Course Guide and Syllabus for

Physical Chemistry I

FCH 360
Fall 2018

Index

Key Information

Class Meets MWF 11:40-12:35
212 Marshall Hall

Instructor Dr. Ted Dibble
470-6596
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Office Hours: M 12:45-1:45 Tu 2-3

Course Web Page: http://www.esf.edu/chemistry/dibble/fch360.htm

Required Text: *Physical Chemistry,* by P.W. Atkins, 8^{th} or 9^{th} edition. The accompanying Student Solutions Manual is recommended.

Exam Schedule

Exam I	Chapters 1 and 2	Wed. 9/26
Exam II	Chapters 3-5	Mon. 10/29
Exam III	Chapters 5-6	Wed. 12/3
Final	(Chap. 6 & Cumulative)	Fri. 12/12, 8-10 a.m. (tentative)

For each exam you will be allowed to bring into class one 8.5” x 11” sheet of paper (the "cheat sheet") containing whatever notes you desire. You are allowed three cheat sheets for the Final Exam. The cheat sheet must prepared by your own hand (no photocopying the textbook) and no magnification equipment allowed. Also, bring your calculators, but you will not be allowed to use programs on them. If desired by the students, review sessions may be held prior to each exam.

Homework *Problems* (about 10) are graded. Due dates are on the Course Schedule. Each Homework has *Exercises* that are highly recommended for you: many are directly related to one of the grade *Problems*. You do not need to turn in your *Exercises* , and they will not be graded. Answers to all these assignments will be posted to Blackboard. Answers to *Exercises* will be posted in advance of the due date for the corresponding *Problems*.

Course Grade:

Determined from:

Homework/Classwork	15%	
Exam I/II/III	50%	
Final Exam	35%	(mandatory)

Grading Scale:

80 -100%	A- to A
70 - 79%	B- to B+
60 - 69%	C- to C+
50 - 59%	D

I reserve the right to may make the scale easier than the above, but will not make it any harder.

Tutoring: contact Ameila Hoffman in the Academic Success Office (Bray 110) at (315) 470-4919 or aghoffma@esf.edu or esftutoring@gmail.com.

Course Schedule 2018

Date	Day	Topic	Reading (9th Ed.)	Assignment Due
27-Aug	M	Introduction. Fundamentals (units)	Section F	
29-Aug	W	Equipartition. Speeds. Ideal Gas Law.	1.1-1.2, 20.1	HW #1 Fundamentals
31-Aug	F	Real Gases. Van der Waals fluid	1.3-1.4	
5-Sep	W	Corresponding States. Review		HW #2 Gas Behavior
7-Sep	F	Work, heat, energy. The 1st Law.	2.1-2.2	Math Review 1
10-Sep	M	Expansion work	2.3	
12-Sep	W	Heat.	2.4-2.5	Math Review 2
14-Sep	F	Enthalpy and Heat Capacity		HW#3 (q and w)
17-Sep	M	Adiabatic Changes. State Functions	2.6-2.7	
19-Sep	W	Thermochemistry	2.8-2.9	
21-Sep	F	Joule-Thomson effect	2.11-2.12	HW#4 Thermochem.
24-Sep	M	Catch Up and Review		Draft of Cheat Sheet
26-Sep	W	**Exam #1**		
28-Sep	F	The 2nd Law	3.1-3.2	
1-Oct	M	Entropy as a State Function	3.3	
3-Oct	W	Entropy Changes and the 3rd Law	3.4	
5-Oct	F	Free Energy isn't free	3.5-3.6	HW #5 ΔS
8-Oct	M	Standard Molar Gibbs Free Energies		
10-Oct	W	Combining the 1st and 2nd Laws	3.7-3.9	
12-Oct	F	Chemical Potential		
15-Oct	M	Phase Diagrams	4.1-4.3	HW #6 G
17-Oct	W	Phase Boundaries and Stabilities	4.4-4.5	
19-Oct	F	Curved Surfaces		
22-Oct	M	Partial Molar Quantities	5.1-5.3	
24-Oct	W	Ideal Dilute Solututions	5.4	HW #7 ΔG
26-Oct	F	Review		Draft of Cheat Sheet
29-Oct	M	**Exam #2**		
31-Oct	W	Colligative Properties 1	5.5	

