ARSD College, University of Delhi

Model Course Handout/Lesson Plan

Course Name : B.Sc. (Hons.) Physics						
Semester	**Course Code**	**Course Title**	**Lecture (L)**	**Tutorial (T)**	**Practical (P)**	**Credit (C)**
I	32221102	Core : Mechanics	4	0	0	4
Teacher/Instructor(s)		Lalit Kumar				
Session		2021-22				

Course Objective:

- This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts.
- It begins with Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity.
- Students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations.

Course Learning Outcomes:

- The students will be able to apply the concepts learnt to several real world problems.
- Also, students will learn about laws of motion and their application to various dynamical situations
- Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.
- In the laboratory course, the student shall perform experiments related to mechanics:
  Like compound pendulum, rotational dynamics (Flywheel), elastic properties (Young Modulus and Modulus of Rigidity), fluid dynamics, estimation of random errors in the observations etc.

Lesson Plan:

Unit No.	Learning Objective	Lecture No.	Topics to be covered
1.	**Fundamentals of Dynamics**	1	Introduction of Reference Frams
		2	Galilean transformations, Galilean invariance
		3	Review of Newton's Laws of Motion
		4	Momentum of variable mass system: motion of rocket
		5	Dynamics of a system of particles
		6	Principle of conservation of momentum. Impulse.
		7	Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D).
2.	**Work and Energy**	8	Work and Kinetic Energy Theorem.
		9	Conservative and non-conservative forces.
		10	Potential Energy. Energy diagram. Stable, unstable and neutral equilibrium.
		11	Force as gradient of potential energy. Work & Potential energy.
		12	Work done by non-conservative forces. Law of conservation of Energy.
3.	**Collisions**	13-14	Elastic (1-D and 2-D) and inelastic collisions. Centre of Mass and Laboratory frames.
		15-16	Centre of Mass and Laboratory frames.
4.	**Rotational Dynamics**	17-18	Angular momentum of a particle and system of particles.
		19	Torque. Principle of conservation of angular momentum.
		20-21	Rotation about a fixed axis. Moment of inertia, theorem of parallel and perpendicular axes.
		22-25	Determination of moment of inertia of discrete and continuous objects [1-D, 2-D & 3-D (rectangular, cylindrical, and spherical)].
		26	Kinetic energy of rotation. Motion involving both translation and rotation.
5.	**Gravitation and Central Force Motion**	27	Law of gravitation. Gravitational potential energy. Inertial and gravitational mass.
		28	Potential and field due to spherical shell and solid sphere.
6.	**Motion of a particle under a central force field**	29-30	Two-body problem, its reduction to one-body problem and its solution.
		31-32	Reduction of angular momentum, kinetic energy and total energy.
		33	The energy equation and energy diagram.

		34-35	Kepler's Laws. Satellite in circular orbit, Geosynchronous orbits
7.	**Oscillations**	36	Idea of SHM.
		37	Differential equation of SHM and its solution.
		38-39	Kinetic energy, potential energy, total energy and their time-average values.
		40	Compound pendulum. Damped oscillation.
		41-42	Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor
8.	**Non-Inertial Systems**	43-46	Non-inertial frames and fictitious forces.
		47	Uniformly rotating frame.
		48-49	Centrifugal force. Coriolis force and its applications
9.	**Special Theory of Relativity**	50	Outcomes of Michelson-Morley Experiment.
		51-52	Postulates of Special Theory of Relativity. Lorentz Transformations.
		53-54	Simultaneity, Length contraction, Time dilation.
		55-56	Relativistic transformation of velocity, acceleration, frequency and wave number.
		57	Mass of relativistic particle.
		58	Mass-less Particles. Mass-energy Equivalence.
		59-60	Relativistic Doppler effect (transverse and longitudinal).
		61-63	Relativistic Kinematics (decay problems, inelastic collisions and Compton effect).
		64-65	Transformation of Energy and Momentum.

Evaluation Scheme:

No.	Component	Duration	Marks
1.	Internal Assessment		25
	• Quiz		
	• Class Test		
	• Attendance		
	• Assignment		
2.	End Semester Examination	3 hr	75

Details of the Course		
Unit	**Contents**	**Contact Hours**
I	**Fundamentals of Dynamics:** Reference frames, Inertial frames, Galilean transformations, Galilean invariance, Review of Newton's Laws of Motion. Momentum of variable mass system:	5

	motion of rocket. Dynamics of a system of particles. Principle of conservation of momentum. Impulse. Determination of Centre of Mass of discrete and continuous objects having cylindrical and spherical symmetry (1-D, 2-D & 3-D). **Collisions:** Elastic (1-D and 2-D) and inelastic collisions. Centre of Mass and Laboratory frames.	
II	**Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable, unstable and neutral equilibrium. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy. **Collisions:** Elastic (1-D and 2-D) and inelastic collisions. Centre of Mass and Laboratory frames.	9
III	**Rotational Dynamics:** Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of inertia, theorem of parallel and perpendicular axes. Determination of moment of inertia of discrete and continuous objects [1-D, 2-D & 3-D (rectangular, cylindrical and spherical)]. Kinetic energy of rotation. Motion involving both translation and rotation.	10
IV	**Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. **Motion of a particle under a central force field:** Two-body problem, its reduction to one-body problem and its solution. Reduction of angular momentum, kinetic energy and total energy. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit, Geosynchronous orbits.	9
V	**Oscillations:** Idea of SHM. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Compound pendulum. Damped oscillation. Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor. **Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications**.**	12
VI	**Special Theory of Relativity:** Outcomes of Michelson-Morley Experiment. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity, Length contraction, Time dilation. Relativistic transformation of velocity, acceleration, frequency and wave number. Mass of relativistic particle. Mass-less Particles. Mass-energy Equivalence. Relativistic Doppler effect (transverse and longitudinal). Relativistic Kinematics	15

	(decay problems, inelastic collisions and Compton effect). Transformation of Energy and Momentum.	
	Total	**60**

Suggested Books:

Sl. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1.	An Introduction to Mechanics , Daniel Kleppner & Robert Kolenkow, 2014, Cambridge University Press.	2014
2.	2. Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education.	2017
3.	Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education.	1977
4.	Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.	2010
5.	Analytical Mechanics, G. R. Fowles and G. L. Cassiday, 2005, Cengage Learning.	2005

Mode of Evaluation:	Internal Assessment / End Semester Exam