CALICUT UNIVERSITY – FOUR-YEAR UNDER GRADUATE PROGRAMME (CU-FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**PROPERTIES OF MATTER & THERMODYNAMICS**				
Type of Course	**Minor (SET II: MATERIALS PHYSICS)**				
Semester	**I**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Awareness of Newton's first law, Hooke's law and static friction				
Course Summary	understanding of fundamental concepts of Equilibrium and Elasticity and their applications				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concept of the center of gravity and its significance in determining stability. Solve problems involving the equilibrium of rigid bodies subjected to various forces and torques. Apply principles of equilibrium to analyze real world scenarios. Get the concept of elastic moduli and their significance in characterizing material properties.	U	C	Instructor-created exams / Quiz
CO2	Understand density and pressure in a fluid and their effects in fluid behaviour. Explain the principle of buoyancy and its application in determining the behavior of floating and submerged objects.	Ap	P	Practical Assignment / Observation of Practical Skills

	Understand Bernoulli's principle and its significance in describing the behaviour of fluids in motion. Analyse viscosity and turbulence.			
CO3	Get the concepts of temperature and thermal equilibrium. Demonstrate a clear understanding of the first law of thermodynamics, including the principles of conservation of energy and the relationships between heat, work, and internal energy. analyze various thermodynamic processes, including the work done during volume changes and the paths between thermodynamic states.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Calculate and interpret the internal energy of ideal gases, understanding the heat capacities and behavior of ideal gases under different conditions, including adiabatic processes.	U	C	Instructor-created exams / Home Assignments
CO5	Grasp the significance of the second law of thermodynamics in determining the direction of thermodynamic processes. Analyze heat engines and refrigerators, applying the principles of the second law to evaluate their efficiency.	Ap	P	One Minute Reflection Writing assignments
CO6	understand fundamental concepts in thermodynamics and apply them in practical situations.	Ap	P	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	**Equilibrium and Elasticity**		**10**	**15**
	1	Conditions of Equilibrium, Center of Gravity	2	
	2	Solving Rigid body Equilibrium Problems	3	
	3	Stress, Strain and Elastic moduli	4	
	4	Elasticity and Plasticity	1	

	Sections from References: 11.1, 11.2, 11.3, 11.4, 11.5, Book 1			
II	**Fluid Mechanics**		**10**	**15**
	5	Gases, liquids and Density, Pressure in a Fluid	2	
	6	Buoyancy, Fluid flow	3	
	7	Bernoulli's Equation	3	
	8	Viscosity and Turbulence	2	
	Sections from References:12.1, 12.2, 12.3, 12.4, 12.5, 12.6, Book 1			
III	**Temperature, Heat and First Law of Thermodynamics**		**15**	**25**
	9	Temperature and Thermal Equilibrium	1	
	10	Thermodynamic systems	1	
	11	Work done during volume changes	2	
	12	Paths between Thermodynamic states	1	
	13	Internal Energy and First law of Thermodynamics	2	
	14	Kinds of Thermodynamic processes	2	
	15	Internal Energy of an ideal gas,	2	
	16	Heat capacities of an ideal gas	1	
	17	Adiabatic process for an ideal gas	3	
	Sections from References:17.1, 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.8, Book 1			
IV	**The Second law of thermodynamics**		**10**	**15**
	18	Directions of thermodynamic processes	1	
	19	Heat Engines, Refrigerators	2	
	20	Second law of thermodynamics	2	
	21	The Carnot Cycle	3	
	22	Entropy	2	
	Sections from References:20.1, 20.2, 20.4, 20.5, 20.6, 20.7, Book 1			
V	**PRACTICALS**		**30**	

