PHYSICS 115

Inquiry Into Physics

Spring 2011
MTW 2-3:50

Section 0101
Room 3316, Toll Physics Building

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"The whole of science is nothing more than a refinement of everyday thinking."
-Albert Einstein

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.

What we hope you will bring into this course:

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, then, 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

What we hope you will take away from this course:

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:

1. Deeper understanding of the physics of motion, heat, and electricity
2. Deeper understanding of how physics is done by generating and evaluating ideas—sensemaking—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

Materials

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 on the Course Wiki on Blackboard.

Milestones

Exam I – Inquiry into motion
(end of February)

Exam II – Inquiry into circuits
(beginning of March)

Exam III – a topic TBA
(beginning of May)

About your instructors

Luke Conlin is a Ph.D. Candidate in the School of Education, department of Curriculum & Instruction. He is writing a dissertation on how groups of people manage the process of building a shared understanding. He has taught high school physics in Massachusetts for five years, as well as astronomy, oceanography, and algebra.

Jessica Watkins is a postdoctoral researcher in the department of physics. She studies student learning in introductory physics and biology courses, exploring the disciplinary differences and their consequences for students. She received her Ph.D. in applied physics, researching how students experienced reformed physics classrooms and gender differences therein.

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 will be able 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 will be collected at the end of each class and returned the following day in class.

Course Wiki – One group each week will be assigned the role of "Wiki Keepers." Instead of completing the daily summaries, they document our progress as a class each day on the course wiki. While one group will have primary responsibility to update the wiki each week, we encourage all students to review and contribute. We will start each class by reviewing the wiki, discussing our ideas and how to best communicate and document them.

Weekly Homework – Every Wednesday (approximately) we will ask you to complete several essay-type questions. These questions will ask you to think more about what we've 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 during the start of 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 we develop in class.

Assessment

Your grade will be based equally on your in-class participation, daily summary sheets/wiki 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. (See the example to the right.) 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. As we as a class establish foothold ideas, you will be asked to make connections and build on these to develop other scientific explanations. We'll be looking for how well you make connections to other ideas, spot inconsistencies, reconcile them, account for our foothold ideas, and identify unexplained phenomena.

Grades

As much as possible, we'd like to keep your attention on the substance of what we're doing rather than on grades. Science is not about accumulating points! Therefore, we will only give written comments on your daily summaries and comments with a coarse rating on your weekly homework. We will give you letter grades on the exams and at the end of each unit so you have an idea of where you stand throughout the semester.

Collaboration

We are going to work together throughout this course. It is important to be able to disagree without making it personal; otherwise the discussion won't be productive. Though we may end up at times pursuing different ideas, and even competing with others' lines of thinking, the big picture is that we are collaborating with each other to accomplish a common goal: understanding the world around us.

Why does a balloon rise when you inflate it?

Q: If someone answered by saying, "because it's lighter than the air around it," does that count as a good causal story?

A: 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?

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' understanding of the phenomena under study. Particularly on daily summaries and exams, we will look for explicit reflections about your progress.

Special Cases:

Excused absences – Participation is really a crucial part of this course, and so we strongly urge you to make it 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 <u>excused absences</u> only. NB: We will still meet when the university has a delayed start, unless otherwise noted via email or on Blackboard.

Special arrangements – If you have any special needs relevant to this course, please don't hesitate to let us know so we can figure out how to best accommodate them.

In case of emergency – We will update Blackboard for plans if the University is closed for an extended period of time (e.g. last winter!)

Foothold Ideas

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.

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.