

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E. Semester: III

Mechanical Engineering (Cryogenic Engineering)

Subject Name **SUPER CONDUCTIVITY & LOW TEMPERATURE PHYSICS**

PART – I QUANTUM FLUIDS

Sr.No	Course content
1.	Properties Of Cryo Liquids, Liquid Air, Liquid Nitrogen, Liquid Oxygen, Liquid Hydrogen, Liquid Helium, General Properties, Phase Diagrams, Thermodynamic Properties
2.	Super Fluid ^4He – Helium II :Experimental Observations, Two – Fluid Model, Bose – Einstein Condensation, Macroscopic Quantum State, Excitation Spectrum of Helium II, Critical Phenomena Near The Lambda Point
3.	Normal Fluid ^3He :Ideal Fermi Gas –Comparison With ^3He , The Landau Fermi Liquid Theory, Zero Sound
4.	Super Fluid ^3He -- Phase Diagrams , Specific Heat, Superfluidity, Nuclear Magnetic Resonance , Relevance Of Two Fluid Model, Quantum States Of Pairs Of Coupled Quasiparticles, Order Parameter Orientation – Textures, Leggett Equations Transverse Resonance, Longitudinal Resonance, Superflow, Macroscopic Quantum Interference – Josephson Effect, Normal Fluid Density – Quasiparticle Scattering , Collective Excitations, Sound Propagation
5.	Mixtures Of ^3He & ^4He : Specific Heat, Phase Diagram And Solubility, Normal Fluid Component, Sound Propagation, Transport Properties, Search For a Superfluid Phase Of ^3He In Mixtures.

Part – II Solids At Low Temperatures

Sr.No	Course content
6.	Properties Like Specific Heat, Thermal Expansion, Thermal Conductivity Of Materials Like Insulators, Metals, Superconductivity Metals, Non Crystalline Solids. Phonons: Specific Heat – Debye Model, Heat Transport, Ballistic Propagation Of Phonons, Thermal Conductivity Of One Dimensional Samples.
7.	Conduction Electrons: Specific Heat, Electrical Conductivity, Thermal Conductivity Of Metals, Kondo Effect, Heavy –Fermion Systems.

8.	Tunnelling Systems: Two Level Tunnelling Systems, Isolated Tunnelling Systems In Crystals, Interacting Tunnelling Systems In Crystals, Asymmetric Tunnelling Systems In Crystals, Amorphous Dielectrics, Metallic Glasses.
9.	^3He Cryostat : Helium -3 Cryostat With External Pump, Helium -3 Cryostat With Internal Adsorption Pumps.
10.	Superconductivity: Transition Temperature, Meissner – Ochsenfeld Effect, Type I Superconductors, Type II Superconductors, Thermodynamics of Superconductors, London Equations, Pipard's Equation, Flux Quantization – Josephson Effect, BCS Theory, Superconducting Magnetometer – Squid , Superconductors With Unusual Properties – Organic Superconductors, Magnetism And Superconductivity, Heavy – Fermion Superconductors, High – T_c Superconductors (HTS), HTS family, Structural and electrical properties, Applications of HTS.
11.	Refrigeration By Solidification Of Liquid ^3He : Phase and Entropy Diagrams Of ^3He , Entropies Of Solid And Liquid ^3He , Pomeranchuk cooling.

List of Experiments:

1. Study of properties of Super Fluid ^4He – Helium II.
2. Study of properties of super fluid ^3He .
3. Study of properties of mixtures of ^3He & ^4He .
4. Study on low temperature resistivity of $\text{LaBa}_2\text{Cu}_3\text{O}_7$ type high T_c superconductor
5. Study of helium -3 cryostat with external pump, helium -3 cryostat with Internal adsorption pumps.
6. Determination of magnetic T_c of High T_c superconductor by AC susceptibility
7. Study of designing features of cryostat for magnetic and non magnetic measurements
8. Fabrication of High T_c superconductor thin film by sol gel chemical technique
9. Analysis of HTS thin film by electrical measurements.
10. Study of refrigeration system by solidification of liquid ^3He .

Reference Books:

1. Low Temperature Superconductivity & Superconductivity By Christian Enss & Siegfried Hunklinger
2. Matter & Methods At Low Temperature By F.Pobell.
Experimental low temperature physics by Anthony Kent