



# **Solar Energy, Theory & Application**

## **ME,MT-518WS**

### **2023 Spring Semester**

Instructor: Charles Cohn

Course Web Address: <https://sit.instructure.com/courses/35203/modules>

Course Schedule: Monday-Sunday

Contact Info: Canvas e-mail or [charlescohn17@yahoo.com](mailto:charlescohn17@yahoo.com), Tel. 973-696-4611

Virtual Office Hours: Any time during the week, 9:00am – 5:00pm

Prerequisite(s): None

Corequisite(s): None

Cross-listed with: MT-518WS

## **COURSE DESCRIPTION**

The course is intended for students who have interest in alternate energy sources as a contributor to sustainability. It provides a comprehensive treatise on the science and technology of solar energy, its collection and the design principles that need to be understood for its effective use in a variety of installations and uses.

## **STUDENT LEARNING OUTCOME**

At the end of the course the students should be able to: Understand the factors that influence the use of solar radiation as an energy source; know the various active and passive technologies that are available for collecting solar energy; have the ability to apply design principles to selection of an appropriate solar energy installation to meet requirements.

## **COURSE FORMAT AND STRUCTURE**

This course is fully online. To access the course, please visit [stevens.edu/canvas](https://stevens.edu/canvas) . For more information about course access or support, contact the Technology Resource and Assistance Center (TRAC) by calling 201-216-5500.

## Course Logistics

Every week you should complete the following:

Study the Power-Point slides for that week, shown in Canvas.

Supplement your reading on the subject utilizing the textbooks and recommended references.

The homework is normally assigned on Mondays and is due a week Later, on Monday (not later than 12:00am EST). The homework should be typed and sent to the professor in **WORD** by Canvas e-mail.

To encourage the student to stay on schedule; 20% of the total points will be deducted for assignments received 1-3 days late; assignments received more than 3 days late will receive 0 points.

## Instructor's Online Hours

I will be available via email and will respond as soon as I am available (generally within 24-48) hours.

## Online Etiquette Guidelines

Your instructor and fellow students wish to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea but you are not to attack an individual. Our differences, some of which are outlined in the University's inclusion statement below, will add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambience. Please read the Netiquette rules for this course:

- Do not dominate any discussion. Give other students the opportunity to join in the discussion.
- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could possibly lead to misinterpretation.
- Keep an "open-mind" and be willing to express even your minority opinion.
- Think and edit before you push the "Send" button.
- Do not hesitate to ask for feedback.

## COURSE SCHEDULE

### Week starting on:

Lecture 1	Wednesday, January 18, 2023
Lecture 2	Monday, January 23, 2023
Lecture 3	Monday, January 30, 2023

Lecture 4	Monday, February 6, 2023	
Lecture 5	Monday, February 13, 2023	
Lecture 6	Monday, February 20, 2023	
Mid-Term Test Posted	Monday, February 27, 2023	
Lecture 7	Monday, March 6, 2023	Mid-Term Test Due
Spring Recess	Monday, March 13, 2023	
Lecture 8	Monday, March 20, 2023	
Lecture 9	Monday, March 27, 2023	
Lecture 10	Monday, April 3, 2023	
Lecture 11	Monday, April 10, 2023	
Lecture 12	Monday, April 17, 2023	
Final Test Posted	Monday, April 24, 2023	
	Monday, May 1, 2023	Final Test Due

Note: The dates shown above start and end on Eastern Standard Time (EST)

