

Syllabus Template

Semester: VII	
Programme : Physics	
Course: Thermal Physics and Minor Lab II	
Paper code: B4PH230712T / B4PH230712P	Credits: 3+1
Hours/week : 3+2	
Category: Core/MDC/SEC/VAC : Minor	
Theory / Practical / Composite : Composite	
No of Modules : 2	
Course Overview: This course introduces the fundamental concepts of Kinetic Theory of Gases, Thermodynamics, Radiation, and Statistical Physics, forming the foundation of classical and modern thermal physics. The course begins with the microscopic description of gases using kinetic theory, including Maxwell's velocity distribution, molecular speeds, degrees of freedom, equipartition of energy, Brownian motion, and real gas behavior through Van der Waals' equation. It then develops the macroscopic framework of thermodynamics, covering the laws of thermodynamics, reversible and irreversible processes, cyclic processes, work done in isothermal and adiabatic transformations, Carnot cycle, entropy, and the concept of disorder. The radiation section introduces blackbody radiation and classical and quantum radiation laws, including Planck's law, Wien's displacement law, Rayleigh-Jeans law, and Stefan's law. Finally, the course transitions to statistical physics, connecting microscopic states to macroscopic observables through the concepts of microstate, macrostate, phase space, thermodynamic probability, partition function, and Maxwell-Boltzmann distribution. The course emphasizes the physical interpretation of mathematical expressions and the connection between microscopic molecular behavior and macroscopic thermodynamic properties. Course Overview: Minor Lab II Minor-Lab II is designed to provide hands-on experimental training in fundamental concepts of electricity, magnetism, electronics, and thermal physics. The laboratory integrates classical electromagnetic experiments with basic electronic circuit analysis and semiconductor device studies. Students perform experiments involving measurement of the horizontal component of the Earth's magnetic field, galvanometer resistance determination, and verification of network theorems such as Thevenin's theorem in a Wheatstone bridge setup. The course also introduces precision measurement techniques using the Carey-Foster bridge and explores resonance phenomena in LCR circuits. In semiconductor electronics, students study the characteristics of a Zener diode and a transistor in common-emitter configuration, gaining insight into voltage regulation and amplification, respectively. The verification of Stefan's law familiarizes students with blackbody radiation principles. Additionally, digital electronics experiments include verification and construction of logic gates (AND, OR, NOT) using discrete components and universal NAND/NOR ICs.	

Course Outcome: Thermal Physics
1. Derive Maxwell's velocity distribution law and calculate most probable, mean and rms speeds
2. Apply equipartition theorem to determine internal energy and specific heats
3. Explain Brownian motion quantitatively
4. Use Van der Waals' equation to analyze deviations from ideal gas behavior
5. Apply the first law to solve problems involving heat and work and calculate work done in isothermal and adiabatic processes
6. Distinguish reversible and irreversible processes using thermodynamic arguments
7. Determine efficiency of Carnot engine and compute entropy change for simple thermodynamic transformations
8. Derive and apply Rayleigh–Jeans and Wien's radiation laws
9. Explain the ultraviolet catastrophe
10. Use Planck's law to describe blackbody radiation spectrum and apply Stefan–Boltzmann and Wien's displacement laws to solve numerical problems
11. Define macrostate, microstate and phase space
12. Calculate thermodynamic probability and partition function for simple systems
13. Derive macroscopic quantities (U, F, S, P) from partition function
14. Apply Maxwell–Boltzmann distribution to molecular systems
Course Outcome: Minor Lab II
1. Apply fundamental principles of electricity, magnetism, and electronics through laboratory experimentation
2. Use standard electrical and electronic instruments to measure physical and circuit parameters accurately
3. Analyze electrical networks, resonance phenomena, and semiconductor device characteristics
4. Construct and verify basic analog and digital electronic circuits
5. Interpret experimental data using graphical methods and develop scientific reporting skills

Prerequisites:**SYLLABUS**

UNIT/ Module	CONTENT	HOURS or NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
I.	<u>THERMAL PHYSICS:</u> A) Kinetic theory of gases: Introduction, law of atmosphere, Maxwell's law of velocity distribution, most probable velocity, r.m.s. speed and mean speed. Degrees of freedom, equipartition of energy, characteristics of Brownian motion, Equation of state of real gases : Van der Waal's equation.	8 CLASSES	CO1 CO2 CO3 CO4	K2, K3, K4
	B) Thermodynamics: Introduction, first law of thermodynamics and its applications, reversible and irreversible processes, cyclic process. Work done by a perfect gas during isothermal and adiabatic process, Second law of thermodynamics – Clausius and Kelvin statements and their equivalence, Carnot's theorem, entropy and disorder.	12 CLASSES	CO5 CO6 CO7	K2, K3, K4, K5
	C) Radiation: Introduction, Planck's law of blackbody radiation, Wien's displacement law, Rayleigh-Jean's law, Stefan's law	4 CLASSES	CO8 CO9 CO10	K2, K3, K4
	D) Statistical Physics: Macrostate and Microstate, phase space, Thermodynamic probability, partition function, calculation of macroscopic properties from partition function. Maxwell-Boltzmann law - distribution of velocity	12 CLASSES	CO11 CO12 CO13 CO14	K1, K2, K3, K4, K5
II.	<u>MINOR-LAB II</u> 1. Determination of the horizontal component of the earth's magnetic field by using a deflection and an oscillation magnetometer. 2. Determination of the resistance of	24 CLASSES	CO1, CO2, CO3, CO4, CO5	K2, K3, K4, K5, K6

