**Syllabus Template**

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| **Semester: VII** | |
| **Programme : Physics** | |
| **Course: Thermal Physics & 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** |
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| **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: | | | | |
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| **SYLLABUS** | | | | |
| **UNIT/ Module** | **CONTENT** | **HOURS or NUMBER OF CLASSES** | **CO Mapping** | **COGNITIVE LEVEL** |
| **I.** | **<u>THERMAL PHYSICS:</u>**<br>**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**<br>**CO2**<br>**CO3**<br>**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**<br>**CO6**<br>**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**<br>**CO9**<br>**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**<br>**CO12**<br>**CO13**<br>**CO14** | K1, K2, K3, K4, K5 |
| **II.** | **<u>MINOR-LAB II</u>**<br><br>1. Determination of the horizontal component of the earth's magnetic field by using a deflection and an oscillation magnetometer.<br><br>2. Determination of the resistance of | **24 CLASSES** | **CO1,**<br>**CO2,**<br>**CO3,**<br>**CO4,**<br>**CO5** | K2, K3, K4, K5, K6 |

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| | a galvanometer by the method of half-deflection.<br><br>3. Verification of Thevenin and Norton theorem for a Wheatstone bridge network.<br><br>4. Determination of unknown resistance of the material of a coil using Carey-Foster bridge.<br><br>5. Study of resonance of a series LCR circuit and determination of Q-factor.<br><br>6. Study of reverse characteristic and voltage regulation of a Zener diode.<br><br>7. Study of output characteristics of a transistor in CE configuration.<br><br>8. Verification of Stefan's law.<br><br>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**

**MODULE – A**

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

**MODULE – B**

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)**

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| Evaluation Theory CIA: 30 (2 x 10 + 5/assgn.+ 5/attn.). Semester Exam:70<br>Practical (if applicable) CA: 38+2/attn |
| **Paper Structure for Theory Semester Exam Module : Theory module of 45 Marks**:<br>15 Marks from 3 marks questions (5 out of 8)<br>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 |