Solar Energy Utilization - EML 4930/6417

Spring 2020 Syllabus

MWF Period 3 (9:35 AM – 10:25 PM), CSE E118

Catalog Description – Gain an understanding of the fundamentals of solar radiation; apply basic heat transfer and thermodynamic topics to solar engineering applications; learn fundamentals of solar concentrating devices and flat plate solar absorbers; critically evaluate state of the art solar technologies, including thermal storage, concentrating power generation systems, thermochemical storage technologies, electrochemical storage technologies and photovoltaic systems. *Prerequisites*: None. *Credits*: 3

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Grader: Vikram Ganesan (vikram.ganesan@ufl.edu) *Office*: MAE-C 107 (Enter from Gale Lemerand Dr.)

Textbook: No textbook is required for this class. Material will be taken from a variety of sources and relevant readings will be available electronically on Canvas using the "Course Reserves" tab or as otherwise noted. Relevant textbooks for the course are indicated below.

"*Solar Engineering of Thermal Processes*"; John A. Duffie and William Beckmann; Wiley (**This will be used most often and is available for free electronically through UF libraries)**

"*Principles of Solar Engineering*"; Yogi Goswami; CRC Press

Complimentary Textbooks

Thermodynamics Textbook – your preference, e.g. "*Fundamentals of Engineering Thermodynamics*"; Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Baily; Wiley;

Heat Transfer Textbook – your preference, e.g. "*Fundamentals of Heat and Mass Transfer*"; Bergman, Lavine, Incorpera, Dewitt; Wiley

Calculus Textbook – your preference

Optics Textbook – "*Nonimaging Optics*"; Winston, Roland; Miñano, Juan C; Benítez, Pablo; Welford, W. T; Elsevier or "*Introduction to Nonimaging Optics*"; Chaves, Julio; CRC Press

Office Hours: Prof. Scheffe: Tuesday 10:00 am – 11:30 am, Thursday 3:00 pm – 4:30 pm

Teaching Assistant: Mr. Kangjae Lee: Monday: 2:00 – 3:30 pm, Wednesday: 2:00 - 3:30 pm

Online Course Information: Canvas

Course Objectives: The objective of this course is for students to learn about solar energy and techniques to utilize it efficiently and cost effectively. Students will learn about the fundamentals of solar energy necessary for designing a wide array of solar utilization systems. A substantial portion of the class will be devoted to the conversion of sunlight to heat for either direct usage or further conversion to other energy carriers. This includes high technology readiness level (TRL) technologies such as solar hot water heaters and concentrated solar power plants and lower TRL technologies such as thermochemical processes for the production and storage of sunlight as fungible fuels. Students will also learn about direct photo-conversion and electro-conversion methods with high and low TRL levels. These include industrially viable technologies such as photovoltaic cells and laboratory scale technologies such as photo-electrochemical conversion methods.

Relevance: All (or almost all) energy ultimately is derived from the sun. In nature, the suns photons are converted to heat, wind, biomass and rain, all of which can be further transformed into heat, work or electricity via a number of processes and thermodynamic cycles; or given enough time even broken down into hydrocarbon based fuels. The suns photons may also be actively captured with various technologies and utilized to drive a wide variety of more efficient processes than nature is capable. Technologies range from the production of industrial waste heat, electricity, chemical commodities or potential energy in the form of chemical bonds (e.g. H_2). This may be achieved by absorbing the suns photons as heat (e.g. think absorption of black surface on a hot sunny day, or even better using optics such as a magnifying glass to concentrate sunlight further prior to absorption) or directly driving chemical processes using the photons directly (photovoltaic conversion, photosynthesis, either natural or artificial).

Grading: A: 93-100, A-: 90-92, B+: 87-89, B: 83-86, B-: 80-82, C+: 77-79, C: 73-76, C-: 70-72, D+ 67-69, D: 63-66, D-: 60-62, Fail: <60

Grading Scale: Participation: 10% Homework: 25%, Exam 1: 20%, Exam 2: 20%, Final Group Report/Presentation: 25%

Participation: Participation will be based on attendance and feedback during guest seminars.

