Physics 115: Inquiry into Physics - Fall 2015

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Science is more than just a body of knowledge about the world; it is about the process of figuring things out. Most science courses (including physics) tend to focus on the content, relegating instruction of the practices to a single chapter at the beginning of the book. In this course, we will focus on this process: we will discover, construct, and refine our ideas about physics by theorizing and experimenting as a class. We will play with our scientific ideas in ways that give us a sense of what scientists actually do.

Although this course would be beneficial to a wide variety of students, we are generally going on the assumption that you are majoring in elementary education and childhood education. It is not necessary for you to have taken physics courses in high school. We will be learning about physics by starting with your own thoughts, observations, and experiences about the world around you. We will have small-group and whole-class discussions, try out different experiments, and document our findings to develop our understanding of physics together. We will build on our ideas that help us understand the phenomena and chip away at the parts that get in the way or that do not match up with the experiments we conduct in class. Much like scientists, we will be collaboratively building the content as we go. This process requires that you tap into the following:
1. Your questions and curiosity about the world around you
2. Your willingness to reflect upon, share, and refine your thinking process
3. Your willingness to be responsive and responsible to your classmates

The main idea of this course is to offer opportunities to take part in the practices of science, particularly the work of physicists. This work involves collaborative theory-building and experimentation. Also, we hope that you will incorporate these practices into your own teaching. We also want you to have fun exploring the creative and playful side of physics. We hope you come away with the following:
1. Deeper understanding of the physics of motion, heat, and electricity
2. Deeper understanding of how physics is done by generating and evaluating ideas – sense making – through argumentation and empirical testing
3. Enriched confidence in your own abilities to learn and teach science
4. Appreciation of the pleasure in figuring things out

Class Meetings
Section 0101: Monday, Wednesday, and Friday, 1:00 pm to 2:50 pm, PHY (Toll Physics Bldg.) Room 3316
Note also Section 0102: 9:00 am to 10:50 am, same room, taught by Dr. Marguerite Tonjes, who also will occasionally substitute teach in my absence.

Textbook
There is no required text for this class. There may be occasional reading assignments, which will be provided. You will be asked to keep a lab notebook and participate in Discussions on ELMS. Since some students do crave a book to which to turn, two gentle introductory volumes will be placed on reserve at EPSL library: *Physics for Poets*, 2nd ed., by Robert H. March and *Conceptual Physics* by Paul G. Hewitt.

Course Activities
Participation: Since this process of learning physics is inherently collaborative, it is critical that you be present (both physically and mentally) during class meetings. We ask that you contribute your own thoughts, experiences, and observations, as well as listen to, refine, and build on those of your classmates.

Lab Notebook: A critical part of science is documenting your thoughts, ideas, findings, and progress. We

ask that you keep an individual notebook to record your observations, the observations of your peers, your ideas, the ideas of your peers, and the evidence for and against each idea. This notebook will be for you; it will not be graded, but you are allowed to use it on exams.

Daily Summaries: At the end of each class, we will ask you to write a short summary (2-3 paragraphs) of the activities and findings that day. In the first part you will summarize what progress we have made as a class. In the second part we ask you to reflect on your individual ideas about both the phenomena and our progress. These summary sheets are to be entered onto the PHYS115 course page on ELMS at the end of each class before you leave the lab. An example summary by the TA can be found linked to the syllabus. In general, your summary should include the following:

Hypothesis (guess before trying the laboratory)
↓
observation
↓
analysis/conclusions
↓
other observations
↓
conclusions/model

Any new terminology should be used appropriately within the above discussion.
Daily questions: Each laboratory will have a series of questions to be submitted, these should be submitted separately on ELMS by the end of the day (by 11:59 pm) on which the particular laboratory was performed.

Course Discussion: One group each week will be assigned the role of "Lab Recorders". They document our progress, for all of the classes that week, in the "Course Discussion" section of ELMS. While one group will have primary responsibility to update the discussion each week (and be graded upon the primary responsibility), we encourage all students to review and contribute. We will start each class by reviewing the discussion, deliberating our ideas and how to best communicate and document them. The non-lab recorder participation will be "extra credit". Once all groups have had the primary responsibility, in following weeks all groups will be required and graded upon this responsibility (5 points apiece). Near the end of the semester (before Thanksgiving), each lab group will give a 10 minute presentation on a topic related to material covered in the class as part of the discussion credit.