	Conduct any 5 experiments from the given list and 1 additional experiment, decided by the teacher-in-charge, related to the content of the course. The 6th experiment may also be selected from the given list. ● Necessary theory of experiments can be given as Assignment/ Seminar.			
	1	**Young's Modulus of the Material of a Given Bar: Uniform Bending** ● Use optic lever and telescope. Take measurements for minimum two lengths. Obtain the elevation (e) from the shift (s) in the telescope reading and calculate Y from it. ● For each length of the bar, plot the load-elevation graph (using GeoGebra) and obtain m/e, and then calculate Y from it. ● Estimate the random error in the measurements and the error of the result using propagation of error formulae.		
	2	**Young's Modulus of the Material of a Given Bar: Nonuniform Bending** ● Use pin and microscope. Take measurements for minimum two lengths. Obtain the depression (e) from the shift in the microscope reading and calculate Y from it. ● For each length of the bar, plot the load-depression graph (using GeoGebra) and obtain m/e, and then calculate Y from it. ● Estimate the random error in the measurements and the error of the result using propagation of error formulae.		
	3	**Torsion Pendulum- Determination of the Moment of Inertia and Rigidity Modulus.** ● Using identical masses on the disc, determine the moment of inertia of the disc. ● Verify the moment of inertia by direct method, $I = \frac{1}{2}MR^2$ ● Using I, calculate rigidity modulus of the material of the wire, $n = \frac{8\pi I}{r^4}\frac{L}{T^2}$		
	4	**Static torsion - Rigidity modulus** ● Using Searle's static torsion apparatus, determine the rigidity modulus of the material of the rod.		
	5	**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.		
	6	**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.		
	7	**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		
	8	**Density of the liquid using manometer** ● Fill a manometer tube partially with water. Pour the given oil (or any liquid which does not mix with water) into the left arm of the tube until the oil–water interface is at the midpoint. Both arms of the tube are open to the air. ● Measure the heights of the oil and water using a traveling microscope and hence estimate the density of the oil assuming that of water. ● Example 12.4 of book 1		
	9	**Verification of Boyle's law and Charle's law** ● Boyle's law (PV= a constant) states that at a constant temperature, volume of a gas is inversely proportional to pressure. ● Determine the volume - pressure relation at constant temperature using the water column. ● Plot the pressure versus volume graph and verify Boyle's law. ● Verify the law at minimum two different temperatures. ● Charle's law (V/T = a constant) states that at constant pressure, volume is directly proportional to temperature. ● In this experiment determine the temperature - volume relation at constant pressure using the water column. ● Plot the temperature versus volume graph and verify the Charle's law.		

		• Verify the law at minimum two different pressures.		
	10	**Verification of Gay-Lussac's law** • Gay-Lussac's law (P/T = a constant) states that at constant volume, pressure is directly proportional to temperature. • In this experiment determine the temperature - pressure relation at constant pressure using metallic bulb and water column or pressure gauge or using Jolly's bulb apparatus. • Plot the temperature versus volume graph and verify the Charle's law.		
	11	**Thermal conductivity by Searle's method** • Determine the thermal conductivity of copper or any other metal using Searle's method / apparatus.		
	12	**Temperature coefficient of resistance of a metal** • Resistance of metals increases with increase in temperature. • Measure the resistance of the metal coil, using Carey Foster's bridge or Potentiometer or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature. • Plot graph and find the temperature coefficient of resistance.		
	13	**Thermo emf of a Thermocouple** • Study the variation of thermo emf of a thermocouple as a function of temperature of the hot junction while maintaining the cold junction at 0 degree Celsius.		
	14	**Newton's law of cooling** • According to Newton's law of cooling, the rate of heat loss of a hot body is proportional to the difference in temperature between the body and the surroundings. • The calorimeter is filled with hot water and the variation in temperature is noted as a function of time. • Cooling rate graph is plotted and law is verified. • Emissivity of the surface of the calorimeter can also be determined. • ExpEYES with PT1000 sensor may be used to record the temperature. https://expeyes.in/experiments/thermal/cooling.html		
	15	**Characteristics of NTC thermistor**		

		• Resistance of Negative Temperature Coefficient (NTC) thermistors decreases with increase in temperature. • Measure the resistance of the thermistor, using Carey Foster's bridge or Potentiometer or ExpEYES or any other suitable method, as a function of temperature from 100 degree Celsius to room temperature. • Plot the graph and study the characteristics.		
	16	**Melting point of wax** • Fill a test tube with wax until half and use a thermometer inside the wax / test tube to measure wax temperature. Avoid the thermometer touching the test tube. • Immerse the test tube in a water bath with the help of a stand, in such a way that the wax is below the water level. • Use a suitable flame / heating rate and measure the wax temperature as a function of time at a suitable time interval. • Plot temperature versus time graph. ExpEYES and PT1000 sensor may be used to record the temperature. https://expeyes.in/experiments/thermal/cooling.html • The temperature increases initially and remains constant until the wax melts completely. The flat temperature gives the melting point of wax (The melting point depends on the type of wax used)		

Books and References:

1.University Physics with Modern Physics- Hugh D. Young, Roger A. Freedman,15th Edition (Book 1)

2.Intermediate Dynamics (Edn.2) by Patrick Hamill

3.An Introduction to Mechanics" by Daniel Kleppner and Robert J. Kolenkow

4.Mechanics" by Keith R. Symon

5.Concepts in Thermal Physics by Stephen J Blundell and Katherine M. Blundell

6.Thermal Physics by Charles Kittel and Herbert Kroemer

7.An Introduction to Thermal Physics by Daniel V. Schroeder

8.Heat and Thermodynamics by Mark Zemansky, Richard Dittman.

