MAJOR COURSE 1

PHY3CJ 201: Mechanics – I

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">MECHANICS -I</td></tr>
<tr><td>Type of Course</td><td colspan="5">Core in Major</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Academic Level</td><td colspan="5">200 - 299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>4</td><td>-</td><td>-</td><td>60</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">PHY1CJ101: Fundamentals of Physics</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course explores Newton’s Laws of Motion and how they can be applied to solve different mechanical systems.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concepts of linear and angular momentum, and dynamics of linear and rotational motion	U	C	Instructor-created exams / Quiz
CO2	Understand the concepts of the conservation laws of linear and angular momentum	U	C	Instructor-created exams / Quiz
CO3	Analyse collisions of particles using the conservation of linear momentum	An	P	Instructor-created exams / Home Assignments
CO4	Analyse rotating systems using the conservation of angular momentum	An	P	Instructor-created exams / Home Assignments
CO5	Demonstrate critical thinking and problem-solving skills by applying the concepts and techniques learned to solve an extended set of real-world problems.	Ap	P	Seminar Presentation / Group Tutorial Work
CO6	Demonstrate computational skills to solve an extended set of computational projects based on real-world problems	Ap	P	Seminar Presentation / Group Tutorial Work / Group Project
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F), Conceptual Knowledge (C), Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		**MOMENTUM, IMPULSE AND COLLISIONS**	**11**	**16**
	1	Momentum and Impulse	2	
	2	Conservation of Momentum	2	
	3	Momentum Conservation and Collisions	2	
	4	Elastic Collisions	2	
	5	Centre of Mass	1	
	6	Rocket Propulsion	2	
		Sections 8.1 – 8.6 of chapter 8 of Book 1		
II		**ROTATION OF RIGID BODIES**	**12**	**18**
	7	Angular Velocity and Acceleration	2	
	8	Rotation with Constant Angular Acceleration	2	
	9	Relating Linear and Angular Kinematics	2	
	10	Energy in Rotational Motion	2	

	11	Parallel-Axis Theorem	1	
	12	Moment of Inertia Calculations	3	
	Sections 9.1 – 9.6 of chapter 9 of Book 1			
III		**DYNAMICS OF ROTATIONAL MOTION**	**12**	**18**
	13	Torque	1	
	14	Torque and Angular Acceleration for a Rigid Body	2	
	15	Rigid Body Rotation about a Moving Axis	3	
	16	Work and Power in Rotational Motion	1	
	17	Angular Momentum	2	
	18	Conservation of Angular Momentum	2	
	19	Gyroscopes and Precession	1	
	Sections 10.1 – 10.7 of chapter 10 of Book 1			
IV		**THE GRAVITATIONAL FIELD**	**13**	**18**
	19	Newton’s Law of Universal Gravitation	2	
	20	The Gravitational Field and Field of an Extended Body	3	
	21	The Gravitational Potential	3	

	22	Field Lines and Equipotential Surfaces	1	
	23	The Newtonian Gravitational Field Equations	3	
	24	The Equations of Poisson and Laplace	1	
	Sections 9.1 – 9,7 of chapter 9 of Book 2			
V	**OPEN-ENDED MODULE: COMPUTATIONAL PROJECTS**		**12**	
	Manageable number of selected computational projects from the list given may be assigned and evaluated. Any other computational projects related to the content of the course may be chosen by the teacher.			
	1. Electrons are randomly distributed in a small region of space. (The dimension is not important, but you can assume a cube with side 10 angstroms.) Numerically determine the position of the center of mass, for 100, 1000, and 10000 electrons. (You should use a random number generator to obtain the coordinates of each of the electrons.)			
	2. A certain (imaginary) comet is in orbit about the Sun. It follows an elliptical path that is given by $r = 10/(1 + 0.8 \cos \theta)$, where *r* is measured in Astronomical Units (AU). Plot the orbit of the comet in polar coordinates.			
	3. A volcanic eruption throws a boulder vertically into the air with an initial speed of 50 m/s. (a) Write a computer program to plot the position and velocity of the boulder as a function of time, (b) Now assume the boulder is ejected at an angle of ten degrees to the vertical. Plot the two components of position and velocity as functions of time and also plot the trajectory of the boulder (on an *x, y* plot). Ignore the effect of air resistance.			
	4. A projectile is fired perpendicular to the Earth's surface with an initial velocity of 600 m/s. Assume a constant gravitational force acts on the projectile so its acceleration is 9.8 m/s^2 downwards. Write a program to determine the position of the particle as a function of time. Next, consider the same problem, but now include the effect of air resistance, assuming			

