Sample Syllabus

Nuclear Engineering 406/ Mechanical Engineering 406: Introduction to Statistical Thermodynamics

Spring Semester 2019

INSTRUCTOR: Prof. Donghai Wang
Email: dwang@psu.edu; Office: 134 MRL Building; Tel: 814-863-1287

CLASSES: Monday, Wednesday, and Friday: 9:05 AM – 9:55 PM, 104 Business Bldg

OFFICE HOURS: 134 MRL Building, Monday, by appointment

TEXT: H. B. Callen, Thermodynamics and an Introduction to Thermostatistics (Wiley, New York, 1985), 2nd edition; ISBN 0-471-86256-8.

PREREQUISITES: CHEM 110, MATH 141, and ME300 or equivalent

COURSE INFORMATION:
This course is an introduction to probabilistic and statistical concepts in the physical sciences, which we refer to as "statistical thermodynamics." In areas such as design and processing of electronic devices, materials engineering, chemical engineering, and combustion engineering, the science of statistical mechanics is a particularly necessary, powerful, and important tool for the engineer.

The underlying foundation of statistical mechanics is developed by (1) reviewing the basic ideas from probability theory, (2) deriving the binomial, Poisson, and Gaussian probability distributions, and (3) using these models to analyze several examples taken from science and engineering. To make a connection between macroscopic quantities and the corresponding probabilistic representation, classical thermodynamics is reviewed using the internal energy, entropy, and free energy functions in the context of the first and second laws. Statistical mechanics for classical and quantum-mechanical systems is presented via the micro-canonical, canonical, and grand canonical ensembles using the associated partition functions.

During the syntheses of ideas, applications from various branches of science are presented. Some examples of applications are the Einstein crystal, the Debye crystal, the ideal gas, and black body radiation.

COURSE GRADES:

First Mid-term Examination	23%
Second Mid-term Examination	23%
Final Examination	30%
Homework	24%
Class Participation.	3%

Late drops prior to first exam -WN
Late drops after first exam:
With a score ≥ 60% -WP
With a score < 60% -WF

Approximate cutoffs:

Total points	93 - 100	90 - 92	87 – 89	83 - 86	80 - 82	77 - 79	70 - 76	60 - 69	Below 60
Letter grade	A	A-	B+	B	B-	C+	C	D	F

ATTENDANCE:
Due to the nature of this course and the fact that the test material will be discussed in class, it is assumed that those who regularly attend lectures will do better; therefore attendance is very important. Those who are habitually late or disruptive will forfeit the 3% class participation grade.

HOMEWORK FORMAT:
All homework should be in the following format, unless it is an open-ended question.

GIVEN: Include a sketch if possible.
ASSUMPTIONS: These need to be justified if they are atypical.
PROBLEM STATEMENT: What is unknown that we are asked to find.
SOLUTION: Solve the problem, step-by-step, and *always include units*. **Box the final answer.**

Note: The most important thing to me is that the solution method is coherent and systematic. One of the major tools you should leave this course with is enhanced engineering problem solving methodology.

Homework schedules approximately every other week.

LATE HOMEWORK:
Homework turned in after the date due will have 15% taken off the grade per weekday it is late, with no exceptions.

HOMEWORK SOLUTIONS:
Will be put available on Canvas.

CLASS NOTES:
The student version of electronically presented lectures will be available on the Canvas web page.

COURSE SCHEDULE:

Week 1: Basic postulates of probability theory

Week 2: Conditional probability, counting methods, permutations and combinations

Week 3: Binomial distribution with examples

Week 4: Poisson distribution and Gaussian distribution, mean and variance, discrete distributions and density functions

Week 5: Review of probability models and Midterm Exam 1 (evening exam)

Week 6: Applications of probability models including radioactive decay

Week 7: Review of classical thermodynamics; connection between thermodynamics and classical mechanics

Week 8: First law of thermodynamics; quasi-static, reversible, and irreversible processes

Week 9: Second law of thermodynamics; extremum principles

Week 10: Review of application probability models and Midterm Exam 2 (evening exam)

Week 11: Legendre transforms, free energy, and chemical potential; applications

Week 12: Statistical mechanics in the entropy representation; principle of equal *a priori* probability, statistical definition of the entropy

Week 13: Einstein crystal and two-state system and their thermodynamics

Week 14: Helmholtz representation and the canonical ensemble; thermodynamic functions of the canonical ensemble

Week 15: Harmonic crystals, the Debye crystal model and heat capacities of Debye crystals

Additional References:

F. Reif, Fundamentals of Statistical and Thermal Physics, (McGraw-Hill, NY, 1965).

T. L. Hill, An Introduction to Statistical Thermodynamics, (Dover Publications, NY, 1986, reprint); (Addison-Wesley, Reading, MA, 1960, original).

ACADEMIC DISHONESTY:
Academic dishonesty will not be tolerated ***at all***. I hope that everyone can develop enough pride in his or her own work and abilities that this will never be a problem. It is encouraged, however, to discuss problems solving techniques with classmates in study groups as long as each person does their own work. Absolutely no copying of homework/quizzes etc. will be tolerated. Evidence of academic dishonesty will be dealt with by University Policy 49-20, described at: http://senate.psu.edu/policies-and-rules-for-undergraduate-students/47-00-48-00-and-49-00-grades/#49-20

ADDITIONAL INFO:
Penn State welcomes students with disabilities into the University's educational programs. If you have a disability-related need for reasonable academic adjustments in this course, contact the Office for Disability Services (ODS) at 814-863 1807 (V/TTY). For further information regarding ODS, please visit the Office for Disability Services Web site at http://equity.psu.edu/ods/.

In order to receive consideration for course accommodations, you must contact ODS and provide documentation (see the documentation guidelines at http://equity.psu.edu/student-disability-resources/applying-for-services/applying-for-services). If the documentation supports the need for academic adjustments, ODS will provide a letter identifying appropriate academic adjustments. Please share this letter and discuss the adjustments with your instructor as early in the course as possible. You must contact ODS and request academic adjustment letters at the beginning of each semester.