• The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List. • The institution may suggest a minimum number of experiments (say 3) to be performed by each student per semester from the Online Virtual Lab Experiment List / Link.

Programme Class: **Degree**	Year: **Third**	Semester: **Fifth**
Subject: **PHYSICS**		
Course Code: **(B010501T)**	Course title: **Classical & Statistical Mechanics**	
Course Outcomes: 1. Understand the concepts of generalized coordinates and D'Alembert's principle. 2. Understand the Lagrangian dynamics and the importance of cyclic coordinates. 3. Comprehend the difference between Lagrangian and Hamiltonian dynamics. 4. Study the important features of central force and its application in Kepler's problem. 5. Recognize the difference between macrostate and microstate. 6. Comprehend the concept of ensembles. 7. Understand the classical and quantum statistical distribution laws. 8. Study the applications of statistical distribution laws.		
Credits: **4**	Core Compulsory / Elective	
Max. Marks: **25+75**	Min. Passing Marks:	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**		
Unit	**Topics**	**No. of Lectures**
Part A: Introduction to Classical Mechanics		
I	**Constrained Motion:** Constraints - Definition, Classification and Examples. Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Principle of Virtual work and D'Alembert's principle.	6
II	**Lagrangian Formalism:** Lagrangian for conservative & non-conservative systems, Lagrange's equation of motion (no derivation), Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws (with proofs and properties of kinetic energy function included). Simple examples based on Lagrangian formulation.	9
III	**Hamiltonian Formalism:** Phase space, Hamiltonian for conservative & non-conservative systems, Physical significance of Hamiltonian, Hamilton's equation of motion (no derivation), Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian. Simple examples based on Hamiltonian formulation.	8
IV		7

	Central Force: Definition and properties of central force. Equation of motion and differential equation of orbit. Bound orbits, stable & non-stable orbits, closed & open orbits. Motion under inverse square law of force and Kepler's laws.	
	PART B: Introduction to Statistical Mechanics	
V	**Macrostate & Microstate:** Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D.	6
VI	**Concept of Ensemble:** Problem with time average, concept of ensemble, postulate of ensemble average and Liouville's theorem (proof included). Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability, Postulate of Equilibrium and Boltzmann Entropy relation.	6
VII	**Distribution Laws:** Statistical Distribution Laws: Expressions for number of accessible microstates, probability & number of particles in i^{th} state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & Fermi-Dirac statistics. Comparison of statistical distribution laws and their physical significance. Canonical Distribution Law: Boltzmann's Canonical Distribution Law, Boltzmann's Partition Function, Proof of Equipartition Theorem (Law of Equipartition of energy) and relation between Partition function and Thermodynamic potentials.	10
VIII	**Applications of Statistical Distribution Laws:** Application of Bose-Einstein Distribution Law: Photons in a black body cavity and derivation of Planck's Distribution Law. Application of Fermi-Dirac Distribution Law: Free electrons in a metal, Definition of Fermi energy, Determination of Fermi energy at absolute zero, Kinetic energy of Fermi gas at absolute zero and concept of Density of States (Density of Orbitals).	8

Suggested Readings:

PART B

1. Herbert Goldstein, Charles P. Poole, John L. Safko, "Classical Mechanics", Pearson Education, India, 2011, 3e
2. N.C. Rana, P.S. Joag, "Classical Mechanics", McGraw Hill, 2017
3. R.G. Takwale, P.S. Puranik, "Introduction to Classical Mechanics", McGraw Hill, 2017

PART B

1. F. Reif, "Statistical Physics (In SI Units): Berkeley Physics Course Vol 5", McGraw Hill, 2017, 1e
2. B.B. Laud, "Fundamentals of Statistical Mechanics", New Age International Private Limited, 2020, 2e
3. B.K. Agarwal, M. Eisner, "Statistical Mechanics", New Age International Private Limited, 2007, 2e

Suggestive Digital Platforms / Web Links:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation Methods:

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Quiz/ Assignment	(05 marks)
Class Test-I	(10 marks)
Class Test-II	(10 marks)

- This course can be opted as an Elective by the students of Chemistry / Computer Science / Mathematics / Statistics
- **PREREQUISITE:** Passed Semester I, Theory Paper-1 (B010101T)

