PHYS 2320
Spring 2018

Course Syllabus

Physics for Scientists II

electricity | magnetism | light | quanta

Lecture:	MWF / 10:30-1:20 pm / SER 122
Studio:	M / 3:30 pm / ESLC 046
Texts:	Wolfson, Essential Univ. Physics, 3rd Edit. w/ online access Evolution of Physics, Einstein & Infeld

About the Course

Physics 2320 surveys a seminal branch of physics known as electromagnetism, relating an impressively diverse set of physical phenomena to a single physical notion: ELECTRIC CHARGE. Rainbows and radio waves; clinging socks and compass needles; friction, lightning, the aurora; and the very concept of light—are all unified under this description. It is even this field of electromagnetism that lead Albert Einstein to his revolutionary theory of Special Relativity.

We begin the semester by defining two fundamental physical notions: ELECTRIC CHARGE and the ELECTRIC FIELD. Together with Coulomb's Law describing the electric interaction between two charges, these two notions will underly the semester . Confining ourselves at first to the special case of stationary charges – a branch of electromagnetism known as *electrostatics* — we'll develop an extraordinarily useful relationship between field and charge (Gauss' law) and introduce the concepts of electric energy, electric potential, and capacitance. Generalizing to the realm of electrodynamics, in which we deal with charge in motion , the fundamental notions of current and resistance are introduced and the discussion turns for awhile to their practical application in electrical circuits.

Our attention then shifts (seemingly!) to magnetism. Magnetic interactions are described and the magnetic field is introduced. But our diversion from electric phenomena is fleeting, for we discover that magnets effect the motions of electric charges — giving us our first inkling that electric and magnetic phenomena are linked. Electrodynamics is quickly drawn back into the story as we discover a connection between electric currents and magnetic fields and examine the laws describing this connection (those of Biot-Savart, Ampere, and Faraday). The crescendo builds to Maxwell's unification of the electric and magnetic theories in the form of his four famous equations. Elegant and powerful, these equations stand as one of humankind's greatest intellectual achievements.

And what Maxwell tells us is that electric and magnetic fields travel in waves, and that these electromagnetic waves… are light! We explore some fundamental behaviors of light, including reflection, refraction, and interference. With all seemingly wrapped up, we nevertheless find a few loose threads, tug on them, and find that electromagnetism holds with in it a revolution. Through Maxwell Einstein discovers that space and time are connected and relative; and through the study of light Planck is led to the quantum. We conclude the semester, then, with an exploration of some of the most fascinating aspects of our physical description of nature — Special Relativity and Quantum Mechanics.

Our Purpose

Nature is what it is — knowing nothing of our concocted abstractions and "laws". It is important, therefore, to understand that physics is a description of nature, not its reality. (Specifically, physics is our *scientific* description—as opposed to, say, an artistic or philosophical description.) Humankind has, through centuries of effort, formulated this quantitative description — this *model* of our universe— based on observation and measurement. It is testable (i.e., falsifiable) and predictive. That is, physics is a conceptual framework within which we attempt to understand and categorize our observations and make predictions about future events, and this framework is subject to agreement with observation.

Learning physics and doing physics comprise several challenges: (i) learning the framework itself (conceptual), (ii) learning to manipulate the elements of the framework (mathematical), and (iii) learning to recast unfamiliar situations in terms of this framework (analytical). This course is about all of these distinct challenges, so a few words about each…

1. Conceptual Development

Our conceptual framework is "physics specific" — something akin to learning the vocabulary of a particular language. In mechanics, for example, we learn that projectile motion can be described in terms of kinetic and potential energy, and that collisions can be described in terms of momentum. These terms do not have the same meaning in, say, economics. As another example, more fitting to this quarter, there is a base level of knowledge required to describe (from within our scientific framework) the operation of a light bulb: specifically, the notions of charge, current, resistance, energy, intensity, power and electric potential. One of the beauties of physics is that the volume of this base level of knowledge is relatively small — only a few definitions and general rules are needed. (In your introduction to mechanics, for example, you may be surprised to know that you used only about two dozen concepts and six laws. In electromagnetism we will add only about a dozen more concepts and three more laws.)

Our goals regarding conceptual development are straightforward: to learn the basics of the framework — that is the definitions and rules of our description — and to gain a base level of proficiency in sizing up natural phenomena according to this framework. The physical concepts introduced this quarter – particularly those of *field* and *potential* — will be more abstract than those of mechanics (e.g., work, energy and momentum). While this can make them more challenging, it also makes them more interesting. Thus our continuing goal in this respect (as with mechanics) will be to introduce and get comfortable with a small but powerful set of core physical notions.

