

EP 777  
Advanced Photovoltaics

*Shockley, smockley – nanostructures, self-assembly and the promise of solar for all*  
Graduate Studies  
Fall 2020  
Course Outline

**CALENDAR/COURSE DESCRIPTION**

3 unit(s)

This course gives an overview of the theoretical and experimental developments in photovoltaics, focussing on materials for 2nd generation solar cells and novel “3rd” generation technologies.

**PRE-REQUISITES AND ANTI-REQUISITES**

Prerequisite(s): None

Antirequisite(s): None

**INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION**

**Dr. A. Turak**  
JHEA 321  
[turaka@mcmaster.ca](mailto:turaka@mcmaster.ca)  
ext. 23448

**Office Hours:**  
Monday – 2:30 pm  
Or by appointment

**TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION**

**COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION**

<http://avenue.mcmaster.ca/> (Avenue, A2L)

Delivery of synchronous lectures: Zoom

Lectures available asynchronously on MacVideo (link available through Avenue)

**COURSE INTENDED LEARNING OUTCOMES**

By the end of this course, students should be able to:

- Differentiate between various types of solar cell technologies
- Distinguish the basic physics underlying the operation of various device architectures
- Critique chief technical challenges and critical materials issues for solar cells
- Examine the state of the art of modern solar cell technology

**MATERIALS AND FEES**

**Optional texts:**

1. “The Physics of Solar Cells” by Jenny Nelson, Imperial College Press 2003
2. “Materials Concepts for Solar Cells” by Thomas Dittrich, Imperial College Press

**COURSE FORMAT AND EXPECTATIONS**

The course is organized as follows:

- 1 synchronous lecture per week on Wednesdays
- 1 synchronous class discussion per week on Mondays
- 1 final report on an advanced PV technology of your choice
- Weekly synopsis of 2 articles related to lecture topic for your PV technology, discussed on Mondays

**COURSE SCHEDULE**

Date/Week	Topic	Synopsis topic (Monday following)
Sept 9th	<b>Organization meeting</b>	Choice of PV technology
Sept 16 <sup>th</sup>	<b>Topic 1 Energy costs</b>	Costs of solar energy (efficiency vs cost)
Sept. 23 <sup>d</sup>	<b>Topic 2 Photons to electrons: The sun</b>	Spectrum coverage Absorption efficiency
Sept. 30 <sup>th</sup>	<b>Topic 3 Photons to electrons: Device measurements</b>	Maximum power conversion efficiency achieved to date (lab and/or module) Device characteristics (Jsc, Voc, FF)
Oct. 7 <sup>th</sup>	<b>Topic 4 Photons to electrons: Photocurrent</b>	Maximum EQE achieved to date Target parameters for improved efficiency
Oct. 14 <sup>th</sup>	<b>Topic 5 Photons to electrons: Photovoltage</b>	Maximum Voc achieved to date Major loss factor
Oct. 21 <sup>st</sup>	<b>Topic 6 Photons to electrons: Non-ideality</b>	Predicted FF Achieved FF Factor with highest impact on FF
Oct. 28 <sup>th</sup>	<b>Topic 7 Processing and manufacturing</b>	Methods of manufacturing
Nov. 4 <sup>th</sup>	<b>Topic 8 Sustainability and economics</b>	Environmental impact assessment/parameters: Energy payback time, green house gas emissions, embodied energy, toxicity
Nov. 11 <sup>th</sup>	<b>Topic 9 Photons to electrons: Recombination</b>	Ideality factor Recombination mechanism
Nov. 18 <sup>th</sup>	<b>Topic 10 Heterojunctions and Contacts</b>	Device architecture (images) Primary role of heterojunctions
Nov. 25 <sup>th</sup>	<b>Topic 11 Maximum energy conversion efficiency</b>	Maximum predicted PCE Currently achieved PCE Efficiency as a function of energy (image)
Dec. 2 <sup>nd</sup>	<b>Possible special topics</b>	
Dec. 9 <sup>th</sup>	<b>Summary</b>	

### ASSESSMENT

Component	Due Date	Weight
Synopses	Every week (Monday)	40%
Participation	Every week (Monday)	10%
Final Report	Dec. 14 <sup>th</sup>	50%
Total		100%

### EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Engineering Physics is committed to creating an environment in which students of all genders, cultures, ethnicities, races, religions, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Graduate Chair, Academic Advisor, or to contact the [Equity and Inclusion Office](#).

These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

### PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the [Student Wellness Centre](#).

### ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the [Academic Integrity Policy](https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/), located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of common academic dishonesty:

1. plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. copying or using unauthorized aids in tests and examinations.

Note that **allowing** another student to copy one's work also falls under academic dishonesty and will be treated in the same way as copying another student's work.

#### AUTHENTICITY / PLAGIARISM DETECTION

**We will** use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to [www.mcmaster.ca/academicintegrity](http://www.mcmaster.ca/academicintegrity).

#### COURSES WITH AN ON-LINE ELEMENT

**We will** use on-line elements (e.g. e-mail, Avenue to Learn (A2L), Zoom). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss them with the course instructor.

#### CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities](#) (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

#### ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or [sas@mcmaster.ca](mailto:sas@mcmaster.ca) to make arrangements with a Program Coordinator. For further information, consult McMaster University's [Academic Accommodation of Students with Disabilities](#) policy.

Note that accommodations granted while in the undergraduate program do not transfer automatically to the graduate program.

#### ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the [RISO](#) policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation or to the

Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

#### COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

#### EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.