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PS O5	PSO 6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO 1	3	2	2	3	2	2	3	2	2	1	2	2	0
CO 2	1	3	2	1	2	1	2	3	2	1	2	2	0
CO 3	1	1	3	3	3	1	2	2	3	2	3	2	0
CO 4	3	1	2	1	1	2	3	2	2	2	2	2	0
CO 5	1	2	1	1	2	2	2	1	2	2	3	2	0
CO 6	2	2	1	1	1	3	2	2	2	2	2	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	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	

CALICUT UNIVERSITY – FOUR-YEAR UNDER GRADUATE PROGRAMME (CU-FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. Physics Honours**				
Course Title	**MODERN PHYSICS AND NUCLEAR PHYSICS**				
Type of Course	**Minor (SET II: MATERIALS PHYSICS)**				
Semester	**II**				
Academic Level	**100 - 199**				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1.Foundational understanding of classical physics, particularly in mechanics and electromagnetism. 2. Proficiency in algebra, calculus and trigonometry.				
Course Summary	This course explores the dual nature of particles and waves, as well as the structure and behavior of atomic and nuclear systems. Through theoretical discussions and practical applications, students will investigate electromagnetic waves, particle-wave duality phenomena, atomic structure, nuclear composition, and nuclear transformations.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the duality of particles and waves, Describe experimental evidence supporting the wave-particle duality, including the photoelectric effect and Compton effect.	U	C	Instructor-created exams / Quiz
CO2	Define pair production and its significance in quantum	U, Ap	P	Seminar Presentation /

	mechanics, Understand the concept of matter waves proposed by Louis de Broglie.			Group Tutorial Work
CO3	Explain the structure of the atom according to the nuclear model, Understand Energy Levels and Spectra	Ap	P	Practical Assignment / Observation of Practical Skills
CO4	Investigate Nuclear Structure Understand stable nuclei, binding energy, and models such as the liquid drop model and shell model	U	C	Instructor-created exams / Home Assignments
CO5	Understand radioactive decay processes and their implications for nuclear stability,	Ap	P	One Minute Reflection Writing assignments
CO6	Analyse nuclear reactions, including fission and fusion, and their relevance in energy production and stellar evolution.	Ap	P	Writing assignments /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		**Particle properties of waves & Wave properties of particles**	**12**	**15**
	1	Electromagnetic Waves, Black body Radiation	3	
	2	Photoelectric Effect	2	
	3	Compton Effect	2	
	4	Pair Production	3	
	5.	De Broglie Waves	2	
	Sections from References: 2.1, 2.2, 2.3, 2.7,2.8, 3.1, Book 1			
II		**Atomic Structure**	**10**	**22**
	6	The Nuclear Atom	2	
	7	Electron Orbits	2	

	8	Atomic Spectra	2	
	9	The Bohr Atom	2	
	10	Energy Levels and Spectra	2	
	Sections from References:4.1, 4.2, 4.3, 4.4, 4.5, Book 1			
III	**Nuclear Structure**		**13**	**20**
	11	Nuclear composition	2	
	12	Nuclear properties	2	
	13	Stable nuclei	2	
	14	Binding energy	2	
	15	Liquid drop model, Shell model	2	
	16	Magic numbers	1	
	17	Meson theory of nuclear forces.	2	
	Sections from References:11.1, 11.2, 11.3, 11.4, 11.5, 11.6, 11.7, Book 1			
IV	**Nuclear Transformations**		**10**	**13**
	18	Radioactive decay, radioactivity and the Earth	1	
	19	Half-life, Radiometric dating	2	
	20	Alpha decay, Beta decay, Gamma decay	3	
	21	Nuclear reactions, Nuclear fission	3	
	22	Nuclear fusion in stars	1	
	Sections from References: 12.1, 12.2, 12.4 (Tunnel theory concept only), 12.5, 12.6, 12.8, 12.9, 12.10, 12.11, Book 1			
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	**7. 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 specific rotation of the sugar solution using a polarimeter.** • Determine the specific rotation corresponding to different concentrations of the sugar dissolved in water. • Draw a graph between rotation and concentrations and verify the linear relationship.		
	10	**Verification of Malus's law using polarizer, analyzer and photo detector** • Unpolarized light is allowed to pass through a polarizer and is observed through an analyzer. • Vary the angle between the axes of polarizer and analyzer and measure the intensity of the light (current output of the photodetector). • Plot $\theta - I$ and $cos^2\theta - I$ graphs and verify the Malus's law.		

