# Sankalchand Patel University

Faculty of Science & Humanities

**Master of Science (SEM-1) (Physics)**

In Effect from Academic Year 2021-22

| **Subject Code:**1SC2050103 | **Subject Title:** Atomic & Molecular Spectroscopy and Statistical Mechanics |
|---|---|

**COURSE OBJECTIVE:**

Physics is a science to understand the nature. This course is designed to get basic understanding of the physical world.

**LEARNING OUTCOMES:**

- Develop the understanding of Spectroscopy and statistical Mechanics.

| **Teaching scheme (hours) per week** | | **Credit** | | **University Examination** | | **Internal Examination** | | **Total** |
|---|---|---|---|---|---|---|---|---|
| **Theory** | **Practical** | **Theory** | **Practical** | **Theory** | **Practical** | **Theory** | **Practical** | |
| **4** | -- | **4** | -- | **60** | -- | **40** | -- | **100** |

| Unit | Content | Lectures | Weight (%) |
|---|---|---|---|
| 1 | **Atoms and Molecules**: Schrödinger equation for one-electron atoms – H-atom, the dipole selection rules. Fine structure of hydrogenic atoms, The Lamb shift and its determination, Hyperfine structure and isotopic shifts. Schrödinger equation for Two-electron atoms, the role of Pauli Exclusion Principle, Energy levels of He atom, Doubly excited states, Auto-ionization in Helium. Thomas-Fermi model for many-electron atoms. The Born-Oppenheimer approximation for molecule, electronic structure of diatomic molecules, LCAO approximation for H2+ ion. | 15 | 25 |
| 2 | **Laser Spectroscopy**:<br>Emission and absorption spectroscopy: UV-visible-IR absorption (introduction),Classical view of Einstein coefficients; two-level system, Three-level Laser system, Variation of Laser power around threshold.NH3 maser, He-Ne Laser (energy level diagram), CO2 Laser, Semiconductor Lasers, Rayleigh and Raman scattering, Stimulated Raman effect, Hyper-Raman effect: Classical treatment, Quantum mechanical treatment, Coherent anti-stokes Raman scattering (CARS), Spin- flip Raman Laser, Free-electron Laser. | 15 | 25 |
| 3 | **Quantum Statistical Mechanics**<br>Density operators: properties of density matrix, the density Operators of various ensembles, Examples, Density matrix, Partition function of a system of free particles, monoatomic molecules, diatomic molecules. The ideal Bose gas, Bose-Einstein Condensate. The ideal Fermi Gas, Degenerate Fermi gas, Applications: Black body radiation, Relativistic Fermi gas at T= 0, White dwarf stars. Cluster expansion for a classical gas, expansion of the equation of state, Evaluation of virial coefficients. | 15 | 25 |
| 4 | **Non-equilibrium Statistical Mechanics**<br>Classification of phase transitions, Landau theory of second order phase transition, Examples of phase transitions, Ising model in one and two dimensions, Critical indices, Scaling laws, Boltzmann Transport Equation, Boltzmann H – theorem, Theory of Brownian motion, Diffusion equation. | 15 | 25 |

**Basic Reference book:**

1. Physics of Atoms and Molecules, by B. Bransden and C. J. Joachain (Pearson Education Publication, New Delhi).
2. Fundamentals of molecular spectroscopy, by C. N. Banvel.
3. LASERS Theory and Applications, by K. Thyagarajan and A. K. Ghatak (Macmillan India Ltd., 2008).
4. Lasers and Non-linear Optics, by B. B. Laud (New Age International P Ltd., India, 2ndedition, 1996) .
5. Mechanics, 3rd Ed. by Landau &Lifshitz, Pergamon Press, 1976
6. Statistical Mechanics, by R K Pathria, 2nd Ed. 1996, Butterworth- Heinemann, Ordan Hill, Oxford.
7. Statistical Mechanics, by Kerson Huang, Jhon Wiley & Sons, 1987
8. Thermodynamics and Statistical Mechanics, by Griener, Neise and Stoecker, Springer-Ind., Ed.1997.
9. Statistical Mechanics, by R K Srivastava and J Ashok, Prentice Hall of India, 2005