PHY 416, THERMAL PHYSICS

Course Syllabus

I. Basic Information

Instructor: Dr. R. J. Pfeiffer

Office: P-134 Science Complex (Physics Department) Telephone: 771-2557, or 771-2569 (Dept. No.)

Office Hours: Mon. and Thurs. 14:00 – 15:20; other times by appointment of course.

Text: Sears and Salinger, Thermodynamics, Kinetic Theory, and Statistical Thermodynamics, third edition, 1970, Addison-Wesley (Now Brooks Cole Longman).

References:

Carter, A. H. 2001, Classical and Statistical Thermodynamics, Prentice Hall, Upper Saddle River, NJ.
Espinola, T. P. 1994, Introduction to Thermophysics, Wm. C. Brown Publishers.
Schroeder, D. V. 2000, An Introduction to Thermal Physics, Addison-Wesley.
Also see the Bibliography in Carter, page 413.

Purpose Statement:

PHY 416 is a required upper level course in the physics curriculum for all physics majors entering as of Fall 2010, and is a mandatory course for those in the in Liberal Arts Physics Track prior to Fall 2010. The course is intended to provide physics majors with the mathematical skills and background knowledge necessary to perform in the area of thermodynamics, kinetic theory, and statistical physics. The course is also aimed at showing how the concept of the internal energy of a system and the laws of thermodynamics are germane to all branches of physics.

Course Description:

The course is scheduled for two 80-minute periods of lecture per week. The subject matter of the course includes the interrelationships between temperature, thermal energy, work, and entropy, and how these quantities are involved in the interactions of physical systems. The main topics covered are thermodynamic coordinates or variables, equations of state, the laws of thermodynamics, adiabatic processes, heat engines, kinetic theory of atoms, and statistical thermodynamics.

Prerequisites: PHY202, PHY306, and CSC215 or equivalent.

Course Outline and Schedule (tentative):

Chapters noted are my chapters. The corresponding Chapters in Carter are in parentheses and labeled as C, for those who like to frequent the Library.

Week 1, Chap. 1 & 2 (C, Chp.1 & 2)

A. Basic concepts and principles
B. Thermodynamic systems, processes, and variables
C. Pressure
D. Equations of state

Week 2, Chap. 2 & 3 (C, Chp. 2 & Append. A)

A. Meaning of partial derivatives.
B. Compressibility and expansivity.
C. Exact and inexact differentials.
D. Relationships among partials.

Week 3, Chap. 4 (C, Chp. 3 and 4)

A. Heat and Work, by and on a system.
B. Cyclic processes
C. Adiabatic processes
D. Internal energy
E. Heat capacities

Week 4, Chap. 4 (C, Chp. 4 & 5)

A. Phase changes and enthalpy
B. Conservation of Energy and the first law.
C. Consequences of the first law of thermodynamics

Week 5, Chap. 5 (C, Chp. 5 & 6)

A. Gay-Lussac-Joule Experiments
B. Adiabatic equations
C. Carnot cycle
D. Heat engines

Week 6, Chap. 5 (C, Chp. 6)

A. The 2^{nd} Law and entropy
B. The Caratheodory Principle

Week 7, Chap. 6 (C, Chp. 6 & 7)

A. Combined 1^{st} and 2^{nd} laws
B. The Tds equations and applications.

Week 8, Chap. 7

A. Thermodynamic potentials (C, Chp. 8)
    1. The Helmholtz function
    2. The Gibbs function
    3. The chemical potential (C, Chp. 9)
B. The Third Law of Thermodynamics (C, Chp 10)

Week 9, Chap. 9 (I have no Chap. 8)

Kinetic theory of matter (C, Chp. 11.1 – 11.6)

A. Molecular flux
B. Pressure as the time average of molecular momentum changes
C. The equipartition of energy.
D. Theory of specific heat capacity

Week 10, Chap. 10

The Maxwell velocity distribution function (C, Chp. 11.6)

Week 11, Chap. 11 (C, Chp. 12)