## COURSE CONTENT

Lecture	Topic	Description
1	Introduction to Solar Energy	<ul style="list-style-type: none"> <li>• Historical Perspective</li> <li>• Energy Use in the United States</li> <li>• Why is Solar Power on the Rise Now</li> <li>• Use of Solar Photovoltaics in the US</li> </ul>
2	Review of Basic Heat Transfer Principles	<ul style="list-style-type: none"> <li>• Conduction</li> <li>• Radiation</li> <li>• Convection</li> <li>• Combined Heat Transfer Mechanisms</li> </ul>
3	Fundamentals of Solar Radiation	<ul style="list-style-type: none"> <li>• The Nature of Solar Radiation</li> <li>• Radiation on Earth's Surface <ul style="list-style-type: none"> <li>➤ Solar and Local Standard Time</li> <li>➤ Isogonic Chart</li> <li>➤ Sun Path Chart</li> </ul> </li> <li>• Variation in Insolation</li> <li>• Measurement of Insolation</li> <li>• Radiation on Tilted Surfaces <ul style="list-style-type: none"> <li>➤ Absorption, Transmission, Reflection</li> </ul> </li> </ul>
4	Solar Design Criteria	<ul style="list-style-type: none"> <li>• Site Planning <ul style="list-style-type: none"> <li>➤ Building Location, Shape and Orientation</li> </ul> </li> <li>• Shading Effects</li> <li>• Building Heat Losses <ul style="list-style-type: none"> <li>➤ Heat Load Calculations <ul style="list-style-type: none"> <li>❖ Internal Heat Sources in Buildings</li> <li>❖ Climate – Degree Days</li> </ul> </li> </ul> </li> <li>• Principles of Building for Energy Conservation</li> </ul>
5	Collectors of Solar Radiation	<ul style="list-style-type: none"> <li>• Photovoltaic (PV) Modules</li> <li>• Solar Thermal Collectors</li> </ul>

		<ul style="list-style-type: none"> <li>• Types of Solar Thermal Collectors <ul style="list-style-type: none"> <li>- Flat Plate Collectors <ul style="list-style-type: none"> <li>➤ Liquid-Type Collectors</li> <li>➤ Air Collectors</li> <li>➤ Construction <ul style="list-style-type: none"> <li>❖ Absorber Plate</li> <li>❖ Cover Plate</li> <li>❖ Enclosure / Insulation</li> </ul> </li> <li>➤ Thermal Analysis of Flat Plate Collectors</li> <li>➤ Collector Efficiency</li> </ul> </li> <li>- Evacuated Tube Collectors</li> <li>- Concentrating Collectors <ul style="list-style-type: none"> <li>➤ Parabolic Dish and Trough Concentrators</li> <li>➤ Central Receiver Collector - Power Tower</li> </ul> </li> </ul> </li> <li>• Collector Selection</li> </ul>
6	Transfer and Storage of Heat	<ul style="list-style-type: none"> <li>• Types of Transfer Fluids <ul style="list-style-type: none"> <li>➤ Water and Water/Glycol Mixtures</li> <li>➤ Hydrocarbon Oils</li> <li>➤ Silicone Liquids</li> </ul> </li> <li>• Heat Pipes</li> <li>• Types of Thermal Energy Storage <ul style="list-style-type: none"> <li>➤ Sensible Heat Storage <ul style="list-style-type: none"> <li>❖ Water Heat Storage</li> <li>❖ Rock Bed Storage</li> </ul> </li> <li>➤ Latent Heat Storage <ul style="list-style-type: none"> <li>❖ Solid ↔ Liquid, Liquid ↔ Vapor, Solid ↔ Solid</li> </ul> </li> <li>➤ Thermo-chemical heat storage <ul style="list-style-type: none"> <li>❖ Decomposition of metal hydrides, oxides, peroxides etc.</li> </ul> </li> </ul> </li> <li>• Design of Storage System <ul style="list-style-type: none"> <li>➤ Selection of Storage Material</li> <li>➤ Design of Containment</li> <li>➤ Sizing of Storage System</li> <li>➤ Temperature Stratification</li> </ul> </li> </ul>
	Midterm exam	
7	Passive Solar Heating Systems	<ul style="list-style-type: none"> <li>• Introduction to Passive Solar Technology</li> <li>• Types of Passive Heating Systems <ul style="list-style-type: none"> <li>➤ Direct Gain Systems</li> <li>➤ Indirect Gain Systems <ul style="list-style-type: none"> <li>❖ Attached Green House</li> <li>❖ Masonry and Water Thermal Storage Wall</li> <li>❖ Convective Loop</li> <li>❖ The Envelope House</li> </ul> </li> <li>➤ The Passive Hybrid System</li> </ul> </li> <li>• Thermal Mass <ul style="list-style-type: none"> <li>➤ The Trombe Wall <ul style="list-style-type: none"> <li>❖ Design</li> </ul> </li> </ul> </li> <li>• Predicting Passive Solar Heating Performance</li> </ul>
8	Active Solar Heating Systems	<ul style="list-style-type: none"> <li>• Domestic Hot Water Heating <ul style="list-style-type: none"> <li>➤ Thermo-siphoned and Pumped Circulation Systems</li> <li>➤ Domestic Hot Water Heating Loads</li> <li>➤ Sizing of System Components</li> <li>➤ System Installation Principles</li> </ul> </li> </ul>

