Description: This course covers in depth main topics: 1- Analysis of faulted power systems which includes bus impedance and admittance matrices; network equations in matrix form; symmetrical components; sequence networks; balanced and unbalanced faults, 2- Load flow studies; the static load flow equations, classification of system buses, Gauss-Seidel and Newton-Raphson methods, 3- Power system stability; modeling of the synchronous machine during transients; swing equation; equal area criterion; digital computer solution of the swing equations; small signal stability, 4- Smart grid.

Prerequisites: EE 342

Pre- or Corequisites:

Instructor: Sherif O. Faried, Ph.D., P.Eng.
Professor, Department of Electrical and Computer Engineering
Office: Room 3B13, Engineering Building
Phone: (306) 966-5422
Email: sherif.faried@usask.ca

Lectures: Tuesday, Thursday, 1:00 p.m.–2:20 p.m., Room 1B77 Engineering

Website: Assignments, solutions, formulae sheets, general course information, and announcements will be posted on the course website. Students are responsible for keeping up-to-date with the information on the course website.

http://www.engr.usask.ca/classes/EE/441/

Course Reference Numbers (CRNs): 81000 (lectures)

The textbook is recommended.

Office Hours: There are no formal office hours. Students are welcome and encouraged to stop by the instructor's office at any time for help. A student can also send email to make an appointment.

Reading List: none

Assessment: The methods of assessment and their respective weightings are given below.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments</td>
<td>10%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>30%</td>
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<tr>
<td>Final Exam</td>
<td>60%</td>
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</table>

Final Grades: Final grades will be based on the numeric assessment given above. However, the final grades might be adjusted to be consistent with the “literal descriptors” specified in the university’s grading system.

http://students.usask.ca/current/academics/grades/grading-system.php
For information regarding appeals of final grades or other academic matters, please consult the University Council document on academic appeals.

http://www.usask.ca/university_secretary/honesty/StudentAcademicAppeals.pdf

**Course Content:**

**Module I: Analysis of Faulted Power Systems**
- Internal voltages and reactances of synchronous machines under fault conditions
- Three-phase fault calculations using Zbus
- Symmetrical fault analysis using digital computer
- Short circuit capacity
- The selection of circuit breakers
- Symmetrical components
- Sequence impedances of static loads, synchronous machines, transformers and transmission lines
- Single line-to-ground, line-to-line and double line-to-ground faults
- Fault calculations using Zbus
- Unsymmetrical fault analysis using digital computer

**Module II: Load Flow Studies**
- The static load flow equations
- Classification of system variables
- Solution of the SLFE for a 2-bus system
- Generalization to n-bus system
- Definition of the load flow problem
- Practical state and control variable constraints
- Iterative computation of nonlinear algebraic equations
- Iterative computation of load flow equations
- A sample load flow study using a digital program

**Module III: Power System Stability**
- The swing equation
- Synchronous machine models for stability studies
- Transient stability
- The equal area criterion
- Representation of system faults in stability studies
- Transient stability studies using digital computers
- Small signal stability
- Linearization of the swing equation
- Stability boundaries

**Module IV: Introduction to Smart Grid**
- The future of power transmission
- What makes the transmission grid smart
- Meeting the smart grid information technology challenge

**Assignments:**
There will be about one assignment per week. Each assignment is due the following week at the time specified on the problem sheet. Usually assignments will be due in class. Late assignment papers will be accepted without penalty until the solutions are posted (which might be immediately) unless this policy is abused. Solutions will be provided. Assignments and solutions are distributed on the course website.

**Quizzes:**
none

**Exams:**
There will be one midterm examination after Module II is complete. The date and time will be arranged in class. The midterm exam will be either 1.5 or 2 hours in length depending on scheduling. Solutions to the midterm exam will be posted.
All exams (midterm and final) are closed book and closed notes; calculators (any type) are allowed. A one formulae sheet is allowed.

**Important Dates:**
- Thursday, September 3, 2015: first lecture
- About mid-November: Midterm exam
- Tuesday, December 8, 2015: final lecture
- Wednesday, December 9, 2015: final exams begin

**Student Conduct:**
Ethical behaviour is an important part of engineering practice. Each professional engineering association has a Code of Ethics, which its members are expected to follow. Since students are in the process of becoming Professional Engineers, it is expected that students will conduct themselves in an ethical manner.

The APEGS (Association of Professional Engineers and Geoscientists of Saskatchewan) Code of Ethics states that engineers shall “conduct themselves with fairness, courtesy and good faith towards clients, colleagues, employees and others; give credit where it is due and accept, as well as give, honest and fair professional criticism” (Section 20(e), The Engineering and Geoscience Professions Regulatory Bylaws, 1997).

