University of Kerala

Discipline	**PHYSICS**				
Course Code	**UK4DSCPHY200**				
Course Title	**CLASSICAL DYNAMICS**				
Type of Course	**DSC**				
Semester	**IV**				
Academic Level	**200 - 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 Hrs	-	2 Hrs	5 Hrs
Pre-requisites	1. Knowledge about Newton's laws and their implications. 2. Basic knowledge about a simple pendulum, centre of mass and oscillations				
Course Summary	The course has the following major objectives: 1. Gain deeper understanding of classical mechanics: Consolidate the understanding of concepts in mechanics such as Lagrangian, Hamiltonian, central force field, relativity and small oscillations. 2. Advance skills and capability for formulating and solving problems: applications of LaGrange's and Hamilton's equations of motion, motion in central force field, theory of relativity and the theory of small oscillations. 3. Expand and exercise the students' physical intuition and thinking process through the understanding of the theory and application of this knowledge of classical mechanics to the solution of practical problems.				

BOOKS FOR STUDY:

1. Classical Mechanics: G. Aruldhas, PHI Learning Pvt Ltd., 2008.
2. Classical Mechanics: J. C. Upadhyaya, Himalaya Publishing House.,2005.
3. Mechanics: H. S. Hans and S. P. Puri, Tata-McGraw Hill.,1984

BOOKS FOR REFERENCE:

1. Classical Mechanics, Goldstein, C.P. Poole, J.L. Safko, 3rd Edition. 2002, Pearson Education

2. Introduction to Special Relativity: R. Resnick, John Wiley and Sons, 2005.

3. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

4. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edition., McGraw Hill

DETAILED SYLLABUS: THEORY

Module	Unit	Content	Hrs	CO No
I		**Lagrangian Dynamics** (Book 2: Chapter 2 and Book1: Chapter 3)	**09**	
	1	A brief review of Newtonian mechanics of a particle and a system particle	1	1
	2	Constraints and generalized coordinates	1	1
	3	Principle of virtual Work and D' Alembert's principle	1	1
	4	Lagrange's equation from D'Alembert's Principle, Comparison between Newtonian and Lagrangian dynamics	3	1
	5	Applications of Lagrange's equation in simple pendulum, Atwood's machine and compound pendulum	3	1
II		**Hamiltonian Dynamics** (Book 2: Chapter 3)	**09**	
	6	Generalized momentum and cyclic coordinates	1	2
	7	Hamiltonian function and Conservation of energy	2	2
	8	Hamilton's equation	2	2
	9	Examples of Hamiltonian dynamics: Equation of motion of i) one dimensional harmonic oscillator ii) particle in central force field	3	2
	10	Comparison between Hamiltonian and Lagrangian dynamics	1	2
III		**Motion in Central Force Field** (Book 2: Chapter 4 and Book1: Chapter 5)	**09**	
	11	Reduction to one body problem-equations of motion-equivalent one-dimensional problem	2	3

	12	Differential equation for the orbit in the case of integrable power law potentials	2	3
	13	Virial theorem	1	3
	14	Kepler's problem	2	3
	15	Inverse square law of force	2	3
IV	**Special Theory of Relativity** **(Book 2: chapters 1, 11 & 12 and Book 3: chapters 10, 11 & 12)**		**09**	
	16	Inertial and non- inertial frames of reference, Galilean transformations	1	4
	17	Ether Hypothesis, The Michelson-Morley experiment and explanation of negative result	1	4
	18	Postulates of special theory of relativity and Lorentz transformations.	2	4
	19	Consequences of Lorentz transformations- length contraction, simultaneity, time dilation, twin paradox	3	4
	20	Addition of velocities, Variation of mass with velocity– mass energy relation	2	4
V*	**Theory of Small Oscillations** **Book1: Chapter 9 and Book2: Chapter 9**		**09**	
	21	Equilibrium and potential energy	3	5
	22	Theory of small oscillations-normal modes	4	5
	23	Two coupled pendula	2	5

DETAILED SYLLABUS: PRACTICALS

Part A – At least 5 Experiments to be performed		CO No
Sl No	**Name of Experiment**	
1	Verification of Newton's second law using an Air Track	6
2	Verification of conservation principles (momentum and energy) using a friction free metal track.	6