Weekly Homework: Every Monday (approximately) we will ask you to complete several essay-type questions. These questions will ask you to think more about what we have discussed in class and push you to use the foothold ideas in new ways. They will typically be due on Mondays, and you may be asked to revise and resubmit them, especially early in the semester.

Exams: At the end of each unit, we will take stock of what progress we have made as a class in understanding a given phenomenon and how to approach related physics questions. Parts of the exams will ask you to make predictions, observations, and explanations about physical phenomena using new materials, while others will consist of essay questions asking you to use the foothold ideas that we develop in class. There will be 3 such exams but no cumulative final exam.

Assessment

Your grade will be based equally on your in-class participation, daily summary sheets/discussion participation, weekly homework, and exams. We will be assessing your work with how well it lines up with the central elements of good scientific inquiry, which we have distilled into several principles below.

Causal stories: Scientific explanations and predictions are based on understanding what causes physical phenomena, producing what can be thought of as "causal stories". A causal story explains or predicts a phenomenon by piecing together the chain of events that makes it happen. A good causal story clearly describes all the important causal "characters" and what roles they play in bringing about an outcome.

Example:

Q: Why does a balloon rise when you inflate it?
If someone answered by saying, "Because it is lighter than the air around it?", does that count as a good causal story? It is a good start, but it is not yet clear what "lighter" means, or what makes a balloon lighter than air, or why air plays any role in it at all – and this is one sort of feedback you will be getting from us. What would you say? We will be looking for how well you seek out and incorporate causal stories in your work, focusing less on correctness and more on linking cause-and-effect.

Coherence: Scientific explanations also have to make sense, meaning they must account for different observations, connect to previous ideas and experiences, and/or recognize when something is unexplained. Foothold ideas are something we will arrive at as a class: ideas we think we can accept as true, at least for the time being. We will use these ideas as building blocks for further investigations, by making attempts to reconcile new ideas and findings with our footholds. If it becomes too difficult to reconcile any contradictions, we will have to search for new foothold ideas on which to base our understanding. As we establish foothold ideas, you will be asked to make connections and build on these to develop other scientific explanations. We will be looking for how well you make connections to other ideas, spot inconsistencies, reconcile them, account for our foothold ideas, and identify unexplained phenomena.

Clarity: In physics, progress is achieved by working as a community to develop shared understanding about terms, descriptions, explanations, and predictions. This shared understanding has been negotiated over hundreds of years through a process of introducing ideas, clarifying those ideas, testing them, and resolving any disagreements through respectful argumentation and discussion. We will be looking for how well you participate in this process in our course: how well you make your own ideas clear to us and your classmates, as well as how well you strive to understand others' ideas and seek clarity in our discussions.

Creativity: Science is a creative process; you have to look at things in a new way, come up with innovative connections, or dream up an experiment to test an idea. Sometimes this will involve thinking up a "crazy" idea and refining it, or taking a leap on a hunch that you can't quite articulate yet. We want you to bring your unique perspective to our class and group discussions, not just restate others' ideas.

Reflection: Part of expertise in physics is having multiple ways of thinking about a phenomenon. Another aspect of expertise is knowing that you have multiple ways of thinking, and being able to evaluate yours and others' thinking according to the inquiry guidelines mentioned above. Therefore, we ask that you reflect on your own, your groups', and the class's understanding of the phenomena under study. Particularly on daily summaries and exams, we will look for explicit reflections about your progress.

Course Policies
Academic Integrity: Honesty is the foundation upon which science is built. Academic dishonesty is particularly disgraceful in science, perhaps because it affects not just individuals the whole scientific community and any work that builds upon it. We take academic integrity seriously. Please take a look at University policy regarding the Honor Pledge and if you have any questions about academic integrity relevant to this class please don't hesitate to ask.