	it is a retarding force that can be expressed as = 2.5 x $10^{-4}v^2$, where v is the velocity of the projectile.			
	5. An asteroid of mass 5000 kg is at 40 AU from the Sun (beyond the orbit of Pluto) when it undergoes a collision with another asteroid, leaving it with zero velocity. The asteroid then slowly (at first) falls toward the Sun. Write a program to evaluate the velocity of the asteroid as it reaches the surface of the Sun. Use the Euler-Cromer algorithm. Check your result by comparing with the value obtained analytically. The purpose of this project is for you use variable time steps. Assume the radius of the Sun is 5.6 x 10^7 m. (1 AU = 1.5 x 10^{11} m).			
	6. A 5 MeV alpha particle is approaching a gold nucleus. The impact parameter is 1 A°. You may assume the gold nucleus is initially at rest. Plot the trajectory of the two particles and determine the angles at which both are scattered.			
	7. You are required to design a two-stage rocket that will accelerate a 5000 kg payload to Earth's escape velocity. Assume that 95 percent of the mass of the rockets is fuel. Assume the exhaust velocity of the rocket motors is 2000 m/s. Investigate the possible ranges of masses for the two stages and determine the configuration that will minimize the take-off weight. Determine why a single-stage rocket, burning the same amount of fuel, cannot accomplish the same objective.			
	8. Write a computer program to determine the position and velocity of a projectile fired vertically from the Earth's surface with an initial speed of 3000 m/s. Plot the position and velocity as a function of time. The Earth is assumed to be a sphere. You may neglect air resistance, the rotation of the Earth, and the effect of any other astronomical bodies, but note that the acceleration due to gravity varies with distance from the center of the Earth.			
	● Computational Projects 1.1 – 1.4, 2.1 – 2.6, 3.1 – 3.3, 5.1 – 5.2, 6.1 – 6.6, 7.1, 9.1 – 9.4			
	Sections from References: Computational Projects in chapters 1, 2, 3, 5, 6, 7, 9 of Book 2			

Books and References:

1. University Physics with Modern Physics (Edn.15) by Young & Freedman (Book 1)
2. Intermediate Dynamics (Edn.2) by Patrick Hamill (Book 2)
3. An Introduction to Mechanics by Daniel Kleppner and Robert J. Kolenkow
4. Mechanics by Keith R. Symon
5. Mechanics: Berkeley Physics Course, Volume 1 by Charles Kittel, Walter D. Knight and Malvin

   A. Ruderman
6. Mechanics: From Newton's Laws to Deterministic Chaos by Florian Scheck
7. NPTEL video lectures: https://nptel.ac.in/courses/115106090

Mapping of COs with PSOs and POs :

	PSO1	PSO 2	PSO 3	PS O4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	1	1	0	3	1	3	0	0	1	3	0	0
CO 2	3	1	1	0	3	1	3	0	0	1	3	0	0
CO 3	3	2	3	0	3	1	3	0	1	1	3	0	0
CO 4	3	2	3	0	3	1	3	0	1	1	3	0	0
CO 5	3	0	3	1	2	1	3	2	1	1	3	0	0
CO 6	3	3	1	2	2	2	3	0	1	2	3	0	0

