FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

BSc APPLIED PHYSICS HONOURS

Programme	**B.Sc. Applied Physics Honours**				
Course Title	**SOLID STATE PHYSICS AND SPECTROSCOPY**				
Type of Course	**Minor (SET II: MATERIALS 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 knowledge calculus, atomic theory and electromagnetic spectrum				
Course Summary	This course discusses the concepts of quantum mechanics, band theory and different types of spectroscopy at a fundamental level.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define quantum mechanics and its fundamental principles, explain the concept of quantization, understand the mathematical representation of wave functions and their interpretation. Application of Schrodinger equation for solving different physical systems.	U & Ap	P	Instructor-created exams / Quiz/Assignments

CO2	Understanding of Crystalline and Amorphous Solids and distinguishing between them. Understand the relationship between bonding and properties in different types of crystals	U	C	Instructor created Assignment / Exams/Seminars
CO3	Explain band theory of solids and apply it in explaining the electronic structure of materials. Describe the formation of energy bands and band gaps in solids and their influence on material properties.	Ap	P	Seminar/Presentation / Group Tutorial Work
CO4	Explain the concept of quantization of energy and its importance in spectroscopy. Identify the types of molecular energies. Describe the process of absorption and emission of radiation and understand the Einstein coefficients governing these processes and their relation.	U	C	Instructor-created exams / Home Assignments
CO5	Classify various spectroscopic methods used for sample analysis, like microwave spectroscopy, Infrared Spectroscopy, Electronic spectroscopy, Raman spectroscopy and analyse the possibility of applying these techniques to identify material properties.	An	P	One Minute Reflection Writing assignments and exams
CO6	Develop practical skills to perform spectra and material property related experiments and analyse characteristics of different spectras.	E & C	M	Practical Assignment / Observation of Practical Skills / Viva Voce
* - 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	**Quantum Mechanics**		**16**	**22**
	1	Quantum Mechanics	2	
	2	The Wave Equation	2	
	3	Schrodinger's equation : Time Dependent form	2	
	4	Expectation Values	3	
	5	Operators	2	
	6	Schrodinger's Equation : Steady state form	3	
	7	Particle in a box problem	2	
	Sections 5.1, 5.2, 5.3, 5.5, 5.6, 5.7, 5.8 of chapter 5 of Book 1			
II	**Bonding in Solids and Energy Bands**		**11**	**18**
	8	Crystalline and amorphous solids	2	
	9	Ionic Crystal	2	
	10	Covalent Crystal	1	
	11	Van der Waal's bond	2	
	12	Metallic bond	2	
	13	Band Theory of Solids	2	
	Sections 10.1, 10.2, 10.3, 10.4, 10.5, 10.6 of Book 1			
III	**Introduction to Spectroscopy**		**10**	**16**
	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 of chapter 1 of Book 2 (Chapter 1 complete)			
IV	**Spectroscopic Methods of sample analysis**		**8**	**14**
	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, 8.7, 8.8 of chapter 8 of Book1, sections 8.1, 8.2.2 and 8.3.1 of chapter 8 of 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. Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Band gap of a semiconductor** ● Measure the reverse bias current/resistance of a semiconductor diode as a function of temperature, using Carey Foster's bridge or Potentiometer or ExpEYES or any other suitable method. ● Plot the logarithm of resistance/current against the inverse of temperature. ● From the slope, the band gap from the semiconductor can be obtained.		
	2	**Wavelength of laser using grating** ● The laser light diffracted from the transmission grating is allowed to fall on a screen and record the maxima points in a paper and calculate the wavelength of the laser. ● Determine the number of lines/ meter of the grating using the green line of the mercury.		
	3	**Single slit diffraction using laser - Determination of slit width.** ● The laser light diffracted from the narrow slit is allowed to fall on a screen and record the maxima or minima points in a paper.		