Programme Class: **Degree**	Year: **Third**	Semester: **Fifth**
Subject: **PHYSICS**		
Course Code: **(B010502T)**	Course title: **Quantum Mechanics & Spectroscopy**	
Course Outcome: 1. Understand the significance of operator formalism in Quantum mechanics. 2. Study the eigen and expectation value methods. 3. Understand the basis and interpretation of Uncertainty principle. 4. Develop the technique of solving Schrodinger equation for 1D and 3D problems. 5. Comprehend the success of Vector atomic model in the theory of Atomic spectra. 6. Study the different aspects of spectra of Group I & II elements. 7. Study the production and applications of X-rays. 8. Develop an understanding of the fundamental aspects of Molecular spectra.		
Credits: **4**	Core Compulsory / Elective	
Max. Marks: **25+75**	Min. Passing Marks:	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: **4-0-0**		
Unit	**Topics**	**No. of Lectures**
Part A: Introduction to Quantum Mechanics		
I	**Formulation of quantum mechanics & Operators** Basic idea about particle aspect of radiation, wave aspect of particles and wave particle duality; Double slit experiment, Probabilistic interpretation, wave packet, observables and operators, Hermitian operator (Definition, Proof, properties), commutative and simultaneous operators, Wave function, Orthonormalization condition of wave function, Swartz inequality. Review of matrix algebra, definition of an operator, special operators, operator algebra and operators.	6
II	**Eigen & Expectation Values and Uncertainty Principle:** Eigen & Expectation Values: Eigen equation for an operator, eigen state (value) and eigen functions. Linear superposition of eigen functions and Non-degenerate & Degenerate eigen states. Expectation value pertaining to an operator and its physical interpretation.	6

	Heisenberg uncertainty principle: Commutativity & simultaneity (theorems with proofs). Noncommutativity of operators as the basis for uncertainty principle and derivation of general form of uncertainty principle through Schwarz inequality. Uncertainty principle for various conjugate pairs of physical-dynamical parameters and its applications.	
III	**Quantum Postulates and Schrodinger Equation:** Postulates of quantum mechanics: statements and their physical interpretation. Hamiltonian operator. Schrodinger Equation: formulation (time independent & time dependent forms), Schrodinger equation as an eigen equation, Deviation & interpretation of equation of continuity in Schrodinger representation, and Equation of motion of an operator in Schrodinger representation. Free particle solution of Schrödinger equation.	7
IV	**Applications of Schrodinger Equation:** Application to 1D Problems: Infinite Square well potential (Particle in 1D box), Finite Square well potential, Potential step, Rectangular potential barrier and 1D Harmonic oscillator. Application to 3D Problems: Infinite Square well potential (Particle in a 3D box) and the Hydrogen atom (radial distribution function and radial probability included). (Direct solutions of Hermite, Associated Legendre and Associated Laguerre differential equations to be substituted).	11
PART B: Introduction to Spectroscopy		
V	**Vector Atomic Model:** Inadequacies of Bohr and Bohr-Sommerfeld atomic models w.r.t. spectrum of Hydrogen atom (fine structure of H-alpha line). Modification due to finite mass of nucleus and Deuteron spectrum. Vector atomic model (Stern-Gerlach experiment included) and physical & geometrical interpretations of various quantum numbers for single & many valence electron systems. LS & JJ couplings, spectroscopic notation for energy states, selection rules for transition of electrons and intensity rules for spectral lines. Fine structure of H-alpha line on the basis of vector atomic model.	10
VI	**Spectra of Alkali & Alkaline Elements:** Spectra of alkali elements: Screening constants for s, p, d & f orbitals; sharp, principle, diffuse & fundamental series; doublet structure of spectra and fine structure of Sodium D line. Spectra of alkaline elements: Singlet and triplet structure of spectra.	6
VII	**X-Rays & X-Ray Spectra:** Nature & production, Continuous X-ray spectrum & Duane-Hunt's law, Characteristic X-ray spectrum & Mosley's law, Fine structure of Characteristic X-ray spectrum, and X-ray absorption spectrum.	7
VIII	**Molecular Spectra:** Discrete set of energies of a molecule, electronic, vibrational and rotational energies. Quantisation of vibrational energies, transition rules and pure vibrational spectra. Quantisation of rotational energies, transition rules, pure rotational spectra and determination of inter nuclear distance. Basics of UV Visible & photoluminescence spectroscopy	7

Suggested Readings:

PART A

1. D.J. Griffiths, “Introduction to Quantum Mechanics”, Pearson Education, India, 2004, 2e
2. H. K. Malik and A.K. Singh “Engineering Physics”, McGraw Hill Education (India) Private Limited, 2018, 2e.
3. N. Zettili, “Quantum Mechanics, Concepts and Applications”, ohn Wiley and Sons, Ltd., Publication 2009.
4. E. Wichmann, “Quantum Physics (In SI Units): Berkeley Physics Course Vol 4”, McGraw Hill, 2017
5. Richard P. Feynman, Robert B. Leighton, Matthew Sands, “The Feynman Lectures on Physics - Vol. 3”, Pearson Education Limited, 2012
6. R Murugeshan, Kiruthiga Sivaprasath, “Modern Physics”, S. Chand Publishing, 2019, 18e

