Energy on this World and Elsewhere

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This document provides information, including a preliminary syllabus, on the course Physics 1110, Energy on this World and Elsewhere. If you accessed this document through the sis course catalog or UVa Collab, please note that the primary website for this course can be found at:

http://people.virginia.edu/~gdc4k/phys111/fall13/

However you are viewing this document, if you find that you cannot click on the link given above directly, try downloading this pdf document , opening it in Acrobat or Acrobat Reader, and then clicking on the link. Alternatively, go to www.phys.virginia.edu and follow the link to "classes" under "Academics" for links to this and all the other physics courses. You should treat the Physics 1110 website as your primary source of information for this course (at least until classes begin).

Course info

Energy is a word that we encounter in many diverse contexts. It is a term that we see in newspapers, a subject that is addressed by politicians, and even an attribute that we apply to how we feel personally. Our bodies need energy. Our cars and factories need energy. Our society consumes a huge amount of energy every day, and without it, our society as it exists could not function.

In Physics 1110, we will be considering energy from the perspective of physics. We will develop a sharper understanding of the physical character of energy, and by doing so, we will bring deeper understanding to a host of subjects. We will explore the possible sources of energy, and the degree to which those sources might meet our needs. We will also work to better understand the ways in which we consume energy, and the constraints we face in trying to limit our consumption. You will come out of this course with greatly improved understanding of one of the most important issues that our society faces.

Physics, as a discipline, cannot address all aspects of the subject of energy. You cannot use physics to address complex economic issues, nor can you use physics to understand the intricacies of energy-related politics. You can, however, answer a host of other questions that are of enormous importance. If we were to get all of our energy from solar power, how much land area would be required? If we wanted to get all our electricity from wind, is it even physically possible? Using current technology, how much energy could be derived from all known reserves of uranium? Toward the end of the course, we will even begin addressing energy-related questions that are relevant to issues such as space travel and space colonization.

While Physics 1110 will certainly cover many important energy-related topics, perhaps the most important skill you will take away from this course is an improved ability to apply sound quantitative reasoning to real-life problems. We will use source material such as government reports, studies that have been undertaken by nonprofit organizations, physical facts about our planet and solar system, and try to draw our own conclusions about a number of very important issues. It is my hope that upon completing Physics 1110, students will be in a better position to apply quantitative analytical thinking to a wide variety of subjects.

Course structure

The lectures will be central to the course, and the lecture slides will be posted on the web. As for reading, we will draw on many different sources, and there is no single textbook. The most important written resource will be a set of class notes that will be passed out in class. Collectively, these notes comprise a roughly 180 page manuscript that will act as something of a unifying document for the material we will cover. In addition to the class notes, we will be reading from several additional books, four of which I strongly recommend that you buy (I will list them shortly). There will also be readings from a fifth book, but that one is available for free on the web. Among the four books that you should buy is **Physics and Technology for Future Presidents** by Richard Muller, which is formatted more-or-less like a conventional textbook. Remember, this is **NOT** the textbook for the course. It is just one of the sources we will be using. A second book by Muller, **Energy For Future Presidents**, just came out in April of 2013, and is aimed at a fairly wide audience. There will be additional readings such as government reports, studies performed by various organizations, and even a short story by Isaac Asimov. The materials from which you will be working will thus include:

- ⋆ Lectures (with the slides posted on the web)
- ⋆ Class notes (will be available as hardcopy only).
- ⋆ Four books that are strongly suggested for purchase.
- ⋆ Research on the web.
- ⋆ Other assigned readings including various articles and reports.

Important Course Policies

Lectures

There are important, and you are expected to attend. We will be using clickers, and your "clicker points" will be part of your final grade. Note that you will be given the full value of the clicker points irrespective of whether or not you answer "clicker questions" correctly.