3	To determine g and velocity for a freely falling body using Digital Timing Technique	6
4	Estimation of the value of "g" using a Kater's pendulum.	6
5	Estimation of the moment of inertia about the different axes of a bifilar suspension.	6
6	Estimation of the Rigidity modulus of a metallic wire using a torsion pendulum.	6
7	Estimation of the moment of inertia of a Fly wheel (Calculate percentage error and standard deviation).	6
8	Estimation of acceleration due to gravity and Radius of gyration using Compound pendulum (Symmetric)	6
9	Estimation of acceleration due to gravity and Radius of gyration using Compound pendulum (Asymmetric)	6
10	Estimation of the Rigidity modulus of a metallic wire using a torsion pendulum with two equal masses	6
Part B* – At least One Experiment to be performed		
11	Numerical interpolation using Newton and Lagrangian methods	6
12	Study of motion of projectile in a central force field	6
13	Study of Planetary motion and Kepler's laws	6
14	Symplectic integration for linear harmonic oscillator	6
15	Solve the simple harmonic oscillator problem with /without damping and visualize the phase-space diagram.	6

COURSE OUTCOMES

No.	Upon completion of the course the graduate will be able to	Cognitive Level	PSO addressed
CO-1	To define generalised coordinates, generalised velocities, and generalised force and write Lagrangian for mechanical system in terms of generalised coordinates.	R, U, Ap	PSO-1,2

CO-2	To write Hamiltonian for mechanical systems and derive and solve Hamilton's equation of motion for simple mechanical systems.	R, U, Ap	PSO-1,2
CO-3	To define equations of motion corresponding to reduction to one body problem and to derive equation for orbit and learn about Virial theorem, Kepler's problem and inverse square law of force.	R, U, Ap	PSO-1,2
CO-4	Recapitulate and learn the special theory of relativity and postulates of the special theory of relativity and develop applications of special theory of relativity to dynamical systems of particles.	R, U, Ap	PSO-1,2
CO-5	Formulate the problem of small amplitude oscillation and solve them to obtain normal modes of oscillation and their frequencies in simple mechanical systems.	R, U, Ap	PSO-1,2
CO-6	Able to do simple experiments related to applications of classical dynamics and to perform simple computer programs related to applications of classical dynamics.	U, Ap	PSO-5,7

R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

Name of the Course: CLASSICAL DYNAMICS

Credits: 3:0:1 (Lecture: Tutorial: Practical)

CO No.	CO	PO / PSO	Cognitive Level	Knowledge Category	Lecture (L)/ Tutorial (T)	Practical (P)
CO-1	To define generalised coordinates, generalised velocities, and generalised force and write Lagrangian for mechanical system	PO-1,2,3,4,5,6,8/ PSO-1,2	R, U, Ap	F, C	L	-

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	in terms of generalised coordinates.					
CO-2	To write Hamiltonian for mechanical systems and derive and solve Hamilton's equation of motion for simple mechanical systems.	PO-1,2,3,4,5,6,8/ PSO-1,2	R, U, Ap	F, C	L	-
CO-3	To define equations of motion corresponding to reduction to one body problem and to derive equation for orbit and learn about Virial theorem, Kepler's problem and inverse square law of force.	PO-1,3,4,5,6,8/ PSO-1,2	R, U, Ap	F, C	L	-
CO-4	Recapitulate and learn the special theory of relativity and postulates of the special theory of relativity and develop applications of special theory of relativity to dynamical systems of particles.	PO-1,3,4,5,6,8/ PSO-1,2	R, U, Ap	F, C	L	-

| CO-5 | Formulate the problem of small amplitude oscillation and solve them to obtain normal modes of oscillation and their frequencies in simple mechanical systems. | PO-1,3,4,5,6,8/ PSO-1,2 | R, U, Ap | F, C | L | - |
| CO-6 | To do simple experiments related to applications of classical dynamics and to perform simple computer programs related to applications of classical dynamics. | PO-1,2,3,6,7/ PSO-5,7 | U, Ap | P | - | P |

F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8
CO-1	2	2	-	-	-	-	-	2	-	3	2	2	2	-	2
CO-2	2	2	-	-	-	-	-	3	-	2	2	2	2	-	3
CO-3	2	2	-	-	-	-	-	2	-	2	2	2	2	-	3
CO-4	2	2	-	-	-	-	-	2	-	2	2	2	2	-	2
CO-5	2	2	-	-	-	-	-	2	-	2	2	2	2	-	2
CO-6	-	-	-	-	2	-	3	2	2	3	3	2	-	2	2

Correlation Levels:

Level	-	1	2	3
Correlation	Nil	Slightly / Low	Moderate / Medium	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Discussion / Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics :

CO No	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO-1	✓	-	-	✓
CO-2	✓	✓	-	✓
CO-3	✓	✓	-	✓
CO-4	✓	✓	-	✓
CO-5	✓	-	-	✓
CO-6	✓	-	-	-