PART B

7. H.E. White, “Introduction to Atomic Spectra”, McGraw Hill, 1934
8. C.N. Banwell, E.M. McCash, “Fundamentals of Molecular Spectroscopy”, McGraw Hill, 2017, 4e
9. R Murugeshan, Kiruthiga Sivaprasath, “Modern Physics”, S. Chand Publishing, 2019, 18e
10. S.L. Gupta, V. Kumar, R.C. Sharma, “Elements of Spectroscopy”, Pragati Prakashan, Meerut, 2015, 27e

Local Author’s Books

1. Refresher Course in Physics; Vol-II, C.L. Arora, S. Chand Publication.
2. Optics & Spectroscopy, Kiruthiga Sivaprasath, S. Chand Publication.
3. Quantum Mechanics, Kamal Singh & S.P. Singh, S. Chand Publication.
4. Elements of Quantum Mechanics, Agarwal, Jain & Sharma, Krishna Prakashan.
5. क्वाण्टम यांत्रिकी के अवयव, अग्रवाल, जैन व शर्मा, कृष्णा प्रकाशन ।

Suggestive Digital Platforms / Web Links:

11. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
12. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
13. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
14. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

Suggested Continuous Evaluation Methods:

Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Quiz/ Assignment	**(05 marks)**
Class Test-I	**(10 marks)**
Class Test-II	**(10 marks)**

- This course can be opted as an Elective by the students of Chemistry / Computer Science / Mathematics / Statistics
- **PREREQUISITE:** Passed Semester IV, Theory Paper-1 (B010401T)

<table>
<tr><td>Programme Class:
Degree</td><td colspan="2">Year: Third</td><td>Semester:
Fifth</td></tr>
<tr><td colspan="4">Subject: PHYSICS</td></tr>
<tr><td>Course Code:
(B010503P)</td><td colspan="3">Course Title: Demonstrative Aspects of Optics & Lasers</td></tr>
<tr><td colspan="4">Course Outcomes:
Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the optical properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.</td></tr>
<tr><td>Credits: 2</td><td colspan="3">Core Compulsory / Elective</td></tr>
<tr><td>Max. Marks:
25+75</td><td colspan="3">Min. Passing Marks:</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4</td></tr>
<tr><td>Unit</td><td colspan="2">Topics</td><td>No. of Lectures</td></tr>
<tr><td colspan="4">Lab Experiment List</td></tr>
<tr><td rowspan="3"></td><td colspan="2">1. Fresnel Biprism: Wavelength of sodium light
2. Fresnel Biprism: Thickness of mica sheet)
3. Wavelength of Laser light using diffraction by single slit
4. Study of Spectra of Hydrogen & Deuterium (Rydberg Constant)
5. Laser – Wavelength of Laser light using diffraction by single slit.
6. Study of polarization of light by simple reflection & variation of degree of polarization.
7. Study of Absorption spectrum of Iodine Vapour.
8. Laser beam divergence & spot size.
9. Newton’s Rings: Refractive index of liquid
10. Plane Diffraction Grating: Resolving power</td><td rowspan="3">60</td></tr>
<tr><td colspan="2">Online Virtual Lab Experiment List/Link</td></tr>
<tr><td colspan="2">Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/?sub=1&brch=189

1. Michelson's Interferometer
2. Michelson's Interferometer: Wavelength of laser beam
3. Newton's Rings: Wavelength of light
4. Newton's Rings: Refractive index of liquid
5. Brewster’s angle determination
6. Laser beam divergence and spot size

Virtual Labs at Amrita Vishwa Vidyapeetham
https://vlab.amrita.edu/index.php?sub=1&brch=281

7. Spectrometer: Refractive index of the material of a prism
8. Spectrometer: Dispersive power of a prism
9. Spectrometer: Determination of Cauchy’s constants
10. Diffraction Grating</td></tr>
</table>

Suggested Readings:

1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e
2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e
3. R.K. Agrawal, G. Jain, R. Sharma, "Practical Physics", Krishna Prakashan Media (Pvt.) Ltd., Meerut, 2019
4. S.L. Gupta, V. Kumar, "Practical Physics", Pragati Prakashan, Meerut, 2014, 2e

Suggestive Digital Platforms / Web Links:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=189
2. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/index.php?sub=1&brch=281
3. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities

Suggested Continuous Evaluation Methods:
Continuous internal evaluation shall be based on allotted assignment and class tests. The marks shall be as follows:

Record File	**(15 marks)**
Viva Voce	**(05 marks)**
Class Interaction	**(10 marks)**

- This course can be opted as an Elective by the students of Chemistry / Computer Science / Mathematics / Statistics
- **PREREQUISITE:** Passed Semester III, Theory Paper-1 (B010301T)

Further Suggestions:

- The institution may suggest a minimum number of experiments (say 6) to be performed by each student per semester from the Lab Experiment List.
- The institution may suggest a minimum number of experiments (say 3) to be performed by each student per semester from the Online Virtual Lab Experiment List / Link.