Course Outline

UNIVERSITY OF CALGARY
DEPARTMENT OF PHYSICS and ASTRONOMY
COURSE OUTLINE

1. Course: **Physics 449, Statistical Mechanics**

   Lecture/Time/Session(s): L01; TR, 15:30-16:45, SB 105, Fall 2013

   Instructor(s): Dr. D.L. Feder **Office:** SB 535, 220-3638
   Office Hours: T, 13:30-15:30
   Email: dfeder@ucalgary.ca
   Physics and Astronomy Office: SB 605, 220-5385

   Course website: http://people.ucalgary.ca/~dfeder/449

2. Prerequisite(s): Physics 325: Applied Mathematics 219 or Mathematics 253 or 263.

3. **GRADING**: The University policy on grading and related matters is described sections F.1 and F.2 of the online University Calendar. In determining the overall grade in the course the following weights will be used:

Weekly Previews	10%
Assignments	40%
Midterm Examination	25% (date to be determined by common consent)
Final Examination	25% (to be scheduled by the registrar)

   A table of conversion from final course percentage to final course letter grade can be found on the Phys 449 site.

   There will be a final examination scheduled by the Registrar's Office.

4. **Missed Components of Term Work**. The regulations of the Faculty of Science pertaining to this matter are found in the Faculty of Science area of the Calendar in section 3.6: **http://www.ucalgary.ca/pubs/calendar/current/sc-3-6.html**. It is the student's responsibility to familiarize himself/herself with these regulations. See also **http://www.ucalgary.ca/pubs/calendar/current/e-3.html**.

5. **TEXTBOOK:** There is no official textbook for this course, but we will be loosely following "*An Introduction to Thermal Phy* Daniel Schroeder (Addison-Wesley, 2000). Other suggestions for textbooks can be found on the course website.

6. **EXAMINATION POLICY**: Students are encouraged to read the Calendar, Section G, on Examinatic **http://www.ucalgary.ca/pubs/calendar/current/g.html**

7. **Writing across the curriculum**: In this course, the quality of the student's writing in laboratory reports will be a factor in the evaluation of those reports. See **also http://www.ucalgary.ca/pubs/calendar/current/e-2.html**.

8. OTHER IMPORTANT INFORMATION FOR STUDENTS:

(a) **Academic Misconduct:** (cheating, plagiarism, or any other form) is a very serious offence that will be dealt with rigorously in all cases. A single offence may lead to disciplinary probation or suspension or expulsion. The Faculty of Science follows a zero tolerance policy regarding dishonesty. Please read the sections of the University Calendar under Section K, Student Misconduct to inform yourself of definitions, processes and penalties

(b) **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on assembly points.

(c) **Academic Accommodation Policy:** Students with documentable disabilities are referred to the following links: Calendar entry on students with disabilities and Student Accessibility Services.

(d) **Safewalk:** Campus Security will escort individuals day or night (http://www.ucalgary.ca/security/safewalk/). Call 220-5333 for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.

(e) **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). As one consequence, students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information see also http://www.ucalgary.ca/secretariat/privacy.

(f) **Student Union Information:** VP Academic Phone: 220-3911 Email: suvpaca@ucagary.ca.
SU Faculty Rep. Phone: 220-3913 Email: sciencerep@su.ucalgary.ca
Student Ombudsman

(i) **Internet and Electronic Device Information:** You can assume that in all classes that you attend, your cell phone should be turned off unless instructed otherwise. Also, communication with other individuals, via laptop computers, Blackberries or other devices connectable to the Internet is not allowed in class time unless specifically permitted by the instructor. If you violate this policy you may be asked to leave the classroom. Repeated abuse may result in a charge of misconduct.

Here's the breakdown of the material. This table of contents is pulled directly from the course notes.

