Course Information

Course: PHYS 317 Fall 2018
Thermodynamics and Statistical Mechanics

Instructor: Katharina Vollmayr-Lee
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Classes: MWF 1 – 2 Olin 264

Office Hours: M 10 – 11, W 10:30 – 11:30, TR 3 – 4, and by appointment

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Webpage: For updated information on our course, see the webpage
http://www.eg.bucknell.edu/˜kvollmay/phys317_f2018/

- assignments (HW & reading
- journal entries

(see next page)

Text: Daniel V. Schroeder, *An Introduction to Thermal Physics*, Addison Wesley Longman, San Fancisco 2000.

- super cool!
- see link on our webpage

Objectives: We have an intuitive understanding of temperature and know that heat flows from hot to cold. Yet, to really understand what temperature is and why heat prefers to flow in one direction but not the other is very difficult, very interesting, and at the heart of this course.

In a more general sense, this course is about systems of very many particles in which case new "collective phenomena" occur. For example with a minimal change in density a gas might become a liquid. There are two approaches to large systems: the macroscopic approach (thermodynamics) and the microscopic approach (statistical mechanics). We will use both approaches following the modern description of D. Schroeder's textbook. On the way we will encounter many applications with examples both of daily life and Noble Prize winning topics such as the Bose-Einstein condensation.

cool!

Although the math of this course is fairly simple, the concepts are not at all. I encourage you to try hard to enter deeply into the world of thermal physics.

very interesting!
neat!

Goals: For more general learning goals for physics, astronomy, and biophysics, see

`http://coursecatalog.bucknell.edu/collegeofartsandsciencescurricula/areasofstudy/physicsandastronomy/#goalstext`

For our course the following goals apply:

- "Be able to solve quantitative problems that require an understanding of the fundamental principles in each of the major areas of physics. Show a working knowledge of how a broad array of physical phenomena can be explained using these fundamental concepts."
- "Use critical thinking skills to formulate and solve quantitative problems."

or more specific I hope that you will gain:

- a deep understanding of main concepts in thermal physics
- an appreciation (passion) for the beauty of thermal physics

Course Structure: This course will be interactive, and therefore it will be *essential that you come prepared to class.* For each reading assignment you will have to submit a **journal entry**. The purpose of these journal entries is to encourage you to do the reading and to spend class time most effectively. Your journal entry should reflect that you have done the reading and can contain any or all of the following: a summary, comments on what part of the reading was most difficult, easy, and interesting, or general comments about the course. I encourage your feedback. These journal entries will be due 10 am on the day of the class. However, it would be extremely helpful if you could get them to me earlier, to give me time to incorporate your feedback into the lecture planning.

our web page :
username
pwd = username
then changepassword

as early as possible (for feedback)

There will be **homework assignments** for each class both for you to be continuously involved with the class material and for me to get feedback on your understanding of the class material. Homework assignments will be due at the beginning of class. I will randomly decide (based on a tossed die!) whether to collect the homework (1/2 of the time) or have you self-grade it. I will provide guidelines for the self-grading, and solution sets for each homework set. Usually I will start the class with a brief summary of the last class. Then the course material will be discussed in lecture form, and will be practiced in the form of in-class problems for which **you** will be working on the blackboard.

see webpage

bring your book to class

Grading: Since the course structure relies on you coming to class prepared, it is important that you work steadily on the reading with journal entries and homework assignments. For this reason, journal entries are due 10 am before class and will *not* be accepted late. Scoring of the journal entries will be on a 2-point scale. You will be able to drop two of your lowest journal entry scores. Your participation is essential for the class discussions, during lecture and during work at the blackboard, and therefore counts together with the journal entries 5% towards your grade.

Homework will take a considerable amount of your time and is intended to give you plenty of practice. **No late homework will be accepted!** This is because the solution sets will already have been distributed, and because the goal is for you to be working on the problems while we are discussing the material. You will get to drop your lowest two homework grades. You are encouraged to work together on the homework, but you must write up your solutions individually. There will be three in class exams and a cumulative final. Attendance is required.

Reading Assignments & Participation	5 %
Homework Assignments	30 %
Exam 1	15 %
Exam 2	15 %
Exam 3	15 %
Final	20 %

Accommodations: If you have a disability that may have some impact on your work in this class and for which you may require accommodations, please see me and Heather Fowler, Director of the Office of Accessibility Resources at hf007@bucknell.edu, 570-577-1188 or in room 212 Carnegie Building so that such accommodations may be arranged.

