Syllabus
Physics 404
Introduction to Thermodynamics and Statistical Mechanics
Spring 2005

Meeting Time: Tues./Thurs. 12:30-1:45 P.M.
Place: Room 1402, Physics

Instructor: J.R. Anderson; Office - Physics 2346; Phone – (301)-405-6142
Office Hours – Mon. 1:30-3:00 P.M.; Wed. 10:00-11:30 A.M.
TA: To be announced Office -
Office Hours –
Text: **Thermal Physics** (1997 printing), by Charles Kittel and Herbert Kroemer

Supplementary Texts: **Elements of Classical Thermodynamics** by A.B.Pippard.
Heat and Thermodynamics by M.W. Zemansky and H.R. Dittman
Statistical Physics by F. Reif
Thermal Physics by R. Baierlein

Grading: Homework will count for about 30% of your grade. Homework will be assigned approximately weekly and will be due at the beginning of class on days to be announced. You are responsible for knowing the homework assignments and due dates. Late homework will be accepted - with a valid excuse.

There will be two hour exams, each of which will count for about 20% of the course grade.

The final exam will cover the entire course and will account for about 30% of the course grade.

Absence from exams will be dealt with according to Standard University Policy.

Course Outline (Tentative): Chapters 1-10 and 12 of your text; any additional time will be devoted to special topics from the text, for example the Boltzmann transport equation or semiconductors.

Office Hours: To be arranged later to fit with your schedules and mine. You are welcome to telephone or drop by anytime or to make an appointment.

Advice: "The statistical approach which the text uses depends upon your understanding a tightly-reasoned sequence of ideas, with essential concepts introduced from the beginning. *Keep up with the class, ask questions, come to office hours, and* ***do the homework***." Feedback from you is important. Let me know if I am going too fast. Since t*his is a small class, we can be very informal and you may ask questions and comment at any time.*

Physics 404
Semester Schedule (First Approximation)
Spring 2005

Date (Day/Month)	Reading Assignment* (Chapt.)	Homework**	Date Due (Day/Month)
27/1-2/2	Intro. and **Ch**-1	#1	3/2
3/2-9/2	**Ch**-1 & **Ch**-2	#2	10/2
10/2-16/2	**Ch**-2 &**Ch**-3	#3	17/2
17/2-23/2	**Ch**-3 & Probability	#4 (Prob.)	24/2
24/2-1/3	**Ch**-4 & Review	#5	2/3
3/3	Exam I		
8/3-15/3	**Ch**-5	#6	17/3
16/3-29/3	**Ch**-6	#7	31/3
30/3-5/4	**Ch**-7	#8	5/4
7/4-12/4	Review & Exam II (12/4)		
14/4-19/4	**Ch**-8	#9	20/4
20/4-26/4	**Ch**-9	#10	26/4
27/4-3/5	**Ch**-10	#11	3/5
4/5-12/5	**Ch**-12	#12	12/5
11/5	Review		
20/5	**Final Exam** (Scheduled for 1:30 P.M.-3:30 P.M. in Phys. 1402***)		

* All assignments are from Kittel and Kroemer unless specified otherwise.
** Homework assignments, preliminary version, are given below. **Any modifications in homework assignments will be announced in class. You are responsible for knowing the correct assignments.** The majority of the problems will be from Kittel and Kroemer.
*** By unanimous agreement of all, including me, the date and time of the final exam may be changed.

Homework Assignment 1. <u>Read the relevant chapters in your introductory physics text and answer the following questions</u>

1. Briefly describe the absolute temperature scale.

2. The volume expansion of liquid mercury is given by

$$V_t = V_0(1 + 1.8182 \times 10^{-4}t + 7.8 \times 10^{-9}t^2),$$

where t is the true temperature in ^{0}C and V_0 is the volume at 0^0C. If the mercury is placed in a quartz tube (quartz has essentially zero volume thermal expansion), and the change in length of the mercury used as a thermometric parameter (the length changes now being volume changes, in effect), calculate $\Delta t = t_{Hg} - t$ at 25^0, 50^0, and 75^0C (t_{Hg} is the temperature measured by the Hg thermometer. (Hint: This is an easy problem with a calculator.)

