DEPARTMENT OF PHYSICS				*CLASS: I M.Sc. Physics*				
Sem	**Course Type**	**Course Code**	**Course Title**	**Credits**	**Contact Hours/week**	**CIA**	**Ext**	**Total**
I	Major Core–2	21P1PMC2	Classical Mechanics	4	5	25	75	100

Nature of Course				
Knowledge and skill	✓		Employability oriented	
Skill oriented			Entrepreneurship oriented	

Objectives:

- To enhance the knowledge of mechanics of particles
- To solve the equation of motion using Lagrangian, Hamilton and Hamilton – Jacobi equations.
- To study the kinematics of the rigid body through Euler equation.
- To acquire knowledge in equations of motion for systems with small oscillations.

Unit	Description	Hours	K-level	CLO
I	**Lagrangian Formulation:** Generalized coordinates – Principle of virtual work – D'Alembert's Principle – Lagrange's equation of motion from D'Alembert's Principle – Procedure for formation of Lagrange's equation – Lagrange's equation in presence of non conservative forces – Generalized potential – Lagrangian for a charged particle moving in a Electromagnetic field.	15	Up to K2	1
II	**Hamilton's Equations :** Generalized momentum and Cyclic coordinates – Hamiltonian function – Hamilton's canonical equations – Hamilton's equation in different coordinate systems (Cartesian, polar and cylindrical) – Examples – Harmonic Oscillator – Charged Particle moving in an electromagnetic field – Modified Hamilton's Principle – Hamilton's equations from Variational principle – Δ Variation – Principle of Least action – other forms of least action.	15	Up to K3	2
III	**Canonical Transformation :** Canonical transformations – Legendre transformation – Generating functions – Condition for canonical transformations – Examples – Bilinear Invariant Condition – Poisson brackets and its properties – Lagrange bracket – Relation between Poisson and Lagrange Brackets – Angular momentum and Poisson Brackets – Invariance of Poisson brackets under canonical Transformations.	15	Up to K3	3

IV	**Hamilton – Jacobi theory & Small oscillations :** Hamilton – Jacobi equation – Solution of Harmonic oscillator problem by Hamilton – Jacobi method – Hamilton's characteristic function – Kepler's problem by Hamilton – Jacobi Method – Action and angle variables – Small Oscillations – General theory – Eigen value equation – Two coupled pendulum – Vibrations of linear tri atomic molecule.	15	Up to K4	4
V	**Kinematics of Rigid body & Central force problem:** Generalized coordinates of a rigid body – Euler angle – infinitesimal rotations – Angular momentum and inertia tensor – Euler's equations of motion for a rigid body derived from Lagrange's method –Torque free motion of a rigid body – Reduction of the two - body central force to the equivalent one body problem – Equation of motion under central force and first integrals – Differential equation for an orbit – Inverse square law– Kepler's laws of planetary motion and their deduction – Virial theorem – Scattering in a central force field.	15	Up to K4	5

Book for study:

1. J.C. Upadhyaya, 2018, Classical Mechanics, Published by Himalaya Publishing House Pvt. Ltd.

    Unit 1: 2.4 – 2.10.

    Unit II: 3.2, 3.4, 3.5, 3.6, 3.7.1, 3.7.3, 5.4, 5.5, 5.10, 5.11, 5.12

    Unit III: 6.1, 6.2, 6.3, 6.5, 6.6, 7.2 – 7.7.

    Unit IV: 8.2 – 8.6, 9.4 – 9.6.

    Unit V: 10.1, 10.3, 10.4, 10.6, 10.11.2, 10.12.1, 4.1, 4.3 – 4.6,4.9,4.10.

Books for reference:

1. Classical Mechanics – H. Goldstein, C. Poole and J. Safko,Pearson Education Asia, New Delhi, Third Edition, 2002.
2. Classical Mechanics – G. Aruldhas, PHI Learning Private Limited, New Delhi, 2015.
3. Classical Mechanics – S. L. Gutpa, V. Kumar and H.V. Sharma, Pragati Prakashan, Meerut, 2016.
4. Classical Mechanics of Particles and Rigid Bodies – K.C. Gupta, New Age International Publishers,New Delhi, Third edition,2018.

Web Resources:

1. https://worldscientific.com/doi/10.1142/9789814551496_0031
2. https://nptel.ac.in/courses/115/105/115105098/
3. https://www.iiserpune.ac.in/~santh/course/phy311 – cm/phy311 – cm.html
4. https://galileoandeinstein.phys.virginia.edu/7010/CM_10_Canonical_Transformations.html
5. http://www.scholarpedia.org/article/Hamilton – Jacobi_equation
6. https://rotations.berkeley.edu/kinematics – of – rigid – bodies/

Rationale for Nature of the course

In this course, Classical Mechanics which is the study of macroscopic mechanical systems is considered from different perspectives of Lagrangian and Hamiltonian methods. Practical applications of these general principles towards simple problems of oscillatory systems, rigid bodies would enhance comprehension of the principles of Classical Mechanics and develop the skills necessary to analyze the behavior of the mechanical systems based on variety of mathematical methods of Classical Mechanics.

Activities having direct bearing on Skill development/ Employability/Entrepreneurship

Lagrangian and Hamiltonian equations of motion derived for different systems develops the application of mathematical and simulation skills to understand various practical applications involving macroscopic and microscopic objects in motion.

Pedagogy

Chalk and Talk, PPT, Quiz, Group discussion, Seminar, Interaction, Problem solving.

