PHYS 4400: Principles and Varieties of Solar Energy

Spring 2013. Instructor: Prof. Randy Ellingson

Tuesday & Thursday 12:30 – 1:45 pm; Location: R1, Room 2360

Overview/Syllabus, updated March 14, 2013

Goals for this course:

As we work our way through the semester, we will learn and discuss:

1. The basis of our solar resource (fundamentals of energy and the Sun):
    a. Energy and power: distinguish between different forms of energy; the value of each form of energy, energy sources, and how to determine average as well as peak power in various scenarios.
    b. Light and photons: energy and power, generation and destruction of light, interactions between light and matter.
    c. The Sun: physics of the Sun, the photosphere, the solar spectrum, and the physics of blackbody radiation.
    d. Sunlight and Earth's atmosphere: standard solar spectra, units of insolation, extraterrestrial vs. terrestrial spectra, air mass, atmospheric effects, direct vs. circumsolar insolation.
2. Conversion of solar energy:
    a. The greenhouse effect: atmospheric CO_2 concentration, greenhouse gases, fossil energy, effect on Earth's climate, weather vs. climate.
    b. Photosynthesis: scientific principles, quantified solar energy conversion, contribution to food supply, production of biofuels.
    c. Solar thermal energy: physics of conversion of light to heat, uses of solar thermal (building-integrated for water and air heating, solar thermal power plants).
    d. Wind energy: connection to the Sun, history, physics and technology, implementation, and industry trends.
    e. Photovoltaics (PV): purpose of PV devices, principles of the photovoltaic effect, architecture of a solar cell; working with the solar spectrum, one electron per photon, integrating the solar spectrum; device characterization (optical absorption and reflection, current vs. voltage, power conversion efficiency, quantum efficiency); types of PV cells; concentrating PV. Semiconductor physics for understanding PV devices.
3. Energy markets, policies, and the environment:
    a. Calculating the Levelized Cost of Energy
    b. Energy consumption: major fuels, Carbon impact, trends, role of energy efficiency.
    c. Renewable energy policies: US, Ohio, and global.
    d. Carbon management: cap and trade, carbon tax, case studies.

Guest Lectures:

- physics of the Sun (Astro faculty)
- photosynthesis (Bio faculty)
- renewable energy policy in Ohio (Ohio Environmental Council)

- carbon economy (A. Jorgenson)
- Acquisition, installation, and operation of a residential PV system (B. Martner from Lafayette, CO))
- Perspectives on the PV industry: CdTe solar cells (TBD)

Final Exam: Tuesday, April 30, 12:30 – 2:30 pm.

Information on how the course will be taught.

1. Keep current with the coursework, and complete assigned reading prior to lecture. As part of the class time, students will present solutions and information on relevant problems in order to initiate and facilitate discussion of important, fundamental, and/or interesting topics. Participation in class through questions and discussion is essential for the most effective learning. As necessary, read the assignment again after lecture to help consolidate your knowledge.

2. Complete the assigned homework on time; the instructor reserves the right to deduct points for homework submitted late: 10% if late, then 10% additional for each day late.

3. Follow the University's Missed Class/Excused absence policy; the simplest link may be this one: [http://www.utoledo.edu/facsenate/missed_class_policy.html].

4. Turn cell-phones and pagers off when in class.

5. Know the University's class withdrawal rules: http://www.utoledo.edu/offices/registrar/registration_dates_spring.html (you must withdraw either on-line or in person at the Registrar's Office).

Grading and Exams

Only material covered in class or in homework will be used for quizzes/exams:

1. Quiz

The quizzes will be 25-30 minutes and may include short answer and/or multiple choice questions (MCQ). Quizzes are intended to test your familiarity and understanding of the basic concepts taught up to that point in the course; quizzes are closed-book, closed-notes.

2. Final exam

The Final exam will be a combination of MCQ and problems. The Final exam will be open-book, open-notes (written or typed class notes only, no PowerPoint slides). Necessary physical constants and equations will be provided.

Grading

Grades will be determined according to: In-class participation (asking and answering questions, participation in discussion): 15%. Homework: 35%. Three in-class quizzes: 25%. Final exam: 25%.

Textbook: The primary text will be "The Physics of Solar Cells", by Jenny Nelson: http://www.amazon.com/Physics-Solar-Properties-Semiconductor-Materials/dp/1860943497/ref=sr_1_1?ie=UTF8&qid=1326207348&sr=8-1

Additional Resources: Additional introductory reading will draw sources such as Wikipedia and Georgia State University's HyperPhysics (http://hyperphysics.phy-astr.gsu.edu/hbase/hph.html).