

## Solar Energy Utilization

EML 4416 Section 8791

**Class Periods:** MWF, Period 4, 10:40 AM - 11:30 AM

**Location:** CSE E118

**Academic Term:** Fall 2023

### **Instructor:**

Dr. Jonathan Scheffe

[jscheffe@ufl.edu](mailto:jscheffe@ufl.edu)

352-392-0839

Office Hours: T (10:00 am – 11:30am), H (2:00pm – 3:30 pm), MAE-A 208

### **Teaching Assistant/Peer Mentor/Supervised Teaching Student:**

Please contact through the Canvas website

- Kathryn Trimm, [ktrimm@ufl.edu](mailto:ktrimm@ufl.edu), MAE-A 315, office hours – M(1:30-2:30pm) & W(2:30-3:30pm)

### **Course Description**

(3 credits) - Fundamentals of solar radiation; basic heat transfer and thermodynamic topics with solar engineering applications; solar concentrating devices and flat plate solar absorbers; state of the art solar technologies, thermal storage, concentrating power generation systems, thermochemical storage, electrochemical storage technologies, photovoltaic systems.

### **Course Pre-Requisites / Co-Requisites**

EML 3100 or equivalent.

### **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.

The objectives will be achieved through:

- In class lectures and examples
- Student completion of homework
- Student completion of class project
- Industry Experts/Guest presentations
- Student completion of mid-term exams

### **Materials and Supply Fees**

None

### **Relation to Program Outcomes (ABET):**

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with	Medium

consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. An ability to communicate effectively with a range of audiences	Medium
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Medium
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Medium

\*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

### **Required Textbooks and Software**

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)

### **Recommended Materials**

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

### **Other Useful Course Related Resources**

Thermochemical Tables - <https://janaf.nist.gov/>

Thermophysical Properties - <https://webbook.nist.gov/chemistry/fluid/>

NIST Chemistry WebBook - <https://webbook.nist.gov/chemistry/>

Python and Jupyter - <https://www.anaconda.com/>

Cantera - <https://cantera.org/>

### **Python Programming**

We will use basic Python programming throughout this class. I recommend installing Python through the Anaconda Distribution (<https://www.anaconda.com/>) because several examples and homework’s will be provided

that require a Python interpreter – I will provide a quick Python overview in class but expect that you take the initiative to familiarize yourself.

### **Course Schedule**

- Week 1: Solar radiation fundamentals
- Week 2: Estimation of solar radiation, HW 1 Due
- Week 3: Solar measurement principles
- Week 4: Modelling solar radiation from historical and measured data , HW 2 Due
- Week 5: Selected heat transfer topics
- Week 6: Selected heat transfer topics, cont., HW 3 Due
- Week 7: Solar thermal collectors, **Exam 1 (Oct. 4<sup>th</sup>)**
- Week 8: Sensible and latent heat storage, HW 4 Due
- Week 9: Solar thermal power generation
- Week 10: Thermochemical energy storage and solar fuels, HW 5 Due
- Week 11: Ray tracing strategies for concentrating solar applications, Class Project Announced
- Week 11: Photovoltaic principles and technologies, **Exam 2 (Nov. 3<sup>rd</sup>)**
- Week 12: Battery storage, HW 6 Due
- Week 13: Emerging technologies
- Week 13: Emerging technologies
- Week 14: Guest speakers from energy and solar industries
- Week 15: Class project presentations

### **Attendance Policy, Class Expectations, and Make-Up Policy**

Regular attendance is expected but attendance is not factored into the grade for the course. Contact the instructor in a timely manner to arrange any make-up work.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:

<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

If you need extra accommodations for homework or exams please reach out to the Disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/> - more information below.

### **Evaluation of Grades**

Assignment	Percentage of Final Grade
Homework	30%
Participation	5%
Exam 1	20%
Exam 2	20%
Final Project	25%

### **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 submitted as a pdf through Canvas.

### **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.

We will provide a weekly updated and comprehensive equation sheet with relevant equations that you can use on homework and exams. This will be available in the Canvas files folder. For exams, we will provide the equation sheet (i.e. do not print it off on your own).

### ***Final Project and Presentation***

Tentative Topic - Teams of 4-5 students are tasked with designing and estimating cost of a de-centralized silicon based solar array and lithium battery energy storage for emergency power generation for a typical residential home. Students will prepare a 15-minute presentation documenting 1) a high level design and description of system (i.e. no specifics of component size, type, etc), 2) discussion breakdown of system components and costs and 3) all calculations necessary to determine sizing and components, 4) Capital cost in \$/kWh over 25 year period and 5) discussion.

### ***Final Report***

NA

### ***Participation***

Participation will be based on attendance and feedback during guest seminars, as well as providing constructive feedback and summaries of in-class and recorded project presentations.

### ***Grading Policy***

<b>Percent</b>	<b>Grade</b>	<b>Grade Points</b>
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

### ***Students Requiring Accommodations***

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

### ***Course Evaluation***

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.ua.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluer.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.ua.ufl.edu/public-results/>.

### ***In-Class Recording***

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

### ***University Honesty Policy***

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

### ***Commitment to a Safe and Inclusive Learning Environment***

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University’s core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- HWC OE Human Resources, 352-392-0904, [student-support-hr@eng.ufl.edu](mailto:student-support-hr@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

### ***Software Use***

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

## ***Student Privacy***

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

## ***Campus Resources:***

### *Health and Wellness*

#### **U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

#### **Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

#### **Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

### *Academic Resources*

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Connections Center**, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio, 302 Tigert Hall**, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus:** <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

**On-Line Students Complaints:** <https://distance.ufl.edu/getting-help/>; <https://distance.ufl.edu/state-authorization-status/#student-complaint>.