MAJOR COURSE 2

PHY3CJ 202 : Computational Physics

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

<table>
<tr><td>Programme</td><td colspan="5">B.Sc. Physics Honours</td></tr>
<tr><td>Course Title</td><td colspan="5">COMPUTATIONAL PHYSICS</td></tr>
<tr><td>Type of Course</td><td colspan="5">Core in Major</td></tr>
<tr><td>Semester</td><td colspan="5">III</td></tr>
<tr><td>Academic Level</td><td colspan="5">200-299</td></tr>
<tr><td rowspan="2">Course Details</td><td>Credit</td><td>Lecture per week</td><td>Tutorial per week</td><td>Practical per week</td><td>Total Hours</td></tr>
<tr><td>4</td><td>3</td><td>-</td><td>2</td><td>75</td></tr>
<tr><td>Pre-requisites</td><td colspan="5">Basic computer knowledge.</td></tr>
<tr><td>Course Summary</td><td colspan="5">This course aims to equip students with computational and simulation methods in physics using Python programming. Numerical methods for differentiation, integration, solving differential equations, interpolation and curve fitting are introduced.</td></tr>
</table>

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand computational thinking by learning Logical and algorithmic thinking.	U	F	Instructor created exams.
CO2	Understand python syntax and write basic python programs using loops, several data types etc	U, Ap	F, P	Instructor created exams / Practical Assignment

CO3	Understand Numpy and matplotlib modules and apply them to matrix manipulation and graphing data.	U, Ap	P	Instructor-created exams / Practical Assignment
CO4	Understand the significance of computational methods in physics.	U	F	Instructor-created exams / Seminar Presentation
CO5	Understanding the concepts of interpolation, curve fitting, numerical differentiation, integration and ODEs in physics using python	U, Ap	P	Instructor-created exams / Practical Assignment
CO6	Applying the computational and simulation methods to several branches of physics using python.	Ap	P	Instructor-created exams / Practical Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**THE COMPUTATIONAL THINKING**	**6**	**10**
	1	Approach, Logical thinking, Algorithmic thinking	4	
	2	Writing algorithm - Sum of Two Numbers, Factorial Calculation, Bubble Sort, Fibonacci series up to a given term [More algorithms other than listed here can be given as assignments and can be asked for examination as application level questions].	2	
	Relevant Sections of Chapter 2 of Book 1			
II		**THE PROGRAMMING LANGUAGE : PYTHON**	**19**	**20**
	3	Print command, Data types in Python, Variables, Input statements, eval() and type casting, String operations.	1	
	4	Operators and Operator precedence, Expressions and Statements, Formatted printing,	2	
	5	List, Set, Tuple, Dictionary	2	
	6	Flow of Control : Sequential, Selective (simple if, if-else, nested	3	

		if, ladder if), Iterative (While, For), Continue, Break		
	7	File Input and Output, Pickling, User defined function. Built-in Functions.	2	
	8	Numpy : Arrays - creation, operations, eigenvalues solvers, dot, determinant, transpose, inverse, random number generation.	4	
	9	Matplotlib : Simple plot, Labelling axes, Title, Multiple plots, Subplots, Pie chart, Hist(), Polar plot, 3D plot - introduction	3	
	Relevant Sections of Book 2 and Book 3			
III	**COMPUTATIONAL TECHNIQUES FOR EXPERIMENTAL PHYSICS**		**10**	**20**
	10	Importance of Numerical Methods in experiments, Discretisation, Accuracy considerations.	1	
	11	Interpolation - Forward Difference Method - Newton's Formula for Interpolation.	2	
	12	Programs : Interpolation using experimental data*	1	
	13	Curve Fitting - Method of Least Squares : Linear, Linearization of Nonlinear Laws.	2	
	14	Programs : Curve fitting using experimental data*	1	
	15	Numerical Differentiation - 1st & 2nd order finite difference differentiation. Numerical Integration - Trapezoidal, Simpson's 1/3 Methods.	2	
	16	Root Finding Methods - Bisection, Newton-Raphson.	1	
	Sections : 3.1, 3.3.1, 3.6, 4.1, 4.2.1, 4.2.3, 6.2.3, 6.4.1, 6.4.2, 2.2, 2.5 of Book 4			
IV	**COMPUTATIONAL TECHNIQUES FOR THEORETICAL PHYSICS**		**10**	**20**
	17	Importance of Simulation in Physics. Solving First order ODE - Euler Method, Second Order Range-Kutta Method	2	
	18	Programs : Radioactive Decay*, Newton's Law of Cooling*	1	
	19	Solving 2nd Order ODE - Euler Method, Numerov's method	3	