3. a) Define heat capacity and specific heat. What are the SI dimensions of those quantities?

b) How would you measure the heat capacity of water, using a thermos bottle, a thermometer, a waterproof 100 Ω resistor, a battery, and electrical meters?

4. A hypothetical gas thermometer experiment (using an ideal constant volume gas thermometer) gave the following data for the fixed points:

$$P_{ice} = 760.00 \text{ mm Hg and } P_{steam} = 1039.00 \text{ mm Hg.}$$

The thermometer was then placed in liquid hydrogen boiling under atmospheric pressure, and a pressure of 56.17 mm Hg was found.

a) Using the two-fixed-point method and assuming an ideal gas, calculate the Celsius temperature of the boiling point of liquid hydrogen and the value of absolute zero given by these data. From these, calculate the absolute temperature of the boiling point of liquid hydrogen.

b) Use the single-fixed-point or Giauque proposal to calculate both the boiling point of hydrogen and the boiling point of steam from the above data and compare with part a) and 100^0C, respectively. (The Giauque proposal consists in setting a single fixed point, the triple point of water, at 273.16 K. Assume the reference pressure P_0 is 760 mm of Hg.)

5. State the first law of thermodynamics, defining any symbols you use in an equation.

6. Show the configurations that give the degeneracies indicated by the parentheses in Fig. 1.1 of K & K for the two lowest-lying levels of

a. Li (2) and (6)

b. B. (6) and (12).

Use the Hund's Rule hypothesis and refer to a modern physics text on atomic spectra if you need help.

7. a. If the number of spins N is an odd number, show that Eq. 14 of Chapter 1 in K&K is still valid.

b. What are the values of s in this case?

c. Evaluate g(N,s) for all allowed values of s if N = 5.

8. Calculate the maximum value of g(N,s) in Chapt. 1 by the exact formula (Eq. 37) and by the approximate formula (Eq. 35) and compare the results. Make the calculation for all even values of N up to and including 20. Show your results in a table with the four columns shown below:

N	g(exact)	g(approx.)	[g(approx.)-g(exact)]/g(exact)

What can you conclude about the validity of the approximation?

Homework 2

1. Kittell & Kroemer, Chapt. 2, Prob. 1

2. Kittell & Kroemer, Chapt. 2, Prob. 2

3. Kittell & Kroemer, Chapt. 2, Prob. 3

4. Kittell & Kroemer, Chapt. 2, Prob. 4

5. Kittell & Kroemer, Chapt. 2, Prob. 5

6. A block of metal is slightly confined by its surroundings. Initially, it is at a temperature of 20^0C and a pressure of one atmosphere. When the temperature rises by 12 ^{0}C, its volume is observed to increase by one part in 10^4. What is its final pressure? Assume $\beta = 5x10^{-5}$ deg^{-1} and $K_T = 6.7x10^{-7}$ atmos^{-1}.

Homework 3

1. Kittel & Kroemer, Chapt. 3, Prob.1

    a. Find the free energy from the partition function.

    b. Find U and σ from F.

    c. From part b. find C_v. This is the Schottky anomaly for a two-state system.

    d. Sketch $U(\tau)/\varepsilon$ and C_v versus τ/ε as shown in Fig. 3.4 and show the limits for τ/ε =0 and $\tau/\varepsilon \rightarrow\infty$.

    e. Estimate the value of τ/ε at which the maximum in C_v occurs and discus the physical reason for this maximum.

2. Kittel & Kroemer, Chapt. 3, Prob. 9

3. Kittel & Kroemer, Chapt. 3, Prob. 2

    Use the generalization of Prob. 2 above that the partition of N independent distinguishable systems is

    Z(1+2+3+...+N) = Z(1)Z(2)Z(3)....Z(N).

4. Kittel & Kroemer, Chapt. 3, Prob. 3

    It is not necessary to convert this partition sum to an integral. The sum can be evaluated exactly. Note that $e^{sx} = [e^x]^s$.

5. Kittel & Kroemer, Chapt. 3, Prob. 4

6. Kittel & Kroemer, Chapt. 3, Prob. 6

7. Kittel & Kroemer, Chapt. 3, Prob. 11