PHY 137S: Energy in the 21st Century and Beyond

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"A seminar course covering the fundamentals of energy science and related emerging technologies, presented at a level that is accessible to students from all undergraduate majors."

Bulletin description:

Concepts of energy from a scientific perspective for understanding problems of energy conversion, storage, and transmission in modern society. Topics include fundamental concepts (kinetic and potential energy, heat, basic thermodynamics, mass-energy equivalence), established power generation methods and their environmental impacts, emerging and proposed technologies (solar, wind, tidal, advanced fusion concepts). Final team project. Sophomores, juniors, and seniors from non-science majors are particularly encouraged to attend; no previous knowledge of physics is assumed.

Course Structure:

Seminar – Course meets on Tuesdays and Thursdays, 4:40 pm – 5:55 pm, in Room 047 in the Physics Building. Each meeting consists of a mix of lecture, problem solving techniques, discussion of current interest topics, and demonstrations.

Team Project – For the last third of the semester, students will work in groups of 3 and prepare an oral presentation with written commentary on a topic pertaining to the course. Possible topics could be a new type of energy source, a novel and innovative approach over current practice in an existing energy technology, or examining the viability of an energy-related start-up company. The last few class meetings will be devoted to group oral presentations with question/answer periods for each presentation. Student reviewers will be assigned to each presentation so that each student is a reviewer for at least one presentation.

Grading:

- Homework (5 assignments) = 20 %
- Weekly mini-reports and in-class discussion = 25 %
- Midterm Exam (**Thursday, APR 3**) = 15 %
- Course paper = 20 %
- Final Team Project = 20 %

Textbooks:

- *Sustainable Energy – without the hot air*, by David MacKay (UIT Cambridge, 2009); available for free download at https://www.withouthotair.com/ . (primary)
- *Beyond Smoke and Mirrors – Climate Change and Energy in the 21st Century*, 2nd ed., by Burton Richter (Cambridge Univ. Press, 2014).
- *The Physics of Energy*, by Robert Jaffe and Washington Taylor (Cambridge Univ. Press, 2018).
- *Energy Science – Principles, Technologies, and Impacts*, 4th ed., by John Andrews and Nick Jelley (Oxford Univ. Press, 2022).
- *Energy and Civilization: a History*, Vaclav Smil (MIT Press, 2017).

Course Schedule (v 06JAN2025):

Jan. 9 - 21: Introductory remarks; motivations - climate change, fossil fuels, and Hubbert's peak; fundamental physical concepts - energy, heat, efficiency, Faraday's Law of electromagnetic induction, energy conversion (generators and motors), and the 1st Law of Thermodynamics.

Jan. 23 - 28: Heat engines, heat pumps, refrigerators, and power plants; the remarkable 2nd Law of Thermodynamics!

Jan. 30 - Feb. 6: Hydrodynamics and aerodynamics; turbines; hydroelectric power, wind power.

Feb. 11 – 13: Light and photons; solar energy and photovoltaic cells.

Feb. 18 - 25: Mass-energy equivalence and the basics of nuclear physics; power generation from nuclear fission; novel fission power approaches; nuclear fusion; novel fusion energy generation approaches.

Feb. 27 – Mar. 6: Energy storage and battery technology; energy transmission and the grid.

Mar. 20: Course paper is due.

Mar. 25: Energy for transportation. Formation of team project groups.

Mar.27 – April 1: Energy for computing; energy usage trends.

Apr. 3: In-Class Exam

Apr. 8 - 10: Complex systems theory and climate dynamics.

Review final draft reports and presentations with individual groups.

April 15, 17 & 22: In-Class group presentations.