Energy on this World and Elsewhere
26 August 2008

Preliminaries and course info

Energy is a word that we encounter in many diverse contexts. It is a term that we encounter in newspapers, a subject that is addressed by politicians, and even an attribute we apply to the way we feel. Energy is something very basic, and the fact that it appears in so many different settings makes it extremely important. 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 this course 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 better understand the possible sources of energy, and the degree to which those sources might meet our needs. We will also better understand the ways in which we consume energy, and the constraints we face in trying to limit that 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?

In many ways, the most important thing you are likely to get out of this course goes well beyond the subject of energy. One of my primary goals is to use questions related to energy as a vehicle to help each of you develop keener skills of quantitative reasoning. While you may not be able to use physics to address complex economic issues, you may be able to dig up the amount that various companies have invested in building wind farms. Knowing these costs, and imagining (sadly, unrealistically) that it is trivial to store electricity, you can compute the cost of providing all of our nation's electricity from wind. It may be an idealized question, but it is an interesting one never-the-less. In late 2004, New York Times columnist Tom Friedman suggested that we need an organized effort on the scale of the Apollo project to move our country toward energy independence within ten years. How realistic is this suggestion? Wikipedia suggests that the Apollo program cost $135 billion in 2006 dollars. Would this be enough to achieve energy independence? Is it way too low? How would you decide?

A quick snapshot of what we will cover

A highly simplified summary of the material we will cover is given below:

- A brief overview of the energy infrastructure of the country.
  - Primary energy sources.
  - The "end-use" consumption of energy.
- The development of a common language, based on physics, with which to discuss energy and energy issues.
  - Enumerate the different forms of energy.
  - Look at conservation laws.
  - Learn about thermal physics and why not all energy is useful.
- Fossil fuels.
- Renewable energy sources.
- Nuclear power.
- Transportation.
- A more serious analysis of the world's energy infrastructure and its future.
- Energy and its implications for the industrialization and colonization of space.
- A serious look at energy in the 21st century.

Course structure

We will draw on many different sources of information over the course of the semester. There is no single textbook. For instance, we will be using "Energy: Its Use and the Environment" as much as a reference as we will a textbook. You should look at the class notes, passed out every lecture, as the single unifying document for the course. If you are trying to figure out if you are responsible for something, the first questions you should as yourself are 1) was it covered in lecture? and 2) was it covered in the notes? The lectures and notes will give you a good sense of what is important.

⋆ Lectures (slides will be posted on the web)
⋆ Readings.
  - Class notes (will be available as hardcopy only).
  - Four books suggested for purchase.
  - Research on the web.
  - Other assigned readings.

⋆ Homework.
⋆ Quizzes and tests.
⋆ Papers (if possible).

Partial Reading List

- **Class notes** by G. Cates (Handed out in class, roughly 120 pages).

Materials that would be best to purchase

- **The Character of Physical Law** by Richard Feynman.
  Chapters 1–5
- **Energy: Its Use and the Environment**, Fourth Edition, by Roger A. Hinrichs and Merlin Kleinbach, Brooks/Cole Thomson Learning Inc. (2006).
- **Global Energy Perspectives**,
  ed. by Nebojša Nakićenović, Arnulf Grübler, and Alan McDonald,
  Cambridge University Press, Cambridge, U.K., (1998).
  Chapter's 1–8
- **The High Frontier**, 3rd edition, by Gerard K. O'neill

Examples of other materials I have used in the past

- **Scientific American**, September 1990 issue and/or **Energy for Planet Earth**.
  Energy from Fossil Fuels
  Energy from the Sun
  Energy from Nuclear Power
- **Opus 100**, by Isaac Asimov, "The last question".
- **Scientific American**, September 1989 Issue and/or **Managing Planet Earth**
  Strategies for Energy use
- **Nuclear Safety 33**, p. 36 (1992), "Westinghouse Advanced Passive 600 Plant".
- **Science, vol 285** (July '99)
  Various readings, issue is devoted to renewable energy.

Tentative sylabus

Week #1	A snapshot of our energy infrastructure
Week #2	Different forms of energy, and the conservation of energy.
Week #3	The formal concept of work and friction.
Week #4	Entropy and its implications.
Week #5	Understanding power plants.
Week #6	Fossil fuels.
Week #7	Nuclear energy.
Week #8	Fourth-generation fission reactors and the advanced fuel cycle.
Week #9	Renewable energy sources (hydroelectric, wind, solar, ...).
Week #10	Renewable energy sources (hydroelectric, wind, solar, ...).
Week #11	Transportation.
Week #12	A more serious analysis of our energy future.
Week #13	Energy solutions for the 21st century.
Week #14	Energy and the industrialization and colonization of space.
Week #15	Dyson spheres, and the distant outlook for our civilization.

Grading

The exact grading scheme will depend on the total enrollment in the class, which we are allowing to grow in comparison to last year. I believe in personally reading and grading any papers that I ask you to write, so I will need to limit that component if the numbers start getting large. The following gives you some idea of what I have in mind:

* Class participation: 10–15% (measured *in part* through the use of clickers)
* In-class quizzes: 10–15%
* Homework: 25–35%
* Tests/Papers 50–60%. Might include some or all of the following:
  * ⋆ Midterm paper/test
  * ⋆ Final paper/test

By Tuesday September 2, I should know what the numbers are and be in a position to give you a better idea of the tests and papers for which you will be responsible.