2. Mathematical Development

In literature core concepts and descriptions are represented by words. In physics our core concepts and descriptions are represented not by words, ultimately, but by mathematical objects and equations. The abstract notion of force, for example, is represented by a vector — a mathematical object. And just as there are rules (a grammar) for assembling words into a verbal description, there are rules for assembling mathematical objects (a mathematics) into a scientific description. In order to write his sonnets Shakespeare needed to understand not only the abstract notions of love and sacrifice and jealousy and vengeance that his words represented, but also how to arrange those words according to the rules. Likewise Albert Einstein and Emily Noether needed to understand not only the concepts that their mathematical objects represented, but also the fundamentals of how to manipulate them. [Here I should note that the analogy is imperfect: Shakespeare's words could not reveal to him things about his characters he didn't already know–they were purely descriptive; in physics, however, our mathematical symbols and their manipulation not only describe, but predict. We shall encounter several elegant and powerful examples of this aspect of physics this quarter.]

Just as there are differing levels of literary sophistication (from Shakespeare to See Spot Run), there are many levels of mathematical (quantitative) analysis. Sometimes we may simply want to know whether the object will speed up or slow down, while other times we may need to know by how much and with precision to the eight decimal. Specific mathematical skills we will emphasize in this class are:

- *Deriving Symbolic Relationships* — This means discerning dependencies between physical parameters (both recognizing these dependencies and quantifying them). For example, through simple application of conservation of energy, you found last quarter that the speed v an object reaches when falling from a height h is given by $v = \sqrt{2gh}$. (You also found, perhaps surprisingly, that v does not depend on the mass of the object.) Our techniques for deriving these relationships are more sophisticated this term, with considerable emphasis on the power of integration. But for us it is not solving integrals that will be the prime focus, but properly stating them (after all, once an integral is properly stated it's solution is is just math).

- *Proportional Analysis* — Given a mathematical relationship between parameters, what will be the affect on one of changing another. For example, returning to our v vs. h example, we might want to know how tripling the height from which an object falls will affect its final speed. From the above symbolic relationship we see that the affect will be to increase v — specifically, by a factor of 3 .

- *Order-of-Magnitude Estimation* — Relying exclusively on calculators tends to deprive us of "number sense". It turns out that one can get good estimates for most calculations in less time than it takes to use a calculator. For example, in just a few seconds one can easily estimate a final speed of 45 m/s for an object falling 314 feet — no calculator required. Estimation is a useful skill and will be emphasized.

- *Bounding and Intuition* — Even when detailed calculations are complicated, it is often possible to extract useful information simply by bounding an answer — i.e., finding its maximum and/or minimum possible values. For example, our expression for *v* vs. *h* assumed the absence of air resistance. If we include air resistance the answer turns out to be $v = \sqrt{2g \cdot \left(\frac{1}{h} - \frac{2\alpha}{m}\right)}$, where α is a parameter that can depend in some very complicated way on such things as the object's shape and surface smoothness. If we don't have specific knowledge about α, we can still extract useful information. For example, the maximum speed this object could ever reach is when α = 0 (no air resistance), in which case we get our old equation back, $v = \sqrt{2gh}$. We can also see that making the object's mass (*m*) very large makes the second term in the parenthesis smaller, reduces the effect of air resistance on the final velocity.

- *Translating Words into Math* — One generally poses physical questions with words; in order to answer those questions, however, it is necessary to translate them into mathematical statements, in which words are replaced by mathematical objects (scalars or vectors) and sentences are replaced by equations. For example you might wonder "If a proton and electron have the same kinetic energies, how are their speeds related?" Our translation takes the form:

"If a proton and electron have the same kinetic energies…": $KE_p = KE_e$

"…how are their speeds related?": $\Rightarrow \frac{v_p}{v_e} = ?$

3. Analytical Development

Learning a vocabulary, alphabet ,and grammar allows us to read and write. Similarly, learning physical concepts and mathematical skills allows us to make scientific descriptions and predictions of nature's behavior — more specifically, the behavior of unfamiliar physical situations. After all what good is learning the alphabet if you're not going to read and write, and once you start to read, you don't want to read the same thing again and again; and once you start to write you don't want to write the same thing again and again. Thus the ability to *use* the concepts and math is our ultimate goal (eep this in mind when the going gets a little tedius at times).