2-Nov	F	Colligative Properties 2	5.10-5.11	
5-Nov	M	Colligative Properties 3		
7-Nov	W	Phase Diagrams 1	5.6-5.7	HW #8 Colligative Properties
9-Nov	F	Phase Diagrams 2	5.8-5.9	
12-Nov	M	Chemical Equilibrium 1	6.1	
14-Nov	W	Chemical Equilbrium 2	6.2	
16-Nov	F	Shifts in Position of Equilibrium	6.3-6.4	HW #9 Chem. Equilibrium 1
Thanksgiving Break				
26-Nov	M	Activities of Ions	5.13	
28-Nov	W	Electrochemical Cells 1	6.5-6.8	
30-Nov	F	Electrochemical Cells 2	6.9	HW #10 Chem. Equilibrium 2
3-Dec	M	Review		Draft of Cheat Sheet
5-Dec	W	**Exam #3**		
7-Dec	F	Special Topics	TBD	
Friday, Dec. 12, 8-10 a.m. Final Exam (tentative)				

Attitudes

Physical chemistry has a reputation as a difficult course. Some students arrive in class the first day already convinced they cannot do the work, and therefore they do not see any reason to study hard or to study smart. With this attitude, they create a self-fulfilling prophecy. DO NOT MAKE THIS MISTAKE!!! Physical chemistry can be very rewarding. The material is deep; there is much more than just what appears on the surface or in any textbook. Yet the struggle for mastery of physical chemistry can be rewarded with a sense of accomplishment and the power of a new type of knowledge.

My Attitudes

> "Chemistry is a game that electrons play."
>
> Joseph J. W. McDouall. *Computational Quantum Chemistry: Molecular Structure and Properties in Silico,* 2013, p. 4

I am in my 23rd year at ESF but I have not taught FCH 360 for 20 years. I came here by way of the University of Michigan and four years of post-doctoral research at Wayne State University and the California Institute of Technology. My appreciation for the power and profound insights to be found in thermodynamics led me to choose my thermodynamics professor as a research advisor in graduate school. While none of my research has centered on thermodynamics, I have found the skills and knowledge gained enormously valuable in my work since then. Also, I think that thermodynamics is fun!

Prerequisites - Knowledge, Skills, and Attitudes

To take this course, you must have passed one year of college physics (Mechanics, Electricity and Magnetism) and one year of calculus (Differential and Integral). There are no exceptions without the written permission of the instructor, which may or may not be forthcoming.
The physics we use is primarily Mechanics at an elementary level, such as, $d\mathbf{V}/dx = \mathbf{F} = m\mathbf{a} = d\mathbf{p}/dt$ (note that you will definitely need your Electricity and Magnetism background next semester for Physical Chemistry II). If your algebra and calculus are rusty, then you need to brush up on those areas. The instructor will introduce a few topics in calculus that you probably have not seen before; you will be given help in mastering them. You will need a good scientific calculator for homework assignments and examinations.

There are skills and attitudes required for this course beyond the prerequisites cited in the course catalog. Here I present an <u>incomplete</u> list of skills you should have mastered and attitudes you should have wholeheartedly adopted:

1) Graph numerical data and interpret graphical data.
2) Extract numerical data from a statement of a problem, identify needed information, and identify the equations necessary to solve the problem.
3) Take the initiative to obtain data from reference works like the CRC Handbook, or other data sources.
4) Mathematically derive the equivalence of two quantities.
5) Make estimates, such as deciding when a quantity in an equation is negligibly small and can be ignored in calculations; estimating uncertainties.
6) Analyze the units and dimensions of quantities or equations.
7) Understand the meaning of a derivative or integral.
8) Know and use your knowledge of common values of physical properties, etc., such as the density or boiling point of water.
9) Check to see whether you answers on homework or test problems are reasonable physically, chemically, and mathematically.