		• A flat computer monitor (or LCD TV screen) in plain white color can be used as the source of linear polarized light. • The ambient light sensor of the smartphone and the orientation sensor of the smartphone can be used to measure the illuminance and the angles respectively. • A small piece of polarizer (a square of about 1 cm side) from an old calculator's display was placed over the ambient light sensor as analyser. • https://arxiv.org/pdf/1607.02659		
	11	**Brewster's law experiment, determination of angle of polarisation and refractive index.** • Experimental arrangement- Sodium vapour lamp, Spectrometer, Polarizer (Graduated on 360° rotating) coupled in front of the spectrometer telescope, prism or glass plate. • Get the angle of incidence corresponding to the minimum intensity of light and hence calculate the refractive index of the material. • https://www.youtube.com/watch?v=f2A8sM1xhbQ		
	12	**Mapping of the magnetic field lines of a bar magnet.** • Fix a paper on a drawing board kept on a table and place the bar magnet at the center along the magnetic meridian. • Using a small compass needle, map the magnetic field lines of the magnet placed with north pole pointing south • Mark the null points (where the horizontal component of Earth's magnetic field, Bh cancels the field due to magnet) along the axial/equatorial line and measure the distance, 2d, between them. • Calculate the moment of the magnet. $m = \frac{4\pi}{\mu_0}\frac{(d^2-l^2)^2}{2d}B_h$		
	13	**Circular coil- Verification of Biot Savart's law and determination of Bh.** • Move a compass through a platform along the axis of the coil carrying a study current. Note the deflection of the needle and plot magnetic flux density ($B = B_h tan\theta$) as a function of distance. • Optional: Smartphone magnetometer may be used to measure the strength of the magnetic field along the axial line and plot the data. https://phyphox.org/experiment/magnetic-field/ • Experiment 62 of Book 2 • By varying current and (or) distance of the compass box along the axial line of the coil, note the deflection and hence determine the value of Bh.		
	14	**Calibrate the ammeter using potentiometer** • Standardize the potentiometer using a Danial cell or any other standard voltage source.		

		• Determine the current for at least 8 trials and draw the calibration graph.		
	15	**Parallel plate capacitor. (a) verify the relationship between capacitance and the area of the plates (b) determination of dielectric constant of thin dielectric sheet.** • Form a parallel plate capacitor with dielectric material filled between the plates. • Multimeter/ ExpEYES can be used to measure the capacitance. (For a significantly measurable value of the capacitance, use plates of dimension 10cmx10cm, or greater) • Change the area of the capacitor plates and verify the relationship of the capacitance on the area (Using the same set of plates, the area can be changed by varying the overlapping region of the plates) • By measuring the capacitance for different areas of the capacitor plates and (or) thickness of the dielectric material,determine the dielectric constant of the given material/liquid. http://www.indosawedu.com/dielectric-constant.php https://www.youtube.com/watch?app=desktop&v=sx0tzAj-Dm4 https://www.youtube.com/watch?v=lKfIkUuFT-U		

Books and References:

1. Concepts of Modern Physics, Arthur Beiser 6th Edition (Book 1)
2. Smartphones as Mobile Minilabs in Physics(Edn. 1) by Jochen Kuhn & Patrik Vogt, Springer, (Book 2)
3. Modern Physics for Scientists and Engineers" by John Morrison
4. Modern Physics by Raymond A. Serway
5. Introduction to Nuclear and Particle Physics - V K Mittal, R C Verma and S C Gupta
6. Introductory Nuclear Physics by Kenneth S. Krane
7. Principles of Nuclear Physics by A. B. Migdal
8. https://phyphox.org/
9. https://physlets.org/tracker/
10. https://expeyes.in/

Mapping of COs with PSOs and POs :

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

CO 4	1	1	1	3	2	2	2	1	2	2	3	0	0
CO 5	1	2	1	1	3	1	2	2	2	2	3	0	0
CO 6	1	2	1	1	3	2	2	1	2	2	3	0	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		✓	✓	

CALICUT UNIVERSITY – FOUR-YEAR UNDER GRADUATE PROGRAMME (CU-FYUGP)

BSc PHYSICS HONOURS

Programme	**B.Sc. 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	PS O5	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	Assignmen t /Viva	Practical Skill Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4	✓	✓		✓
CO 5	✓	✓		✓
CO 6		✓	✓	