Analyzing unfamiliar situations is a skill which, like any other skill, must be developed. In physics, this involves:

- Just getting started, even when you don't have a clue;

- Identifying what you need to find, what the question is about;
- Classifying phenomena and identifying useful tools

EXAMPLE: Consider the following unfamiliar situation: A person is on the roof of a burning building and needs to jump into a fireman's net. The firemen have several nets, some tighter, some looser. Which net is safer? To answer, we need to recast the problem in the physics framework. "Safer" is not in that framework, so our first point of confusion centers on this word. After consideration we decide that, from a physics standpoint, the question is about the person's acceleration in the net: more acceleration (a more sudden stop) means more dangerous. Next we need to think of "tighter" and "looser": what are these terms related to in physics-speak? We decide we can model the net as a spring, where the terms 'tighter' and 'looser' refer to the size of the spring constant. Having recast the problem conceptually, we can now formulate an equation for acceleration in terms of the spring constant, using conservation of energy as a tool.

Our Approach

You are taking a formal course in introductory physics — electricity and magnetism, to be specific. My task is to help you learn and the framework of a formal course offers us a number of tools: lectures, the text, homework, quizzes and exams. A few words about each…

1. Class time (The Agony and the Ecstasy of Articulation). We will approach lectures in this course as interactive discussions about material you are currently studying. We'll clarify common sticking points and then practice applying and articulating concepts. We will not spend the time re-reading the text; the assumption will be that you've read the day's material and are ready to start applying it. I'll briefly review the day's core concepts and then pose questions, which you will attempt to answer through discussion with other students in the class. This format is based on the notion that exposition–attempting to explain something to someone else–is an extremely effective teacher. There are two advantages to this approach. First, it is often the case that we don't understand something as well as we think we do; while it can be easy to delude oneself that understanding has been achieved, it is more difficult to slip faulty reasoning past another. Thus, being forced to articulate our reasoning to others often exposes chinks in our armor that might otherwise go undetected. Second, it can happen that our understanding of a particular matter is actually better than we think it is; that is, we might actually be following a proper line of reasoning, but simply lack confidence in our approach. In this case, expositing to others can have the affect of bolstering your confidence in your own understanding.

2. Reading the Text ('Ya Gotta Do It). It should be obvious that critically important to your success under this system is having read the textbook assignment <u>prior</u> to each day's class. This point is so important, I'll restate it: Vital to your success in this class is your reading of the relevant sections from the textbook <u>prior to each days class</u>. Having said this, it is now important to note that reading a physics text is not like reading a newspaper or a novel. There is a technique to reading technical material, which we'll discuss.

3. Reading Quizzes. The material in this course does not lend itself to cramming; keeping up will greatly increase the quality of your experience. As an additional incentive to keep up with the material and to come to class primed for the discussion, we'll take short reading quizzes nearly every day. As a learning tool, they are purely motivational: prepare as requested before each day's class and you will do fine. The Reading Quiz ground rules are as follows:

- Reading quizzes cover the current day's assigned reading, and the previous day's reading and lecture.

- The quizzes will be given at the beginning of the class period and consist of one or two short answer questions.
- The questions may be quantitative or conceptual and will be designed to be answerable in less than a minute (if you've been keeping up).
- <u>There will be no make-up quizzes.</u> However, allowing for illness and unavoidable absences, approximately 10% of the quizzes will be dropped from your total at the end of the semester.

4. Homework. Often heard in physics department corridors the world over are the words, "I understand the concepts, I just can't do the problems." While I appreciate the sentiment, this isn't a philosophy we'll subscribe to in this course. If you are having difficulty solving a problem, chances are you do not understand the concept involved. But working problems involves more than conceptual understanding: analytical and mathematical skills are also essential, and these skills require practice to develop. Lots of practice. This is why a considerable number of homework problems are assigned and a sizable portion of your grade derives from them. Remember, your goal is to learn, and you will learn the most from the problems you have to struggle with. It will be helpful if you keep this in mind: the point of the homework is not to solve the problems, the point is to understand the solutions. Some details:

- You are required to submit your homework assignments for credit (see the assignment schedule). Some of this work will be through the Mastering Physics online system, some will be assigned in class and turned in in hard copy.
- Late assignments will be accepted, but generally awarded reduced credit.
- There are two important factors in receiving a high score on your homework: (i) properly understanding and solving the problem; and (ii) effectively communicating your understanding and solution. If I can't understand your work and follow it with reasonable clarity, I will award a lower score and move on.