Homework: A series of homework questions will be provided every one to two weeks to complete. Assignments will be given at least one week prior to their due date (during class and posted on Canvas), and must be turned in electronically through Canvas prior to class on the due date. 50% of the grade will be based on correctness of the work and 50% based on effort. All homework must be turned in on ruled, printer or engineering paper and stapled, with your name clearly labeled on all pages. Answers should be clearly indicated. Paper torn from spiral notebooks or not stapled will not be graded.

Exams: Two mid-term exams will be given. Each mid-term examination is worth 20% of the course grade. All exams will be graded based on the correctness of final answers but partial credit will be given. 100% credit will be given for correct answers with appropriate work shown. Full credit will be given for answers that are incorrect because of previously incorrect answers (i.e. cascading effects will not be possible). No examinations will be dropped.

Final Group Report and Presentations: *Undergraduate Students* – Teams of 4-5 students will prepare a 15 minute presentation on a topic to be determined. *Graduate Students* – Teams of 4-5 students will prepare a 15 minute presentation and written report at least 3500 words on a topic to be determined. *Edge Graduate Students* – Students will write a 3000 word report on a topic of their choosing, pending approval by Prof. Scheffe.

Python Programming: An understanding of basic programming will be helpful for this class. I recommend installing Python through the Anaconda Distribution (https://www.anaconda.com/)

because some examples will be provided that require a Python interpreter – I will provide a quick overview in class but expect that you take the initiative to familiarize yourself. Mathematica (available through UF apps) and Matlab (available through UF app) will be equally useful for problem solving and any of the three are fine to use. Some examples during class may also use Mathematica and if so a brief overview will be provided.

Honesty Policy: UF students are bound by The Student Honor Code and violations will be reported to the Division of Student Affairs. Homework can be solved in groups (and is encouraged), but each student is required to submit their own unique final version. This may not be simply copied from others, and to stress the difference between *copying* and *group work*, individuals may be questioned on a case by case basis to test their knowledge of the problem. Tests and quizzes should be representative of the student's work only and will be strictly subjected to the Honor Code.

Make-up Policy: Late homework will not be accepted, except under extenuating circumstances. Make-up exams will not be granted except in cases of emergency and will be handled on a case by case basis.

Course Schedule: Below is a rough timeline of the expected course schedule but is subject to change. Any changes will be clearly indicated during class and posted to Canvas.

	Monday	Wednesday	Friday
January	6th Introduction	8th Solar Radiation Fundamentals	10th Solar Radiation Fundamentals
	13th Solar Radiation Fundamentals	15th Solar Radiation Fundamentals	17th Solar Optics
	20th Holiday	22nd Solar Optics	24th Solar Optics
	27th Solar Optics	29th Solar Optics	31st Selected Heat Transfer Topics
February	3rd Selected Heat Transfer Topics	5th Selected Heat Transfer Topics	7th Solar Thermal Collectors
	10th Solar Thermal Collectors	12th Exam Review	14th Exam #1
	17th Sensible Heat Storage	19th Latent Heat Storage	21st Thermochemical Energy Storage
	24th Solar Thermal Power Generation	26th Solar Thermal Power Generation	28th Solar Thermal Power Generation
March	2nd Spring Break – No Class	4th Spring Break – No Class	6th Spring Break – No Class
	9th Thermochemical Fuel Production Technologies	11th Thermochemical Fuel Production Technologies	13th Photovoltaics
	16th Photovoltaics	18th Photovoltaics	20th Other Applications Team/Topic Selections
	23rd Other Applications	25th Emerging Technologies	27th Exam Review

April	30th Exam #2	1st Emerging Technologies	3rd Emerging Technologies
	6th Emerging Technologies	8th Emerging Technologies	10th Guest Presentations: TBD
	13th Emerging Technologies	15th Guest Presentations: TBD	17th Group Presentations
	20th Group Presentations	22nd Group Presentations Reports Due (Grad and Edge)	25th Reading Day