COURSE PROFILE

Course Title: Heat and Thermodynamics

Course Code: 0533-121 [PHY-121]

Credit Hours: 03

Academic Program: B.Sc. (Honours) in Physics

Department: Department of Physics

Institution: Comilla University, Cumilla-3506, Bangladesh

Course Duration: 14 Teaching Weeks

Course Type: Core Course

1. Rationale/Course Summary

Heat and Thermodynamics is a foundational physics course that covers thermal phenomena, energy transfer, and the macroscopic laws governing physical systems. It introduces key concepts such as temperature, heat transfer, kinetic theory of gases, thermodynamic laws, thermodynamic potentials, phase transitions, and thermal radiation. The course enables students to analyze energy transformations through theoretical, mathematical, and applied approaches. It also provides a basis for advanced studies in condensed matter physics, statistical mechanics, materials science, and energy-related technologies while strengthening analytical, problem-solving, and quantitative reasoning skills.

2. Course Learning Outcomes (CLOs)

After successful completion of the course, students will be able to:

- **CLO-1:** Recall and define fundamental concepts of heat, temperature, thermal expansion, heat transfer mechanisms, and basic thermodynamic quantities.
- **CLO-2:** Explain physical laws and principles related to heat transfer, kinetic theory of gases, and thermodynamic processes using appropriate scientific terminology.
- **CLO-3:** Apply mathematical relations and physical laws to solve problems involving heat conduction, gas behavior, work, and thermodynamic processes.
- **CLO-4:** Analyze thermodynamic systems by interpreting isothermal, adiabatic, reversible, and irreversible changes, including entropy changes.
- **CLO-5:** Evaluate the performance of thermodynamic systems such as heat engines and radiation systems using efficiency, entropy, and thermodynamic potentials.

3. Weekly Teaching Plan (14 Weeks)

Week	Topics and Contents	Teaching-Learning Strategies	CLOs
1	**Concept of Temperature and Heat Transfer:** Temperature, thermal equilibrium, Zeroth law of thermodynamics, thermal expansion, Seebeck effect, and thermocouples.	Lecture, discussion, numerical examples	CLO-1, CLO-2
2	**Heat Transfer:** Newton's law of cooling, heat capacities, conduction, thermal conductivity and thermal diffusivity, rectilinear flow of heat, and experimental measurement of thermal conductivity of good and bad conductors.	Lecture, problem-solving, demonstration	CLO-1, CLO-2, CLO-3
3	**Heat Transfer (Continued):** Heat conduction through composite walls, thermal resistance, and convection. Introduction to applications of heat transfer.	Lecture, numerical exercises, discussion	CLO-2, CLO-3
4	**Kinetic Theory of Gases:** Fundamental assumptions, equation of state of an ideal gas, pressure from molecular motion, RMS velocity, and translational kinetic energy.	Lecture, derivation, numerical problem-solving	CLO-1, CLO-2, CLO-3
5	**Kinetic Theory (Continued):** Equipartition of energy, degrees of freedom, molar specific heats, mean free path, Maxwell's distribution of molecular velocities, and Brownian motion.	Lecture, mathematical derivation, problem-solving	CLO-2, CLO-3, CLO-4
6	**Real Gases and Transport Phenomena:** Van der Waals equation of state, deviations from ideal-gas behavior, and transport phenomena, including viscosity, thermal conductivity, and diffusion.	Lecture, comparative analysis, numerical exercises	CLO-2, CLO-3, CLO-4
7	**First Law of Thermodynamics:** Internal energy, heat and work, thermodynamic systems, isothermal and adiabatic processes, work done by expanding gases, statement of the first law, and its applications.	Lecture, derivations, numerical problem-solving	CLO-2, CLO-3, CLO-4
8	**Second Law of Thermodynamics:** Statements of the second law, reversible and irreversible processes, heat engines,	Lecture, PV diagrams, problem-solving	CLO-2, CLO-3,

