# Fundamentals of Power Electronics for Energy Systems

**ENPM 809M**
**Fall 2020**

## Course Overview

This course is focused on PEESs issues and, as a result, it is not intended to be a comprehensive reference for other related subjects such as RE. Due to the global nature of PEES development, we would make a great effort to represent a broad range of international perspectives. This course is organized into four sections based on the relevant subjects on PEES for students from different prospective: Review of Electric Circuits, Energy Conversion and Electric Machinery, Fundamentals of Power Electronics, and the Applications of Power Electronics for Energy Systems:

- The first section, Review of Electric Circuits, includes the topics that are concerned with the students' background on Electric Circuits mainly focuses on both DC and AC circuit analysis.
- The second section, Energy Conversion and Electric Machinery, covers electric machinery fundamentals such as DC machines (motors and generators), AC machines (motors and generators), and transformers (single and three phase).
- The third section, Fundamentals of Power Electronics, covers the fundamentals of power electronics used for energy systems. The topics include: DC-DC Rectifiers, DC-DC Converters, and DC-AC Inverters.
- The forth section, Applications of Power Electronics for Energy Systems, presents the use of power electronics in energy conversion for energy systems.

## Learning Outcomes

After successfully completing this course you will be able to:

The purpose of this course is to improve students' understanding of the PEESs, and to acquaint students with various types of current topics and issues in the field. Upon completing the course, the student will be able to do the following:

- Apply various techniques to analyze DC and AC circuits.
- Become familiar with electric machinery and energy conversion.
- Design and simulate Power Electronics converters (rectifiers, DC-DC converters, DC-AC inverters) for an energy systems.

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**Class Meets**
Wednesday
4-6:40 p.m.
TBA

**Office Hours**
Online Webex
Fridays 9:30-11:30 a.m.
and by appointment

**Teaching Assistants**
n/a

**Prerequisites**
Basic knowledge of calculus, algebra. Some coding skills like Matlab/Simulink is required for homeworks.

**Course Communication**
The assignment and time-sensitive information will be posted on Canvas. Students can communicate via Canvas or email with the instructor.

## Course Schedule

| Weeks | Topics | Sections |
|---|---|---|
| 1 | • Charge, Current, Voltage, Power, Energy<br>• Dependent and Independent Voltage and Current Sources<br>• Ohm's Law, Resistor<br>• Kirchhoff's Voltage and Current Laws<br>• Resistors in Parallel and Series<br>• Voltage Division<br>• Current Division | Review of Electric Circuits |
| 2 | • Supernode and Supermech<br>• Superposition Theorem<br>• Source Transformation<br>• Thevenin Equivalent Circuits<br>• Norton Equivalent Circuits<br>• Maximum Power Transfer<br>• Delta and Wye Conversion | |
| 3 | • Capacitors and Inductors<br>• Sinusoids<br>• Phasor Analysis<br>• Kirchhoff's Voltage and Current Laws for Phasors<br>• Impedance<br>• Instantaneous Power<br>• Apparent Power<br>• Power Factor<br>• Average Power<br>• Complex Power | |
| 4 | • Polyphase<br>• Three-Phase Sources<br>• Three-phase Connections | |

| | | |
|---|---|---|
| | • Phase Sequence<br>• Per-Phase Analysis | |
| 5 | • DC Motors (Series, Shunt, Separately Excited, Compound)<br>• DC Generators (Series, Shunt, Separately Excited, Compound) | Energy Conversion and Electric Machinery |
| 6 | • Synchronous Generators<br>• Synchronous Motors | |
| 7 | • Transformers<br>• Open-Circuit Test<br>• Closed-Circuit Test<br>• Per-Unit System<br>• Three-Phase Transformers | |
| 8 | **Midterm** | |
| 9 | • Power Electronics Devices<br>• Diode Rectifier<br>• Half-Wave Diode Rectifier<br>• Single-Phase Diode Rectifier<br>• Three-Phase Diode Rectifier | Power Electronics |
| 10 | • DC-DC Converters<br>• Buck Converter<br>• Boost Converter<br>• Buck-Boost Converter<br>• Cuk' Converter | |
| 11 | • PWM Switching<br>• Unipolar Voltage Switching<br>• Bipolar Voltage Switching<br>• Switch-Mode DC-AC Inverter<br>• Single-Phase Half-Bridge Inverter<br>• Single-Phase Full-Bridge Inverter | |

