Programme: M. Sc. (Physics)
Course Code: PHSO-312 **Title of the Course:** Spectroscopic Techniques in Condensed Matter Physics
Number of Credits: 4
Effective from AY: 2021-22

Prerequisites for the course:	Should have studied courses in classical mechanics, electromagnetism, elementary quantum mechanics and nuclear physics.	
Objective:	To introduce different spectroscopic techniques that can be used for characterization of materials, especially in condensed matter.	
Content:	**1. Electronic Spectroscopy** Electromagnetic radiation, Absorption and Emission of radiation, Line width and its broadening mechanisms, One- electron and two-electron atoms: spectrum of hydrogen, helium and alkali atoms; Many electron atoms: Hund's rule, L-S and j-j coupling, Spectroscopic terms, Lande interval rule; Interaction with Electromagnetic fields: Zeeman, Paschen Back and Stark effects, electron spin resonance spectroscopy, Hyperfine structure and isotope shift, selection rules; Lamb shift, Spontaneous and stimulated emissions, Einstein coefficients, Introduction to lasers and laser spectroscopy	10 hours
	2. Molecular Spectroscopy Microwave spectroscopy, Infrared spectroscopy, the vibrating diatomic molecule – simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating rotator, Interaction of rotation and vibrations, the vibrations of polyatomic molecules, Raman spectroscopy– Electronic spectra of diatomic molecules – Born-Oppenheimer approximation, vibrational coarse structure – progressions. Intensity of vibrational transitions – the Franck-Condon principle. Optical absorption: Free carrier absorption-optical transition between bands-direct, and indirect-excitons, Luminescence in crystal - excitation and emission - decay mechanism, Fluorescence, Phosphorescence, Crystal Field Theory, Spectroscopy of transition metals complexes.	14 hours
	3. X-rays: Sources and Interaction with matter X-rays: Waves and photons, Scattering, Absorption, Refraction and Reflection. X-ray tubes, Synchrotron radiation, Bending magnet sources, Undulator radiation, Wiggler radiation. X-ray detection	12 hours
	4. Nuclear Spectroscopy Nuclear Magnetic Resonance:Principles, Classical treatment of NMR (Bloch equations), experimental methods, Chemical shift, Knight shift in metals, spin-lattice relaxation, Applications	12 hours

	Mossbauer Spectroscopy: Principles, The Debye-Waller Factor, Mossbauer Sources and Experimental Apparatus, Isomer Shifts, Electric quadrupole interaction, Magnetic Dipole Interaction, Quadratic Doppler effect, Results of Mossbauer spectroscopy.	
Pedagogy:	lectures/ tutorials/ seminars/ assignments/ presentations/ etc. or a combination of some of these.	
References/Readings	1. B. H. Bransden and C. J. Joachain; Physics of Atoms and Molecules; Pearson; 2008/2nd Ed.. 2. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, Tata McGraw;2004/4thEd. 3. H. E. White; Introduction to Atomic Spectra; Tata McGraw Hill; 1934. 4. K. Thayagarajan and A.K Ghatak; Lasers Theory and Applications; Macmillan (Tata McGraw Hill) 1995. 5. D. Satyanarayana; Handbook of Molecular Spectroscopy; I K International Publishing House, 2015, 1st edition 6. J. Als-Nielsen, D. McMorrow; Elements of Modern X-ray Physics; Wiley; 2011. 7. G. Schatz and A. Weidinger; Nuclear condensed matter physics: nuclear methods and applications; John Wiley; 1997. 8. H. Kuzmany; Solid-state spectroscopy; Springer; 2009. 9. A. H. Kitai; Solid State Luminescence; Chapman and Hall London; 1993. 10. Luminescence of Solids edited by D. R. Vij, Plenum Press, New York, 1998.	
Learning Outcomes	1. Explain different spectroscopic techniques 2. Better understanding of atomic and molecular physics 3. Apply the techniques in experimental characterisation of materials.	