Physics 370 Thermal Physics Fall 2016

Instructor:	Daniel Robb	Class Times:	MWF 2:20-3:20 (TREX 273)
Office:	TREX 266B	Office Hrs:	MWF 12-2, Thurs 10-12
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Course Description:

Thermal behavior of systems; energy and entropy; equations of state; changes of phase; elements of continuum and statistical approaches

Textbook:

• *Thermal Physics* by Ralph Baierlein. Cambridge University Press, 1999. (Available in paperback)

Purpose of the Course:

What do automobile engines, cloud formations and rubber bands have in common? The behavior of each of these systems depends on the flow of matter and energy among the constituent elements of these systems and the surrounding environment. Whereas mechanics, electricity and magnetism, and quantum mechanics describe the behavior of individual particles under the influence of forces, thermal physics attempts to explain and predict the behavior of large collections of particles.

“A theory is the more impressive the greater the simplicity of its premises, the more different kinds of things it relates, and the more extended its area of applicability. Hence the deep impression that classical thermodynamics made upon me. It is the only physical theory of universal content concerning which I am convinced that, within the framework of the applicability of its basic concepts, it will never be overthrown” – Albert Einstein.

This course will give you a practical understanding of how to use classical thermodynamics, as well as an appreciation for its wide range of applicability. We will work hard to understand the link between the mathematical formalism of statistical mechanics, which is rooted in the microscopic properties of systems, and the macroscopic properties (temperature, pressure, volume, etc.) described by classical thermodynamics. Finally, we will look at an application of thermal physics – the modeling of the Earth’s climate – gaining an understanding of the types of models used, as well as separating fact from fiction in the current “climate debate”.

<u>Specific Goals of the Course:</u>

1. Acquire the ability to apply classical thermodynamics to physical systems, and understand the Three Laws of Thermodynamics
2. Understand the link between statistical mechanics and thermodynamics, and gain a beginning proficiency in "stat mech"
3. Study an issue at the intersection of science and politics (climate change)

<u>Feedback and Evaluation:</u>

I will assign numerical grades to all your work. I *may* curve your final grades (upward), but otherwise you can expect to receive an "A" for 90-100, a "B" for 80-89, etc. I will assign +/- to your final grades by examining the distribution of grades and taking into account my perception of your effort in the course. These are the categories and percentages that will be used:

<u>Problem sets</u>:	35% (5 @ 7 % each)
<u>Tests</u>:	30% (2 @ 15 % each)
<u>Final exam:</u>	20%
<u>Writing Assignment:</u>	10%
<u>Participation:</u>	5%

<u>Problem sets</u> are due at the start of class on the due date. I encourage you to discuss problems with other students, but the work you turn in should be your own (i.e., don't copy work from another student, or allow another student to copy your work.) See the next page for the policy on late work.

<u>Tests</u> during the semester will be given in our classroom during class periods. Each test will consist of several conceptual questions requiring written responses, and several calculation problems. The first test will cover the first two course units, i.e., classical thermodynamics and kinetic/transport theory. The second test will cover the third course unit on statistical mechanics. Note that *you will be given all necessary formulas on each test.*

The <u>final exam</u> will be comprehensive, including all four course units. It will also include conceptual questions, and calculation problems.

The <u>writing assignment</u> will concern our short unit on theories of the Earth's climate. You will be required to summarize and critique article(s) from the mainstream press in light of our study of climate modeling and currently available climate data. No collaboration will be allowed on this assignment (except with me), and you must cite any sources you have used in footnotes. You will be required to turn in a rough draft (worth 1/3 of the grade), and then to revise your draft based on my comments (2/3 of the grade). See the next page for the policy on late work.

Your <u>participation grade</u> is based on your reflections on (at least) <u>two</u> MCSP Colloquium Series talks, as well as on your class attendance.

<u>MCSP Colloquium Series:</u>

The MCSP department offers a series of discussions that appeal to a broad range of interests related to these math, computer science and physics. Members of this class are invited to be involved with all of these meetings; however participation in **<u>at least two</u>** of these sessions is mandatory. Within **one week** of attending a colloquium you must submit (via Inquire) a one-page single-spaced paper reflecting on the discussion. This should not simply be a regurgitation of the content, but rather a personal contemplation of the experience.

Attendance Policy:

You are expected to attend every class. Attendance is checked at each class meeting, and you must be in class to participate in the in-class activities which form part of the class participation grade. If you are going to be absent from class, I must be notified in advance. If 3 classes are missed without prior notification, then I will assume you are not interested in completing the course and you will be dropped from the class with a grade of DF. Furthermore, you are accountable for all work missed because of an absence. I will provide class materials for a missed class, but will not re-teach a missed class during office hours.