> A chemist who does not know mathematics is seriously handicapped.
> — Irving Langmuir
> Quoted in Albert Rosenfeld, *Langmuir: The Man and the Scientist* (1962), 293.

If you are already skilled in all the above, great! If not, then you will want to further develop these skills this semester. Here are some ways to do that:

- We will be addressing some of these issues in class and on the Homework. So come to class, and work hard.
- See the Mathematical Background sections at the end of each chapter for reviews of mathematics and of units analysis.
- Read your text books and notes from previous classes in high school and college. Review old exams and homework.

Background and Purpose of the Course

You may have been exposed to many of the ideas presented in this course in your first college chemistry course or even in high school. Why then, are they presented again? One obvious reason is that there is far more to these ideas than what you saw in previous courses, and many more applications. For some students the ability of mathematics to illuminate chemistry may be surprising. Yet an environmental chemist who does not understand the basis and pitfalls of the common expression for the equilibrium constant might make serious errors. A polymer chemist will have difficulty understanding the behavior of a membrane (or other structural material) without thermodynamics. Even a biochemist needs to be aware of physical chemistry in order to follow the powerful advances in structural biochemistry arising out of the application of physical methods. Organic chemists apply thermodynamic concepts all the time to optimize reaction conditions.

Exothermic?

More generally, chemical reactions, catalysis, and separations processes critical in various fields of study depend on enthalpy, entropy, and Gibbs free energy. Solution properties and chemical and physical equilibrium must be understood to understand biochemistry and control the chemistry of the papermaking wet end.

Course Goals/Objectives

Broadly speaking, there are two. One is to help you master fundamental chemical concepts within a much more rigorous and powerful mathematical framework, the second is to help you develop an intuition about physical and chemical processes.

These two goals may seem contradictory, but they are not. There are very few researchers who can use the mathematics of thermodynamics <u>well</u> without keeping a physical framework in mind. Those who try too often make ridiculous errors without even knowing it. On the (all to frequent) occasions when I have forgone physical thinking, I have made major blunders. Most of them were caught before doing damage, but I know at least one that made it to print. If this is the result when experienced professionals try to blindly do mathematics, you can guess what happens when novices try.

While the physical model is crucial, much of its power lies in how it lends itself to calculation. The attitude of a physical chemist (like that of a physicist) is that the physical and chemical properties of matter are subject to mathematical modeling, leading to the power to make predictions for species not yet studied. If you begin to adopt this attitudes, you will be making a large step towards understanding, not only this course, but any physical system you will encounter in the future.

> **Definition of physical chemistry**:
> Anything that you can take the natural log of, plot it versus 1/T, and get a straight line
> - Proverbial.

More specifically, below you will find an itemized list of abilities I expect you to develop this semester. They are keyed to the Chapters in the 9th Edition of the required text by Atkins and de Paula. They form much, though not all, of the basis of the test questions.

Course Learning Outcomes

After completing this course the student should be able to:

1. Perform calculations using equations of state to relate pressure, temperature, and molar volumes to each other, and to substance-specific parameters related to the critical constants.

2. Perform thermochemical calculations involving standard enthalpies of formation, reaction, and phase transition.

3. Calculate changes in enthalpy and entropy associated with a range of thermochemical processes, and use the second law of thermodynamics to assess whether or not a proposed process, reaction, or change can be expected to take place spontaneously or not.

4. Calculate how phase co-existence conditions for first-order phase transitions vary as temperature and pressure are changed; for example, calculate how boiling and melting point temperatures respond to changes in pressure.

5. Relate colligative properties, such as shifts in boiling and melting points and the osmotic pressure, to the composition of solutions; estimate the molecular weights of solutes from measurements of these phenomena; predict how non-reactive systems will change to reach equilibrium.

6. Calculate equilibrium constants from standard free energies of formation; use standard free energies and enthalpies of formation, and heat capacity data, to calculate the dependence of equilibrium constants upon temperature.