Excused absences: Participation is really a crucial part of this course, and so we strongly urge you to come to class. Of course, circumstances may arise that are out of your control that may keep you out of class, such as medical emergencies and religious holidays. Please let us know of any anticipated excused absence as soon as possible. Makeup exams will be made available for excused absences only. *NB*: We will still meet when the university has a delayed start, unless otherwise noted via email or on ELMS.

Special arrangements: If you have any special needs relevant to this course, please do **NOT** hesitate to let me know so we can determine how to best accommodate you.

In case of emergency: We will update ELMS with plans if the University is closed for an extended time.

Note: Syllabus adapted from previous instructors: David Buehrle, Prabal Adhikari, & Marguerite Tonjes

PHYS115 Course Schedule
Minor changes to this plan are possible.

ELECTRICITY AND MAGNETISM		
Experiment 1:	Mon 08/31	E01: Batteries and bulbs
Experiment 2:	Wed 09/02	E02: Good and bad conductors
Experiment 3:	Fri 09/04	SE01: Static electricity
Labor Day	**Mon 09/07**	
Experiment 4:	Wed 09/09	E03: Batteries in series
Experiment 5:	Fri 09/11	E04: Size and direction of current
Experiment 6:	Mon 09/14	E05: Bulbs in series
Experiment 7:	Wed 09/16	E06: Parallel circuits
Experiment 8:	Fri 09/18	E07: Voltmeters, ammeters and power supplies
Experiment 9:	Mon 09/21	E08: Introduction to linear relationships
Experiment 10:	Wed 09/23	E09: Ohm's law, resistors and power
Experiment 11:	Fri 09/25	E10: Resistors in series and parallel
Experiment 12:	Mon 09/28	E12: Magnets
Experiment 13:	Wed 09/30	E13: Currents and magnetism
HEAT AND ENERGY		
Experiment 14:	Fri 10/02	H01: Heat and temperature
Experiment 15:	Mon 10/05	H02: Heat transfer and thermal equilibrium
Experiment 16:	Wed 10/07	H03: Mixing water at different temperatures
Experiment 17:	Fri 10/09	H04: Mixing unlike materials
Experiment 18:	Mon 10/12	H05: Specific heats of aluminum and copper
Exam 1 (Electricity & Magnetism)	**Wed 10/14**	
Experiment 19:	Fri 10/16	H06: Mixing ice and water latent heat of fusion
Experiment 20:	Mon 10/19	H07: Freezing Water
Experiment 21:	Wed 10/21	H08: Condensing steam - latent heat of vaporization
Experiment 22:	Fri 10/23	H09: Temperature of liquid nitrogen
Experiment 23:	Mon 10/26	H10: Rate of cooling and conservation of energy
MOTION AND FORCE		
Experiment 24:	Wed 10/28	M01: Introduction to motion detector
Experiment 25:	Fri 10/30	M02 & M03: Predicting what a graph will look like & Readi
Experiment 26:	Mon 11/02	M04: Instantaneous velocity and acceleration
Experiment 27:	Wed 11/04	M05: Equation of distance versus time (constant force)
Experiment 28:	Fri 11/06	M06: Relation between mass, velocity and acceleration
Exam 2 (Heat & Energy)	**Mon 11/09**	
Experiment 29:	Wed 11/11	M07: Force due to gravity
Experiment 30:	Fri 11/13	M08: Pendulum
Experiment 31:	Mon 11/16	M09: Masses & springs
Experiment 32:	Wed 11/18	M10: Motion of a ball thrown in an arbitrary direction
OPTICAL PHENOMENA		
Experiment 33:	Fri 11/20	L01: Light propagation and geometrical optics
Presentations	**Mon 11/23**	
No class	**Wed 11/25**	
Thanksgiving Break	**Fri 11/27**	
Experiment 34:	Mon 11/30	L02: View through a pinhole camera (magnification)
Experiment 35:	Wed 12/02	L03: Reflection and images
Experiment 36:	Fri 12/04	L04: Refraction, ray diagrams and Snell's law
Experiment 37:	Mon 12/07	L05: Lenses and ray diagrams
Review	Wed 12/09	
Exam 3 (Motion & Force, some Optical)	**Fri 12/11**	
No Final Exam		