Programme	**B.Sc. Physics Honours**				
Course Title	**ATOMIC STRUCTURE AND SPECTROSCOPY**				
Type of Course	**Minor (GROUP 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		✓	✓	