7. Determine whether a system is at equilibrium, compute equilibrium concentrations of species in a reaction, determine how concentrations will shift (or not) due to changes in the volume or pressure of a system.

Program and College Learning Outcomes

This course contributes to meeting the Chemistry Department's objective that undergraduate students develop a "sound understanding of the fundamental chemical principles, underlying theories, and applications of physical chemistry."

> "The 2nd law of thermodynamics has the same degree of truth as the statement that if you throw a [glass] full of water into the sea, you cannot get the same glass of water out again."
> - J.C. Maxwell, Letter to Lord Rayleigh, December 6, 1870.

This course addresses the following College-wide learning outcomes. For detailed information about the college learning outcomes please visit www.esf.edu/facgov/iqas.htm

(1) Scientific Reasoning
(2) Quantitative Reasoning
(4) Technological and Information Literacy
(6) Critical Thinking

Course Description and Organization

The course will largely follow Chapters 1-6 in the textbook, with additions and deletions.

Chapter 1 emphasizes the behavior of gases, including the ideal gas law, its physical basis, and its failure. It will provide insight into the nature of molecular motions and interactions. Chapter 2 gets us into the guts of thermodynamics, namely, the First Law of Thermodynamics. Changes in internal energy, U, due to work and heat will be examined, using the ideal gas as a frequent example. The more familiar quantity, enthalpy (H) will be discussed, and the thermodynamic basis of heat capacities will be covered. Chapter 3 emphasizes the fact that the internal energy and enthalpy of a system depend only on the state of the system, which is a powerful tool for computing changes in

There is a single criterion for the spontaneity of any process in the universe; read Chapter 4 and discover it! The Second Law of Thermodynamics and its applications to, once again, an ideal gas, will reveal the working of this criterion. Chapter 4 will also combine the First and Second Law to treat the Gibbs free energy (G). The elements of non-textbook situations (varying temperature, non-ideal gases, and solutes) will be dealt with here.

The familiar use of ΔG as a criterion for the whether a process favors reactants or products is now seen as a consequence of the Second Law of thermodynamics. Its application depends on quantifying entropies using the Third Law.

Chapter 5 centers on phase equilibria, and how that affects physical properties. Activity coefficients, colligative properties, and phase diagrams are key parts of this chapter.

You already have experience with chemical equilibrium, which is the topic of Chapter 6. Here you have a chance to learn the source and meaning of equilibrium constants.

> "The physical chemists never use their eyes and are most lamentably lacking in chemical culture. It is essential to cast out from our midst, root and branch, this physical element and return to our laboratories."
> Henry Edward Armstrong, 1848 to 1937

Academic Integrity

Academic dishonesty (a fancy word for cheating) is a breach of trust between a student, one's fellow students, and/or the instructor(s). By registering for courses at ESF you acknowledge your awareness of the ESF Code of Student Conduct (http://www.esf.edu/students/handbook/StudentHB.05.pdf). In particular academic dishonesty (http://www.esf.edu/students/handbook/integrity/) includes but is not limited to plagiarism and cheating. The penalties for cheating that will be administered by this instructor will include a zero on the particular assignment and, possibly, failing the course. The incident will be reported to the administration per ESF guidelines (see the ESF Grading Policy (http://www.esf.edu/provost/policies/documents/GradingPolicy.11.12.2013.pdf).

An older version of the academic integrity policy read:

> Examples of academic dishonesty include, but are not limited to, actions defined below.
>
> …

c) Writing, or attempting to write an examination paper, computer work, or other material for another student; allowing someone else to take one's examination.

d) Possession of examinations or other test materials without permission of the instructor.

e) Using …books; looking at another's paper; or talking to someone other than the instructor or proctor during an examination, without the instructor's permission.

f) Failing to follow the rules of conduct for taking an examination as stipulated by the instructor prior to the examination or as stated by the instructor in a written course syllabus.

Cooperation on exams is not allowed.

My attitude towards cooperation on graded *Problems* is described below in the section entitled "How to Get a Good Grade in this Course". Also, read point (f) above, substituting the word "*Problems*" for "examination."

