Details of this course syllabus are subject to change throughout the term.

Instructor Information
Instructor: Sahar Azad, Ph.D., PEng
Office: EIT 4017
Office Phone: 519-888-4567, ext. 33974
Office Hours: By appointment via sending an email to the instructor the day before the appointment.
Email: sahar.azad@uwaterloo.ca

Note: When sending an email to the course instructor:

1. Ensure that the email’s subject contains ECE 760.
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.

Prerequisites: ECE 361, ECE464 or equivalent and general knowledge of fault analysis.

Course website
The course website is on LEARN and it contains all lecture materials, assignments/solutions, and it will be used as the primary medium for communication.

Course Description
This course focuses on the protection of various component of a power system including transmission lines, rotating machinery, transformers, busbars, reactors, capacitors and distribution lines. The course will review the fundamental features of a reliable protection system and will discuss the major components of a protection system including current and voltage transformers, circuit breakers, and relays. Various protection strategies such as non-pilot overcurrent protection, nonpilot distance protection, pilot protection and differential protection will be discussed in this course.

Course Goals and Learning Outcomes
Upon completion of this course, students should be able to:

A. Provide an in-depth understanding of power system protection requirements;
B. Describe the operational principle of the main components of a protection system;
C. 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, busbars and compensation devices;
D. 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.

Course Content

- **Module 1 - Protection system requirements (1.5 hours)**
  - Overview of power system structure
  - Causes and types of faults
  - Protection system main requirements
- **Module 2 – Elements of protection systems (4.5 hours)**
  - Relay types and operating principles
  - Circuit breaker types and operating principles
  - Instrument transformers types and operating principles
- **Module 3 - Review of symmetrical components and power system fault calculations (2 hours)**
  - Balanced 3-phase faults
  - Unbalanced faults
  - Symmetrical components
  - Sequence network construction
- **Module 4 – Overcurrent protection (3 hours)**
  - Principles of overcurrent protection
  - Fuses, sectionalizes and reclosers
  - Inverse, time-delay overcurrent relays
  - Instantaneous overcurrent relays
- **Module 5 – Coordination principle of overcurrent protection devices (2 hours)**
  - Guidelines for coordination of overcurrent protection devices
- **Module 6 – Directional overcurrent relays (2 hours)**
  - Application of directional relays
  - Different connections and maximum torque angles
- **Module 7 – Distance protection (3 hours)**
  - Distance relay characteristics
    - Reactance
    - Impedance
    - Admittance (MHO)
    - Quadrilateral
    - Special (lens, figure 8, etc..)
  - Factors affecting impedance relay performance
    - Fault resistance
    - Load encroachment
- Remote in-feed
  - Effect of transmission line compensation devices on relaying

- **Module 8 - Pilot protection of transmission lines (6 hours)**
  - Communication channels
  - Directional comparison blocking
  - Directional comparison unblocking
  - Direct underreaching transfer trip
  - Permissive overreaching transfer trip
  - Permissive underreaching transfer trip
  - Current-based pilot schemes

- **Module 9 - Transformer protection (3 hours)**
  - Overcurrent protection
  - Differential protection
  - Nonelectrical protection

- **Module 10 - Busbar and compensation devices protection (3 hours)**
  - Common busbar arrangements
  - Busbar protection
  - Compensation devices protection
    - Shunt reactors
    - Capacitor banks

- **Module 11 - Generator protection (4 hours)**
  - Typical power plant layouts
  - Grounding methods for generators
  - Protection principle against
    - Stator faults
    - Rotor faults
    - Unbalanced currents
    - Overexcitation
    - Overspeed
    - Abnormal voltages and frequencies
    - Loss of excitation

- **Module 12 - Motor protection (2 hours)**
  - Motor failures
  - Thermal protection
  - Stall or locked rotor protection
  - Short circuit protection
  - Ground fault protection
  - Load-loss/load jam protection
  - Overspeed protection
  - Unbalance current protection
  - Undervoltage protection
  - Overvoltage protection
Text and References (Recommended)

- Stanely H. Horowitz, & Arun G. Phadke, Power System Relaying, 4th edition, Wiley (Text-1)
- J.L. Blackburn, Protective Relaying: Principles and Applications, Taylor & Francis Ltd. (Text-2)

Course Requirements and Assessment

The course grade will be based on five assignments and a final examination, which will be held during the official examination schedule. The breakdown is as follows:

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Date of Evaluation</th>
<th>Weighting</th>
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<tbody>
<tr>
<td>Final Exam</td>
<td>Date and time TBD</td>
<td>70%</td>
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<tr>
<td>Assignment I</td>
<td>Date and time TBD</td>
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<tr>
<td>Assignment II</td>
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<td>Assignment III</td>
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<td>Assignment IV</td>
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<tr>
<td>Assignment V</td>
<td>Date and time TBD</td>
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<td>Total</td>
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Assignments

- **Five assignments** are to be given. The assignments will be posted on LEARN (on Wednesdays) after the corresponding chapters are covered in class. The assignments are due the following Thursday.
- **All assignments should be handed to the instructor at the end of the Thursday lectures.**
- All assignments should be neat and clear. Messy and crumpled assignments will not be marked.
- Late assignments will not be accepted unless a legitimate reason (illness, religious conviction, etc.) is discussed with the instructor prior to the assignment due date.
- Solutions to the assignments will be posted on LEARN after the due date of the assignments.

Final Exam

- The final exam will be held during the official examination schedule.
- The students can bring a single-sided formula sheet (letter size) to the final exam; but no books, class notes, or other materials are allowed. The formula sheet should be hand-written.
- A student missing the final exam will automatically receive a score of 0 for that exam.
- A student missing the exam must provide appropriate documentation (e.g. verification of illness form of an illness).
- The instructor reserves the right to curve any of the exam and assignment grades, and the final marks.
- In the final exam, approved programmable and non-programmable calculators are permitted.
Information on Plagiarism Detection

Turnitin.com: Text matching software (Turnitin®) may be used to screen lab reports and 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 the alternate assignment.

Academic Integrity

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo are expected to promote honesty, trust, fairness, respect and responsibility.

Discipline: A student is expected to know what constitutes academic integrity, to avoid committing academic offences, and to take responsibility for his/her actions. 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 professor, academic advisor, or the Undergraduate Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 – Student Discipline. For information on categories of offenses and types of penalties, students should refer to Policy 71 - Student Discipline.

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 - Student Petitions and Grievances, Section 4.

Appeals: A student may appeal the finding and/or penalty in a decision made under Policy 70 - Student Petitions and Grievances (other than regarding a petition) or Policy 71 - Student Discipline if a ground for an appeal can be established. Read Policy 72 - Student Appeals.

Other sources of information for students

Academic integrity (Arts) Academic Integrity Office (uWaterloo)

Accommodation for Students with Disabilities

Note for students with disabilities: The AccessAbility Services office, located in Needles Hall Room 1132, 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 the AS office at the beginning of each academic term.