ECE 53200: Computational Methods for Power System Analysis

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Office Hours: TBA
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Web: Material will be posted on Brightspace
Instructional Modality: Hybrid
Meeting Day & Time: MWF 12:30 pm - 1:20 pm
Classroom: Max W & Maileen Brown Hall 224

Course Description

Credit Hours: 3.00. System modeling of power networks. Description of modern electricity markets. Analysis of the economic dispatch problem using optimality conditions. Planning of distributed energy resources. Smart grid applications. Machine learning applications to power systems (forecasting, demand-side management, and fault detection). Assigned projects will involve implementing some of the methods using realistic power system models.

Prerequisites

This class requires basic knowledge of power systems, probability, linear algebra, and calculus. Familiarity with a programming language such as Matlab or Python is preferred. Some knowledge of optimization is helpful, but not necessary. ECE 31032 (or equivalent).

Learning Outcomes

By the end of the course, students will be able to

1. explain how electricity markets work and how various computational methods are used in power system operations and planning.
2. understand formulation and solution techniques applied to normal operation of large power systems.
3. implement existing optimization packages to solve power system problems.
4. use machine learning methods to answer questions about power system operations.

References

This course has no required text. References include:

1. Lecture slides.
2. Power System Analysis, 4th Edition, J. Grainger & W. Stevenson, McGraw-Hill, 1994, ISBN No. 0070612935.
3. Convex Optimization, S. Boyd & L. Vandenberghe, Cambridge University Press, 2004, ISBN No. 0521833787.
4. Applied Linear Regression Models, 4th Edition, M. Kutner, C. Nachtsheim & J. Neter, McGraw- Hill Education, 2004, ISBN No. 0073014664.

Assignments and Evaluation

Your learning will be assessed through a combination of homework assignments (50%), a midterm (20%), and a final project (30%).

- **Homework:** There will be regular homework assignments (~ 6, roughly one every 2 weeks) that will be posted on the Web. Many homework problems will require implementing the solution with a programming language. These will be graded by the instructor based on the accuracy of the numerical results and the overall presentation quality. Assignments should be submitted via Brightspace by the end of the due date (11:59 p.m. Eastern Time). You are encouraged to use LaTeX to write up your homework (a template will be posted on Brightspace).
- **Midterm:** There will be a 24-hour take home midterm exam for this course. Midterm dates will be confirmed as the course progresses. All online resources are permitted, but you must cite any source that you use. You are not permitted to consult others.
- **Final project:** The final project provides an opportunity for you to use the tools from class to solve interesting problems of your choice. Projects should be done in groups of 1 to 3 students. Each project will be evaluated based on a project presentation and a project report (no more than 5 pages excluding references and appendices in IEEE template). A list of potential project ideas will be uploaded to Brightspace. You are also welcome to propose your own project ideas and discuss with the instructor.
- **Late work:** Each student has 3 free late days they may use over the entire semester for homework assignments and the project report. Beyond these 3 late days, missed or late work will not be accepted in general. Under extenuating circumstances, you may request an extension by contacting the instructor.
- **Collaboration policy**: We encourage you to form study groups and discuss homework. However, you must write up all homework from scratch independently without referring to any notes from the joint session.
- **Programming language:** For problems involving programming, solutions will be provided in Matlab. You may choose to use other high level languages (e.g., Python and Julia) but no support will be provided for these languages.

Grading Scale

Letter grades will be determined by the following guidelines:

- A: $\geq 85\%$
- A$-$: $\geq 80\%$
- B+: $\geq 75\%$
- B: $\geq 70\%$
- B$-$: $\geq 65\%$
- C+: $\geq 60\%$
- C: $\geq 55\%$
- C$-$: $\geq 50\%$
- F: $< 50\%$

Tentative Schedule of Lectures

Weeks	Topics
1	Introduction, steady-state power network models, electricity markets.
2	Overview of optimization. Analysis of economic dispatch using optimality conditions.
3	Planning methods for distributed energy resources (DERs): sizing and placement of solar PV and storage
3	Smart grid applications: Control of energy storage, distribution system analysis with DERs
3	Overview of supervised learning methods. Applications to renewable/load forecasting, fault detection.
3	Overview of unsupervised learning methods. Applications to demand-side management.

Acknowledgement

Some of the course material is adapted from courses taught by Prof. Baosen Zhang (University of Washington), Prof. Kameshwar Poolla (UC Berkeley), Prof. Ram Rajagopal (Stanford University), and Prof. Subhonmesh Bose (University of Illinois at Urbana-Champaign).

Purdue Policies

Attendance Policy during COVID-19

Students are encouraged to attend all classes in-person unless they are ill or otherwise unable to attend class. If they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus, students should stay home and contact the Protect Purdue Health Center (496-INFO).

In the current context of COVID-19, in-person attendance cannot be a factor in the final grades. However, timely completion of alternative assessments can certainly be part of the final

grade. Students need to inform the instructor of any conflict that can be anticipated and will affect the timely submission of an assignment or the ability to take an exam.

Classroom engagement is extremely important and associated with your overall success in the course. The importance and value of course engagement and ways in which you can engage with the course content even if you are in quarantine or isolation, will be discussed at the beginning of the semester. Student survey data from Fall 2020 emphasized students' views of in-person course opportunities as critical to their learning, engagement with faculty/TAs, and ability to interact with peers.

Only the instructor can excuse a student from a course requirement or responsibility. When conflicts can be anticipated, such as for many University-sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency conflicts, when advance notification to an instructor is not possible, the student should contact the instructor/instructional team as soon as possible by email, through Brightspace, or by phone. In cases of bereavement, quarantine, or isolation, the student or the student's representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link to the Dean of Students under "Campus Resources".

Academic Guidance in the Event a Student is Quarantined/Isolated

If you must quarantine or isolate at any point in time during the semester, please reach out to me via email so that we can communicate about how you can continue to learn remotely. Work with the Protect Purdue Health Center (PPHC) to get documentation and support, including access to an Academic Case Manager who can provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Your Academic Case Manager can be reached at acmq@purdue.edu. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation.

Classroom Guidance Regarding Protect Purdue

The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask in classrooms and campus building, at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace before and after use, maintaining appropriate social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will

be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not properly wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss the next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

Academic Integrity

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

Nondiscrimination Statement

A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

Accessibility

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Mental Health/Wellness Statement

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc. sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you're struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available.

For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.