Physics 312 – Thermodynamics and Statistical Mechanics - Spring 2014

Professor: Dr. Ryan E. Johnson, Masters Hall 205, x6021, rjohnson@gettysburg.edu

Office Hours: MWTh 3:00 – 4:00 pm

Course Description:
This is an upper level course in thermal physics and an introduction to statistical mechanics. No prior knowledge of thermal physics is assumed, however this course does require a working knowledge of both partial differential and integral calculus.

At its heart, thermodynamics is the study of energy flow into or out of a system and that system’s response to this change. Thermodynamics began as an empirical science, where bulk properties of matter (conductivity, heat capacity, specific heat), and how these properties change, were determined experimentally. Only many decades later was a theory developed to explain why these properties changed the way they did. This theory posited that the bulk properties of materials could be derived from a thorough understanding of the molecules that comprise the material. Initially called the “kinetic theory of gases,” it was now referred to as statistical mechanics.

Statistical mechanics examines the dynamics of the molecules that make up material and provides a framework within which thermodynamics gains meaning. The reason that many physics programs will use statistical mechanics in lieu of a thermodynamics course is that statistical mechanics predicts the laws that were empirically derived in thermodynamics. This idea that studying the very small can inform us about the very large is central to this course.

Meeting Times: MWF 11:00-11:50 am, recitation hour TBD

Course and Curricular Goals
This course supports the Physics department’s curricular goals by providing:
• An understanding of the concepts and techniques basic to our present understanding of the physical universe.
• A broad understanding of physical phenomena, principles and theories.
• A skill in problem solving and mathematical analysis techniques.
• A familiarity with specific topics valuable for graduate school, teaching, or technical careers.

Textbook and Required Materials
An Introduction to Thermal Physics by Daniel V. Schroeder
Scientific/Graphing Calculator

Grading
Your course grade will be computed from a combination primarily of quizzes, exams and homework using the following weights:
3 exams (12% each, 36% total)
cumulative final exam (24%)
homework (10%)
quizzes (25%)
in-class work/participation (5%)

At a minimum, letter grades are assigned by your percentile score (i.e. the range 60-70 is some kind of D, 70-80 is some kind of C, 80-90 is some kind of B and 90-100 is some kind of A). So if you score 81 percent, you are guaranteed at least a B-. Late homework will not be accepted for credit and any work missed due to an unexcused absence will be given a zero.

Exams
You will be given three midterm exams in this class, each comprising 12% of your final grade. The cumulative final exam will be worth twice a midterm exam. The tentative (except for Final) exam dates are: Exam #1 - 2/14, Exam #2 - 3/21, Exam #3 - 4/11, Final Exam on Saturday, May 10 (8:30-11:30 am).

Homework and Quizzes
Homework will be assigned weekly and due the following week. Your work will be checked for correctness but your grade will be assigned primarily based on completeness. The reason for this is that I want homework to be a formative exercise; practice, if you will. Since your work will be primarily graded for completeness, your motivation for completing the homework correctly will be that some fraction of the homework problems will reappear on weekly in-class quizzes. During the recitation following when the assignment is due, you will have an opportunity to review/complete any problems you missed in advance of the quiz.

Fourth Hour/Recitation
A recitation is a regularly scheduled weekly session designed to review and apply concepts presented in the lecture portion of the course. The recitation is designed to provide structure to your individual study time and homework review. The intent is to help optimize the time that you spend on studying by providing you a supportive and efficient environment in which to work. During the recitation, you will have the opportunity to review your homework problems in small groups with one another and myself. This will provide you an opportunity to prepare for the following class’ quiz. Recitation attendance is a mandatory part of the course.

During those weeks where a midterm exam is given, or after exams are handed back, I may also use the recitation time to review the exam to help you better understand problems you may have missed.

In-Class Work and Participation
Often we will stop in class to ponder questions and/or solve problems. In some instances, I will ask that you write your responses down on small white boards and present them to me. Whether you are working alone, or in small groups, each person is responsible for participating in these activities. In-class work will include conceptual questions, quantitative problems, and anything else that helps us process and think through new material. When you come to class you should be prepared, engaged and ready to think on your feet.

Late work/absences
Late work will not be accepted without a valid excuse and unexcused absence from class will result in a zero for any missed material. If you expect to miss class for some reason you should let me know as early as possible. I understand that on very rare occasions students will have valid reasons (for example: medical or family emergencies) that will cause them to miss material covered in class. To accommodate these situations, I will drop your 2 lowest quiz scores at the end of the term. I also have the following grade replacement policy regarding exams: If your score on the final exam is higher than at least one of your exam grades, your final exam grade will replace your lowest exam score. Naturally, if you must miss an exam due to an emergency, the missed exam (graded as a zero) will be your lowest exam score and is
eligible to be replaced by your grade on the final. For example, a student scores a 70, 80, and 90 on their three exams, and then scores an 80 on the final. The student’s lowest exam score (a 70) will then be replaced with their final exam score (an 80). If a student were instead to have an unexcused absence during the second exam, they would be given a zero and their three exam scores would be 70, 0, and 90. In this case, their final exam score would still replace the lowest exam score (a zero in this case). This policy is meant to offset a poor performance on one exam, for whatever reason, and should not be used as an excuse to miss an exam entirely. Remember that the final exam is cumulative, and the three midterm exams are the best source of studying for material that may be on the final.