5. Exams. Exams afford the opportunity for both you and I to periodically assess our progress. They are a mixed bag. On one hand they are contrived, stressful situations (for you). On the other hand they can be an extremely effective learning tool, and this is how you should regard them. From my perspective as an instructor, exams allow me to identify systematic misconceptions in the class. From your perspective as students, exams are a feature of the course that motivate you to go back through blocks of material in a focused fashion. Time spent <u>preparing</u> (not "cramming") for exams is invaluable to the overall level of learning.

- Two mid-term exams exams, spaced approximately evenly throughout the term, and a final exam will cover basic information and skills.

- Each exam will comprise multiple choice and short answer questions. Additionally, expect one or two purely conceptual questions in which you will be required to articulate a particular line of reasoning.
- Each exam is comprehensive (including last semester's material).
- None of the exams are optional.
- None of the exams will be dropped.
- All of the exams are weighted equally
- We'll be using the testing center for exams, so there will be no need for make-up exams.

6. Physicist's Studio. Our Monday afternoon "studio" sessions are an important part of this course experience. We'll be reading and discussing a book; you'll be assigned a small number of short essays; and you'll present your solution to what I've turned a "problem jury" (more on all of this below).

Physicist's Studio

As a first-year physics student you'll spend endless hours calculating angles of the inclined planes before the book begins to slip, the components of velocity vectors in two-dimensional collisions, or the centripetal accelerations of some poor bug on a rotating table. Developing these skills is a necessary step. That said, their appeal, in and of themselves, fades quickly — rather like learning the alphabet. And just as sounding out words and memorizing spelling rules aren't always necessarily interesting in and of themselves, they are keys to a much wider world. At this stage of your studies, consequently, it's worth spending time glimpsing the broader landscape, and then connecting the dots from where you are… to where you're going. This will be the role of our Monday afternoon *Physicist's Studio* — *perspective* and *purpose*. Our task is to begin to understand the creative and collaborative nature of not simply learning science, but doing science. Time in studio will be divided among several headings:

1. Evolution of Physics

A critical piece of learning physics is organizing the subject in one's own mind. Albert Einstein was extraordinary not only for his scientific acumen and achievement, but also for his ability to distill complexity into essence — and then articulate this essence to a wide audience. In the late 1930s, as the dust was settling from an unprecedented forty-year storm of discovery, Einstein sat with his friend and colleague Leopold Infeld to trace the path of physics for the layman. The result, *The Evolution of Physics: The Growth of Ideas from Early Concepts to Relativity and Quanta*, is a cogent, concise framework of how our understanding of the physical universe has arisen—from the "primal" concept of motion, to the highly abstract notions of *field* and *quanta*. Einstein and Infeld develop this framework as follows:

- The rise of the Mechanical View
- The Decline of the Mechanical View
- Field & Relativity
- Quanta

It is a holistic perspective that will help you orient yourself as you progress in physics through the remainder of the curriculum. We'll read their book is seven installments throughout the semester and discuss them in our Monday afternoon studios.

2. Scientific Habit of Mind

As you embark upon your study of physics, considered by many to be the most foundational of the physical sciences (Ernest Rutherford famously proclaimed "*In science there is only physics; all else is stamp collecting!*"), it is worth spending time discussing explicitly what it means to think as a scientist — as a physicist. The philosopher and mathematician Bertrand Russell has written…

> *"The increased command over the forces of nature which is derived from science is undoubtedly an amply sufficient reason for encouraging scientific research, but this reason has been so often urged and is so easily appreciated that other reasons, to my mind quite as important, are apt to be overlooked. It is with these other reasons, especially with the intrinsic value of a scientific habit of mind in forming our outlook of the world, that I shall be concerned in what follows.*
>
> *— Bertrand Russell, in The Place of Science in a Liberal Education, 1913*

More than anything it is Russell's *scientific habit of mind* that you will be cultivating as you progress.

3. Problem Juries

Once one has begun to acquire a scientific habit of mind, it's a good idea to exercise it. In your problem sets you'll apply the concepts of the day to generally straightforward applications. Every now and then, however, it's nice to really wring things out; to take your skills, knowledge and mindset out for a spin to what they can do. In this spirit you'll be assigned a number of challenging questions to address. Your task is not necessarily to answer the questions definitively (though this will be possible), but to identify an approach and get as far as you can. Each of you will be required to present your solution to the course for discussion and feedback.

