

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

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Duke - Physics

Physics bldg. room 089

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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 – (Hybrid course) Course meets on Tuesdays and Thursdays, 5.15 pm – 6.30 pm, in Room 047 in the Physics Building or via ZOOM, with location announced via SAKAI. Each meeting consists of a mix of lecture, discussion, occasional demonstrations, and possible guest presentations.

Team Project – For the last third of the semester, students will work in groups of 2 – 4 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 such that each student is a reviewer for at least one presentation.

Grading:

- Homework (approx. 5 assignments) = 20 %
- Weekly mini-reports and short paper = 25 %
- In-class participation = 10 %
- Midterm Exam (**Thursday, MAR 19**) = 20 %
- Final Team Project = 25 %

Textbooks:

- *Sustainable Energy – without the hot air*, by David MacKay (UIT Cambridge, 2009); available for free download at <https://www.withouthotair.com/>. (primary - required)
- *Beyond Smoke and Mirrors – Climate Change and Energy in the 21st Century*, 2nd ed., by Burton Richter (Cambridge Univ. Press, 2014). (required – available for download from Duke Library.)
- *The Physics of Energy*, by Robert Jaffe and Washington Taylor (Cambridge Univ. Press, 2018).
- *Energy Science – Principles, Technologies, and Impacts*, 2nd ed., by John Andrews and Nick Jelley (Oxford Univ. Press, 2013).
- *Energy and Civilization: a History*, Vaclav Smil (MIT Press, 2017).

Course Schedule (v 19 JAN 2021):

Jan. 21 - 28: 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.

Feb. 2 - 9: Heat engines, heat pumps, refrigerators, and power plants; the remarkable 2nd Law of Thermodynamics!

Feb. 9 - 18: Hydrodynamics and aerodynamics; turbines; hydroelectric power, wind power.

Feb. 18 – 25 : Light and photons; solar energy and photovoltaic cells.

Mar. 2 - 16: Mass-energy equivalence and basic nuclear physics; power generation from nuclear fission; novel fission power approaches; nuclear fusion and novel fusion approaches.

Mar. 16 - 25: Energy storage and battery technology.

Mar. 18: Short paper is due.

Mar. 30: In-Class Exam

Mar. 25 – Apr. 1: Energy transmission and the grid; energy for transportation. Formation of final project groups.

Apr. 6 - 8: Global effects: pollution, population, and climate dynamics; life cycle analysis.

Apr. 8 - 13: Special topics; may include, for example, unconventional renewables (tidal, hydrokinetic, wave, geothermal), advanced fusion concepts, emerging energy-related ventures. Review final draft reports and presentations with individual groups.

April 12: Group presentation materials are due on SAKAI.

April 15 - 22: In-class group presentations.