1. Energy in Thermal Physics (First Law of Thermodynamics)
    (a) Thermal Equilibrium
    (b) The Ideal Gas
    (c) Thermodynamic Derivation
    (d) Mechanical Derivation
    (e) Equipartition of Energy
    (f) Heat and Work
    (g) Compression Work: the Adiabat
    (h) Heat Capacity
2. The Second Law of Thermodynamics (aka The Microcanonical Ensemble)
    (a) Two-State Systems (aka Flipping Coins)
        i. Lots and lots of trials
        ii. Digression: Statistics
    (b) Flow toward equilibrium
    (c) Large Systems
        i. Discrete Random Walks
        ii. Continuous Random Walks
        iii. Quantum Walks and Quantum Computation
    (d) Entropy
        i. Boltzmann
        ii. Shannon Entropy
        iii. von Neumann Entropy
3. Equilibrium
    (a) Temperature
    (b) Entropy, Heat, and Work
        i. Thermodynamic Approach
        ii. Statistical Approach
    (c) Paramagnetism
    (d) Mechanical Equilibrium and Pressure
    (e) Diffusive Equilibrium and Chemical Potential

Midterm Examination

4. Engines and Refrigerators
   (a) Heat Engines
   (b) Refrigerators
   (c) Real Heat Engines
      i. Stirling Engine
      ii. Steam Engine
      iii. Internal Combustion Engine
   (d) Real Refrigerators
      i. Home Fridges
      ii. Liquefaction of Gases and Going to Absolute Zero

5. Free Energy and Chemical Thermodynamics
   (a) Free Energy as Work
      i. Independent variables S and V
      ii. Independent variables S and P
      iii. Independent variables T and V
         - Independent variables T and P
         - Connection to Work
      vi. Varying particle number
   (b) Free Energy as Force toward Equilibrium

6. Boltzmann Statistics (aka The Canonical Ensemble)
   (a) The Boltzmann Factor
   (b) Z and the Calculation of Anything
      i. Example: Pauli Paramagnet Again!
      ii. Example: Particlein aBox(1D)
      iii. Example: Particlein aBox(3D)
         - Example: HarmonicOscillator(1D)
         - Example: HarmonicOscillator(3D)
      vi. Example: The rotor
   (c) TheEquipartitionTheorem(reprise)
      i. Density of States
   (d) The Maxwell Speed Distribution
      i. Interlude on Averages
      ii. Molecular Beams
   (e) Gibbs' Paradox

7. Grand Canonical Ensemble
   (a) Chemical Potential Again
   (b) Grand Partition Function
   (c) Grand Potential

Final Examination

Grading Philosophy and Scheme

Because I try to encourage participation as much as possible, I have put a heavier accent on assignments and previews than is maybe customary. Each week, students will be expected to write a preview of at most one page each. These will summarize the main conceptual points to be covered in the next week. The emphasis is on understanding rather than on the formalism, so mathematics should be avoided unless absolutely required. Marks will be deducted for unnecessary use of mathematics! The reviews are to be submitted at the beginning of the first lecture of each week, and no late reviews will be accepted. These don't have to be long, often a paragraph or two does the trick. Also if you would prefer to do something more artistic that would be great! In years past we have had poetry, comics, song lyrics, songs, movies, you name it! If you decide to do something like this then you will also be graded on your creativity and your ability to communicate technical topics effectively in these kinds of media.

I have never liked exams much so if people would like to have a take-home exam for the midterm instead, that's fine with me – let's work it out together. The final exam will only explicitly test material from the second-half of the course (i.e. the material not explicitly covered in the midterm). That said, you can't forget what you learned in the first half, because the second-half material builds on it. For this reason I have chosen to weight the midterm and final equally. But I have a long-standing policy of wiggling here: for your final grade I will take the best result of a 20-30, 25-25, or 30-20 split between the midterm and final grades. Other than this, I do no further manipulations of the grades.

To help figure out where you stand during the course of the semester, here is the grading scheme I use for all my courses. It might look tough, but I tend to mark easy! Keep this in mind as you progress through the course so that you always know what your current letter grade is:

94+	A+
90+	A
86+	A-
82+	B+
78+	B
74+	B-
70+	C+
66+	C
62+	C-
58+	D+
54+	D
54-	F