	20	Programs : Configuration and Phase Space Plots of Simple and Damped Harmonic Oscillator*	2	
	21	Monte Carlo Method : Simple Integration - Hit or Miss Method, Mean-value Method (only)	1	
	22	Programs : Value of Pi*, Radioactive Decay*	1	
	Sections 8.4, 8.5 of Book 4 and 14.1, 14.2 of Book 5 [* Programs must be done using Python 3]			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7^{th} experiment may also be selected from the given list. Other experiments listed here may be used as demonstrations of the concepts taught in the course.			
	1	**Solution of equations by bisection and Newton-Raphson methods** ● Implement the bisection method in Python from scratch. ● Provide at least 4 functions with a specific mathematical equation and find the root using their implementation. ● Analyze and explain the conditions under which the bisection method converges and discuss any potential pitfalls. ● Similarly, implement the Newton-Raphson method in Python. ● Provide the same or different functions and find the root using their implementation. ● Compare the convergence speed of the Newton-Raphson method with the bisection method for different functions.		
	2	**Least square fitting – straight line fitting** ● Write a code that fits a straight line to the data given and calculates the slope and intercept. ● Plots the regression line along with the data points by giving, labels, title, legends and different colors ● A real-world scenario or dataset can be used to apply linear regression to solve a practical problem.		
	3	**Numerical Integration – Trapezoidal and Simpson's 1/3 rd rule** ● Implement the Trapezoidal and Simpson's 1/3 Rule in Python for a function given. ● A physics scenario can be provided, where quantities like displacement, work, or energy are needed to calculate		

		through integration. Use both methods to perform the integration and interpret the results. ● Visualize the integration process by plotting the function and the areas under the curve corresponding to the Trapezoidal and Simpson's 1/3 Rule.		
	4	**Simulation of projectile using Euler Method** ● Implement projectile motion simulation using the Euler method in Python. ● Simulate the trajectory/ Plot using matplotlib (y vs x, y vs t and x vs t) ● Compare with the theoretical values of range, maximum height and time of flight. ● Change initial conditions such that the projectile is now a freely falling body. Plot y vs t. ● Extend the simulation to include air resistance and compare the projectile motion with and without air resistance.		
	5	**Simulation of simple and damped pendulums using RK2 Method** ● Simulates the damped pendulum and stores phase space coordinates to arrays using second order Runge-Kutta method. ● Provide initial conditions and damping parameters for the damped pendulum scenario. ● Plot the motion of the pendulum and phase space trajectories. ● Change the Initial conditions and damping factor and analyse the results. Make sure turning the damping off reproduces the simple pendulum result.		
	6	**Numerical differentiation using difference table.** ● Implement numerical differentiation using a difference table in Python. ● Provide a function y = f(x) and a set of data points. Compute the numerical derivative at specific points using the forward difference method. ● Discuss the sensitivity of numerical differentiation to the choice of step size. ● Present physics problems like compute the velocity or acceleration of a particle based on position data.		
	7	**Monte- Carlo simulation of radioactive decay**		

		• Implement a simulation of radioactive decay in Python. • Provide initial conditions (number of particles, decay constant) and analyze the results, including plotting the decay curve over time. • Calculate the half-life of the radioactive substance based on the simulation results and check how it compares to the theoretically expected half-life. • Provide information about a specific radioactive isotope with a known half-life to simulate the decay of this isotope and compare the simulation results with the expected decay.		
	8	**Estimation of value of pi using Monte-Carlo Simulation** • Implement a Monte Carlo simulation to estimate the value of pi in Python. • Analyze how the estimated value of pi converges as the number of samples increases. • Create visualizations of the simulation results. Plot the points used in the simulation and visually demonstrate how the estimation of pi improves as more points are sampled.		
	9	**Solution system of linear equations and calculation of eigenvalues** • Solve a system of linear equations with three variables. • Diagonalize a 3x3 matrix and verify that by evaluating the eigenvalues. Also evaluate the eigenvectors for the matrix. • For better understanding, use Python (interactive mode) to verify that the eigenvector for an eigenvalue satisfies the eigenvalue equation: matrix times eigenvector equals eigenvalue times eigenvector.		
	10	**Least square fitting to an exponential function** • Take the data of transient effect in RC circuit (growth / decay) and write a code that fits an exponential function to the data and calculates the time constant. • ExpEYES may be used to record the data. • https://expeyes.in/experiments/electrical/rctransient.html • https://expeyes.in/experiments/electrical/rltransient.html		
	11	**Taylor series- evaluation of sine and cosine** • Evaluate sine and cosine of a given angle, using Taylor expansion about zero. • Print the difference with the built-in sine function. • Analyse how the error reduces with the number of terms. • Modify the program to calculate for higher angles to observe the effect of accuracy.		