Policy on Late Work:

I will grade an assignment with a 10% lateness deduction if turned in by 5:00PM on the due date. Following that, assignments will receive a further 10% lateness deduction for each successive schoolday late (schooldays are Monday-Friday; days are considered to end at 5:00 PM). As a result, after one week assignments receive a 50% deduction and after two weeks, assignments receive a 100% deduction; that is, no assignment will be accepted if more than two weeks late. Under extreme circumstances only will I consider adjusting the late policy for an assignment.

Make-up Tests:

Make-up tests and quizzes will not be given. If you miss a test, and have an official college excuse for that absence, then your final exam grade will count for the missed test.

Academic Integrity:

The College academic integrity policies are vigorously enforced. Although you are encouraged to work in groups on your homework assignments, all work turned in for a grade must be your own. Please familiarize yourself with the College's academic integrity policies.

Disability Support Services:

If you are on record with the College's Office of Disability Support Services as having academic or physical needs requiring accommodations, please meet with me during my regular office hours or schedule an appointment as soon as possible. We need to discuss your accommodations before they can be implemented. Also, please note that arrangements for extended time on exams and testing in a semi-private setting must be made at least one week ***before every exam***.

To register for Disability Support Services, students must self-identify to the Office of Disability Support Services, complete the registration process, and provide current documentation of a disability along with recommendations from the qualified specialist. Please contact JoAnn Stephens-Forrest, MSW, Coordinator of Disability Support Services, at 540-375-2247 or e-mail her at: stephens@roanoke.edu to schedule an appointment. If you have registered with DSS in the past, and would like to receive academic accommodations for this semester, please contact Ms. Stephens-Forrest at your earliest convenience, to schedule an appointment.

#	Date	Topic	Reading	Due
		UNIT 1: Classical thermodynamics		
1	Aug. 31	Introduction and preview	--	
2	Sept. 2	Heat, temperature and the 1st Law	1.1-1.4	
3	5	Adiabatic processes	1.5-1.7	
4	7	Multiplicity and the 2nd Law	2.1-2.3	
5	9	Entropy I	2.4-2.5	
6	12	Entropy II	2.6-2.8	
7	14	The Carnot cycle	3.1-3.4	
8	16	Reversibility and real engines	3.5-3.7	
		UNIT 2: Transport theory		
9	19	Random walks	15.1-15.2	PS 1
10	21	Momentum transport and viscosity	15.3-15.4	
11	23	Thermal transport and diffusion	15.5-15.6	
12	26	Climate modeling I	6.4, Handouts	
13	28	Climate modeling II	Handouts	PS 2
14	30	Review and catch-up		
15	Oct. 3	**TEST 1**		
		UNIT 3: Statistical mechanics		
16	5	Density of states	4.1	
17	7	General definition of temperature	4.2-4.4	Paper draft
18	10	Thermal probabilities	5.1-5.3	
19	12	The partition function	5.4-5.5	
20	14	The canonical distribution	5.6-5.8	Paper final, PS 3
		Fall break		
21	24	Chemical potential I	7.1	
22	26	Chemical potential II	7.2-7.5	
23	28	Ideal gas: quantum treatment	8.1-8.3	
24	31	Ideal gas: classical limits	8.4	
25	Nov. 2	Free energy	10.1-10.3	
26	4	“Minimize the free energy”	10.4-10.8	
27	7	Chemical equilibrium	11.1-11.2	
28	9	Chemical equilibrium II	11.3	
29	11	Classical stat mech	13.1-13.2	PS 4
30	14	Equipartition theorem	13.3	
31	16	Review and catch-up		
32	18	**TEST 2**		
		UNIT 4: Phase Transitions and the 3rd Law		
33	21	Phases of matter I	12.1-12.3	
34	28	Phases of matter II	12.4-12.5	
35	30	Fermions at low temperature I	9.1	
36	Dec. 2	Fermions at low temperature II	9.1	
		Thanksgiving break		
37	5	Prelude to the 3rd Law	14.1-14.3	PS 5
38	7	The 3rd Law	14.4-14.5	
39	9	Review and catch-up		
		FINAL: Tuesday, December 13, 2:00-5:00		

Note: You should expect to spend a combined total of 12 hours per week on lecture, homework, and reading for PHYS 370.