Inclusive Excellence Statement

As an institution, we embrace inclusive excellence and the strengths of a diverse and inclusive community. During classroom discussions, we may be challenged by ideas different from our lived experiences and cultures. Understanding individual differences and broader social differences will deepen our understanding of each other and the world around us. In this course, all people (including but not limited to, people of all races, ethnicities, sexual orientation, gender, gender identity and expression, students undergoing transition, religions, ages, abilities, socioeconomic backgrounds, veteran status, regions and nationalities, intellectual perspectives and political persuasion) are strongly encouraged to respectfully share their unique perspectives and experiences. This statement is intended to help cultivate a respectful environment, and it should not be used in a way that limits expression or restricts academic freedom at ESF.

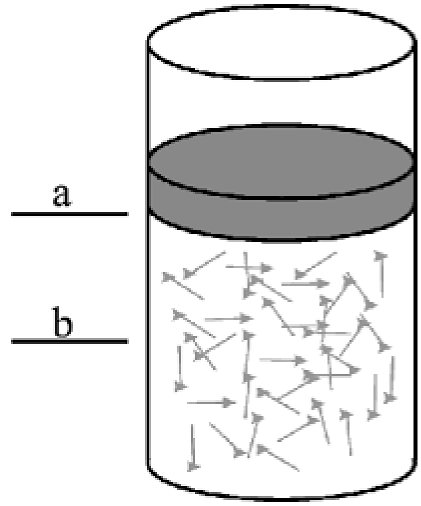
Students with Learning and Physical Disabilities

SUNY-ESF works with the Office of Disability Services (ODS) at Syracuse University, which is responsible for coordinating disability-related accommodations. Students can contact ODS at 804 University Avenue- Room 309, 315-443-4498 to schedule an appointment and discuss their needs and the process for requesting accommodations. Students may also contact the ESF Office of Student Affairs, 110 Bray Hall, 315-470-6660 for assistance with the process. To learn more about ODS, visit **http://disabilityservices.syr.edu**. Authorized accommodation forms must be in the instructor's possession one week prior to any anticipated accommodation. Since accommodations may require early planning and generally are not provided retroactively, please contact ODS as soon as possible.

If You Are Struggling

As noted in the ESF **Student Handbook**, there are offices at ESF available to **provide academic support, as well as career and mental health counseling**. The Division of Student Affairs (110 Bray Hall, 470-6660) can provide help and guide you to resources. The Counseling Services Office (105 Bray Hall, 470-4716) can also assist and **confidentiality is assured**.

If you are absent for several days due to hospitalization, emergency, or other critical incident, the Division of Student Affairs can assist in these instances to coordinate notification to instructors.



How to Get a Good Grade in Physical Chemistry

My goal for you is not that you get a good grade in this course, although I would be delighted if you all earn high marks. Rather, my goal is to have you learn the principles of physical chemistry and how to apply them.

Why then, do you ask, do I give advice on getting a good grade?

The answer is that the graded assignments will be structured so that it is very difficult to do well without understanding the material. I will attempt to set up this course so that studying for the exams is learning physical chemistry rather than an exercise in memorization of facts, formulas, and algorithms for doing problems. Perhaps the most obvious means by which I devalue memorization is that I permit each student to bring to each exam a single 8.5" x 11" piece of paper (the "cheat sheet") with whatever notes the student wants to put there.

This class is not about memorization. If you try to get through this class by memorizing formulas and algorithms for solving certain types of problems, you are likely to fail the class. Studying for mastery does not take much more time or effort (perhaps less) than memorization, and it leads to better grades, better long-term retention, and a greater ability to apply your knowledge to real problems.

> *"You damn sadist,' said mr cummings,*
> *'you try to make people think.'*
> Ezra Pound, Canto 89, 1956

So how should you study?