	efficiency of heat engines, Carnot cycle, Carnot's theorem, and thermodynamic temperature scale.		CLO-4, CLO-5
9	**Entropy and the Third Law:** Concept of entropy, entropy changes in reversible and irreversible processes, entropy and the second law, entropy and disorder, principle of increase of entropy, and the third law of thermodynamics.	Lecture, mathematical derivation, analytical discussion	CLO-2, CLO-3, CLO-4, CLO-5
10	**Thermodynamic Functions:** Enthalpy, Helmholtz free energy, Gibbs free energy, thermodynamic potentials and their physical significance.	Lecture, derivations, application-based problems	CLO-2, CLO-3, CLO-5
11	**Thermodynamic Relations:** Maxwell's thermodynamic relations, specific heat equations, and chemical potential.	Lecture, mathematical derivation, problem-solving	CLO-2, CLO-3, CLO-4, CLO-5
12	**Phase Transitions and Applications:** Classification of phase transitions, phase equilibrium, Clausius–Clapeyron equation, and Gibbs phase rule.	Lecture, derivation, real-world examples	CLO-2, CLO-3, CLO-4, CLO-5
13	**Thermal Radiation:** Blackbody radiation, emissive and absorptive powers, Kirchhoff's law, Stefan–Boltzmann law, Wien's displacement law, and Rayleigh–Jeans law.	Lecture, graphical interpretation, numerical exercises	CLO-1, CLO-2, CLO-3, CLO-5
14	**Quantum Theory of Radiation and Course Review:** Planck's quantum hypothesis, Planck's radiation law, comparison with classical radiation laws, integrated problem-solving, and revision of key concepts.	Lecture, problem-solving, discussion, revision	CLO-2, CLO-3, CLO-4, CLO-5

4. Teaching-Learning Methods

1. Interactive lectures and board-based mathematical derivations.
2. Numerical problem-solving and analytical exercises.
3. Demonstrations and discussion of practical applications.

4. Student presentations, assignments, and guided discussions where appropriate.
5. Formative assessment, feedback, and revision sessions.

5. Assessment Strategy

Assessment Component	Weight (%)	Purpose
Class tests/ Quizzes/Assignment / Problem-solving Exercises	5	Assess students' conceptual understanding, fundamental knowledge, and ability to solve basic problems.
Presentation	10	Develop students' communication, analytical reasoning, and ability to explain physics concepts and applications.
Midterm Examination	20	Evaluate students' understanding and application of the concepts and principles covered in the first half of the course.
Class Attendance	5	Encourage regular class participation, engagement, and continuity in learning.
Final Examination	60	Assess comprehensive knowledge, conceptual understanding, analytical reasoning, and problem-solving skills across the entire course syllabus.
Total	**100**	

6. CLO–Assessment Mapping

CLO	Class Tests / Quizzes/ Assignment	Presentation	Midterm	Final Examination
CLO-1	✓	✓	✓	✓
CLO-2	✓	—	✓	✓
CLO-3	✓	—	✓	✓
CLO-4	✓	✓	—	✓
CLO-5	—	✓	—	✓

7. Recommended Textbooks

1. Brijlal, N.Subrahmanyam, P.S. Hemne, *Heat and Thermodynamics and Statistical Physics*, S. Chand & Company.
2. Sears, F. W., Salinger, G. L., and other relevant editions, *Thermodynamics, Kinetic Theory, and Statistical Thermodynamics*.
3. Hossain, T., *Text Book of Heat*, Rainbow Book Mall.
4. Halliday, D., Resnick, R., and Walker, J., *Fundamentals of Physics*, Wiley.

8. Expected Course Outcomes

Upon completion of this course, students are expected to demonstrate a sound understanding of thermal phenomena, gas behavior, thermodynamic laws, entropy, thermodynamic potentials, phase transitions, and thermal radiation. They should be able to solve quantitative problems, interpret thermodynamic processes, and evaluate the performance and limitations of thermal systems. The course also prepares students for advanced study in statistical mechanics, condensed matter physics, and energy-related research.

Prepared by:

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