Power System Protection Spring 2024

ECE 6605PD

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Class Schedule

Section	Location	Time	Instructor(s)
ECE 6605PD 001 *[LEC]*	ONLN - Online		Sahar Pirooz Azad sahar.azad@uwaterloo.ca
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Instructor & TA (Teaching Assistant) Information

Instructor: Sahar Azad, Ph.D., PEng

Office: EIT 4017

Office Phone: 519-888-4567, ext. 33974

Email: sahar.azad@uwaterloo.ca

Office Hours: Book an appointment by email

Note: When sending an email to the course instructor:

1. Ensure that the email's subject contains ECE 6605PD.
2. The email is sent from a University of Waterloo mail server with your official UWid. Email from Gmail and the like will not be received.

Piazza

If you have any questions, you can anonymously ask your questions on Piazza. If you don't have access to the course Piazza, you can sign up using the following link:

https://piazza.com/uwaterloo.ca/spring2024/ece6605pd

This platform will give you the opportunity to ask your questions anonymously. You can answer each other's questions and I will also monitor the platform on a daily basis. A **2% bonus mark** will be given to the student who achieves the highest participation rate in Piazza in terms of responding to other students questions.

Course Description

> *Calendar Description for ECE 6605PD*
>
> Power system protections schemes are designed primarily to minimize the duration of a fault as well as to minimize the number of customers affect by the fault. The scope of this course is to study the main elements and techniques for power system protection. The course is divided into two main parts; protective equipment and protective techniques. In the protective equipment; circuit breakers, relay, enclosures, fuses and isolating switches are discussed. Different protection techniques dedicated to protect feeders, transformers, generators and motors are discussed in the second part of the course. Recommended Background: Basic knowledge in power system engineering is required, basic knowledge in optimization techniques, statistics, and electric circuits.
>
> ECE Electric Power Engineering Grad Students

Learning Outcomes

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

Provide an in-depth understanding of power system protection requirements;
Describe the operational principle of the main components of a protection system;
Describe the fundamental principle of various protection methods for the main power system components including transmission and distribution networks, rotating machinery including generators and motors, transformers, and busbars;
Explain the advantages and disadvantages of various protection methods for each power system component and specify the proper protection method for the component in any given power system.

Tentative Course Schedule

- **Module 1-Protection system requirements (1 lecture):** Overview of power system structure, causes and types of faults, and protection system main requirements
- **Module 2-Elements of protection systems (2 lectures):** Relay types and operating principles, circuit breaker types and operating principles (optional), and instrument transformers types and operating principles
- **Module 3-Review of symmetrical components and power system fault calculations (2 lectures):** Balanced 3-phase faults, Unbalanced faults, Symmetrical components, and Sequence network construction
- **Module 4-Overcurrent protection (1 lecture):** Principles of overcurrent protection, fuses, sectionalizers and reclosers, time-delay overcurrent relays, and instantaneous overcurrent relays
- **Module 5-Coordination principle of overcurrent protection devices (2 lectures):** Guidelines for coordination of overcurrent protection devices
- **Module 6-Directional overcurrent relays (2 lectures):** Application of directional relays, different connections and maximum torque angles
- **Module 7-Distance protection (2 lectures):** Distance relay characteristics, and factors affecting distance relay performance
- **Module 8-Pilot protection of transmission lines (4 lectures):** Communication channels, directional comparison blocking, directional comparison unblocking, direct underreaching transfer trip, permissive

overreaching transfer trip, permissive underreaching transfer trip, and current-based pilot schemes

- **Module 9-Transformer protection (2 lectures):** Overcurrent protection, differential protection, and nonelectrical protection
- **Module 10-Busbar Protection (2 lectures):** Common busbar arrangements and busbar protection
- **Module 11-Generator protection (2 lectures):** Typical power plant layouts, grounding methods for generators and protection principle against stator faults, rotor faults, unbalanced currents, overexcitation, overspeed, abnormal voltages and frequencies, and loss of excitation
- **Module 12-Motor protection (2 lectures):** Motor failures, thermal protection, stall or locked rotor protection, short circuit protection, ground fault protection, load-loss/load jam protection, overspeed protection, unbalanced current protection, undervoltage protection, and overvoltage protection

Note: The number of lectures for each module may vary based on class progress.