Come to class and PARTICIPATE

I will be presenting material that is not in the text or in a different manner than the text. I will also try to organize the material and make it more coherent; it is often difficult for students to see this organization of material in a textbook. Also, the act of writing down formulas I put on the board or things I say in class is a first step towards learning the material. This is particularly true if you can edit what I say and write, either while taking notes or in while studying outside of class. If you can do this, you will have already begun grappling with the material. In the jargon of pedagogy this grappling is called active learning, the opposite of passive learning. Active learning is the way people actually master skills or knowledge.

We will be discussing answers to *Problems* in class. Questions based on the same logic as the *Problem* will appear on the exams. We may use class time to address problems that are not part of the homework, but do address important concepts (i.e., ones worthy of a test question). Much of your learning may take place in class discussing answers to the problems.

<u>Ask questions in class</u>. If you have a question, it is possible that half the class also is also wondering about the same topic. Even the best students in the class often learn something from the answer to the question you feel is too "dumb" to ask.

Finally, do not skip class to study for an exam in a later class. What you miss in my class will probably lower your final grade much more than your cramming will raise your grade in the other class.

<u>The Textbook</u>

Read ahead of the topics being discussed in class. This will help you to get an idea of where I am going in lecture, which will help you take better notes and get more out of the lecture. When studying outside of class, try to see how presentations in the book and in the lecture are linked. Do the example problems in the text while covering up the answer.

You may be able to get oriented to some of the material by reviewing your notes and text from General Chemistry.

<u>Exercises</u>

I will assign some relatively straightforward questions (*Exercises*) for you to do: these will not be graded. These are mostly intended to be fairly straightforward. You should be able to solve them by reading the book and your lecture notes. Answers to some questions are at the bottom of each set of *Exercises*; answers to others are in the Student Solutions Manual. You are responsible <u>outside of class</u> for making sure you understand the correct answers. The idea of the *Exercises* is to get you familiar with the mechanics of using, one at a time, the many equations which are a part of this course. *Exercises* will <u>not</u> be graded so you are allowed to give or accept help on the *Exercises* that would constitute cheating if done for graded assignments (like the *Problems*).

To do well in this class you need to not only understand the basics, but be able to apply the individual equations automatically. The analogy is, if you go to bake a cake from scratch, you want to already know a lot about baking first. (If you don't believe me, start writing instructions for your favorite recipe, starting with identifying measuring tools and baking pans, and go on through to explaining how test for doneness.) If the basics are automatic, then you will likely solve the problem (or bake the cake) efficiently and well.

For the *Exercises* I have usually selected some of the questions that the textbook designates "Exercises." This is to enable you to check your answers in the *Solutions Manual*. When you finish the assigned *Exercises* you should ask yourself "Can I now solve the same type of problem quickly and get the correct answer?" You definitely should do the other half (a)/(b) of the Exercises from the textbook to check that you have achieved this level of competency with the material. If you have not, then you need to work harder and/or better!

<u>Problem Sets</u>

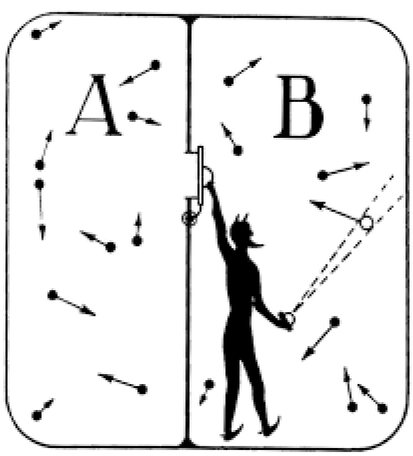
I will be collecting and grading your answers to *Problem*s; answers will be posted on Blackboard. Most *Problems* are my own creations. You will not likely do well on the Problem Sets unless you have mastered the material in the *Exercises*!

The *Problems* are designed to help you achieve a higher level of understanding of the material. Some problems are conceptual: these are often questions about the assumptions behind an *Exercise* or point out a pattern or oddity in its answer. Other problems are calculations, but often not ones for which the statement of the question allows you to “plug and chug.” You should not expect to answer problems without thinking for a time about the question: What is being asked? What are the knowns and unknowns? What needs to be done to get from the knowns to the unknowns?

Don't wait until the night before the due date to start doing the *Problems*!