| | | |
|---|---|---|
| | • Three-Phase Inverter | |
| 12 | • Renewable Energy Sources<br>• Hydro Energy<br>• Wind Energy<br>• Biomass Energy<br>• Geothermal Energy<br>• Radiant Energy<br>• Energy Storages<br>• Fuel Cells<br>• Roles of Power Electronics in Energy Systems | Application of Power Electronics in Energy Systems |
| 13 | **Final Exam** | |

## Required Resources

**Course website:** elms.umd.edu

The lecture is not based on a single resource exclusively, but it draws from several textbooks collectively. This list of books that cover related topics. Other books and literature will be recommended throughout the class to highlight specific topics. The instructor will also provide the PDF of the resources for students.

**Readings:**

Recommended Textbooks:

**1-** Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications, ISBN: 9781118634035, John Wiley & Sons, Ltd., (2014).
**2-** Power Electronics for Microgrids, ISBN 978-0-470-82403-0, John Wiley & Sons, Ltd., (2014).
**3-** Smart Grid Handbook, 1E, ISBN: 978-1-118-75548-8, John Wiley & Sons, Ltd., (2016).

Information Technology Project Management 8E, ISBN: 9781285452340, Schwalbe, K. (2015).

**Hardware/Software:**

Matlab/Simulink

## Campus Policies

It is our shared responsibility to know and abide by the University of Maryland's policies that relate to all courses.

• Academic integrity
• Grades and appeals
• Accessibility and accommodations
• Student and instructor conduct
• Copyright and intellectual property
• Attendance and excused absences

Please visit https://academiccatalog.umd.edu/graduate/policies/academic-record/ for the Office of Graduate Studies' list of campus-wide policies.

## Activities, Learning Assessments, and Expectations

Students should expect to spend a minimum of two hours studying or completing assignments outside of class for every hour spent in class or direct faculty instruction.

Please refer to the question/assignment detail for respective grading instruments expectations and rubric details.

## Grading Policy:

Grades are not given, but earned. Your grade is determined by your performance on the learning assessments in the course and is assigned individually (not curved). If earning a particular grade is important to you, please speak with me at the beginning of the semester so that I can offer some helpful suggestions for achieving your goals.

All assessment scores will be posted on the course ELMS page. If you would like to review any of your grades (including the exams), or have questions about how something was scored, please email me to schedule a time for us to meet in my office.

I am happy to discuss any of your grades with you, and if I have made a mistake I will immediately correct it. Any formal grade disputes must be submitted in writing and within one week of receiving the grade.

| Final Grade Cutoffs | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| + | 97.00% | + | 87.00% | + | 77.00% | + | 67.00% | |
| A | 94.00% | B | 84.00% | C | 74.00% | D | 64.00% | F <60.0% |
| - | 90.00% | - | 80.00% | - | 70.00% | - | 60.00% | |

Finally, students will be evaluated according to a number of dimensions, such as class attendances/activities, teamwork/sole projects, homeworks, and exams.

**Class Attendances and Activities (5%)**
This is your active class participation. It includes question/answer sessions in-class, canvas activities, etc.

**Group Project (35%)**
Instructions to follow in a separate document.

**Homework Assignments (20%)**
There will up to six problem sets assigned during the course. These will include programming projects and may also include written exercises. Design the algorithm, write code and test, and then present the result in a creative way.

**Midterm (20%) and Final Exam (20%)**
Midterm Exam: There will be an in-class midterm exam which will include paper and pencil exercises.
You are allowed to bring one page (front and back) of personal notes to the exam. The exam contents will mostly come from the lecture materials.
Final Exam: There will be an in-class final exam that will mostly cover the materials after the midterm, but may also include some materials from before the midterm.