**Cellphones/Smartphones/Computers in class**

Unless you have a documented special need, I do not permit the use of cellular phones or computers in class. Despite the potential usefulness of these devices in the classroom, experience has shown them to be more often a distraction than anything else. I expect all cellular/smart phones to be silenced and put away during every class.

**Academic Integrity and the Gettysburg Honor Code**

Any instance of academic dishonesty in any aspect of this course will result in severe consequences, including possible failure of the course. While you may work together on homework assignments, there is a stark difference between collaborative work and submitting another’s efforts as your own. While you are encouraged to work together to complete homework assignments, the work that you hand in must be born of your own efforts and knowledge. Submitting work that is not born of your own efforts, and in your own words, not only robs you of the opportunity to learn but also lessens the academic integrity of the entire institution. Neither ignorance nor carelessness is an acceptable defense in cases of plagiarism. A guideline for whether a collaborative effort could be considered plagiarism is to ask yourself the question: Could I reproduce all of the work I am handing in without the aid of any person and using only those sources I have specifically cited in the assignment? If you are at all in doubt about whether your planned course of action would violate the Gettysburg Honor Code, ask me before continuing. Your academic integrity is extremely important at Gettysburg and, as such, the lack thereof will be met with serious consequences.
**Tentative Schedule**

The following schedule of topics and the relevant text chapters is to be used as a guide for your reading. This schedule is tentative in that the topics we discuss each day may warrant more or less time than I’ve allotted. Each topic is listed with the corresponding chapter in the text in parentheses. You are expected to have read the appropriate sections on each topic **before** the week they are listed on the syllabus. For each exam, I have listed the chapters I expect to contain testable material at that point.

<table>
<thead>
<tr>
<th>Week Beginning</th>
<th>Topics/Chapters</th>
<th>Important Dates</th>
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<tbody>
<tr>
<td>1/20</td>
<td>Introduction, Ideal Gases, and Equipartition of Energy (1.1-1.3)</td>
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<tr>
<td>1/27</td>
<td>Heat and Work, Compression Work, Heat Capacities, Thermal Conductivity (1.4-1.7)</td>
<td>HW #1 due, Quiz #1</td>
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<tr>
<td>2/3</td>
<td>Two-State Systems, Einstein Model of a Solid, Interacting Systems (2.1-2.3)</td>
<td>HW #2 due, Quiz #2</td>
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<td>2/10</td>
<td>Large Systems and Multiplicities of Large Systems (2.3-2.5)</td>
<td>HW #3 due, Quiz #3, Exam #1 (1.1-2.3) on Fri (2/14)</td>
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<td>2/17</td>
<td>Entropy and the 2(^{nd}) Law (2.6), Temperature and Heat (3.1-3.2)</td>
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<td>2/24</td>
<td>Mechanical Equilibrium and Pressure (3.4) Diffusive Equilibrium and Chemical Potential (3.5-3.6)</td>
<td>HW #4 due, Quiz #4</td>
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<td>3/3</td>
<td>Heat Engines and Refrigerators (4.1-4.2)</td>
<td>HW #5 due, Quiz #5</td>
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<td>3/10</td>
<td>Spring Break</td>
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<td>3/17</td>
<td>Free Energy as Available Work and a Force toward Equilibrium (5.1-5.2)</td>
<td>Exam #2 (2.3-4.2) on Fri (3/21)</td>
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<td>3/24</td>
<td>Phase Transitions of Pure Substances (5.3) The Boltzmann Factor, Partition Function and Average Values (6.1-6.2)</td>
<td>HW #6 due, Quiz #6</td>
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<td>3/31</td>
<td>Equipartition Theorem and Maxwell Speed Distribution (6.3-6.4) Partition Function and Ideal Gas Revisited (6.5-6.7)</td>
<td>HW #7 due, Quiz #7</td>
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<td>4/7</td>
<td>The Gibbs Factor (7.1) Bosons and Fermions (7.2)</td>
<td>HW #8 due, Quiz #8 Exam #3 (5.1-6.7) on Fri (4/11)</td>
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<td>4/14</td>
<td>Degenerate Fermi Gases and Blackbody Radiation (7.3-7.4)</td>
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<td>4/21</td>
<td>CMB (7.4) Debye Theory of Solids (7.5)</td>
<td>HW #9 due, Quiz #9</td>
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<td>4/28</td>
<td>Bose-Einstein Condensation 7.6 Final Review</td>
<td>HW #10 due 5/2 - Last day of classes</td>
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<td>5/5</td>
<td>Finals Week – no classes</td>
<td>Final Exam Sat, May 10 (8:30-11:30am)</td>
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