Description: Provides an in-depth analysis of electric machines and the dynamic behavior of electric machines. Topics include inrush current, synchronous machine transients, single-phase induction motors, induction generators, brushless motors, variable reluctance and stepping motors, power electronic drives for speed and torque control of machines, DC machine and synchronous generator dynamics. (Official Description from the Course and Program Catalogue)

Prerequisites: EE 341

Corequisite: None

Instructor: Ramakrishna (Rama) Gokaraju, Ph.D., P.Eng.
Associate Professor
Dept. of Electrical & Computer Engineering
University of Saskatchewan

Office: 3B33, Email: rama.krishna@usask.ca
Tel: (306) 966-5385, Fax: (306) 966-5407
Email: rama.krishna@usask.ca

Lectures: Tuesday, Thursday, 10:00–11:15AM, Room 2B52E

Laboratory: --

Website: General course information, announcements, useful data sheets, assignments, and solutions 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/444/

Course Reference Numbers (CRNs): 81002 (lectures)


Office Hours: Monday’s, Wednesdays & Friday’s: 2:30pm-3:00pm. Students could also drop by my office (3B33) at any time for help with the course material (If I have another commitment we can find an alternate meeting time). Alternatively, students can email or phone Dr. Gokaraju to schedule a meeting time.

Reading List: ----
Assessment: The methods of assessment and their respective weightings are given below:

Assignments (6-8) 15%
Midterm Exam 35%
Final Exam 50%

Final Grades: The final grades will 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: MAJOR TOPICS: (Approximate Time Allotment)

1. Electromechanical Energy Conversion Principles (2 hours)
   Singly Excited Magnetic Field System, Multiply Excited Magnetic Field System.

2. Instrument Transformers & Transformer Related Problems (6 hours)
   Current and voltage transformers, errors, burden, dc saturation, ac saturation, capacitor
   voltage transformers, inrush currents, inrush currents, three-phase transformer differential
   protection.

3. Synchronous Machines (9 hours)
   Generator Capability Curves, Power-Angle Characteristics, Effects of Salient Poles;
   Power-Angle Characteristics of Salient-Pole Machines, Frequency-Power & Voltage-
   Reactive Power Characteristics, Synchronous Generator Transient Analysis. Synchronous

4. Wind Energy Conversion Systems & Induction Machines (9 hours)
   Wind Turbine Generators, Type 1, Type 2 & Type 3 Wind Generators, Modeling Wind

5. Power Semiconductor-Controlled Drives (7 hours)
   Switched Mode Converters for AC and DC Motor Drives, Design of Synchronous Motor
   Drives, Design of Induction Motor Drives.

6. DC Machines Behaviors (2 hours)
   Braking or Reversing DC Motors, DC Machine Dynamics.

7. Other Special Purpose Machines (1.5 hours)
   Variable Reluctance Machines, Stepping Motors.

Assignments: Assignments will be handed out approximately every two weeks, depending on how
slowly/quickly the course content is covered in the lectures. Assignments must be submitted on
time in EE444 assignment box opposite to Room 2C94E. Late assignments will not be marked
and will be given a mark of zero.

Tutorials: None
Quizzes: None

Exams: The midterm exam is scheduled for October 31st (Thursday), 6:00PM-8:00PM (room to be announced). 2-page formula sheet will be allowed for the mid term examination and 4-page formula sheet will be allowed for the final examination (no solved problems in the formula sheet are allowed). Hand calculator is allowed but all other electronic devices are not allowed.

Important Dates:

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>Thursday, September 5, 2013</td>
<td>EE 444 class begins</td>
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<tr>
<td>Thursday, October 31, 2013</td>
<td>Midterm exam (6pm-8pm)</td>
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<tr>
<td>Tuesday, December 3, 2013</td>
<td>Last day of EE444 class</td>
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<tr>
<td>Friday, December 6, 2013</td>
<td>Fall-term final exams begin</td>
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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

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.

http://www.usask.ca/university_secretary/honesty/StudentAcademicMisconduct.pdf
http://www.usask.ca/university_secretary/council/academiccourses.php

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 in the laboratories 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:**

1. Students will be able to obtain an expression for energy from the magnetic characteristics. Student will be able to calculate forces and torques in a magnetic field system.
2. Students will be able to explain the sources of error in instrument transformers. Students will be able to calculate the errors in CTs & PTs. Students will be able to explain magnetization inrush current phenomenon. **Students will be able to design a 3-phase transformer differential protection.**
3. Students will be able to explain and obtain the active/reactive power capability of synchronous generators. Students will be able to derive the power angle characteristics of more advanced type of synchronous machines (ie salient pole machines). Students will be able analyze the transient and dynamic behavior of synchronous machines due to sudden three-phase short circuits. Students will be able to calculate the sub-transient, transient reactances and time constants of the synchronous machines.
4. Students will be able to determine the transient equivalent circuit of an induction machine. Students will be able to explain the modeling complexities of Wind Generators. Students will be able to model a Type 1 Wind Generator (Squirrel Cage Induction Generator).
   Students will be able calculate the maximum short circuit current at the terminals of a Type 1 Wind Generator (Squirrel Cage) using a voltage behind transient reactance (VBR) model. Students will be able to model a Type 2 Wind Generator (Wound Rotor Induction Generator).
   Students will be able to calculate the maximum short circuit current at the terminals of a Type 2 Wind Generator.
   Students will be able to explain a Type 3 Wind Generator (Doubly Fed Induction Generator).
   Students will be able to calculate the maximum short circuit currents at the terminals of a Type 3 Wind Generator using a voltage behind reactance model.
5. Students will be able to explain speed, armature voltage, torque control of a DC motors using power electronics drives and do calculations. Students will be able to explain speed, torque control of a synchronous motor using power electronics drives and do calculations. Students will be able to explain speed, armature frequency control of induction motors using power electronics and do calculations. A phase controlled rectifier, in combination with a dc link filter inductor will be used to create a dc-link current. Students will be able to mathematically analyze the dynamic behavior of DC machines.
6. Students will be able to explain and analyze special purpose machines such as stepping motors and reluctance machines.
### Attribute Mapping:

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>A1</th>
<th>A2</th>
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<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
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<th>A9</th>
<th>A10</th>
<th>A11</th>
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**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>
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### 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 (5-8)</td>
<td>15%</td>
<td>S</td>
<td>1, 2, 3, 4, 5, 6</td>
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<tr>
<td>Midterm Exam</td>
<td>35%</td>
<td>S</td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Final Exam</td>
<td>50%</td>
<td>S</td>
<td>2, 3, 4, 5, 6, 7</td>
</tr>
</tbody>
</table>

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