Engineering Faculty Document No. 51-21
December 17, 2020

TO: The Faculty of the College of Engineering
FROM: The Davidson School of Chemical Engineering
RE: New Graduate Course, CHE 56300 Advanced Solar Energy Conversion

The faculty of the Davidson School of Chemical Engineering have approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Course: CHE 56300 Advanced Solar Energy Conversion
Fall/Spring, Lecture, Cr. 3
Restrictions: May not be enrolled as the following Classifications: Freshman, Sophomore, Junior

Description:

The course will focus on: (1) the fundamentals of solar energy conversion, primarily with photovoltaics, (2) critical analysis of the state-of-the-art, and (3) the methods to develop the next generation of solar energy converters. Specific topics will include: Analysis of the solar spectrum, methods of solar energy utilization, thermodynamic analysis, electronic structure of materials, electronic transport, electron-hole generation, recombination, semiconductor junctions, device structure, minority carrier-based devices, excitonic based devices, light management, economic analysis, experimental methods, state-of-the-art of silicon, thin film, and III-V technologies, next generation technologies.

Reason:

This course has been taught as CHE 59700 Advanced Solar Energy Conversion during the following semesters: fall 2011 (44 students), fall 2012 (17 students), fall 2013 (19 students), fall 2015 (29 students), fall 2016 (14 students), fall 2017 (25 students) and fall 2020 (20 students).

Sangtae Kim
Jay and Cynthia Ihlenfeld Head of Chemical Engineering

PURDUE UNIVERSITY

Fall 2020

CHE 59700 – Advanced Solar Conversion

T/TH 10:30 AM – 11:45 AM

Remote | WebEx or Zoom

Instructor: Dr. Rakesh Agrawal
Office: FRNY, RM 3053D
Email: agrawalr@purdue.edu

TA: Aaron B. Woeppel
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Melissa LaGuire
NRT Program Coordinator
Email: **mlaguire@purdue.edu**

Recommended Books: There is no textbook for this course, but following are recommended as references.

1. The Physics of Solar Cells, by Jenny Nelson, Imperial College Press. ISBN: 1-86094-349-7 (pbk).

2. Physics of Solar Cells – From Principles to New Concepts, by Peter Würfel, Wiley – VCH. ISBN: 3-527-40428-7.

Both books are available in the Reserve Section of the Potter Engineering Library. Although, not essential, it may like to own one of the books, preferably the one by Nelson.

Homework and Exams: The following weightages assigned to homework and exams:

Homework	30%
Exam 1	35%
Exam 2	35%

In order to master the course, it is essential that you do all the home works in a timely manner. *Since the course is being offered remotely, please email your home work to Aaron Woeppel in a timely manner- generally on the due date before the class lecture.*

Homework Policy:

For the first homework that is less than one day late, 30% mark will be deducted. For the second homework that is less than one day late, 50% mark will be deducted. For any other late homework, no credit will be given.

Important Dates:

Exam 1 – Thursday 8th October
Exam 2 – Thursday 19th November

All the exams will be during the lecture period. Final grading for the course will be done using letter grades A, B, C, D and F.

Makeup Classes:
Please be aware there is a possibility of makeup classes for this course. The dates and times will be announced in advance if necessary.

BrightSpace: You can access the course via Brightspace. It is strongly suggested that you explore and become familiar not only with the site navigation, but with content and resources available for this course.

Guidelines for Academic Integrity:
All students will conduct according to Purdue's Honor Pledge (https://www.purdue.edu/provost/teachinglearning/honor-pledge.html): "As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue." Every student will sign this pledge in their first homework assignment, each exam and project report.

While Students are encouraged to discuss homework problems with each other, the submitted work must be work of the individual and no copying is allowed.

We will enforce the penalty if a student is caught cheating as proposed by Purdue:

"Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that particular assignment, and at the instructor's discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered."

Expected Conduct in the Class:
Avoid being late to the lectures (even though it is remote).
Be attentive during lectures.
It is encouraged to ask clarifying questions during lecture.

Covered Topics: The following major topics will be covered in the lectures:

1. Solar Radiation
    a. Thermal radiation from a black body – Planck's law
    b. Thermal radiation from Sun on an area on Earth
    c. Solar radiation through Earth's atmosphere

2. Thermodynamic Efficiency of Solar Energy Recovery as work

3. Solar Thermal Power
    a. Concentrating Solar Power
    b. Advantages and disadvantages for solar thermal

4. General Introduction to Solid State Solar Cells
    a. Concept of a diode

    b. Current-voltage, relationship in a solar cell – short circuit current, open circuit current, open circuit voltage, fill factor series and shunt resistance.

5. Electrons and Holes in Semiconductors
    a. Brief Review of the Physical Structure of Solids
    b. Energy bands in Solids
    c. Brief Introduction to quantum mechanics
    d. Density of energy states for free electrons in a box
    e. Density states for a 3D body
    f. Fermi-Dirac distribution function (Fermi function)
    g. Electron in a periodic potential – Origin of band diagrams
    h. Concept of holes in valence band
6. Intrinsic and Extrinsic Semiconductors
    a. Electron and hole concentrations in intrinsic semiconductors
    b. n & p type extrinsic semiconductors

7. Charge transport in a semiconductor
    a. Charge neutrality relationship
    b. Mobility of electron and holes in an electric field – drift current
    c. Diffusion current
    d. Einstein relationship relating diffusion coefficient and mobility
    e. Nonequilibrium semiconductor – quasiFermi levels
    f. Charge separation and collection – charge separation under illumination

8. Generation and recombination in semiconductors

9. p-n junction in the absence of light
    a. Internal electric field in a homo p-n junction
    b. Calculation of built in potential
    c. Width of space charge region under forward or reverse bias
    d. Transport equations for the p-n junction
    e. Saturation current and diode factor
    f. Performance of thin p-n diodes

10. Solar Cells – p-n junction under illumination
    a. Governing equations for p-n junction under light illumination
    b. Dimensionless parameters for assessing solar cell performance

11. Different Solar Cell Structures – Advantages and Limitations
    a. Silicon solar cells
    b. Thin film inorganic solar cells – CdTe/CdS, CIGS/CdS etc.
    c. Organic solar cells
    d. Solar modules and the balance of systems
12. General Discussion on the Future of Solar Cells
    a. Interdisciplinary nature of solar cells
    b. Cost and efficiency issues

Additional Information:

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Here are ways to get information about changes in this course.

- *Blackboard Learn website: http://www.itap.purdue.edu/learning/tools/blackboard/* (Melissa – what is the equivalent site on Brightspace?)

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at drc@purdue.edu or by phone: 765-494-1247.

In addition to the University policy, the Davidson School of Chemical Engineering has established procedures for students seeking accommodations. These can be found online at the ChE Undergrad Office website. Only those accommodation requests that conform to both University and ChE policy guidelines will be implemented.