A person can't learn to drive a car just by reading: one needs to actually get in the car and drive. By this analogy, the *Problems* might be the practice drives you take in an empty parking lot before you first get on the road: you learn in a place where no one can get seriously hurt (your performance on the *Problems* does not count a lot towards your grade). Doing problems is usually the only way to begin to learn physical chemistry (and most technical subjects).

You are allowed, nay, encouraged, to cooperate a little bit on the homework. If you are stumped about how to approach a problem, don’t stay that way. Ask for a hint (“What equations do I need in order to solve this problem? What error am I making in what I have so far?”). Once you have an answer that seems right, it is appropriate to check with your classmates, and to think together about the way to understand or do a problem, or to point out and explain flaws of logic or math. Giving this type of assistance to a classmate benefits the giver, also, by forcing them to clarify their own thinking about the material. If you compare answers with a fellow student, and disagree, it is appropriate to work together to figure out what errors have been made by either student. Then, however, you should work separately to correct your answer; you may turn in the corrected work!



It is not appropriate to accept help on how to do a problem line by line or to copy someone else's answers.* This is true even when comparing answers with another student. A key concept here is to work in parallel with other students, and only come together when you are done or stuck. If two students work in parallel, they will likely express things differently, expand equations in different numbers of steps, or do some steps in slightly different order, so that their answers will not be identical.

Because the *Problems* count little towards your grade, incorrect answers on the homework will not greatly hurt your grade for the course. It also follows that copying answers from somebody else will not raise your grade very much. The goal of the Problem Sets is for you to learn the material. If you accept inappropriate help, you defeat the goal of doing homework and lower your chances of getting a good grade.

* I have four surefire ways of catching and penalizing people who make a habit of accepting such "help." They are: Examination I, Examination II, Examination III, and the Final Exam.

While we will discuss the answers to *Problems* in class, we will not have time to go over all the questions in detail. Answers will be posted online. **Take the time to examine the things you did right and wrong on your *Problems*.**

It is not sufficient to merely be able to do the problems. You need to think about the answers, whether they make sense physically and mathematically, and why they are what they are. **About 30% of the points on the exams** will be for conceptual (qualitative) questions that do not involve use of a calculator (part B of the in-class exams). In addition, some of the **calculation questions require a clear understanding of concepts in order to do the right calculation!** If you can do all the numerical problems in the homework, you may just be able to do well enough on the examinations to pass the course. However, if numerical problems are all you try to master, you are only aiming for a D in the course (and risking an F).

Sometimes students spend half of an hour or more trying to figure out how to start problem on the homework, without much success. This results in frustration and wastes a lot of time. Few problems should require that much time just to figure out the way to begin. Time to get help!

If you ask me or a classmate for help, try to formulate a specific question. That way, you may get the clues that allow you to solve it yourself. You will learn the material much better this way than if you have someone else show you how to do the problem.

Office Hours

> GETTING A SIMPLE ANSWER FROM A PROFESSOR IS LIKE GETTING A THIMBLE OF WATER FROM A FIRE HYDRANT.
> -- PROF. LEN SHAPIRO, NDSU

Times for office hours are listed on page 2, but you are welcome to meet with me outside of office hours. The best bet is email me or talk to be right before/after class to make an appointment to see me. or to talk to me right after class. If you drop by my office and I am in, I *may* be available to help you, but I cannot guarantee that. If you don't feel secure asking questions in class, you should be coming to office hours on a regular basis. Some questions can be handled by e-mail.

If your exam score is lower than you expected, or you are confused about the homework, I expect to see you in my office from time to time.

Studying for Examinations

Do all the homework assignments again. Also re-do any additional problems that have been suggested or assigned. If you have questions, ask them in the class prior to the exam or come to my office hours. Also, you will benefit enormously by getting together with your fellow students to figure out the difficult points.

Do not wait until the day before the examination to take your first (or second) look at lecture notes, the textbook, or homework problems. That’s how people get D’s and F’s in my courses. Rather, start several days before an exam to go over things for the *second or third time*. Review your notes and the textbook to identify ideas that are unclear; then clarify them.

