Superconductivity - Web course

COURSE OUTLINE

The course is a one semester course on Superconductivity at the M. Sc. Level. The course begins with a description of the changes in the properties of metals on becoming superconducting. The thermodynamics of the associated phase transition is then elucidated.

The theoretical treatment starts with the phenomenological Ginzburg-Landau approach and is followed by the microscopic theory of superconductivity due to Bardeen, Cooper and Schrieffer (BCS). The theoretical understanding is used to explain tunneling and quantum interference phenomena in superconductors.

Following this, some of the experimental methods for probing the superconducting state are also described. Finally, various superconductors, including high-T_c, which do not appear to follow the BCS theory are discussed.

COURSE DETAIL

Sl.No.	Modules	No. of hrs.
1.	**A historical overview:** Superconductivity in Hg, cuprates, MgB_2 and Fe pnictides.	1
2.	**Basic properties of metals in normal state:** Resistivity, electronic and phonon specific heats, thermal conductivity, magnetic susceptibility and Hall effect.	2
3.	**Phenomenon of superconductivity:** Zero resistance, persistent currents, superconducting transition temperature T_c, isotope effect, perfect diamagnetism and Meissner effect, penetration depth and critical field.	3
4.	**Thermodynamics of superconducting transition:** First-order and second-order transition, specific heat above and below T_c, thermal conductivity.	3
5.	**Phenomenological theory of superconductivity:** Free energy, order parameter, Ginzburg-Landau equations, predictions of Ginzburg-	5

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Physics

Pre-requisites:

Quantum Mechanics based Condensed Matter Physics course.

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	Landau equations, flux-quantization, penetration depth.	
6.	**Microscopic theory of superconductivity:** Electron-phonon interaction, Cooper pairs, Bardeen-Cooper-Schrieffer (BCS) Hamiltonian, variational approach, canonical transformation, finite temperatures, properties of the BCS ground state, macroscopic properties of superconductors.	6
7.	**Tunneling and the energy gap:** Tunneling phenomenon, energy-level diagram, Josephson effect, quantum interference.	4
8.	**Type-I and Type-II superconductivity:** Type-I and type-II superconductors, intermediate states, mixed states.	5
9.	**Experimental methods for probing the nature of the superconducting state:** Nuclear magnetic resonance and Knight shift, planar, scanning and point-contact spectroscopy.	5
10.	**Unconventional superconductors:** Heavy-fermion superconductors, metal-oxide superconductors, organic superconductors, magnesium diboride, iron pnictides.	2
11.	Basics of High-T_c superconductivity.	4
	Total	**41**

References:

1. C. Kittel, "Introduction to Solid State Physics", 7th Edition, John Wiley & Sons, Inc., Singapore (1995).
2. A.C. Rose-Innes and E.H. Rhoderick, "Introduction to Superconductivity", 2nd Edition, Pergammon, Oxford (1978).
3. M. Tinkham, "Introduction to Superconductivity", 2nd Edition, Dover Publications, Inc., New York (1996).
4. P.G. de Gennes, "Superconductivity in Metals and Alloys", W.A. Benjamin, New York (1966).
5. C.P. Poole Jr., H.A. Farach, R.J. Creswick, and R. Prozorov, "Superconductivity", 2nd Edition, Academic Press (2007).