

Photovoltaics: Solar Energy

Spring 2013 Syllabus



Course Number	ENCH468L, ENCH648L, ENMA489Q
Meeting times, location	MW 4:00-5:15pm 2121 JMP
Instructor	Raymond A. Adomaitis
Office	2255 A. V. Williams
Website	www.isr.umd.edu/~adomaiti/PVclass
Textbook	<i>Modeling and analysis of photovoltaic, thermal, and electrochemical solar energy systems</i> by R. A. Adomaitis (2013). Available as a pdf from the instructor.
Technology	Access to a computer with MATLAB, Excel, and/or Python is necessary for most of the assignments.
Prerequisites	None – this is an elective class. However, students will benefit from some background in materials science, thermodynamics, elementary material and energy balance concepts, differential equations, and computational methods.
Communications	Email and class website.
Emergencies	To be addressed by email and the class website.

General description

The emphasis of this class is on developing a conceptual understanding of the device physics and manufacturing processes of crystalline and thin-film photovoltaic cells, and to develop elementary computational skills necessary to quantify solar cell efficiency. The class material includes detailed, system-level energy balances necessary to understand how solar energy fits into the complete energy generation, conversion, and storage picture. Quantitative comparisons of PV technology to solar chemical conversion processes and biofuels are made.

Specific topics to be covered include

- 1) A review of energy, thermodynamic, and electrical quantities and units.
- 2) The solar spectrum, blackbody radiation, direct and diffuse insolation, modeling cloud cover, the projection effect, and computing the optimal tilt angle of a solar panel.

- 3) Transient energy balances, an introduction to solar thermal systems, compressed air, and pumped water grid-scale energy storage.
- 4) PV physics, band structure and Fermi level in semiconductors, pn-junctions, diode models, photon interactions with semiconductors.
- 5) PC cell architecture and fabrication steps, crystalline Si substrates, thin film deposition, amorphous Si, CIGS, and CdTe thin-film cells.
- 6) Computing PV cell power, equivalent circuit models, short- and open-circuit properties, fill factor, and parasitic resistances.
- 7) PV cell external and internal quantum efficiency, and computing the spectral response.
- 8) Theoretical cell efficiency, multijunction devices, the Shockley-Queisser limit.
- 9) Antireflection coatings, cell passivation, and cell optical properties.
- 10) PV cells wired in series and parallel, shaded and faulty cell effects, system integration and inverters.
- 11) Photoelectrochemical systems, electrochemistry review, p- and n-type cells, quantification of H₂ production by PEC cells, and photosynthesis.
- 12) Concentrating PV and thermal energy systems, concentrating thermochemical systems, reaction equilibrium review, concentrator design.

Learning outcomes

The Chemical and Biomolecular Engineering Department educational outcomes most relevant to this class are:

- a) An ability to apply knowledge of mathematics, science, and fundamental engineering principles
- c) An ability to design a chemical product or process to meet designated specifications
- h) The broad education necessary to understand the impact of engineering solutions in a global and societal context
- i) A recognition of the need for, and an ability to engage in lifelong learning
- j) A knowledge of contemporary issues and applications of chemical engineering
- k) An ability to use the techniques, skills, and modern engineering tools for engineering practice

Expectations

Students are expected to participate in class discussions, turn in all homework assignments, and to conform to the academic Integrity and attendance requirements listed below.

Grading procedure

Two quizzes, approximately ten homework assignments, and a final exam will be used to determine class grades. Grading is done on an absolute basis with A+ \geq 97, A \geq 93, A- \geq 90; B and C grades are assigned in a similar manner in the 80 and 70 ranges, respectively; D is assigned to totals between 60 and 70 and F for all averages below 60.

Homework, quiz, and exam materials are the same for both the graduate and undergraduate sections; however, graduate student work will be held to a proportionally higher level of expectations when graded.

Attendance policy

Students are expected to attend each class; quizzes will not be given during major religious holidays. Students are responsible for any material discussed in class regardless of whether they were able to attend class.

Academic integrity policy

All assignments are to be the students' own work; signing the honor pledge is considered a statement of that fact.

Copyright notice

The course notes which serve as the class text should only be used by the students taking this class; no additional copies should be made or distributed.

Last updated: 23 January 2013