As you review this material, start making a draft of your cheat sheet. Once again, the night before the exam is too late. Once you have gone over all the material, you can look back at the draft of the cheat sheet and see how best to pare it down and organize it. If you construct the cheat sheet this way, you may hardly need it during exams!

Examinations

About 30% of the points on the exams will be for conceptual (qualitative) questions that do not involve use of a calculator. These questions may ask you to briefly explain an observation of predict the result of an experiment. They may ask you to sketch a figure representing the behavior of a system or some phenomenon, or explain phenomena presented in a graph. If you do not learn concepts, you will not be able to answer these questions. If that is the case, you will not do well in the course. In addition, some of the calculation questions may require a clear understanding of concepts in order to do the right calculation! The point is: LEARN CONCEPTS!

Standard Advice for Examinations

Look over the entire examination when you first get it. People often gain confidence by answering the easier questions before going on to harder ones, and you may benefit by skipping around (but be sure to come back to the problems you skipped!). Not all problems on the exam are worth the same number of points. If you are pressed for time, you might concentrate on the ones that are worth more.

Non-Standard Advice for Examinations

If you are simply running out of time**,** then give an outline of the way you would go about answering the question if you did have time**.** Provide some information about the answer. A numerical estimate is best**,** but you may get credit for providing information along the lines of whether the answer will be larger or smaller than the initial value, positive rather than negative, a large number or a small number.

Similarly, if you know an answer is wrong, but don't have time to figure out how you got the wrong answer, you can help yourself by writing something like: "This answer is wrong because _____; a more reasonable answer would be X." If you do this you might not lose as many points as you otherwise would for the error. The blank in the above should be something like "the answer should have been larger than the initial value (positive, a large number) rather than smaller (negative, a small number)." The "X" in the above would be a numerical estimate.

Many students get into trouble by not reading the questions carefully. If you answer the wrong question without realizing it, you will get **zero** credit.

The best use of the cheat sheet during the exam is as a way to double check formulas, results, or ways of approaching a problem. Students who are constantly scanning their cheat sheet to find a formula generally do not find the **right** formula. As is noted in the section on studying for examinations, the value of a cheat sheet is greatest *before* the exam, when you use it to organize the material.

Methodology for Understanding the Physical Meaning of an Equation

(A. P. Chatterjee and T. S. Dibble)

1) Source of Equation: is it empirical, theoretically derived (or justifiable), or, merely a simplifying assumption or hypothesis?
2) Precisely define the physical meaning of each variable.
3) Identify the limits to its use and its domain of validity.
4) Identify units and dimensions of all variables and constants.
5) Identify, if appropriate, which variables are likely to be treated as dependent, and which as independent, in its use.
6) Rearrange it to isolate each variable on the L.H.S., where possible.
7) Try to express the content of the equation for each variable purely in words, as far as possible.
8) Draw graphs, sketch lines, to illustrate key behaviors predicted by the equation; identify relevant turning points, slopes, intercepts, and asymptotes.
9) How is the equation likely to be used by a professional in science or engineering?

Methodology for Checking the Reasonableness of a Calculation

(T. S. Dibble and A. P. Chatterjee)

1) Identify the quantity to be determined and its units
2) Determine the sign of the quantity, or if it should be zero.
3) Estimate the magnitude of the quantity to be determined (or of the change from the initial value).
4) Compare your responses from items (1) - (3) to the answer you are checking and identify discrepancies.
5) Review the calculation to find sources of any discrepancies; your initial analysis could be in error!
6) List things done correctly and incorrectly during the calculation.
7) Identify key error(s), if any.
8) Prepare an assessment of the at least one strength, one area for improvement, and one insight, into the statement of the question or the nature/assumptions of the calculation.

On an exam, you may not have time to redo the calculation, but if you correctly identify the key error(s) and/or write down the answer to (1)-(3), you will probably have earned significant partial credit.

On an exam, step (8) will usually need to be postponed until after the exam, but don't forget to do them!