ET 332a
Dc Motors, Generators and Energy Conversion Devices

Instructor: Dr. Carl Spezia, PE

Office: Engr. D110
Phone: 453-7839
E-mail: powerguy@siu.edu

Office Hours: 10:00 am - 10:50 am M-W-F
2:00 pm - 3:00 pm M-W-F
or by appointment


References: Electric Machinery and Transformers, Irving L. Kosow
Energy Science Principles, Technologies, and Impacts, John Andrews and Nick Jelley

Grading Scale: 100-90% A
89-80% B
79-70% C
69-60% D
59-below F

Hour Exams (3 at 100 points each) 50%
Final Exam (200 points) 20%
Homework 10%
Laboratory Experiments/Activities 20%

Total 100%

Note: the final exam is optional for all students that have a 90% or higher average on the hour exams, homework, and experiment/activities
ET 332a

Dc Motors, Generators and Energy Conversion Devices

Course Policies

1. Late Work and Makeup Exams
   No make-up exams. All homework handed in at the beginning of the period it is due. No late
   homework accepted. Late lab grades reduced by 5% per working day starting from due date.

2. Attendance Policies
   Class attendance is required and attendance will be taken at the beginning of every period.
   Students are allowed four unexcused absences. Any further absences will reduce the TOTAL
   grade by 5% per day absent.

3. Cell Phone/Electronic Device Usage
   Cell phone usage during meeting periods is prohibited. Devices should be TURNED OFF prior
   to entering class. Other electronics devices (Tablets, iPads, Readers etc) are only allowed for
   academic/research purposes. No electronic devices other than calculators are allowed during
   exams. Those violating this policy are subject to disciplinary action under the Student Conduct
   Code. Follow this link to review this code: [http://policies.siuc.edu/policies/conduct.html](http://policies.siuc.edu/policies/conduct.html)

Nicotine Consumption

4. No use of electronic cigarettes during class.

Final Exam Scheduling Policy

The course final exam is comprehensive. The course instructor will give the exam
during finals week at the time and place prescribed by the University in its final exam
schedule. The University final exam schedule, which you can find on Salukinet, gives
the date and time for this course final exam. The course instructor will also announce
this time and date of the exam in the class several times before semester end. The final
will take place in the normal lecture room.

Course Description and Prerequisites

This course is introduces the theory and operation of DC machines with an emphasis on
the testing and measurement of machine characteristics and parameters. The course
introduces the science, application, and economics of renewable DC power using
photocells. Laboratory exercises will demonstrate the theoretical concepts and give
experience using various types of measurement devices and software.

Prerequisite: Engineering Technology 304a or concurrent enrollment
Course Content Overview

This course will examine the theory and operation of DC machines. DC machines are energy conversion devices that can operate as either motors or generators. This course will cover the theory and operation of these machines. Circuit models and mathematical formulas will describe their operation. The course develops torque-speed and voltage-load characteristics of common types of DC machines. The course introduces simple protection and control schemes. The course content will emphasize machine efficiency and proper motor application. Photocell arrays are a source of dc power. This course introduces the science and application of photovoltaic devices. Simple economic comparisons highlight the cost of solar energy when compared to grid-supplied electricity. The measurement and test of machine characteristics will be carried out in laboratory experiments. Software packages will be used to eliminate tedious calculations and speed data acquisition.

Course Objectives

At the end of this course, you will be able to:

1.) Explain how electromagnetism can transfer electric energy to mechanical energy.
2.) Use the basic principles of physics to describe simple linear and rotational motion.
3.) Determine the torque-speed relationships for typical mechanical loads.
4.) Explain the key parts of magnetic circuits and perform basic magnetic circuit calculations.
5.) List the sources of power loss in magnetic circuits.
6.) Explain how electromagnetic forces produce motor action.
7.) Explain how electromagnetic induction produces generator voltage.
8.) Explain how elementary dc machines generate voltage.
9.) Define commutation in dc machines and list factors that affect it.
10.) List the parts of a practical dc machine.
11.) Use the model of separately excited dc generator to perform electrical calculations.
12.) Determine the voltage regulation of a dc generator.
13.) Explain how torque a separately excited dc motor develops torque.
14.) Use the equivalent circuit model of the separately excited dc motor to perform calculations.
15.) Explain the operation of a shunt connected dc motor and use an equivalent circuit model to perform calculations.
16.) Determine the losses and efficiency of a dc motor.
17.) Interpret NEMA ratings.
18.) Read basic motor control ladder diagrams.
19.) Interpret standard motor/generator terminal markings.
20.) List dc motor starting methods.
21.) Compare and contrast the torque speed characteristics of separately excited, shunt, series, and compound connected dc motors.
22.) Calculate speed regulation of a dc motor.
23.) Calculate motor performance when magnetic circuits saturate.
24.) Explain how photocells convert light into electric current.
25.) Compute photocell voltage, current, and efficiency.
26.) Draw and perform calculations with a solar cell circuit model.
27.) Find the maximum power transfer of a solar cell.
28.) Analyze the economics of owning a solar panel.

