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Rutgers, The State University of New Jersey

15:256:551:01 DEVELOPMENT OF IDEAS IN PHYSICAL SCIENCE
Fall 2016
MONDAY, 4:50 – 7:30 PM
GSE ROOM 25A

Instructor: Eugenia Etkina	Eugenia.etkia@gse.rutgers.edu
Phone Number 732 690 5284	10 Seminary Pl Rm 217
Office Hours: by appointment	Prerequisites or other limitations:
Mode of Instruction: ___ Lecture __X_ Seminar ___ Hybrid ___ Online ___ Other	Permission required: __ No _X_Yes Directions about where to get permission numbers: from the instructor

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Course Description

Learning goals:
1. To understand how scientists devised the ideas and relations that constitute the content of a general physics course.
2. To learn how to use a similar process in a classroom to help students construct physics concepts and relations.
3. To learn how student learning of physics/physical science relates to the scientists' learning.
4. To experience what it means to design and implement classroom instruction.

New Jersey Professional Standards for Teachers (2014)[1]:

1 (Recognizing how patterns of learning and development vary individually; designing and implementing appropriate learning experiences,

[1] http://www.state.nj.us/education/code/current/title6a/chap9.pdf

3 (Demonstrating respect for cultural backgrounds and differing perspectives that learners bring to the learning environment; Use of various communication strategies and technological tools to build local and global learning communities that engage learners, families and colleagues)
7 and 8 (Planning in use of assessment data and students' prior knowledge and interest; Collaborative planning among teachers and with learners to support design of relevant learning experiences)

Council for the Accreditation of Education Professionals (2013)[2]:

Standard 1: Candidate Knowledge, Skills, and Dispositions
1.1 Content Knowledge and Pedagogical Knowledge
1.2 Instructional Practice
- Learning Experiences

Course catalog description:
The main goal of the course is to help you understand the epistemology of physical science and its implications to science instruction. Epistemology is the study of the construction of knowledge. Basically in this course you will learn how scientists know what they know, how they approach problems and how they decide what to keep and what to discard. We will focus on the process that lead to the laws of physics and chemistry that we teach our students and how learning of our students sometimes resembles that of real scientists. You will learn how to use the knowledge of epistemology and history of science to design physics/chemistry lessons.

Class materials
Textbooks required: Gerald Holton & Stephen Brush, Physics, The Human Adventure, Rutgers University Press, 2001. ISBN 0-8135-2908;
Not required but will be helpful: Morris Shamos, Great Experiments in Physics, Dover Publications, New York, 1987. ISBN 0-486-25346-5, available at Eugenia's office for a week at a time.

Grading and Activities To achieve a positive grade in the course you need to meet all standards. To achieve a standard you need to be able to convince me that you do indeed meet it. It is your responsibility to do this and after we both agree that the standard is met, you will record this in a special file.
In addition, you will have weekly homework assignments and class quizzes. **Each assignment and each quiz can be improved.** I encourage you to try as many times as you need to make the assignment perfect.
Rubric for assessment of all assignments: 1 – does not meet expectations, 2 – moving towards meeting expectations; 3 – meets expectations; 4 – exceeds expectations (I want to brag about you). I believe that every student in this course will work to exceed my expectations.
List of standards to meet:

[2] http://caepnet.files.wordpress.com/2013/09/final_board_approved1.pdf

General standards:
GS1: Is able to articulate the difference between a hypothesis and a prediction and the logic of hypothetico-deductive reasoning and to provide examples of such reasoning from the history of physics.
GS2: Is able to use ISLE philosophy to trace the history of how scientists devised the concept that is the goal of your project (see the description of class activities below), to design a realistic high school lesson for the part of this development, and to document the development of the concept in an original paper with proper citations.
GS3: Is able to place the name and the clock reading on the development of major concepts and to show the historical connections among the development of physics concepts.
GS4: Is able to analyze a non-expert understanding of those concepts through an interview.
GS5: Is able analyze a popular science article using ISLE cycle.
GS6: Is able to tell an engaging memorable story about a scientist involved in the development of the project related idea.
GS7: Is able to plan and facilitate an interactive engagement lesson related to the topic of the historical project.
Physics specific standards: Is able to solve *any* problem from any unit of a high school physics course using expert approach.

At the beginning of each lesson we will have a short quiz. The questions will show you and me how you meet the weekly goals. An example of a question for Goal E is E8a: Describe Joule's experiments of gas expansion into a vacuum and explain whether those were observational or testing experiments. How do you know? An example of a question for goal U is U3A: A horse is pulling a cart. The horse exerts a force on the cart and the cart exerts a force on the horse that is equal in magnitude and opposite in direction. As the sum of these forces is zero, the cart should never start moving. But it does. How can this be?

Each of you will have a folder on google classroom and there you will have a document where you will document the achievement of the standards. By the end of the semester all standards should be achieved.

Description of activities
<u>Participation in class discussions:</u> Class work will be primarily group work. You will explore contemporary versions of classical experiments, read and interpret original papers of scientists, explore how scientists chose one theory over another, and discuss how to adapt some of the historical materials for high school physics instruction. At the same time you will learn how students construct similar concepts. We will also discuss the readings that you will do at home. Each week you will read several of the chapters of the text and additional articles. We will discuss these chapters in class and in these discussions you have an opportunity to show that you meet specific standards.

