complex mechanical systems.

3: Analyze Canonical Transformations Evaluate the invariance of Poisson brackets under canonical transformations and utilize generating functions to simplify the equations of motion in phase space.

4: Synthesize Symmetries and Conservation Laws Relate physical symmetries to fundamental conservation laws through **Noether's Theorem** and apply Liouville's Theorem to understand the evolution of phase-space density.

5: Solve Hamilton-Jacobi Problems Implement the Hamilton-Jacobi equation and action-angle variables to solve periodic systems, facilitating the conceptual transition from classical trajectories to quantum mechanical states.

6: Model Rigid Body Motion Formulate and solve Euler's equations for rigid body dynamics, specifically analyzing the stability and motion of asymmetrical and symmetrical tops, including precession and nutation.

7: Implement Numerical Simulations (Scilab) Develop and debug **Scilab** scripts to numerically integrate equations of motion, visualize phase-space trajectories, and verify theoretical predictions like the conservation of phase-volume.

MN-7: Atomic and Molecular spectroscopy (Theory) (Credit-2)

1. Atomic spectroscopy

The spectra of hydrogen atom, orbital magnetic moment of an atom, Larmor precession (statement), limitation of old quantum theory, vector atom model, Electron spin, magnetic moment due to electron spin, space quantization, geomagnetic ratio, spin orbit interaction, Land g-factor, Stern-Gerlach's experiment, Zeeman effect: Normal Zeeman effect and Anomalous Zeeman effect, Sodium D-Line Splitting , Paschen-Back effect, stark effect.
Pauli's exclusion principle, Coupling Scheme: L-S and j-j coupling, electronic configuration, distribution of electron in a sub-shell and shells, non-equivalent and equivalent electrons, Hund's rules.

2. Molecular spectroscopy

Category of molecular spectra, Origin of molecular spectra, Energy levels of diatomic molecules under rigid rotator, Selection rules, Spectral structure, Structure determination, Isotope effect, Rotational spectra of polyatomic molecules.
Energy levels of diatomic molecules under simple harmonic (no deduction necessary for this one) models, Selection rules and spectral structures.
Luminescence: Fluorescence and Phosphorescence, Raman Effect: Characteristics of Raman lines, quantum theory of Raman Effect, Stokes and anti stokes Raman lines. Raman Effect with laser source, application, NMR and ESR.

Books Recommended:

1. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
2. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
3. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
4. G. Herzberg. 'Molecular Spectroscopy (Diatomic Molecules)' Van-Nostrand.
5. G. M. Barrow. 'Molecular Spectroscopy'. McGraw-Hill.
6. J.Michael Hollas. ' Modern spectroscopy'. John-Wiley & sons.
7. C. L. Banwell and E. M. McCash. 'Fundamentals of Molecular Spectroscopy',Tata- McGraw-Hill.

8. G. Herzberg. 'Molecular Spectroscopy (Diatomic Molecules)' Van-Nostrand.

MN-7: Atomic and Molecular spectroscopy (Lab) (Credit-1)

1. **Determination of the Rydberg Constant (R_H):** Measure the wavelengths of the Balmer series (H_α, H_β, H_γ).
2. **Measurement of Sodium D-line Splitting:** Measure the angular separation between $\underline{D_1}$ and D_2 lines to calculate the wavelength difference (≈ 6 Å)
3. **Analysis of the Mercury Spectrum:** Identify the prominent lines (Yellow doublet, Green, Blue-violet) and calibrate the spectrometer.
4. **Verification of the Cauchy's Dispersion Formula:**
Measure the refractive index for different colors and fit them to $n=A+B/\lambda^2$.
5. **Study of Fluorescence using Quinine Sulphate:** Observe the blue glow under UV and its disappearance under visible light.
6. **Determination of the Absorption Spectrum of Iodine Vapor:** Gently heat the tube and observe the absorption bands in the visible region.
7. **Dissociation Energy of Iodine (Graphing Project):** Using provided or measured absorption maxima of I_2, students can plot the Birge-Sponer extrapolation to find the dissociation energy.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1: Appraise the Vector Atom Model Critically evaluate the transition from old quantum theory to the **Vector Atom Model**, explaining the physical significance of space quantization, electron spin, and the results of the **Stern-Gerlach experiment**.

2: Analyze Spectral Splitting in External Fields Quantitatively describe the splitting of spectral lines under the influence of magnetic and electric fields (**Zeeman, Paschen-Back, and Stark effects**) and calculate the **Landé g-factor** for various atomic states.

3: Apply Coupling Schemes and Hund's Rules Determine the spectroscopic terms and electronic configurations of multi-electron atoms by applying **L-S and j-j coupling** schemes, **Pauli's Exclusion Principle**, and **Hund's rules**.

4: Interpret Molecular Rotational and Vibrational Data Analyze the rotational and vibrational spectra of diatomic molecules to calculate molecular parameters such as bond length and force constants using **rigid rotator** and **harmonic oscillator** models.

5: Differentiate Scattering and Luminescence Phenomena Distinguish between the mechanisms of **Fluorescence, Phosphorescence, and the Raman Effect**, utilizing selection rules to predict observable transitions and explaining the impact of laser sources on Raman scattering.

6: Summarize Resonance Spectroscopy Principles Explain the basic principles and applications of **Nuclear Magnetic Resonance (NMR)** and **Electron Spin Resonance (ESR)** in the context of studying atomic and molecular magnetic environments.