Books and References:
1. Computational Thinking by Karl Beecher (Book 1)
2. A Student's Guide to Python for Physical Modeling by Jesse M. Kinder, Philip Nelson. Second Edition-Princeton University Press 2021 (Book 2)
3. Python for Education by Dr. B P Ajithkumar, IUAC, New Delhi; e-book freely downloadable from https://scischool.in/python/index.html (Book 3)
4. Introductory Methods of Numerical Analysis by S.S. Sastry, Fifth Edition (Book 4)
5. Basic Concepts in Computational Physics by Benjamin A. Stickler and Ewald Schachinger, Springer International Publishing Switzerland 2014 (Book 5)

Mapping of COs with PSOs and POs :

	PSO1	PSO 2	PSO 3	PSO 4	PSO5	PSO6	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	1	2	0	3	1	0	0	0	1	3	0
CO 2	0	3	2	0	0	3	0	3	0	0	0	3	0
CO 3	0	3	2	0	0	3	0	3	0	0	0	3	0
CO 4	0	2	3	0	0	3	0	3	0	0	0	3	0
CO 5	0	2	3	0	0	3	0	3	0	0	0	3	0
CO 6	0	3	3	0	0	3	0	2	1	2	3	0	0

Correlation Levels

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

Assessment Rubrics:

- Quiz / Discussion / Seminar
- Internal Theory / Practical Exam
- Assignments / Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory / Practical Exam	Assignment / Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

MINOR COURSE 2

PHY3MN 204: Atomic Structure and Spectroscopy

FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**ATOMIC STRUCTURE AND SPECTROSCOPY**				
Type of Course	**Minor (SET IV: OPTICAL PHYSICS)**				
Semester	**III**				
Academic Level	**200 – 299**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic concepts related to optics, electromagnetism, wave mechanics, and electronics.				
Course Summary	This course provides a foundational understanding of quantum phenomena and spectroscopic methods. Students will explore topics such as electromagnetic waves, black body radiation, photoelectric effect, X-ray production, diffraction, De Broglie waves, atomic structure, and spectroscopy.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Studying electromagnetic waves, black body radiation, photoelectric effect, X-ray production, diffraction, and De Broglie waves.	U	C	Instructor-created exams / Quiz
CO2	Understands the dual nature of light and matter, leading to insights into quantum phenomena like particle confinement and uncertainty	Ap	P	Practical Assignment / Observation of Practical Skills

	principles in position, momentum, energy, and time.			
CO3	Understanding the nuclear atom model, electron orbits, and atomic spectra, including the Bohr atom's energy levels and line spectra,	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Elucidates the fundamental structure and behavior of atoms, offering insights into their spectral characteristics and origins.	U	C	Instructor-created exams / Home Assignments
CO5	Exploring spectroscopy introduces the electromagnetic spectrum's quantized energy, various molecular energies, and spectroscopic techniques, addressing spectral line width, absorption emission phenomena, EinstAssignmentein coefficients, and laser principles.	U	C, P	Practical skills/ Assignments
CO6	Important spectroscopic techniques used for sample analysis, like microwave spectroscopy, Infrared Spectroscopy, Electronic spectroscopy and Raman spectroscopy are introduced	U	C, P	Assignments/ Internal Exams

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		**Particle properties of waves & Wave properties of particles**	**17**	**28**
	1	Electromagnetic Waves, Black body Radiation	3	
	2	Photoelectric Effect and Nature of light	2	
	3	X- ray production and diffraction	2	
	4	Pair Production	2	
	5	De Broglie waves and wave function, Wave formula, concept of phase velocity and group velocity (derivation not required)	3	
	6	Particle Diffraction	1	