***Note: This is a tentative schedule, and subject to change as necessary – monitor the course ELMS page for current deadlines. In the unlikely event of a prolonged university closing, or an extended absence from the***

***university (e.g. COVID-19), adjustments to the course schedule, deadlines, and assignments will be made based on the duration of the closing and the specific dates missed.***

## Course Specific Policies

**Late Policy:**
Homework and group projects are due at the start of class. Problems may be turned in late, but with a penalty. For example, if a homework is due on Wednesday, it may be turned in before Thursday at 6:40 p.m., with a 10% penalty, or before Friday at 6:40 pm, with a 20% penalty. After 6:40 pm, Friday, no assignments will be accepted. This means that you better turn in whatever you have available as of Friday, 6:40 p.m..

**Extra Credit:**
Some homework and the exams may have a special challenge problem. Points from the challenge problems are extra credit. This means that I do not consider these points until after the final course grade cutoffs have been set. Students participating in class discussion or asking good questions may also receive extra credit.

**Cell Phones and Laptops:**
Please turn off or silence your cell phone during class. Please only use your laptop for notetaking purposes and make sure the laptop sound is off.

**Class Absence Policy**:
Students are expected to attend classes regularly. Consistent attendance offers students the most effective opportunity to gain command of course concepts and materials. Students are responsible for information and material missed on the day of absence. Students are, within reason, entitled to receive any materials provided to the class during the absence. Students are responsible for making provision to determine what course material they have missed and for completing required exercises in a timely manner.
For this class, the "major scheduled grading events" are the exams and the semester project.

**Academic Integrity:**
All homework assignments are to be done individually and independently; all submitted works must be your own. All students are expected to be familiar with and to uphold the Code of Academic Integrity administered by the Student Honor Council at UMCP (please see http://www.shc.umd.edu).

## Accessibility and Reasonable Accommodations

The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The University of Maryland provides reasonable accommodations to qualified individuals. Reasonable accommodations shall be made in a timely manner and on an individualized and flexible basis.

Discrimination against individuals on the grounds of disability is prohibited. The University also strictly prohibits retaliation against persons arising in connection with the assertion of rights under this Policy.

Accessibility & Disability Service (ADS) facilitates reasonable accommodations to qualified individuals. For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301.314.7682, or adsfrontdesk@umd.edu. More information is available from the Counseling Center.

**Disabilities:**

Any student eligible for and requesting reasonable academic accommodations due to a disability needs to provide the instructor with a letter of accommodation from the Office of Disability Support Services (DSS) within the first two weeks of the semester.

## Get Some Help!


You are expected to take personal responsibility for your own learning. This includes acknowledging when your performance does not match your goals and doing something about it. Everyone can benefit from some expert guidance on time management, note taking, and exam preparation, so I encourage you to consider visiting http://ter.ps/learn and schedule an appointment with an academic coach. Sharpen your communication skills (and improve your grade) by visiting http://ter.ps/writing and schedule an appointment with the campus Writing Center. Finally, if you just need someone to talk to, visit http://www.counseling.umd.edu.

Everything is free because you have already paid for it, and **everyone needs help**… all you have to do is ask for it.

## Names/Pronouns and Self Identifications

The University of Maryland recognizes the importance of a diverse student body, and we are committed to fostering equitable classroom environments. I invite you, if you wish, to tell us how you want to be referred to both in terms of your name and your pronouns (he/him, she/her, they/them, etc.). The pronouns someone indicates are not necessarily indicative of their gender identity. Visit trans.umd.edu to learn more.

Additionally, how you identify in terms of your gender, race, class, sexuality, religion, and dis/ability, among all aspects of your identity, is your choice whether to disclose (e.g., should it come up in classroom conversation about our experiences and perspectives) and should be self-identified, not presumed or imposed. I will do my best to address and refer to all students accordingly, and I ask you to do the same for all of your fellow Terps.