4. Grand Challenges

The good news: a well-trained physicist can do an awful lot. The bad news: a well-trained physicist can do… well… an awful lot.

And so how to spend the minutes of your days — *five million professional minutes* (exercise), more or less? How will you choose to wield your superpowers? The great American inventor Edwin Land once said "*Never undertake a project unless it is manifestly important and nearly impossible*." As it turns out, the world you now inhabit is filled with manifestly important challenges. Some are small; some are great… and some are grand. We'll spend some of our studio time this semester exploring these grand challenges, orienting ourselves to how our physics educations might fit in to the most interesting and important questions of the day.

5. Notebooks

One of the great rewards of a life in physics is simply thinking fascinating thoughts, taking the time to explore ideas and questions in your own mind — never mind who else has thought of them or how silly you're sure the thought must be. To develop this aspect of becoming a physicist you'll be asked to begin keeping a notebook — a personal record of your intellectual life as a physicist. These notebooks will be assessed from time to time throughout the semester.

Administrivia

I. ATTENDANCE

Come to class. This course has been created specifically for you — physics students. Not engineers or pre-med, not chemists or computer scientists. It's an opportunity most students don't have. This course has been designed for you, and class time is a critical piece. This isn't an online course, nor is it simply about mastering a few facts or skills. It's a collaboration. Every day. The vibrancy of live, in-class experience — just as live performance — can't be matched. This is the advantage of being here, not in your basement basking in a computer glow. Science — as with all intellectual pursuit — thrives on interactive discussion. We'll regularly engage in in-class exercises which — obviously — only benefit those who are present to participate. Also, attendance is required. If you don't come, you won't pass. Clarity… :)

II. GRADING

Grades. Sigh. Apparently we must.
Fortunately, they can serve a purpose.

In this course our purpose in grading is not to sort you for graduate schools, potential employers, or any one at all for that matter. Our sole intent is to (i) provide you with a little feedback, and (ii) provide you with a little motivation (because you understand that graduate schools and employers will use these grades to sort you). Optionally, you may also choose to use your grade to self-assess your own self worth. This isn't recommended, though some students insist. But my opinion, for what it's worth, is that life is more interesting than that. :)

Here's the math…

- Exams (~50%) — There will be two mid-terms and a final exam, all comprehensive and equally weighted.
- Problem Sets (~25%) — There will be approximately fourteen graded problem sets over the semester, comprising online and in-class problems.
- Physics Studio (~15%) — Reading, a few short essays, and much class discussion.
- Reading Quizzes (~10%) — Easy points, almost every day. I'll drop three.

Caveat: A minimum 50% score is required in each category (exams, problem sets, studio, quizzes). Perfect scores on exams and problem sets, for example, but zeros in studio and quizzes will not be sufficient to pass the course.

Letter grades will be assigned roughly according to a 90-80-70-60 breakdown, though I do reserve the right to make modest adjustments either way, as individual cases warrant.

Grading Issues — We can always talk about your grade. If you're concerned, proactive is good. Come see me, we'll talk.

Additional Information

I. SEXUAL HARASSMENT

Sexual harassment is defined by the Affirmative Action/Equal Employment Opportunity Commission as any "unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature." If you feel you are a victim of sexual harassment, you may talk to or file a complaint with the Affirmative Action/Equal Employment Opportunity Office located in Old Main, Room 161, or call the AA/EEO Office at (435) 797-1266.

II. STUDENTS WITH DISABILITIES

The Americans with Disabilities Act states: "Reasonable accommodation will be provided for all persons with disabilities in order to ensure equal participation within the program." If a student has a disability that will likely require some accommodation by the instructor, the student must contact the instructor and document the disability through the Disability Resource Center (435) 797-2444, preferably during the first week of the course. Any request for special consideration related to attendance, pedagogy, taking of examinations, etc., must be discussed with and approved by the instructor. In cooperation with the Disability Resource Center, course materials will be provided in alternative format (e.g. large print, audio, diskette, or Braille) upon request.