Inclusive: We will strive for an inclusive classroom as described in The Bucknell University Solidarity Creed
`http://www.bucknell.edu/news-and-media/2015/april/standing-in-solidarity.html`

"As a member of this community, I will respect the diversity of all individuals, including, but not limited to, their sex, gender, identity, expression, race, ethnicity, age, class, citizenship, sexual orientation, nationality, socio-economic status, religion, physical ability and mental ability," the creed reads in part. "I will commit to educating myself about cultures, identities and experiences other than my own."

and as described in Bucknell's Diversity, Equity, And Vision & Statement
`https://www.bucknell.edu/about-bucknell/diversity-equity-and-inclusion-at-bucknell/diversity-equity-and-inclusion-vision-and-statement`

Course Syllabus

I am out of town

dates	topic	text
Aug. 20/22/24/27/29	Intro & Energy	§1.1 – 1.7
~~Aug. 31,~~ Sept. 3/5/7/10/12/14	Entropy	§2.1 – 2.6
Sept. 17	Review	
Sept. 19 Wed	Exam 1	
Sept. 21/24/26/28,Oct. 1	Temperature/Interactions	§3.1 – 3.6
Oct. 3	Engines & Refrigerator	§4.1 & 4.2
Oct. 5/10/12	Free Energy	§5.1, 5.2
Oct. 15/17/19	Phase Transitions	§5.3, 5.4
Oct. 22	Review	
Oct. 24 Wed	Exam 2	
Oct. 26/29/31 Nov.2/5/7	Boltzmann Statistics	§6.1 – 6.7
Nov. 9	Ising Model	§8.2
Nov. 12	Review	
Nov. 14 Wed	Exam 3	
Nov. **15**/16/26	Quantum Statistics: Bosons & Fermions	§7.1 – 7.3
Nov. 28	Blackbody Radiation	§7.4
Nov. 30, Dec. 3	Bose-Einstein Cond.	§7.6
TBA	FINAL	

thermo

stat. mech.

applications

Stat. mech.

make-up class

please check with your other classes

Homework Grading Policy and Guidelines

Each problem is worth 5 points. I may, for a particularly long problem, break it into "two problems." In this case, each will be graded separately, each for 5 points.

Please report to me your self-graded homework scores include in on your journal entry (archives your scores) or if you prefer via email (kvollmay@bucknell.edu). Your grades for a given assignment are due before the next class.

The grading scheme is

5 — completely right or almost completely right. A small calculational error (non-conceptual error) that is a small fraction of the problem does not necessarily warrent taking off a point.

4 — mostly right, but a genuine mistake is made. As an example, a sign error is sometimes a genuine mistake (e.g. a wrong sign for Q, implies the wrong direction of heat flow into or out of the system) in which case a point would be taken off, or it can be a non-conceptual error (copying from one line to the next a sign was copied wrong), in which case it doesn't cost a point.

3 — had the basic idea, but a few mistakes were made.

2 — tried the problem, but really didn't have the basic idea

1 — barely tried the problem - these will probably be rare, usually you've either tried enough for a 2, or you didn't get to the problem

0 — didn't do it.

If you'd like more description, or you have questions about specific cases, please come see me.

Phys 317 In-Class Work Aug. 22, 2018

Problem 1.16 (Schroeder) The exponential atmosphere

(a) Consider a horizontal slab of air whose thickness (height) is $\mathrm{d}z$. If this slab is at rest, the pressure holding it up from below must balance both the pressure from above and the weight of the slab. Use this fact to find an expression for $\mathrm{d}p/\mathrm{d}z$, the variation of pressure with altitude, in terms of the density of air.

(b) Use the ideal gas law to write the density of air in terms of pressure, temperature, and the average mass m of the air molecules. (... KVL comment: use that air is mostly N_2 and therefore molar mass is 2 × 14 g= 28 g.) Show, then, that the pressure obeys the differential equation

$$\frac{\mathrm{d}p}{\mathrm{d}z} = -\frac{mg}{kT}p$$

called the barometric equation.

(c) ...

(d) ... (KVL comment: Here is where you use hints given in class and here in part (b).)

Problem 1.12

Calculate the average volume per molecule for an ideal gas at room temperature and atmospheric pressure (10^5 Pa). then take the cube root to get an estimate of the average distance btween molecules. How does this distance compare to the size of a small molecule like N_2 or H_2O?

Problem 1.12

Calculate the average volume per molecule for an ideal gas at room temperature and atmospheric pressure (10^5 Pa). then take the cube root to get an estimate of the average distance btween molecules. How does this distance compare to the size of a small molecule like N_2 or H_2O?

$$\frac{V}{N}=\frac{kT}{p}=\frac{1.38\times10^{-23}(\mathrm{J/K})\,300\mathrm{K}}{10^5\mathrm{N/m}^2}=4.1\times10^{-26}\mathrm{m}^3=\left(3.4\times10^{-9}\mathrm{m}\right)^3$$

Compare with molecular size of about $1\AA$, so about 30 times larger distance.

Problem 1.6

Give an example to illustrate *why* you cannot accurately judge the temperature of an object by how hot or cold it feels.

Examples:

- wood chair, metal chair in summer
- wood chair, metal chair in winter
- rug or tile floor in winter

Differences in physics:

- $\frac{\Delta Q}{\Delta t}$ §1.7 (rug has less thermal contact)
- $C_V = \frac{\Delta Q}{\Delta T}$ §1.6 (wood and rug smaller C_V)