Programme: M. Sc. (Physics)
Course Code: PHSO-316 **Title of the Course:** Magnetism in Condensed Matter Physics
Number of Credits: 4
Effective from AY: 2021-22

Prerequisites for the course:	Basic knowledge of Solid State Physics / Solid State Chemistry	
Objective:	This course is designed to familiarize students with general and specific aspects of magnetic interaction in condensed matter and methods of magnetic measurements.	
Content:	1. **Magnetic Moments** Magnetic moments and angular momentum, Precessional motion, Bohr Magneton, Magnetization and field, Classical Mechanics and magnetic moments, Quantum mechanical treatment, Spin	4 hours
	2. **Isolated magnetic moments** An atom in magnetic field, Magnetic susceptibility, Diamagnetism, Paramagnetism – semiclassical treatment, Brillouin function, van-Vleck paramagnetism, The ground state of an ion, Hund's rules, Adiabatic demagnetization, Nuclear spin, hyperfine structure, Origin of crystal field, orbital quenching, Jahn-Teller effect	6 hours
	3. **Magnetic Interactions** Dipolar interactions, Exchange interactions – origin, direct and indirect exchange, Indirect exchange in ionic solids, indirect exchange in metals, Double exchange, Anisotropic exchange, Continuum approximation	8 hours
	4. **Order and Magnetic Structures** Ferromagnetism – Weiss model, Magnetic susceptibility, The effect of magnetic field, Origin of the molecular field Antiferromagnetism – Weiss model, Magnetic susceptibility, magnetic field effects, types of antiferromagnetic order Ferrimagnetism, Helical order, Spin glasses, Nuclear ordering Measurement of magnetic order – magnetization and magnetic susceptibility, Neutron scattering, other techniques	8 hours
	5. **Order and broken symmetry** Broken symmetry, Landau theory of ferromagnetism, Heisenber and Ising models (1D and 2D), Consequences of broken symmetry, Phase transitions, Rigidity, Excitations – magnons, Domains, Domain walls, Magnetocrystalline anisotropy, Domain wall width, Magnetization process, Obesrvation of domain wall, small magnetic particles, Stoner-Wohlfarth model, Soft and hard materials	6 hours

	6. Magnetism in metals Pauli paramagnetism, spontaneously spin-split bands, spin-density functional theory, Landau levels, Landau diamagnetism, Magnetism of electron gas – paramagnetic response, diamagnetic response, RKKY interactions, Excitations in the electron gas, Spin-density waves, Kondo effect. 7. **Competing interactions and low dimensionality** Frustration, Spin glasses, Superparamagnetism, One dimensional and two dimensional magnets – spin chainsmSpinons Haldane chains, Spin-Peierls transitions, spin ladders, Magnetoresistance, Magneto-optics **8. Experimental Methods** Magnetic fields, Atomic scale magnetism, Domain scale measurements, Bulk magnetism measurements, Magnetic resonance techniques – ESR, NMR, Mossbauer, X-rays and magnetism.	6 hours 4 hours 6 hours
Pedagogy:	lectures/ tutorials/ seminars/ assignments/ presentations/ etc. or a combination of some of these.	
References/Readings	1. Stephen Blundell, Magnetism in Condensed Matter, Oxford University Press 2001. 2. J. M. D. Coey, Magnetism and magnetic materials, Cambridge University Press, 2010. 3. D. C. Mattis, Theory of Magnetism, Springer Verlag, 1981.	
Learning Outcomes	The student is expected to acquire basic understanding of Magnetism and magnetic interactions in solids. Distinguish between different types of magnetic order and magnetically frustrated states. Have basic knowledge of different experimental methods of measuring magnetization at bulk, domain size and atomic level.	