III. GRIEVANCE PROCESS

Students who feel they have been unfairly treated [in matters other than discipline, admission, residency, employment, traffic, and parking - which are addressed by procedures separate and independent from the Student Code] may file a grievance through the channels and procedures described in the Student Code: Article VII Grievances

Summary Syllabus

Weeks 1-4 Ch. 20-25	*Electrostatics* electric charge | electric force | coulomb's law | electric field | discrete vs. continuous charge distribution | electric flux | gauss's law | electric potential | potential difference | electrostatic energy | capacitors | current | resistance | ohm's law | electric power | emf | resistors | circuits
Weeks 5-10 Ch. 26-29	*Electromagnetism & Light* magnetic force | law of bio-savart | magnetic field | ampere's law | maxwell's eqns | electromagnetic waves | reflection | refraction | mirrors | lenses | coherence | diffraction | interference | huygen's principle
Week 11-15 Ch. 30-36	*Relativity, Quanta & Atoms* special relativity | lorentz transformations | general relativity | blackbody radiation | photons | bohr atom | uncertainty principle | complementarity | particle-wave duality | schrodinger eqn | quantum mechanics | hydrogen atom | spin

Lecture Syllabus

WEEKS 1-5

8 Jan	L 1 | L 2 |	Introductory Lecture (EXPLORATIONS) | Ch. 20 (Sec. 1-3)	PS 1
10 Jan	L 3 |	Ch. 20 (Sec. 4-5)	
12 Jan	L 4 |	Ch. 21 (Sec. 1-3)	DUE
15 Jan		NO CLASS (Martin Luther King, Jr. Day)	PS 2
17 Jan	L 5 |	Ch. 21 (Sec. 4-6)	
19 Jan	L 6 |	Ch. 21 (Sec. 7-8)	DUE
22 Jan	L 7 |	Ch. 22 (Sec. 1-2) electric potential | potential difference	PS 3
24 Jan	L 8 |	Ch. 22 (Sec. 3-4)	
26 Jan	L 9 |	Ch. 23 (Sec.1-2)	DUE
29 Jan	L 10 |	Ch. 23 (Sec. 3-4)	PS 4
31 Jan	L 11 |	Ch. 24 current | resistance | ohm's law | power	
2 Feb	L 12 |	Ch. 25 (Sec. 1-3)	DUE
5 Feb	L 13 |	Ch. 25 (Sec. 4-5)	PS 5
7 Feb	L 14 |	Ch. 20-25 Review	
9 Feb		DEMONSTRATON DAY (RD Traveling)	DUE

Lecture Syllabus

WEEKS 6-10

12 Feb	L 15 L 16	Ch. 26 (Sec. 1-3) (EXPLORATIONS) Ch. 26 (Sec. 4-6)	PS 6
14 Feb	L 17	Ch. 26 (Sec. 4-6)	
16 Feb	L 18	Ch. 26 (Sec. 7-8)	DUE
20 Feb	L 19	Ch. 27 (Sec. 1-2)	SET 7
21 Feb	L 20	Ch. 27 (Sec. 3-4)	
23 Feb	L 21	Ch. 27 (Sec. 5-6)	DUE
26 Feb	L 22	Ch. 28	PS 8
28 Feb	L 23	Ch. 28	
2 Mar	L 24	Ch. 29	DUE
12 Mar	L 25	Ch. 29	PS 9
14 Mar	L 26	Ch. 29	
16 Mar	L 27	Ch. 26-29 Review	DUE
19 Mar	L 28	Ch. 30	PS 10
21 Mar	L 29	Ch. 31	
23 Mar	L 30	Ch. 32	DUE

Lecture Syllabus

WEEKS 11-15

26 Mar	L 31 |	Ch. 32	PS 11
28 Mar	L 32 |	Ch. 32	
30 Mar	L 33 |	ok	DUE
2 Apr	L 34 |	ok	SET 12
4 Apr	L 35 |	Ch. 33	
6 Apr	L 36 |	Ch. 33	DUE
9 Apr	L 37 |	Ch. 33	PS 13
11 Apr	L 38 |	Ch. 34	
13 Apr	L 39 |	Ch. 34	DUE
16 Apr	L 40 |	Ch. 35	PS 14
18 Apr	L 41 |	Ch. 35	
20 Apr	L 42 |	Ch. 36	DUE
23 Apr	L 43 | L 44 |	Ch. 36 (EXPLORATIONS) | Concluding Lecture	PS 15
25 Apr		DEMONSTRATION DAY (RD Traveling)	
27 Apr		NO CLASS (RD Traveling)	DUE