Physics 304-01 – Fall 2022
Statistical and Thermal Physics

- Instructor: Dr. Kalum Palandage
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- Office: MC 224A
- Class dates & time: M/W/F 10.00 am – 10.50 am, Location: LIB 174
- Office Hours: Tu/Th 11.00 am – 12.30 pm /by appointment
- Prerequisite: C- or better in Physics 141L and Mathematics 132

Course Description:
A background in statistical and thermal physics is essential for doing research in many of the hottest subfields of physics and related areas, including astrophysics, biological physics, neuroscience, and materials physics. Basic knowledge in these subjects have become even more important since the pandemic. Many of the tools and ways of thinking that we discuss in this course are helpful in understanding the relationship between the large-scale statistics of pandemics and extreme wealth inequality to small scale individual behavior.

Thermodynamics is a general theory of macroscopic systems and statistical mechanics provides a microscopic foundation for thermodynamics. So, this course is about two closely related, beautiful and elegant subjects, regarded as one of the greatest intellectual achievements and, hopefully, you'll be able to appreciate this as we make progress.

Physics 304 focus on the conceptual foundations of statistical and thermal physics in addition to a standalone introduction to probability theory necessary for understanding statistical mechanics and for understanding many problems in our everyday lives. We will also discuss and use computer simulations and numerical analysis throughout the course.

Among the topics to be discussed are probability theory, random variables, laws of thermodynamics, entropy, chemical potential, chemical equilibrium, the properties of gases, liquids, and solids, ensembles, partition functions, Boltzmann, Bose-Einstein, and Fermi -Dirac distributions.

Textbook:
D V Schroeder, *An Introduction to Thermal Physics* (Addison-Wesley Longman 2000)

Supplemental texts:
Knight, *Physics for scientists and Engineers*
Harvey Gould and Jan Tobochnik, Statistical and Thermal Physics
F Reif, *Fundamentals of Statistical and Thermal Physics* (McGraw-Hill)
M J Evans and J S Rosenthal, *Probability and Statistics* (Freeman)

Homework: The purpose of homework in this course is to help you develop a practical understanding of the concepts of statistical physics. Problems will be assigned bi-weekly. To receive full credit for a homework problem, your solution must be (1) complete (i.e., you must, arrive at a solution), (2) printed neatly with intermediate steps shown and final answer boxed or underlined, and (3) turned in at the start of class by the due date. Assignments, solutions and a link to upload your work will be posted on Moodle. Students may discuss homework problems with one another, but each student is to write up his or her own set of solutions.

Exams: There will be Three Exams
Mid-term Exams (in-class): 10/10/2022, 11/21/2022
Final Exam: 12/19/2022, 12 noon – 3 pm.

Mathematical Software (useful for modeling physical systems):
Mathematica, MATLAB, Python
Modern computers permit you to do explorations in statistical physics that Maxwell, Boltzmann, and Gibbs could scarcely have dreamed of. You can use computers to simulate, by means of internal random number generators, a wide

range of stochastic processes such as those descriptive of the diffusion of particles, decay of atomic nuclei, or fluctuations of the stock market, among many possibilities, or solve nonlinear differential equations for which no exact analytical solutions
are known.

Grades: Tentative weighting (subject to change): Exams 70%, Homework 30%

PHYS 304 Topics (subject to modification depending on time constraints)	Approximate period
PROBABILITY Foundations of probability theory Bayes' theorem Combinatorial reasoning: Partitions and occupancy Distributions: Binomial, Poisson, Gaussian, Exponential, Gamma, and others Means and Variances Distribution of sums of random variables Central Limit Theorem	2-3 weeks
THERMODYNAMICS (TD) Heat, work, energy, temperature, pressure & Zeroth Law of TD First Law of Thermodynamics (energy, entropy, work) Ideal gas model Thermodynamic potentials (U, H, F, G) & Legendre transforms Second Law of Thermodynamics (entropy & probability) Entropy & TD Equilibrium (thermal, mechanical, chemical)	5 weeks
STATISTICAL MECHANICS (SM) Principle of Maximum Entropy and the formulation of SM Statistical Ensembles (microcanonical canonical, grand canonical) Partition functions Fermions & Bosons Maxwell-Boltzmann statistics Bose-Einstein statistics Fermi-Dirac statistics Applications of statistical mechanics Einstein model of a solid; Third Law of TD Ideal gas (classical & quantum) Blackbody (thermal) radiation	5 weeks