University of Puerto
Rico Río Piedras
Campus
Faculty of Natural Sciences, Department of Physics
Graduate Programme

Name of Professor Lutful Bari Bhuiyan
Office Hours Mondays, Wednesdays 8 am – 12 noon, 1.30 pm – 3.30 pm Fridays 8 am – 12 noon, 2 pm – 3.30 pm
Telephone (787) 764 0000/extn 88438
e-mail beena@beena.uprrp.edu

Title: **Statistical Mechanics**

Code: PHYS 6454

Number of Hours/Credits: 4/3

Prerequisites: PHYS 6452

Description

Basic concepts, Liouville's theorem for density of points in phase space. Microcanonical ensemble, ergodic theorem, thermodynamic weight, and connection with thermodynamics. Normal systems in Statistical Mechanics, Canonical, Grand-Canonical, and T-P ensembles. Thermodynamic functions associated with various ensembles and the recipes to obtain the thermodynamics. Entropy and its application to ensembles. Fluctuations. Applications of Statistical Mechanics as in Bose-Einstein, Fermi-Dirac, and Maxwell-Boltzmann distributions. Further applications ---- Non-interacting ground state of a Fermi gas, Blackbody radiation, phonons, and Bose-Einstein condensation.

Objectives

After the completion of this course the student

- will learn the basic concepts and techniques of classical and quantum statistical mechanics.
- will be capable of appreciating the statistical mechanics used in the description of condensed matter.
- will have the required background to understand and perform numerical calculations using programming languages to study simple condensed matter systems.

Course Contents

- **Week 1:** Basic concepts. Brief historical perspective of statistical mechanics, Thermodynamic limit, concepts of micro and macro states, phase space trajectory, ergodic surfaces, Ensemble and distribution function in phase space, Liouville's theorem in classical and quantum statistical mechanics.
- **Week 2:** Fundamental theorem of statistical mechanics - postualate of equal a Priori probability , Microcanonical theorem, Ergodic theorem, Thermodnamic Weight, Quantum statistical mechanics, Quantum Liouville's equation, Connection with

thermodynamics - statistical mechanical definitions of entropy and temperature, recipe to get thermodynamics from microcanonical ensemble

- **Week 3,4:** Normal systems in statistical thermodynamics , Ansatz for a normal system and general relations for entropy, Equipartition theorem, Virial theorem, Adiabatic theorem, and Gibbs' pradaox, Thermal contact between two systems, Thermal and particle transferring contact, Thermal and pressure transmitting contact.

- **Week 5,6:** Various ensembles in statistical mechanics -- Canonical ensemble, Grand canonical ensemble, and T-P ensemble.

- **Week 7,8:** Thermodynamic functions associated with various ensembles, Additivities of free energy, thermodynamic potential, and Gibbs free energy. Recipes to obtain thermodynamics in various ensembles. General expression for entropy and its application to the ensembles Fluctuations -- in energy and in particle number.

- **Week 10** Application of statistical mechanics -- Bose-Einstein distribution, Fermi-Dirac distribution, The classical limit and the Maxwell-Boltzmann distribution

- **Week 11**: Applications of Statistical Mechanis (contd) -- Perfect (non- interacting) ground state of a Fermi gas at $T = 0$ and $T < T_F$, Blackbody radiation (photons), Phonons -- Einstein solid versus Debye solid

- **Week 12**: Application of Statistical Mechanics (contd) -- Ising model in 1 and 2 dimensions, Bose-Einstein condensation

Instructional Strategy

The content of the course will be offered in the form of lectures with emphasis in examples of applications to different branches of Condensed Matter Physics.

Minimum Facilities Required

Traditional lecture room.

Student Evaluation

There will be four partial exams of equal weight distributed as follows:
Exam 1: Week 3, will include the materials covered in Weeks 1-2,
Exam 2: Week 7, will include the materials covered in Weeks 3-6,
Exam 3: Week 9, will include the materials covered in Weeks 7,8,
Exam 4: end-of-semester, will include the materials covered in Weeks 9-12.
There will be practice homework assignments containing problems (similar to the exams) to be solved and later discussed in the classroom. Problems in the exams will be based on examples done in class, suggested problems, and homework assignments.

Grading System

The student completing the course work will be graded according to the standard scale A to F.

Text

Statistical Mechanics, Donald A. McQuarrie, University Science Books, 2000, ISBN 978 1891389153

Bibliography

Classic reference *An Introduction to Statistical Mechanics*, Terrell L. Hill, Dover Publications, 1987, ISBN 978 0486652429

Rights of Students with Disabilities

UPR complies with all federal and state laws and regulations regarding discrimination, including the Americans with Disabilities Act 1990 (ADA) and the Commonwealth of Puerto Rico Law *51*. Students receiving services through Rehabilitación Vocacional must contact the professor at the beginning of the semester in order to plan for a reasonable accommodation and any required support equipment according to the recommendations given by the Oficina de Asuntos para las Personas con Impedimentos (OAPI) of the Dean of Students. Likewise, students with special needs that require some type of accommodation must contact the professor.

Academic Integrity

La Universidad de Puerto Rico promueve los más altos estándares de Integridad académica y científica. El Artículo 6.2 del Reglamento General de estudiantes de la UPR (Certificación Núm. 13, 2009-2010, de la Junta de Síndicos) establece que "la deshonestidad académica incluye, pero no se limita a: acciones fraudulentas, la obtención de notas o grados académicos vallándose de falsas o fraudulentas simulaciones, copiar total o parcialmente la labor académica de otra persona, plagiar total o parcialmente el trabajo de otra persona copiar total o parcialmente las respuestas de otra persona o las preguntas de un examen, haciendo o consiguiendo que otra tome en su nombre cualquier prueba o examen oral o escrito, así como la ayuda o facilitación para que otra persona incurre en la referida conducta" . Cualquiera de estas acciones estará sujeta a sanciones disciplinarias en conformidad con el procedimiento disciplinario establecido en el Reglamento general de Estudiantes de la UPR vigente.