Homework

You will be permitted to collaborate without limit with other students when doing your homework. With this said, what you ultimately write up and turn in must represent your own work. Thus, if you are supplying an essay-style answer, you may discuss it freely with anyone, but your answer must be in your own words. Similarly, if you are doing a calculation, you may get unlimited help, but in the end, you must work through each step on your own. Please note, however, you will always learn the most by first attempting homework on your own, and only then comparing notes with your friends.

Quizzes and tests

Quizzes and tests will be pledged in the usual way. There will be a midterm, a final, and two or more quizzes.

Communicating with me

When there is something I need to know, for example, why your homework is late, or why you cannot be in class on a particular day, it is important to me that the information is not lost. With on the order of 100 students, however, it is impossible for me to avoid forgetting things from time to time. For this reason, while it is always appropriate to talk to me personally, anything that I should not forget MUST BE SENT IN THE FORM OF AN EMAIL. Furthermore, the subject line of the email must contain the words "Physics 1110" as well as one additional keyword that is relevant to the thing about which you are communicating. Examples will include the word "clicker" (more on this later), and "quiz". I will keep a special file of all such emails, and am very careful to review them at relevant times.

Partial Reading List

- **Class notes** by G. Cates (Handed out in class, roughly 180 pages).

Materials that you should purchase:

- **Energy For Future Presidents** by Richard A. Muller, W. W. Norton and Company (New York, 2012), ISBN 978-0-393-34510-0.
- **Physics and Technology for Future Presidents** by Richard Muller, Princeton University Press (Princeton, NJ, 2010), ISBN 978-0-691-13504-5.
- **Beyond Smoke and Mirrors** by Burton Richter, Cambridge University Press (2010).
- **The High Frontier**, 3rd edition, by Gerard K. O'neill

Selected examples of other materials we will use:

You do not need to buy these. They will either be made available in class, or will be available on line.

- **The Character of Physical Law** by Richard Feynman.
- "The last question" from **Opus 100**, a short story by Isaac Asimov, .
- **Annual Energy Report**, United States Department of Energy (either the 2009 or 2010 editions).
  Strategies for Energy use

Tentative syllabus

While we will almost certainly deviate somewhat from the syllabus listed below, what follows is a pretty good indication of the material that will be covered in the course.

Week #1 The big picture
- ⋆ Types of energy and their origins
- ⋆ Primary energy sources and end uses of energy

Week #2 The physics of energy
- ⋆ Kinetic energy, potential energy, etc.
- ⋆ The conservation of energy

Week #3 The physics of energy
- ⋆ Levers - the conservation of energy in disguise
- ⋆ Work, heat and friction
- ⋆ Heat engines and the first law of thermodynamics

Week #4 The physics of energy
- ⋆ Entropy and the second law of thermodynamics
- ⋆ The maximum theoretical efficiency of engines
- ⋆ The concept of power

Week #5 Understanding electrical power generation plants as heat engines.
- ⋆ The limits of conventional approaches
- ⋆ The combined cycle power plant

Week #6 Fossil fuels.
- ⋆ Conventional oil
- ⋆ Non-conventional oil
- ⋆ Natural gas

Week #7 Fossil fuels.
- ⋆ Coal - the most plentiful resource
- ⋆ Carbon dioxide and climate change

Week #8 Renewable energy sources

- ⋆ Ethanol and its production
- ⋆ Biodiesel

Week #9 Renewable energy sources
- ⋆ Wind and its meteoric growth
- ⋆ Photovoltaics and solar thermal

Week #10 Nuclear energy.
- ⋆ Nuclear physics
- ⋆ Nuclear fuels, resources, and fuel breeding
- ⋆ Third and fourth generation power plants

Week #11 The transportation sector
- ⋆ Hydrogen
- ⋆ Hybrids, plug-in hybrids and all-electric cars

Week #12 Global trends and our energy future
- ⋆ History as a guide for the future
- ⋆ Building realistic models

Week #13 Energy in space travel
- ⋆ What it really takes to get up there
- ⋆ Economic realities of space travel

Week #14 Space colonization
- ⋆ Producing energy in space
- ⋆ Dyson spheres and the limits of life in our solar system