The first part of this statement discusses an engineer’s relationships with his or her colleagues. One of the ways in which engineering students can demonstrate courtesy to their colleagues is by helping to maintain an atmosphere that is conducive to learning, and minimizing disruptions in class. This includes arriving on time for lectures, turning cell phones and other electronic devices off during lectures, not leaving or entering the class at inopportune times, and refraining from talking to others while the instructor is talking. However, if you have questions at any time during lectures, please feel free to ask (chances are very good that someone else may have the same question as you do).

For more information, please consult the University Council Guidelines for Academic Conduct.

[http://www.usask.ca/university_secretary/council/reports_forms/reports/guide_conduct.php](http://www.usask.ca/university_secretary/council/reports_forms/reports/guide_conduct.php)

**Academic Honesty:**
The latter part of the above statement from the APEGS Code of Ethics discusses giving credit where it is due. At the University, this is addressed by university policies on academic integrity and academic misconduct. In this class, students are expected to submit their own individual work for academic credit, properly cite the work of others, and to follow the rules for examinations. Academic misconduct, plagiarism, and cheating will not be tolerated. Copying of assignments and lab reports is considered academic misconduct. Students are responsible for understanding the university’s policies on academic integrity and academic misconduct. For more information, please consult the University Council Regulations on Student Academic Misconduct and the university’s examination regulations.


**Safety:**
The APEGS Code of Ethics also states that Professional Engineers shall “hold paramount the safety, health and welfare of the public and the protection of the environment and promote health and safety within the workplace” (Section 20(a), The Engineering and Geoscience Professions Regulatory Bylaws, 1997).

Safety is taken very seriously by the Department of Electrical and Computer Engineering. Students are expected to work in a safe manner, follow all safety instructions, and use any personal protective equipment provided. Students failing to observe the safety rules in any laboratory will be asked to leave.
Course Learning Outcomes: Upon successful completion of the course, students should be able to
1. Calculate the fault currents, the bus voltages during fault and the contributions of the generators to the fault current for any power system configuration.
2. Determine the MVA rating of the circuit breakers installed in the system
3. Calculate the real and reactive power flows through transmission lines, the system bus voltages and the transmission line real and reactive power loss for any power system configuration under steady-state condition.
4. Calculate the critical clearing angle and the critical clearing time for a power system which is represented by a single-machine to an infinite bus system.
Attribute Mapping:

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
<th>A8</th>
<th>A9</th>
<th>A10</th>
<th>A11</th>
<th>A12</th>
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</tr>
</tbody>
</table>

**Attributes:**
- A1: Knowledge base for engineering
- A2: Problem analysis
- A3: Investigation
- A4: Design
- A5: Use of engineering tools
- A6: Individual and team work
- A7: Communication skills
- A8: Professionalism
- A9: Impact of engineering on society and the environment
- A10: Ethics and equity
- A11: Economics and project management
- A12: Life-long learning

**Levels of Performance:**
1 - **Knowledge** of the skills/concepts/tools but not using them to solve problems.
2 - **Using** the skills/concepts/tools to solve directed problems. (*Directed* indicates that students are told what tools to use.)
3 - **Selecting** and using the skills/concepts/tools to solve non-directed, non-open-ended problems. (*Students have a number of S/C/T to choose from and need to decide which to employ. Problems will have a definite solution.*)
4 - **Applying** the appropriate skills/concepts/tools to solve open-ended problems. (*Students have a number of S/C/T to choose from and need to decide which to employ. Problems will have multiple solution paths leading to possibly more than one acceptable solution.*)

Accreditation Unit (AU) Mapping: (% of total class AU)

<table>
<thead>
<tr>
<th>Math</th>
<th>Natural Science</th>
<th>Complementary Studies</th>
<th>Engineering Science</th>
<th>Engineering Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33.9 (74%)</td>
<td>11.9 (26%)</td>
</tr>
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</table>

Assessment Mapping:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weighting</th>
<th>Methods of Feedback***</th>
<th>Learning Outcomes Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments</td>
<td>10%</td>
<td>S</td>
<td>1–4</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>30%</td>
<td>S+F</td>
<td>1–3</td>
</tr>
<tr>
<td>Final Exam</td>
<td>60%</td>
<td>S</td>
<td>1–4</td>
</tr>
</tbody>
</table>

***Methods of Feedback:
- F – formative (written comments and/or oral discussions)
- S – summative (number grades)