<u>Homework (individual assignment):</u> a) each week <u>**on Tuesday**</u> you will read a chapter/chapters from the textbook describing the development of a particular idea that was discussed in class (see tentative list of topics). Then you will combine the material from class, from the book, and from any other convenient sources (I encourage you to use the Shamos' book and resources on the

Web) to write a report reconstructing the inductive, analogical and hypothetico-deductive reasoning and experimental evidence used by scientists to construct a particular idea. In your report try to make a clear distinctions between initial observational experiments, reasoning (hypotheses), predictions of the outcomes of new experiments, based on the hypotheses, and experiments conducted to test hypotheses. Try not to confuse experimental evidence with hypotheses/explanations. Also, do not confuse hypotheses/explanations with predictions. The glossary of terms is at the end of the syllabus.
At the end of the report you need to reflect on how your personal understanding of the concept changed because of the learning of the history.

Report should be submitted to your folder on Google classroom by **Wednesday night** or **Thursday before 8 am**. Make sure this is the best you can do. On **Thursday morning/afternoon** you will receive feedback, and revise the report if necessary by **Saturday** morning. At the beginning of the semester BE READY to do 3-4 revisions per homework. Plan your week accordingly so you can spend Tuesdays and Wednesdays working on the homework. During some weeks you will do on-line assignments, be prepared to spend about one additional hour doing those.

Problem solving (individual): At the beginning of each class we will have 20 min dedicated to problem solving – you will need to solve and present to the class a problem. The purpose of this part of class is to help you focus on the physics/chemistry ideas, concepts and, most importantly, on the new language that we will be using. You can show that you can solve relevant to the standard problem during office hours or with a screencast with narration. An example of a problem: In his book Horologium Oscillatorium published in 1673, Christian Huygens described his method of controlling clocks with a pendulum. In this book one can find the following statement: "If a simple pendulum swings with its greatest lateral oscillation, that is, if it descends through the whole quadrant of a circle, when it comes to the lowest point of the circumference, it stretches the string with three times as great a force as it would if it were simply suspended by it"[3]. Explain why Huygens would make this statement. Draw a picture, a force diagram, and an energy bar chart if necessary.

Interview (individual): As one of the major skills of a teacher is to be able to hear a student, you need to practice listening and hearing. To do this, you will choose one concept whose historical development we will trace in the course and interview two people – an expert in the field of physics and a person who is not familiar with physics. The goal of the interview is to find out what the person understands about the concept and how she/he can apply it. You need to (1) design the interview questions, (2) submit it to Eugenia a week prior to the interview, then (3) conduct the interview, record it and (4) write a report. In the report you need to show that you can connect what you heard during the interview to the history of the development of the concept. The report is due November 1st. Make sure you have enough time for steps 1 though 4.

The New York Times Analysis (individual) Every Tuesday *The New York Times* features *Science Times*. Choose any article from *Science Times* related to physics or chemistry (available on line) to analyze it using your knowledge of scientific epistemology and structural elements of

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[3] The text of the statement can be found Walcott, 1935.

scientific knowledge (observational experiments, patterns, explanatory mechanisms/hypotheses, models, physical quantities and experimental uncertainties, relationships between physical quantities, predictions, additional assumptions, and testing experiments. You will need to type up the article with the annotations on the right side of the page across each statement in the article (see the example attached). When choosing an article try to find one that has a good representation of the elements of the knowledge. You must include the title of the article, its author and her/his affiliation, page number(s), and the date of the article. I reserve the right to give you an additional article that I chose to annotate any time during the semester.

History project (group assignment): You and 2 of your teammates will choose one fundamental idea in physical science (from the list in the table below) and trace its historical development following the *ISLE* cycle. Together you will write **a paper** describing the development of the idea and **prepare a lesson** to teach in class in which *parts* of the historical cycle will be recreated. You will submit both (the paper and the lesson) for feedback to Eugenia, revise (be prepared to do several revisions) and then teach a lesson in class. In your lesson you should use at least one experiment that is analogous to a historical experiment important for the development of the idea (or present data from a historical experiment).

Deadline for submitting the paper: 2 weeks prior to class presentation.

Story telling (individual assignment, part of the history project above): You will choose a physicists or a chemist who contributed to the development of your history project idea (see the history project assignment) and research personal information about her/him and her/his scientific achievements (you need to find a book dedicated to this person; Internet materials are not sufficient). You will write a story about her/him that you will tell in class or record with a screen cast and narration. In the story your character should become alive.

Instructional materials (group assignment): The story telling project and the lesson curriculum materials **after final revisions** will be copied for all class participants.

Deadlines:
Homework is due Wednesday night or Thursday before 8 a.m.
November 1st – Interview report.
End of September NYT article annotations.
History project & story telling:
Idea-scientists should be chosen by September 20th.
First draft of the ISLE cycle for the idea is due October 20th.
First draft of the lesson is due two weeks prior to the presentation.
History project materials – final draft: November 20th.

Academic integrity: Make sure that you provide proper citations for all materials that you use in your reports.

Materials for class will be posted on Google classroom; you are responsible for printing them and bringing a copy to class.

Tentative list of topics for discussions and homework assignments (by week, chapters are from Holton and Brush)

Week	Topic	Assignment (Ch)
1	Epistemology of physics. Size of Earth	1, 3, 12, 13, 14
2	The study of motion	6, 7, 8
3, 4	Newtonian World	9, 10, 11 NY times article
5, 6, 7	The Laws of Conservation, caloric theory	15, 16, 17, 18
8	Atomic Theory, pressure	19, 20, 21, 22
9,10	Electromagnetism	24, 25
11, 12, 13, 14	Quantum physics, atom, and nucleus	23, 26

Possible Ideas and Scientists for projects (groups of two)

Ideas	Scientists
Static electricity, electric charge, conductors and insulators Nov 2nd	Franklin, Coulomb, DuFay, Gray
Battery, Ohm’s law Nov 9th	Galvani, Volta, Ohm
Electron Nov 16th	J. J. Thomson; Millikan,
Quantum model of light Nov 30th	Einstein, Lennard
Radioactivity Dec 7th	Mari Curie