Phy 656T, SUPERCONDUCTIVITY AND APPLICATIONS

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1. **Objectives**: This PG level elective course will attempt to cover some of the fundamentals and applications of the vast field of superconductivity. It will discuss different theoretical formalisms as well as experimental aspects of superconductivity and attempt to present a balanced perspective. I will discuss some of the seminal experiments associated with this phenomenon which led to its advancement. The initial part of the course will discuss classical aspects of superconductors, followed by study of their thermodynamic and magnetic properties and electrodynamic response. In between we will also give an overview of low Temperature techniques, its generation and temperature measurement techniques. Different aspects of modern superconductors will be discussed along with new materials along with device aspects. The course involves a detailed discussion of the BCS theory and developing the gap equation and discuss various thermodynamic quantities within the purview of the microscopic theory. Ginzburg Landau theory for superconductivity, Abrikosov vortex state, pinning and vortex phases and phase transition in these phases, current voltage relationship of a type II superconductor in the presence of a magnetic field. Study of tunneling phenomenon in N-I-S or S-I-S junctions, associated Andreev reflection issues, Josephson effect - junctions and their applications (SQUID), Superconductivity and vortex physics at nanoscales and device applications and experiments related to superconductivity will be introduced and discussed throughout the course at relevant points in the course. Attempts wherever possible will be made to connect some of the physics with that of superfluidity. The course will also attempt to review some of the latest developments in superconductivity and its applications. *If time permits,* we will try and discuss some devices aspects related to quantum computation and superconductivity. However, we will not get into the details of Quantum Computation as it needs a separate layer of formalism to be introduced, which is beyond the scope of the present course.

2. **Prerequisites**: Condensed Matter physics, Quantum mechanics (with familiarity with second quantization formalism -> needed to understand BCS theory), Electrodynamics, Thermodynamics and Statistical mechanics.
3. **Course Policies:** As per Institute Guidelines. The course evaluation will involve exams as well as involve term paper presentations. Participation in all of these activities will be essential to acquire a grade for the course.
4. **Books & References:**

Introduction to Superconductivity : A. C. Rose-Innes and E. H. Rhoderick

Introduction to Superconductivity : Michael Tinkham

Magnetic Flux structures in superconductors: R. P. Huebner

Theory of superconductivity: J. R. Schrieffer

Superconductivity Physics and Applications : Kristian Fossheim and Asle Sudbo

Superfluidity and Superconductivity: D. R. Tilley and J. Tilley