PHY 624: Magnetism in Materials (2026-27-I)

(First Course Handout)

1) **Course Objective:** Despite over 3,000 years of investigation (beginning with ancient observations of lodestone), magnetism remains a vibrant and essential topic in condensed matter physics. This course is targeted toward understanding the fundamentals of magnetism in condensed matter that are important for science and technology around us.

2) **Schedule:** Mon & Thu, 14:00-15:15 hrs, Venue: to be decided.

3) **Mark distribution and Policy:**
Total (300): Assignments (50 marks), Quizzes (50 marks), Midsem exam (80 marks), Endsem exam (120 marks).

Makeup exams for Midsem or Quiz is not possible. Only makeup exam for the Endsem will be conducted for only DOAA recommended students (applied through proper channel).

A minimum of 75% attendance is mandatory to appear for the Endsem exam.

Blatant copying, faking attendance, or any other unfair means in any form at any stage of the course will be very strictly dealt with and zero-tolerance policy will be adopted in such cases. Minimum penalty for adopting such unfair means is *X grade*.

4) **Course topics:**
- Introduction: review of magneto-statics; magnetic moments and angular momentum; Bohr-van Leeuwen theorem; quantum mechanics of spin; Bohr magneton; classical mechanics of magnetic moments.
- Physics of isolated magnetic moments: Diamagnetism and paramagnetism; Adiabatic demagnetization, nuclear spins, hyperfine structure.
- Crystal fields and Magnetic resonance techniques.
- Interactions: Dipolar and exchange interactions.
- Magnetic Ordering: Ferromagnetism; Antiferromagnetism.
- Ferrimagnetism; Spin glasses and other random orders; Nuclear ordering; Measurements of magnetic ordering.
- Models of magnetic ordering: Landau theory; Heisenberg and Ising models; Symmetry breaking and phase transitions; Excitations; Domains and the magnetization process; hard and soft magnetic materials, magnetic anisotropy.
- Magnetism in metals: free electron model; Pauli paramagnetism, Stoner model, Landau diamagnetism, magnetism of electron gas, excitations in the electron gas, The Kondo effect.
- Magnetism in low dimensional systems: nano-particle magnetism; one- and two-dimensional magnets; thin film and multilayers.
- Modern techniques for characterizing magnetic materials.

5) **Recommended books:**
"Magnetism in Condensed Matter" by S Blundell, Oxford 2001.
"Introduction to magnetic materials" by Cullity and Graham, Willey 2009.
"Physics of Magnetism" by S Chikazumi and S H Charap, John Wiley & Sons.

6) **Course Instructor:**
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Office location: SL Extn. (First floor, opposite to Air Quality Lab)
Office hours: Mon 16:00-17:00 hrs.
Preferred mode of contact: meet (in office) during office hours (email before coming to book the slot). Course related announcements/ assignments/ materials sharing will be done either through helloiitk portal or written in the class.