A. Energy States and quantum theory
B. Degeneracy
C. Macro and micro states

Week 12, Chap. 11 & 12 (Not yet completed)

A. Thermodynamic probability (C, Chp. 12.4)
B. Boltzmann Statistics (C, Chp. 13.1 -13.3)

Week 13, Chap. 11(C, Chp. 13.4 – 13.5)

A. Bose-Einstein statistics

B. Fermi-Dirac statistics

Tests:

There will be three given during the semester, one about every 5 weeks. This includes a final examination that will be held during the formal final examination period as scheduled by the registrar. The final exam will constitute approximately 30% of a student's grade. In addition, there may be a few quizzes. Students are advised to do all the assigned homework and to keep up with their studies.

Homework Problems:

There will be more than 100 assigned homework problems, including problems that involve computer programming. Some of these problems will be graded and included in the computation of one's course grade. Students are responsible to know how to solve all assigned problems for testing.

All homework problems are to be adequately annotated or the assignment will be returned ungraded. Use only 8 1/2 by 11-inch paper only, without serrated edges, for all assignments and tests. Write on only one side of each page and start a new problem on a new page. All pages for a given problem must be stapled together, but since each problem will be separately filed and graded, DO NOT staple together the pages of different problems. Students who fail to comply with the above instructions, and insist on bringing about unnecessary increases in the entropy of the universe, must suffer the consequences.

S**ee the WEB document, *Assignments*, for assigned homework and all scheduling.**

II. Learning Goals

A. Content Goals

1. An understanding of the interrelationships among the various branches of physics.
2. To enhance a student's ability to analyze data, find correlations between variables, and draw conclusions.
3. To demonstrate how scientists make hypotheses based on data analysis.
4. To provide a background to assist students in making judgments based on sound scientific principles
5. A working knowledge of the relationships among work, heat, and temperature.
6. A working knowledge of the laws of thermodynamics and how they are applied to analyze a system.
7. A development of the mathematical techniques used for modeling a thermodynamic system.
8. An understanding of the role temperature plays in the kinetic theory of matter.
9. The mathematical methods used to statistically describe the interactions taking place among a large collection of particles that constitute a system.
10. How the statistical average of a large number of microscopic interactions gives rise to a macroscopic parameter that can be directly measured.

B. Performance Goals

1. To be able to analyze data, find correlations between variables, and draw conclusions.
2. To be able to make hypotheses based on data analysis.
3. To be able to make judgments based on sound scientific principles,
4. To be able to apply the laws of thermodynamics
5. To be able to apply the concepts of statistical physics to a variety of problems.
6. To be able to utilize thermodynamic principles, concepts, and methods in other advanced courses, in graduate school, or on the job as a physicist.

III. Student Assessment

Grading Criteria:

1. Perform well on all tests and achieve passing grades.
2. Complete all assigned problems in a satisfactory manner and on time.
3. Complete all other assignments satisfactorily

4. Instructor's judgment of a student's achievement and mastery of the course subject matter.
5. Students will be expected to write computer programs as part of some assignments.

Computation of Course Average and Grade:

A student's course grade will depend mainly on the weighted mean of all test and homework scores. The latter is found by adding together all the points a student has earned on all tests and assignments (total earned course points) and dividing this sum by the total number of possible course points. The grand percentage for each student will be assigned a course letter grade depending on the instructor's analysis of the distribution of the scores for all students in the course.

The following is a partial example for a hypothetical student:

Test #1: 205 out of 210 points
Test #2: 190 out of 220 points
Quiz #1: 18 out of 20 points
Hmwrks: 230 out of 280 points
Final Exam: 300 out of 340 points

Sums: 943 earned course points out of 1070 total number of possible course points.

This is a grand percentage equal to 943 / 1070 = .881 = 88%.

This grand percentage is converted to a letter grade (A, A-, B+, ... F) for the course after the instructor examines the distribution of all such percentages for all the students in the class. This is often referred to as "curving." For example, an 88% usually translates to at least a B+. However, curving may translate an 88% to be a higher letter grade such as A-, but a curve will not lower a grade.