Course Designers

1. Dr.M.Prema Rani
2. Mr.S.Ramakrishnan

Course learning Outcomes

On the successful completion of the course, students will be able to

CLOs	Course Learning Outcome	Knowledge level
CLO 1	Infer basic concepts of mechanics to describe the Lagrangian equations of motion to simple systems.	Up to K2
CLO 2	Develop Hamilton's equation of motion to real life applications.	Up to K3
CLO 3	Apply generating functions and Poisson brackets to solve problems in Canonical transformations	Up to K3
CLO 4	Analyse and evaluate equations of motion for coupled systems having small oscillations.	Up to K4
CLO 5	Formulate equations of motion for rigid bodies using Euler's equations.	Up to K4

Mapping with CLOs with PSOs

#	PSO–1	PSO–2	PSO–3	PSO–4	PSO–5
CLO–1	3	2	1	2	2
CLO–2	3	2	1	2	2
CLO–3	3	2	1	2	2
CLO–4	3	2	1	2	2
CLO–5	3	2	1	2	2

Advance application– 3; Intermediate level–2; Basic level–1

Course plan

Unit	Topics	Hrs	Mode
I	System of particles – Degrees of freedom	**2**	PPT, Chalk and talk, and Group discussion
	Constraints – Types of constraints	**2**	
	constraints in a rigid body	**2**	
	Generalized coordinates	**1**	
	Principle of virtual work	**1**	
	D'Alembert's Principle –	**2**	
	Lagrange's equation of motion from D'Alembert's Principle	**3**	
	Free particle in space	**1**	
	Atwood's machine.	**1**	
II	Generalized momentum and Cyclic coordinates	**1**	PPT, Chalk and talk, and Group discussion
	Hamiltonian function – Hamilton's canonical equations	**1**	
	Hamilton's equation in different coordinate systems (Cartesian, polar and	**3**	
	Examples – Harmonic Oscillator, Charged Particle moving in an	**2**	
	Modified Hamilton's Principle	**1**	
	Hamilton's equations from Variational principle	**2**	
	Δ Variation	**1**	
	Principle of Least action	**2**	
	Other forms of least action.	**2**	
III	Canonical transformations	**1**	PPT, Chalk and talk, Quiz and Group discussion
	Legendre transformation	**1**	
	Generating functions	**3**	
	Condition for canonical transformations – Examples –	**2**	
	Bilinear Invariant Condition –	**1**	
	Poisson brackets and its properties	**2**	
	Lagrange bracket – Relation between Poisson and Lagrange Brackets	**2**	
	Angular momentum and Poisson Brackets –	**1**	
	Invariance of Poisson brackets under canonical Transformations.	**2**	
IV	Hamilton – Jacobi equation	**1**	PPT, Chalk and talk, Assignment
	Harmonic oscillator problem by Hamilton – Jacobi method	**2**	
	Hamilton's characteristic function	**2**	
	Kepler's problem by Hamilton – Jacobi Method – .	**2**	
	Action and angle variables	**1**	
	General theory of small oscillations	**2**	
	Eigen value equation –	**1**	
	Two coupled pendulum	**2**	
	Vibrations of linear tri atomic molecule.	**2**	
V	Generalised coordinates of a rigid body	**1**	PPT, Chalk and talk, Quiz and Group
	Euler angle – infinitesimal rotations	**1**	
	Angular momentum and inertia tensor	**1**	
	Euler's equations of motion for a rigid body derived from Lagrange's	**2**	

	Torque free motion of a rigid body	**1**	discussion
	Reduction of the two – body central force to the equivalent one body	**1**	
	Equation of motion under central force and first integrals	**1**	
	Differential equation for an orbit	**1**	
	Inverse square law	**1**	
	Kepler's laws of planetary motion and their deduction	**2**	
	Virial theorem	**1**	
	Scattering in a central force field.	**2**	

Learning Outcome Based Education (LOBE) & Assessment
Summative Examination – Blue Print
Articulation Mapping-K Levels with Courses Learning Outcomes (CLOs)

Units	CLOs	K- Level	SectionA		SectionB		Section C (Either/OR)	Section D (Open Choice)
			MCQs		Short answers			
			No. of Questions	K- Level	No. of Questions	K- Level		
1	CLO 1	Up to K2	2	K1 & K1	1	K1	2(K1 & K1)	1(K2)
2	CLO 2	Up to K3	2	K2 & K3	1	K2	2(K3 & K3)	1(K3)
3	CLO 3	Up to K3	2	K2 & K3	1	K1	2(K2 & K2)	1(K3)
4	CLO 4	Up to K4	2	K3 & K4	1	K3	2(K4 & K4)	1(K4)
5	CLO 5	Up to K4	2	K3 & K4	1	K2	2(K4 & K4)	1(K4)
No. of Questions to be asked			10			5	10	5
No. of Questions to be Answered			10			5	5	3
Marks for each question			1			2	5	10
Total Marks for each Section			10			10	25	30

Distribution of Section-wise Marks with K Levels

K Levels	Section A (No Choice)	Section B (No Choice)	Section C (Either/or)	Section D (Open Choice)	Total Marks	% of Marks without choice
K1	2	4	10	-	**16**	13.33
K2	2	4	10	10	**26**	21.67
K3	4	2	10	20	**36**	30.00
K4	2	-	20	20	**42**	35.00
Total Marks	10	10	50	50	**120**	100.00