	7	Particle in a box	2	
	8	Uncertainty principle: position – momentum, Energy-time (concept alone)	2	
	Sections : 2.1-2.6, 2.8, 3.1-3.6, 3.8, 3.9, Book 1			
II	**Atomic Structure**		**10**	**15**
	9	Nuclear atom	2	
	10	Electron orbits	2	
	11	Atomic spectra	2	
	12	Bohr atom	2	
	13	Energy levels and spectra	2	
	Sections: 4.1- 4.5, Book 1			
III	**Introduction to Spectroscopy**		**10**	**15**
	14	Electromagnetic spectrum and Quantization of energy	1	
	15	Types of molecular energies and spectroscopic methods	3	
	16	Spectral line width	2	
	17	Absorption and emission of radiation, Einstein coefficient (excluding derivation)	2	
	18	Lasers	2	
	Sections 1.1 - 1.7, Book 2			
IV	**Spectroscopic Methods of sample analysis**		**8**	**12**
	19	Microwave spectroscopy	2	
	20	Infrared Spectroscopy (vibration spectra only)	2	
	21	Electronic spectroscopy	2	
	22	Raman spectroscopy: Introduction, Quantum theory of Raman scattering, Rotational Raman spectra of linear molecules	2	
	Sections 8.6 - 8.8, Book 1, Sections 8.1, 8.2.2 and 8.3.1, Book 2			
V	**PRACTICALS**		**30**	
	Conduct any 6 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 7th experiment may also be selected from the given list. Other experiments			

	listed here may be used as demonstrations of the concepts taught in the course. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Determination of Plank's constant using LEDs** ● Observe the turn-on voltage, V_0 of LEDs and calculate the value of h. Use at least 4 different colors of LED (with transparent casing) ● Plot $\frac{1}{\lambda} - V_0$ graph using Python, fit a straight line to get the slope and estimate the value of h. ● Calculate the %error. ● Programmable voltage source of ExpEYES may be used to find the turn-on voltage.		
	2	**Continuous and line spectra- Determination of the wavelengths and photon energy.** ● Familiarize the initial adjustments and measurements in the spectrometer. ● Mount the grating at normal incidence on the spectrometer. ● Determine the wavelengths of the sodium vapor lamp and calculate the associated photon energy. ● Determine the approximate range of the wavelengths of the continuous spectrum of incandescent/white LED lamp or any one coloured LED and calculate the associated photon energy. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating can be given.		
	3	**Mercury spectrum- Determination of wavelength and photon energy.** ● Determine wavelength of any four prominent lines and associated photon energy of the mercury spectrum using a spectrometer with grating at normal incidence. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	4	**Hydrogen spectrum - Determination of wavelengths and calculation of the Rydberg's constant.** ● Determine the wavelengths and photon energy in eV of the prominent lines of the Balmer series of the Hydrogen		

		spectrum using a spectrometer with grating at normal incidence. ● Calculate the Rydberg's constant and estimate the % error. ● The readings of the first order spectrum will be enough. Number of lines/m of the grating may be given.		
	5	**Wave Packets - Analysis of beats in sound.** ● The experiment is intended to understand the concept of wave packet, phase and group velocities. ● Generate sounds waves of two near frequencies using smartphone/ExpEYES/Function generator and the superimposed wave can be recorded and analysed using smartphone/ExpEYES/CRO ● Change the separation between the frequencies and compare the results with the theoretical values. ● https://expeyes.in/experiments/sound/beats.html ● Multi Tone generator and Audio scope tools of Phyphox may be used https://phyphox.org/experiment/tone-generator/		
	6	**Analysis of Hydrogen spectra using the Tracker Video Analysis tool**. ● Calibrate the video of the Hydrogen spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot the intensity profile, find the prominent wavelengths of the Balmer series and calculate the Rydberg's constant. ● Estimate the %error. ● Pre recorded video of the Hydrogen spectra can be used. ● https://physlets.org/tracker/. ● https://www.youtube.com/watch?v=UCCPkJpUQEw		
	7	**Black body spectrum of Sun -Estimation of surface temperature using the Tracker Video Analysis tool.** ● Calibrate the video of the solar spectra in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity, get λ_{max} and using Wein's law calculate the surface temperature. ● Pre recorded video of the solar spectra can be used.		