IV. Learning Activities

The learning activities incorporated into this course are lecture-discussions. Oral quizzing of the class will be used to stimulate good study habits. The breadth and depth of the course work will require students to invest a goodly amount of time outside the classroom reading, solving problems, completing reports, and interacting with one another in study groups as well as with the instructor.

Additionally students are assigned computer programming projects to model systems and compute the results of interactions. There is usually a goodly amount of student-instructor interaction and consultation for such projects.

V. Selected TCNJ Policies

TCNJ's final examination policy is available on the web: http://www.tcnj.edu/~academic/policy/finalevaluations.htm

Attendance:

Every student is expected to participate in each of his/her courses through regular attendance at lecture and laboratory sessions. It is further expected that every student will be present, on time, and prepared to participate when scheduled class sessions begin. At the first class meeting of a semester, instructors are expected to distribute in writing the attendance policies which apply to their courses. While attendance itself is not used as a criterion for academic evaluations, grading is frequently based on participation in class discussion, laboratory work, performance, studio practice, field experience, or other activities which may take place during class sessions. If these areas for evaluation make class attendance essential, the student may be penalized for failure to perform satisfactorily in the required activities. Students who must miss classes due to participation in a field trip, athletic event, or other official college function should arrange with their instructors for such class absences well in advance. The Office of Academic Affairs will verify, upon request, the dates of and participation in such college functions. In every instance, however, the student has the responsibility to initiate arrangements for make-up work.

Students are expected to attend class and complete assignments as scheduled, to avoid outside conflicts (if possible), and to enroll only in those classes that they can expect to attend on a regular basis. Absences from class are handled between students and instructors. The instructor may require documentation to substantiate the reason for the absence.

Students must have a valid and documented excuse for missing a scheduled test or they will incur a failure. All other appointments must be made scheduled at times that do not conflict with scheduled test times. If a test is missed because of an emergency and the instructor cannot be informed prior to the time of a scheduled test, a student must arrange for a rescheduled test at the earliest opportunity and no later than the first day they return to class.

The instructor should provide make-up opportunities for student absences caused by illness, injury, death in the family, observance of religious holidays, and similarly compelling personal reasons including physical disabilities. For lengthy absences, make-up opportunities might not be feasible and are at the discretion of the instructor. The Office of Academic Affairs will notify the faculty of the dates of religious holidays on which large numbers of students are likely to be absent and are, therefore, unsuitable for the scheduling of examinations. Students have the responsibility of notifying the instructors in advance of expected absences. In cases of absence for a week or more, students are to notify their instructors immediately. If they are unable to do so they may contact the Office of Records and Registration. The Office of Records and Registration will notify the instructor of the student's absence. The notification is not an excuse but simply a service provided by the Office of Records and Registration. Notifications cannot be acted upon if received after an absence. In every instance the student has the responsibility to initiate arrangements for make-up work.

TCNJ's attendance policy is available on the web: http://www.tcnj.edu/~recreg/policies/attendance.html

Academic Integrity Policy

Academic dishonesty is any attempt by the student to gain academic advantage through dishonest means, to submit, as his or her own, work which has not been done by him/her or to give improper aid to another student in the completion of an assignment. Such dishonesty would include, but is not limited to: submitting as his/her own a project, paper, report, test, or speech copied from, partially copied, or paraphrased from the work of another (whether the source is printed, under copyright, or in manuscript form). Credit must be given for words quoted or paraphrased. The rules apply to any academic dishonesty, whether the work is graded or ungraded, group or individual, written or oral.

TCNJ's academic integrity policy *is available on the web:* http://www.tcnj.edu/~academic/policy/integrity.html.

Americans with Disabilities Act (ADA) Policy

Any student who has a documented disability and is in need of academic accommodations should notify the professor of this course and contact the Office of Differing Abilities Services (609-771-2571). Accommodations are individualized and in accordance with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1992. TCNJ's Americans with Disabilities Act (ADA) policy is available on the web:
http://www.tcnj.edu/~affirm/ada.html .

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