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

Prof. Stephen Teitsworth
Duke - Physics
Physics bldg. room 089
Email: stephen.teitsworth@duke.edu, TEL: 919-660-2560

"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, 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 (approx. 5 assignments) = 20 %
- Weekly mini-reports and in-class discussion = 25 %
- Midterm Exam (**Thursday, APR 4**) = 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 08 JAN 2024):

Jan. 11 - 23: 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. 25 – Jan. 30: Heat engines, heat pumps, refrigerators, and power plants; the remarkable 2nd Law of Thermodynamics!

Feb. 1 - 8: Hydrodynamics and aerodynamics; turbines; hydroelectric power, wind power.

Feb. 13 – 15: Light and photons; solar energy and photovoltaic cells.

Feb. 20 - 27: 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. 29 – Mar. 5: Energy storage and battery technology.

Mar. 7 – no class meeting today.

Mar. 20: Course paper is due.

Mar. 19 – 21: Energy transmission and the grid; energy for transportation.

Mar. 26 – 28: Energy usage trends and computing. Formation of team project groups.

Apr. 4: In-Class Exam

Apr. 2 - 9: Global effects: pollution, population, and climate dynamics; life cycle analysis and supply chains.

Apr. 11: Special topics; Review final draft reports and presentations with individual groups.

April 14: Group presentation materials are due on SAKAI.

April 16 - 23: In-class group presentations.