		• From the width of the central maxima or the position of minimum intensity points, calculate the slit width. • Verify the slit width using a traveling microscope. • Wavelength of laser can be found using diffraction grating of known N.		
	4	**Determine the numerical aperture (NA) of an optical fiber using a laser** • Couple the light from the laser source onto one of the fiber ends and the light coming from the other end is allowed to fall on a screen(sheet having circular markings) placed perpendicular to the axis of the fiber. • Measure the diameter of the laser beam on the screen and the distance between the screen and fiber output end and hence calculate the NA.		
	5	**Determination of the dispersive power of a solid prism using a spectrometer** • Find the angle of the prism and the angle of minimum deviation for prominent lines of the mercury spectrum using a spectrometer. • Calculate the refractive indices corresponding to the colors and find the dispersive power of the material of the prism for two pairs of wavelengths.		
	6	**Spectrometer-Determination of the Cauchy's constants of the given prism** • Find the angle of the prism, the minimum deviation angles of the prominent lines of the mercury spectrum and hence calculate the refractive indices for the colors. • Determine A and B from the $\mu - \frac{1}{\lambda^2}$ graph.		
	7	**Determine the refractive index of (a) given liquid and (b)the material of a lens, by forming a liquid lens.**		

		• Through this experiment the students are expected to get the concepts of image formation, combination of lenses and radius of curvature of the surface of lens. • Determine the radius of curvature of the lens by Boy's method and hence calculate the refractive indices.		
	8	**Determine the focal length of the combination of two lenses separated by a distance.** • Determine the focal lengths, f1 and f2 of the two lenses using an illuminated cross-slit screen holder, nodal slide(for placing the lenses) and plane mirror arrangement. • Place the two lenses separated by a distance d, determine the focal length, F of the combination and verify the relation • $\frac{1}{F} = \frac{1}{f1} + \frac{1}{f2} - \frac{d}{f1f2}$. • The combination of the lenses in the eyepiece of the spectrometer/ travelling microscope may be used for the study. • https://www.youtube.com/watch?v=IOlEEtyNPBg • https://www.youtube.com/watch?v=tNo4Ipk74SU		
	9	**Air wedge-determination of the radius of a thin wire/human hair/thin foil.** • Form interference fringes using sodium-source, in the air-film in between wedge formed by placing the given sample between the glass plates. • Measure the positions of the successive dark bands using a travelling microscope and determine the angle of the wedge and thickness of the sample given.		
	10	**Newton's rings-determination of the wavelength of sodium light** • Form of Newton's rings in the air-film in between a plano-convex lens and a glass plate using sodium-source. • Determine the radius of curvature by Boy's method and determine the wavelength of the source.		

	11	**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. ● 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.		
	12	**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.		
	13	**Flywheel- Determination of the Moment of Inertia** ● This experiment aims to help students grasp the concept of energy conservation and the dynamics of rotation. ● Do at least 9 trials for different masses and number of turns wound on the axil.		
	14	**Compound Pendulum- Acceleration Due to Gravity and Moment of Inertia and Verification of Parallel Axis Theorem** ● Plot a graph of distance of knife edge from one end Vs period of oscillations. Using the measurement from the graph, calculate g. ● Calculate the radius of gyration and hence the moment of inertia about CM. Compare the result obtained by the direct calculation $I_{CM} = \frac{ML^2}{12}$		
	15	**Sonometer - Determine the Frequency of AC** ● Estimate the linear mass density of the wire.		

		• Draw $L^2 - m$ graph and from the slope calculate the frequency.		

Books and References:

1.Concepts of Modern Physics, Arthur Beiser 6th Edition (Book 1)

2. Molecular structure and spectroscopy, (Second edition) G. Aruldhas (Book 2)

3.Kittel's Introduction to Solid State Physics, Wiley India Edition

4.Solid State Physics Structure and properties of materials by M.A.Wahab (Third Edition)

5.Solid State Physics" by Neil W. Ashcroft and N. David Mermin.

6.Solid State Physics: Essential Concepts by David W. Snoke.

7.Principles of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash

8. Spectra of Atoms and Molecules by Peter F. Bernath

9.Molecular Spectroscopy by Jeanne L. McHale

10. https://phyphox.org/

11 https://physlets.org/tracker/

12. https://expeyes.in/

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7
CO 1	3	2	2	1	2	2	3	2	2	2	3	3	0
CO 2	1	3	2	2	2	1	2	3	2	1	3	2	0
CO 3	1	2	3	2	2	2	2	2	3	1	3	3	0
CO 4	2	1	2	2	2	1	2	2	2	1	3	2	0
CO 5	2	1	3	2	3	1	2	1	2	2	3	3	0
CO 6	2	3	1	2	3	3	2	2	2	1	3	3	0

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		✓	✓	