Texts / Materials

Title / Name	Notes / Comments	Required
Stanely H. Horowitz, & Arun G. Phadke, Power System Relaying, 4th edition, Wiley (Text-1)	Recommended	No
J. L. Blackburn, Protective Relaying: Principles and Applications, Taylor & Francis Ltd. (Text-2)	Recommended	No
J. Duncan Glover, Mulukutla S. Sarma & Thomas, J. Overbye, Power System Analysis and Design, 5th edition, CENGAGE Learning (Text-3)	Recommended	No

Student Assessment

Component	Value
Assignment I	15%
Asssignment II	15%
Assignmnet III	15%
Assignment IV	15%
Final Exam	40%

The instructor reserves the right to use alternative grading schemes in special circumstances. For example, if an accommodation is necessary, an alternative grading scheme may be used to the benefit of the individual student.

- **Four assignments** are to be given. The assignments will be posted on LEARN after the corresponding

modules are covered in class.
- **These assignments are a combination of analytical questions and simulation problems.**
- All assignments should be neat and clear. Messy and crumpled solutions will not be marked.
- Late assignments will not be accepted unless a legitimate reason (illness, religious conviction, etc.) is discussed with the instructor before the due date.
- Solutions to the assignments will be posted on LEARN after the due date of the assignments.
- Students should upload their solutions on LEARN. A separate Dropbox will be created for each assignment on LEARN.
- The final exam will be open book in the sense that you may consult your textbook, course notes, and materials posted on the course LEARN site. Use of any other resource (including file-sharing services such as chegg.com, coursehero.com, stackexchange.com, ...) is prohibited. You may not communicate directly or indirectly with any person except the course instructor.
- A student missing the final exam will automatically receive a score of zero for that exam.
- The instructor reserves the right to curve any of the assignment grades, and the final marks.

Assignment Screening

Text matching software (Turnitin) will be used to screen assignments in this course. This is being done to verify that the use of all material and sources in assignments is documented. In the first week of the term, details will be provided about the arrangements for the use of Turnitin and alternatives in this course. See Administrative Policy below for more information and links.

Administrative Policy

Faculty of Engineering Guiding Practices.

Territorial Acknowledgement: The University of Waterloo acknowledges that much of our work takes place on the traditional territory of the Neutral, Anishinaabeg and Haudenosaunee peoples. Our main campus is situated on the Haldimand Tract, the land granted to the Six Nations that includes six miles on each side of the Grand River. Our active work toward reconciliation takes place across our campuses through research, learning, teaching, and community building, and is centralized within the Office of Indigenous Relations (https://uwaterloo.ca/indigenous) .

Inclusive Teaching-Learning Spaces: The University of Waterloo values the diverse and intersectional identities of its students, faculty, and staff. The University regards equity and diversity as an integral part of academic excellence and is committed to accessibility for all. We consider our classrooms, online learning, and community spaces to be places where we all will be treated with respect, dignity, and consideration. We welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. We are all expected to contribute to a respectful, welcoming, and inclusive teaching- learning environment. Any member of the campus community who has experienced discrimination at the University is encouraged to seek guidance from the Office of Equity, Diversity, Inclusion & Anti-racism (EDI-R) (https://uwaterloo.ca/equity-diversity-inclusion-anti-racism/) via email at equity@uwaterloo.ca (mailto:equity@uwaterloo.ca) . Sexual Violence Prevention & Response Office (SVPRO) (https://uwaterloo.ca/sexual-violence-prevention-response-office) , supports students at UWaterloo who have experienced, or have been impacted by, sexual violence and gender-based violence. This includes those who experienced harm, those who are supporting others who experienced harm. SVPRO can be contacted at

svpro@uwaterloo.ca (mailto:svpro@uwaterloo.ca)

Religious & Spiritual Observances: The University of Waterloo has a duty to accommodate religious and spiritual observances under the Ontario Human Rights Code. Please inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments. Consult with your instructor(s) within two weeks of the announcement of the due date for which accommodation is being sought.

