The Science and Technology of Energy – PHYS 0114

Meetings: Times: Tuesdays and Thursdays, 2:30 pm – 3:50 pm
Location: Barus and Holley 141

Description:

Energy plays a fundamental role in our society. Its use underlies improvements in the living standard; the consequences of its use are having a significant impact on the Earth's climate; its scarcity in certain forms is a source of insecurity and political conflict. This course will introduce students to the fundamental laws that govern energy and its use. Physical concepts will be discussed in the context of important technological applications of energy. The physical concepts include mechanical energy, thermodynamics, the Carnot cycle, electricity and magnetism, quantum mechanics, and nuclear physics. The technological applications include wind, hydro, and geothermal energy, engines and fuels, electrical energy transmission and storage, solar energy and photovoltaics, nuclear reactors, and biomass.

Instructor: Derek Stein
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Office hours: Wednesdays from 1:30-2:30 pm, Thursdays from 11:00 am - noon
…or drop by anytime
…or e-mail me with questions or to set up an appointment

Goals:

- Build an understanding of the fundamental principles that govern energy and constrain its production, distribution, interconversion, and consumption.
- Provide and overview of the world's dominant energy technologies.
- Introduce students to current research directions in energy science and technology.
- Develop the scientific literacy that students require to follow and participate in current policy debates on energy. This last goal will be reinforced by in-class student presentations on timely energy-related subjects. For example, how is the "Iran deal" and the United States' recent withdrawal from that deal likely to affect Iran's access to nuclear energy and capacity to develop nuclear weapons? Or, what happened at the Fukushima Daiichi nuclear power plant following the Tohoku earthquake of 2011?

Evaluation criteria:

- Homework assignments: 15%
- Mid-term exam: 10%
- Research project 1: 20%
- Research project 2: 20%
- Final exam: 35%

Reading material:

The material for this course will cover a broad range of topics, many of which are relatively new. Consequently, no single textbook is appropriate. The main reading material will consist of lecture notes, slides, and journal articles. I strongly recommend that you download for free David JC MacKay's Sustainable Energy – without the hot air, which provides a good quantitative overview of many important energy systems with worked-out examples. Vaclav Smil's Energy in Nature and Society, is also suggested because it offers an excellent discussion of the major energy systems and technologies as well as perspectives on the history and trends in energy use.

Approximate course calendar:

- Overview of energy, its many forms and its many uses in society. (1 lecture)
- Mechanical forms of energy analyzed in the context of wind and hydro energy. (3 lectures)
- Thermodynamics, including the Carnot fundamental limit on energy efficiency, discussed in the context of solar-thermal energy and engines. Chemical energy and fuels will also be introduced here. (4 lectures)
- Electricity and magnetism, as it relates to power transmission lines, the electrical grid, and turbine generators. (4 lectures)
- Electrochemical energy storage in batteries. (2 lectures)
- Quantum mechanics introduced in the context of solar energy and photovoltaic cells. (3 lectures)
- Relativity, the strong force, the structure of the nucleus and nuclear decay discussed in connection with nuclear energy. (3 lectures)
- Photosynthesis and biomass. (2 lectures)
- Conclusions and perspectives. (1 lecture)

Resources

A variety of resources, including reports, articles, and videos, will be made available through course Canvas site. Announcements and assignment submissions will also be made through the Canvas site.

Time allocation for the course activities

Students will typically spend 3 hours per week in class attending lectures and exams, for a total of 45 hours. Although out-of-class time investments may vary for individual students, a reasonable estimate to support the learning outcomes of this course is 6 hours per week, with 3 hours for reading and 3 hours devoted to the homework sets and mini-presentations for a total of 90 hours. In addition, work on the research projects is estimated to average about 3 hours per week, for a total of 45 hours. The total time spent on the activities of this course is estimated to be about 180 hours.

Accessibility and Accommodations Statement

Brown University is committed to full inclusion of all students. Please inform us early in the term if you have a disability or other conditions that might require accommodations or modification of any of these course procedures. You may speak with us after class or during office hours. For more information, please contact Student and Employee Accessibility Services at 401-863-9588 or SEAS@brown.edu.

Students in need of short-term academic advice or support can contact one of the deans in the Dean of the College office. Students seeking psychological support services should contact Counseling and Psychological Services.

Academic Conduct

Students enrolled in this course are expected to follow the University Academic Code: http://www.brown.edu/Administration/Dean_of_the_College/curriculum/academic_code.php