IIT Mandi
Proposal for a New Course

Course Name	: Superconductivity
Course Number	: PH 605
Credits	: 3-0-0-3
Prerequisites	: Quantum Mechanics-I (PH 513), Condensed Matter Physics (PH 523)
Intended for	: PhD/PG/UG
Distribution	: Elective PG/Elective UG
Semester	: Odd/Even

1. **Preamble:** The course is intended for the physics students at the advanced undergraduate level, or beginning graduate level. It is designed to familiarize students with the phenomenon of superconductivity, its basic theory and the various experimental techniques employed to understand its exotic physics.

2. **Course Modules:**

Module-1
Introduction: Historical perspective, Resistivity, Specific heat, Thermal conductivity, Magnetic Susceptibility and Hall Effect of normal metal; Zero resistance, persistent current, Meissner effect, London-London equations, Penetration depth and critical field. [9]

Module-2
Phenomenological theory of Superconductivity: Free energy, First order and second order transition, specific heat, thermal conductivity, Superconducting order parameter, Ginzburg-Landau equations and its predictions, Coherence length, Type-I and Type-II super- conductors, The vortex lattice. Phase coherence, Flux quantization. [9]

Module-3
Microscopic Theory of Superconductivity: Isotope effect and its significance. The Cooper problem, Formation of Cooper pairs, BCS wave function, Existence of energy gap, Finite temperature properties of BCS ground state. [9]

Module-4
Tunnelling and energy gap: Tunnelling phenomenon, DC Josephson Effect. AC Josephson Effect. Inverse AC Josephson Effect and Shapiro jumps, Superconducting quantum interference device (SQUID). [7]

Module-5
Unconventional Superconductors: Alternate pairing mechanisms (e.g. spin-triplet, d-wave etc.), Symmetry of the gap function, Experimental methods for probing Nodal structure, Parity, spin state, Lattice symmetry and internal structure, Heavy Fermion, High temperature superconductivity, Cuprates, and Fe based Superconductors. [8]

3. **Textbooks:**

- Superconductivity by J.B. Ketterson and S.N. Song (Cambridge University Press 1999)

4. **References:**

- Introduction to Superconductivity by M. Tinkham (McGraw-Hill, Inc, 1996)
- Unconventional Superconductors by Grenet Goll (Springer-Verlag Berlin Heidelberg 2006)
- Superconductivity by Charles p. Poole Jr., H.A. Farach, R.J. Creswick, R. Prozorov (Elsevier, The Netherlands 2007)
- Superconductivity, Superfluids and Condensates by James F. Annett (Oxford University Press, 2004)

5. Similarity Content Declaration with Existing Courses:

S.N.	Course Code	Similarity Content	Approx. % of content
1.	Condensed matter physics	PH 523	~10%
2.	Advanced Condensed Matter Physics	PH 603	~15%

6. Justification for new course proposal if cumulative similarity is >30% : NA