Respectful Communication and Pronouns: Communications with Instructor(s) and teaching assistants (TAs) should be through recommended channels for the course (e.g., email, LEARN, Piazza, Teams, etc.) Please use your UWaterloo email address. Include an academic signature with your full name, program, student ID. We encourage you to include your pronouns to facilitate respectful communication (e.g., he/him; she/her; they/them). You can update your chosen/preferred name at WatIAM. (https://idm.uwaterloo.ca/watiam/) You can update your pronouns in Quest (https://uwaterloo.ca/quest/help/students/how-do-i/view-or-update-my-personal-information) .

Mental Health and Wellbeing Resources: If you are facing challenges impacting one or more courses, contact your academic advisor, Associate Chair Undergraduate, or the Director of your academic program. Mental health is a serious issue for everyone and can affect your ability to do your best work. We encourage you to seek out mental health and wellbeing support when needed. The Faculty of Engineering Wellness (https://uwaterloo.ca/engineering-wellness-program/) Program (https://uwaterloo.ca/engineering-wellness-program/) has programming and resources for undergraduate students. For counselling (individual or group) reach out to Campus Wellness and Counselling Services. (https://uwaterloo.ca/campus-wellness/counselling-services) Counselling Services is an inclusive, non-judgmental, and confidential space for anyone to seek support. They offer confidential counselling for a variety of areas including anxiety, stress management, depression, grief, substance use, sexuality, relationship issues, and much more.

Intellectual Property: Be aware that this course contains the intellectual property of their instructor, TA, and/or the University of Waterloo. Intellectual property includes items such as:

- Lecture content, spoken and written (and any audio/video recording thereof).
- Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides).
- Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and
- Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein are used to enhance a student's educational experience. However, sharing this intellectual property without the intellectual property owner's permission is a violation of intellectual property rights. For this reason, it is necessary to ask the

instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository).

Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of intellectual property rights and academic integrity.

Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online.

Continuity Plan - Fair Contingencies for Unforeseen Circumstances (e.g., resurgence of COVID-19): In the event of emergencies or highly unusual circumstances, the instructor will collaborate with the Department/Faculty

to find reasonable and fair solutions that respect rights and workloads of students, staff, and faculty. This may include modifying content delivery, course topics and/or assessments and/or weight and/or deadlines with due and fair notice to students. Substantial changes after the first week of classes require the approval of the Associate Dean, Undergraduate Studies.

Declaring absences: [*undergraduate students and/or courses only*] Regardless of the process used to declare an absence, students are responsible for reaching out to their instructors as soon as possible. The course instructor will determine how missed course components are accommodated. Self-declared absences (for COVID-19 and short-term absences up to 2 days) must be submitted through Quest (https://uwaterloo.ca/quest/help/students/how-do-i/self-declare-absence-undergraduate-students) . Absences requiring documentation (e.g., Verification of Illness Form, bereavement, etc.) are to be uploaded by completing the form on the VIF System (https://vif.uwaterloo.ca/) . The UWaterloo Verification of Illness form (https://uwaterloo.ca/campus-wellness/health-services/student-medical-clinic/verification-illness-services) , completed by a health professional, is the only acceptable documentation for an absence due to illness. Do not send documentation to your advisor, course instructor, teaching assistant, or lab coordinator. Submission through the VIF System, once approved, will notify your instructors of your absence.

Rescheduling Co-op Interviews: Follow the co-op process for rescheduling co-op interviews (https://uwaterloo.ca/co-operative-education/find-your-co-op-job/find-job-waterlooworks/interview/interview-conflicts) for conflicts to graded assignments (e.g., midterms, tests, and final exams). Attendance at co-operative work-term employment interviews is not considered to be a valid reason to miss a test.

University Policy

Academic integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check the Office of Academic Integrity (https://uwaterloo.ca/academic-integrity/) for more information.]

Grievance: A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4 (https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-70) . When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for their actions. [Check the Office of Academic Integrity (https://uwaterloo.ca/academic-integrity/) for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline (https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-71) . For typical penalties, check Guidelines for the Assessment of Penalties (https://uwaterloo.ca/secretariat/guidelines/guidelines-assessment-penalties) .

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-70) (other than a petition) or Policy 71, Student Discipline (https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-71) may be appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72, Student Appeals (https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-72) .

Note for students with disabilities: AccessAbility Services (https://uwaterloo.ca/accessability-services/) , located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for

students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Turnitin.com: Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.