	a galvanometer by the method of half-deflection. 3. Verification of Thevenin and Norton theorem for a Wheatstone bridge network. 4. Determination of unknown resistance of the material of a coil using Carey-Foster bridge. 5. Study of resonance of a series LCR circuit and determination of Q-factor. 6. Study of reverse characteristic and voltage regulation of a Zener diode. 7. Study of output characteristics of a transistor in CE configuration. 8. Verification of Stefan's law. 9 (a) Verification of the truth table of OR, AND, NOT logic gates using discrete components. (b) Construction of AND, OR and NOT gates using NAND/NOR IC gates and verification of their truth tables.			
Text Books				
<u>MODULE – A</u>				
1. Handbook of Degree Physics, C. R. Dasgupta Vol.1, Book Syndicate Pvt. Ltd. 2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill				
<u>MODULE – B</u>				
1. A textbook on Practical Physics, K.G. Mazumdar & B. Ghosh, Sreedhar Publishers 2. Advanced Practical Physics Vol 1. B. Ghosh & K.G. Mazumdar, Sreedhar Publishers 3. Advanced Practical Physics Vol 2. B. Ghosh, Sreedhar Publishers 4. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency Pvt. Ltd.				
Suggested readings				
1. Heat & Thermodynamics, Zemansky & Dittman, McGraw Hill 2. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger, 1988, Narosa				
Web Resources				
1. Libretext: Thermal Physics (1.7) https://phys.libretexts.org/Courses/Coalinga_College/Physical_Science_for_Educators_Volume_2/01%3A_Energy_Physics_and_Chemistry				

Evaluation Theory CIA: 30 (2 x 10 + 5/assgn.+ 5/attn.). Semester Exam:70
 Practical (if applicable) CA: 38+2/attn

Paper Structure for Theory Semester Exam Module : Theory module of 45 Marks:
 15 Marks from 3 marks questions (5 out of 8)
 30 Marks from 10 marks questions (3 out of 4)

Course outcomes (COs) FOR Thermal Physics and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	Derive Maxwell's velocity distribution law and calculate most probable, mean and rms speeds	K2, K3, K4
CO2	Apply equipartition theorem to determine internal energy and specific heats	K2, K3, K4
CO3	Explain Brownian motion quantitatively	K2, K3, K4
CO4	Use Van der Waals' equation to analyze deviations from ideal gas behavior	K2, K3, K4
CO5	Apply the first law to solve problems involving heat and work and calculate work done in isothermal and adiabatic processes	K2, K3, K4
CO6	Distinguish between reversible and irreversible processes using thermodynamic arguments	K2, K4, K5
CO7	Determine efficiency of Carnot engine and compute entropy change for simple thermodynamic transformations	K2, K3, K4, K5
CO8	Derive and apply Rayleigh-Jeans and Wien's radiation laws	K2, K3, K4
CO9	Explain the ultraviolet catastrophe	K2, K4
CO10	Use Planck's law to describe blackbody radiation spectrum and apply Stefan-Boltzmann and Wien's displacement laws to solve numerical problems	K2, K3, K4
CO11	Define macrostate, microstate and phase space	K1, K2
CO12	Calculate thermodynamic probability and partition function for simple systems	K2, K3, K4
CO13	Derive macroscopic quantities (U, F, S, P) from partition function	K2, K3, K4, K5
CO14	Apply Maxwell-Boltzmann distribution to molecular systems	K2, K3, K4

Course outcomes (COs) FOR Minor-Lab-II and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	Apply fundamental principles of electricity, magnetism, and electronics through laboratory experimentation	K2, K3, K4
CO2	Use standard electrical and electronic instruments to measure physical and circuit parameters accurately	K2, K3
CO3	Analyze electrical networks, resonance phenomena, and semiconductor device characteristics	K3, K4, K5
CO4	Construct and verify basic analog and digital electronic circuits	K3, K4, K6
CO5	Interpret experimental data using graphical methods and develop scientific reporting skills	K2, K4, K5