Indian Institute of Technology Kanpur

Proposal for a New Course

1. Course No: A **200 level (specifically PHY210, if available)** number requested**.**
2. Course Title: **Thermal Physics**
3. No. of Lectures per week: 3 (L), Tutorial: 1 (T), Laboratory: 0 (P), Additional Hours [0-2]: 0 (A),

   Credits (3*L+2*T+P+A): 11 Duration of Course: Full Semester
4. Proposing Department/IDP : Physics

   Other Departments/IDPs which may be interested in the proposed course: All Departments/IDPs

   Other faculty members interested in teaching the course: All Physics Faculty Members
5. Proposing Instructor: DUGC (PHY)
6. Course Description:

A) Objectives: This present course is an extended version of the previous modular Thermal Physics course (PHY210M) and includes an introduction to microscopic thermal physics in the larger version. This course is designed to offer a first course of thermal physics to undergraduate physics students. The first half of the course will be dedicated to the systematic development of thermodynamics from a physicist's perspective whereas the second half is mainly dedicated to the introduction of microscopic understanding of the same in the framework of kinetic theory. The course offers an avenue towards advanced topics like non-equilibrium thermodynamics, statistical mechanics, soft matter physics etc. An attempt to present entropy in the general context of multiplicity and information theory is also included.

B) Contents: **(for 38 lectures)**

1. Introduction to Thermodynamics (2 lectures)

• Macroscopic systems: isolated, closed and open

• Extensive and intensive variables

• Adiabatic vs diathermic walls

• Thermal equilibrium, zeroth law of thermodynamics

2. First Law of Thermodynamics (4 lectures)

• Concept of heat and work

• State functions, internal energy

• Thermodynamic processes (isochoric, isobaric, isothermal, adiabatic)

• Differential form of the first law of thermodynamics

• Cp-Cv relations, compressibility, expansion, real systems

3. Reversibility and Heat Engines (5 lectures)

• Reversible vs irreversible processes

• Heat engines and refrigerators

• Carnot cycle, Otto, Diesel, Stirling engines

4. Second Law and Entropy (5 lectures)

• Kelvin-Planck and Clausius statements – their equivalence

• Clausius theorem and inequality

• Entropy as a state function, T-S diagrams

5. Thermodynamic Potentials and Irreversible Processes (5 lectures)

• Internal energy, enthalpy, Helmholtz and Gibbs free energies; Maxwell relations

• TdS equations, internal energy expressions

• Thermodynamics of radiation

• Joule-Thomson cooling, free expansion

• Free energies and equilibria

6. Phase Transitions (5 lectures)

• First and second order transitions

• Clapeyron and Ehrenfest equations

• Gibbs phase rule, critical phenomena

• Chemical potential, open systems, Gibbs-Duhem relations

7. Concept of Entropy in Statistical Framework (2 lectures)

• Entropy as multiplicity

• Entropy in quantum mechanics, black holes, and information

8. Kinetic Theory of Gases (5 lectures)

• Ideal gas assumptions

• Maxwell-Boltzmann distribution

• Mean, rms, most probable speeds

• Degrees of freedom, specific heats

9. Collisions and Transport (5 lectures)

• Collisions, mean free path

• Viscosity, conductivity, diffusivity

• Brownian motion (Einstein-Langevin), limits of kinetic theory

C) Pre-requisites: None.

D) Short summary for including in the Courses of Study Booklet: Introduction to Thermodynamics, First Law of Thermodynamics, Reversibility and Heat Engines, Second Law and Entropy, Thermodynamic Potentials and

Irreversible Processes, Phase Transitions, Concept of Entropy in Statistical Framework, Kinetic Theory of Gases, Collisions and Transport.

7. Recommended books:
   - M. Zemansky & R. Dittman, Heat and Thermodynamics
   - C. Kittel & H. Kroemer, Thermal Physics
   - Enrico Fermi, Thermodynamics
   - H. B. Callen, Thermodynamics and an Introduction to Thermostatistics
   - M. Saha & B. N. Srivastava, A Treatise on Heat

Dated: 06 November 2025; Proposer: DUGC, PHY

Dated: 06 November 2025; DUGC Convener (PHY): 

The course is approved / not approved

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Chairperson, SUGC

Dated:_____