	8	**Verification of Wein's displacement law and Stefan's law using incandescent bulb.** ● Calibrate the video of the spectra of the incandescent bulb in the Tracker tool using two laser wavelengths/lines of mercury spectra. ● Plot wavelength vs intensity and note λ_{max} . ● Repeat the experiment by increasing the operating voltage of the incandescent bulb(hence increasing the temperature of the source) ● From the plots, verify the Wein's displacement law and Stefan's law.		
	9	**Study the characteristics of Zener diode and construct a voltage regulator.** ● Study the V-I characteristics of zener diode and hence determine the breakdown voltage. ● https://expeyes.in/experiments/electronics/zenerIV.html ● Construct a voltage regulator using a zener diode and determine the percentage of voltage regulation.		
	10	**Construction of the center tapped full wave rectifiers and regulated power supply.** ● Construct a center tapped full wave rectifier without filter and with a filter. ● Connections may be realized through soldering, to get an experience of soldering. ● Measure the AC and DC voltages using a multimeter and calculate the ripple factor without and with a filter. ● Observe the variation of the ripple factor with load resistance, when filter is used. ● Construct 5V/12V regulated power supply using 78XX IC.		
	11	**Study the characteristics of LDR.** ● Measure the dark resistance of LDR ● Place LDR at different distances from an electric lamp and measure its resistance. Plot light intensity($E \alpha \frac{1}{r^2}$) vs LDR resistance. ● Optional: Construct a dark sensor using LDR and transistor. In order to turn on the LED in the desired light intensity, an adjustable resistor can be used in the circuit.		

	12	**Surface tension of liquid - Capillary rise method** ● Clamp a clean capillary tube by dipping its lower end into the liquid in the beaker. ● Measure the rise of water in the tube using a traveling microscope. ● Also measure the radius of the capillary tube using the traveling microscope and estimate the surface tension of the liquid. ● Density of the liquid can be determined using Hare's apparatus of can be given		
	13	**Static torsion Rigidity modulus** ● Using Searle's static torsion apparatus, determine the rigidity modulus of the material of the rod.		
	14	**Viscosity of a liquid - Falling Ball Viscometer** ● Drop a polished steel ball into a glass tube of a somewhat larger diameter containing the liquid. ● Record the time required for the ball to fall at constant velocity through a specified distance between reference marks. ● Use the Stoke's law for the sphere falling in a fluid under effect of gravity, to estimate the viscosity of the liquid.		
	15	**Viscosity of a liquid - Poiseuille's Method** ● Fill the liquid in a vertically fixed burette with its lower end attached to a capillary tube, placed in horizontal position using a rubber tube. ● Note the time taken to reach each 10cc of water and the height of the corresponding marking. ● Also measure the radius of the capillary tube using the traveling microscope and estimate the viscosity of the liquid.		

Books and references:

1. Concepts of Modern Physics, Arthur Beiser 6th Edition (Book 1)
2. Molecular structure and spectroscopy, (Second edition) by G. Aruldhas (Book 2)
3. University Physics with Modern Physics (Edn.15) by Young & Freedman (Book 3)
4. Fundamentals of - Molecular Spectroscopy - THIRD EDITION, by C N Banwell (Book 4)

Mapping of COs with PSOs and POs :

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	2	1	0	0	1	1	2	1	1	1	1	1	1
CO 2	2	2	1	0	1	1	2	1	1	1	1	1	1
CO 3	2	1	1	0	2	1	2	1	1	1	1	1	1
CO 4	2	0	1	0	2	1	2	1	1	1	1	1	1
CO 5	2	1	1	0	3	1	2	1	1	2	1	1	1
CO 6	2	2	1	0	3	1	2	1	1	2	1	1	1

Correlation Levels:

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

Assessment Rubrics:

- Quiz / Discussion / Seminar
- InternalTheory/Practical Exam
- Assignments /Viva
- End Semester Exam (70%)

Mapping of COs to Assessment Rubrics

	Internal Theory /Practical Exam	Assignment /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	