		<ul style="list-style-type: none"> <li>• Swimming Pool Heating</li> <li>• Space Heating <ul style="list-style-type: none"> <li>➢ Liquid and Air Systems</li> <li>➢ System Design Principles</li> <li>➢ Sizing of Collectors and Thermal Storage</li> </ul> </li> </ul>
9	Solar Cooling of Buildings	<ul style="list-style-type: none"> <li>• Cooling Requirements of Buildings (Cooling Load Calculations)</li> <li>• Space Cooling Systems</li> <li>• Absorption Refrigeration</li> <li>• Evaporation Cooling with Rock Bed Storage</li> <li>• Heat Pumps</li> </ul>
10	Photovoltaics (PV)	<ul style="list-style-type: none"> <li>• PV Basic Principles <ul style="list-style-type: none"> <li>➢ The physics behind PV</li> <li>➢ PV Cells</li> <li>➢ PV Materials</li> <li>➢ Solar Cell Fabrication Processes</li> </ul> </li> <li>• Photovoltaic System Types <ul style="list-style-type: none"> <li>➢ Stand-alone Systems</li> <li>➢ Systems with Battery Storage</li> <li>➢ System with Back-up Generator Power</li> <li>➢ System Connected to the Utility Grid</li> <li>➢ Hybrid Systems</li> <li>➢ System Installation</li> <li>➢ PV System Design</li> </ul> </li> <li>• Module Performance</li> <li>• PV Research and Development</li> <li>• A Sampling of Photovoltaic Systems in the United States</li> </ul>
11	Solar Energy Economics	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Principles of Discounted Cash Flow Analysis <ul style="list-style-type: none"> <li>➢ Annualized Present Worth</li> <li>➢ Capital Recovery Factor – Series of Payments</li> </ul> </li> <li>• Solar System Life Cycle Cost</li> <li>• Annualized Solar Costs – Residential Applications</li> <li>• Solar System Optimization</li> </ul>
12	A Sampling of Solar Heated Homes in the United States	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Green Building Design</li> <li>• Solar Design Features</li> <li>• Performance</li> </ul>
	Final exam	

## COURSE MATERIALS

**Required Textbook:**     **“Principles of Solar Engineering”** by D. Yogi Goswami,  
3<sup>rd</sup> ed., Taylor & Francis, 2015  
ISBN-13: 978-1-4665-6378-0

Additional material on the subjects being discussed, is provided to the students via PowerPoint slides.

## References:

### **“Fundamentals of Heat and Mass Transfer”**

by Frank P. Incropera and David P. DeWitt, John Wiley & Sons, Inc., 6<sup>th</sup> Ed., 2006

**“Solar Heating and Cooling”** by John F. Kreider and Frank Kreith, 2<sup>nd</sup> ed., Hemisphere Publishing Corp, 1982

**“The Passive Solar Energy Book”** by Edward Mazria, Rodale Press, 1979

**“Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors”** National Renewable Energy Laboratory, 1994

<http://www.osti.gov/bridge/servlets/purl/10169141-YmPrJc/webviewable/10169141.PDF>

**“Modeling Daylight Availability and Irradiance Components from Direct and Global Irradiance”** by R. Perez, P. Ineichen, R. Seals, J. Michalsky and R. Stewart, Solar Energy 44 (5) pp. 271-289

### **2009 ASHRAE Handbook – Fundamentals (Inch-Pound Edition)**

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (Stevens E-book on line)

### **“Solar Collectors: Different Types and Fields of Application”**

<http://www.solarserver.de/wissen/sonnenkollektoren-e.html>

### **“Passive Solar Design Handbook” - Volume 3**

Prepared for U.S. Department of Energy  
J. Douglas Balcomb, Los Alamos National Laboratory, Robert W. Jones, Editor, DOE/CS-0127/3, July 1982

## COURSE REQUIREMENTS

**Homework:** The homework is normally assigned on Mondays and is due a week later on Monday (not later than 12:00am EST). The homework should be sent to the professor in **WORD** by Canvas e-mail.

To encourage the student to stay on schedule; 20% of the total points will be deducted for assignments received 1-3 days late; assignments received more than 3 days late will receive 0 points.

**Exams:** There is going to be a Mid-Term Exam that will be held after completion of Lecture #6 and will cover Lectures #1 - #6. At the end of the semester there will be a Final Exam covering Lectures #1 - #12. The schedules for the above exams are shown above in “Course Schedule”.

# TECHNOLOGY REQUIREMENTS

## Baseline technical skills necessary for online courses

- Basic computer and web-browsing skills
- Navigating Canvas

## Required Equipment

- Computer: current Mac (OS X) or PC (Windows 10) with high-speed internet connection

## Required Software

- Microsoft Word
- Microsoft Excel
- Microsoft PowerPoint

# GRADING PROCEDURES

Grades will be based on:

Homework – 30%  
Mid-Term Exam – 30%  
Final Exam – 40%

## Late Policy

To encourage you to stay on schedule; 20% of the total points will be deducted for assignments received 1-3 days late; assignments received more than 3 days late will receive 0 points.

## Academic Integrity

### Undergraduate Honor System

Enrollment into the undergraduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all undergraduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online at <http://web.stevens.edu/honor/>

The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, quizzes and exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed.

***"I pledge my honor that I have abided by the Stevens Honor System."***

### Reporting Honor System Violations

Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online at [www.stevens.edu/honor](http://www.stevens.edu/honor).

## Graduate Student Code of Academic Integrity

All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline.

All graduate students are bound to the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at [www.stevens.edu/provost/graduate-academics](http://www.stevens.edu/provost/graduate-academics).

## Special Provisions for Undergraduate Students in 500-level Courses

The general provisions of the Stevens Honor System do not apply fully to graduate courses, 500 level or otherwise. Any student who wishes to report an undergraduate for a violation in a 500-level course shall submit the report to the Honor Board following the protocol for undergraduate courses, and an investigation will be conducted following the same process for an appeal on false accusation described in Section 8.04 of the Bylaws of the Honor System. Any student who wishes to report a graduate student may submit the report to the Dean of Graduate Academics or to the Honor Board, who will refer the report to the Dean. The Honor Board Chairman will give the Dean of Graduate Academics weekly updates on the progress of any casework relating to 500-level courses. For more information about the scope, penalties, and procedures pertaining to undergraduate students in 500-level courses, see Section 9 of the Bylaws of the Honor System document, located on the Honor Board website.

## EXAM CONDITIONS

The following procedures apply to exams for this course. As the instructor, I reserve the right to modify any conditions set forth below by printing revised Exam Conditions on the exam.

1. Students may use the following materials during exams. Any materials that are not mentioned in the list below are not permitted.

Material	Permitted?	
	Yes	No
Handwritten Notes Conditions: i.e. size of note sheet	✓	
Typed Notes Conditions: i.e. size of note sheet	✓	
Textbooks Conditions: i.e. specific books	✓	
Readings Conditions: i.e. specific documents	✓	
Laptop	✓	

2. Students are not allowed to work with or talk to other students about exams.



# LEARNING ACCOMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

For more information about Disability Services and the process to receive accommodations, visit <https://www.stevens.edu/office-disability-services>. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at [pgehman@stevens.edu](mailto:pgehman@stevens.edu) or by phone 201-216-3748.

## Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

# INCLUSIVITY

## Name and Pronoun Usage

As this course includes group work and class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

## Inclusion Statement

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements.

You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.

## MENTAL HEALTH RESOURCES

Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression) and who can visit the office in person. CAPS is open from 9:00 am – 5:00 pm Mondays, Wednesdays, Thursdays and Fridays and from 9:00 am – 7:00 pm on Tuesdays during the Fall and Spring semesters; appointments are highly encouraged. For those students who cannot visit the Stevens campus for an in-person appointment, you can contact a local mental health care provider for an in-person appointment, or if you are enrolled in the Stevens Student Health Insurance, you may call Care Connect for 24/7 mental health support at 1-888-857-5462.

For further information please visit the CAPS webpage on [Seeking Help Off-Campus](#).

## EMERGENCY INFORMATION

In the event of an urgent or emergent concern about the safety of yourself or someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or on their emergency line at 201-216-3911. These phone lines are staffed 24/7, year round. For students who do not reside near the campus and require emergency support, please contact your local emergency response providers at 911 or via your local police precinct. Other 24/7 national resources for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text “Home” to 741-741). If you are concerned about the wellbeing of another Stevens student, and the matter is *not* urgent or time sensitive, please email the CARE Team at [care@stevens.edu](mailto:care@stevens.edu). A member of the CARE Team will respond to your concern as soon as possible.