Others Helpful Information

All members of the faculty and staff of SIUC are here to help you as you begin this course and all others on your schedule this semester. Attached to this syllabus is a summary sheet that includes all the important dates and other valuable information to help you succeed during your academic career at SIUC. Please feel free to communicate with the course instructor and any other staff of the Department of Technology if you have any problems and concerns. Good luck this semester.
ET 332a
Dc Motors, Generators and Energy Conversion Devices
Course Outline

Fundamentals of Electricity
Concept of energy conversion
Conventional currents.
Source and load power conventions.

Class Notes

Review of Basic Mechanics
Physics of mechanical motion, force, torque, transformation of energy.
Torque-speed relationships for mechanical loads

Class Notes

Magnetic Circuits
Magnetic fields
Magnetic circuits
Magnetic circuit equations
B-H curves of non-magnetic materials
B-H curves of magnetic materials
Electric and magnetic circuit analogies
Solving Magnetic circuits
Magnetic losses
Electromagnetic forces on conductors
  Motor action
Electromagnetic induction
  Generator action

Chapter 1
Sections 1-1 to 1-15

Elementary Dc Machines
Generated voltage in elementary dc machines
Commutation process
  resistive commutation
  inductive effects
  armature reaction
  brush shifting

Chapter 10
Sections 10-1 to 10-27

Class notes

TEST 1
ET 332a
Dc Motors, Generators and Energy Conversion Devices
Course Outline

Construction of dc machines
Separately excited dc generator
Equivalent circuit
Voltage regulation
Motor-generator operation
Developed torque
Separately excited dc motors
Equivalent Circuit
Basic shunt motor operation
   Equivalent circuit
dynamic operation
   speed regulation
Speed equations
Torque and power
Losses and efficiency
Class notes
NEMA ratings
Ladder diagrams
DC motor starting
Step Resistor Starting

DC Motor Characteristics
Chapter 11
Shunt motors
Compound motors
Sections 11-1, 11-12
Differential Compound motors
Series motors
Saturation effects
Linear approximations
Characteristics compared
Control
   Variable voltage drive systems
   Dynamic braking
   Plugging/Jogging

Standard terminal markings and connections

TEST 2

Control of Dc Machines
Chapter 13
ET 332a
Dc Motors, Generators and Energy Conversion Devices
Course Outline

Control Components  Sections 13-1 to 13-5, 13-9 to 13-15
Control diagram conventions
Overload protection
Short circuit protection
Auto shutdown for power failure  Class notes
Reversing starters with braking

Renewable dc Power Sources  Class notes
Solar energy  Handouts
Solar intensity
Conductors, insulators, and semiconductors
PN junction
Photo-electric effect
Solar cell electrical characteristics
Circuit model of solar cells
Cell efficiency
Solar panels
Economics of solar power  TEST 3

Final Review  Final Exam
<table>
<thead>
<tr>
<th>Assignment #</th>
<th>Problems</th>
<th>Location</th>
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<tr>
<td>1</td>
<td>1-1/4, 1-2/4</td>
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<tr>
<td>2</td>
<td>1-4/5, 1-5/5</td>
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<tr>
<td>3</td>
<td>1-7/5</td>
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<tr>
<td>4</td>
<td>hw1.wp5</td>
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<td>5</td>
<td>hw2.wp5, hw3.wp5</td>
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<td>6</td>
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<td>7</td>
<td>1-11/7, 1-12/7</td>
<td>Chapter 1</td>
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<td>10-5/7, 10-6/7</td>
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<td>13</td>
<td>hw5.wp5, hw6.wp5</td>
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<td>14</td>
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<td>15</td>
<td>10-8/12</td>
<td>Chapter 10</td>
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<td>16</td>
<td>10-19/22&lt;sup&gt;1&lt;/sup&gt;</td>
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<td>17</td>
<td>hw7.wp5</td>
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<td>18</td>
<td>hw8.wp5, 10-25/26&lt;sup&gt;2&lt;/sup&gt;</td>
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<td>19</td>
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<td>21</td>
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<td>11-11/7</td>
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<td>24</td>
<td>11-10/7</td>
<td>Chapter 11</td>
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<tr>
<td>25</td>
<td>Short Answer Questions 12, 13</td>
<td>Chapter 11</td>
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<td>26</td>
<td>6.1, 6.2</td>
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<td>27</td>
<td>6.6, 6.8</td>
<td>PV handout</td>
</tr>
<tr>
<td>28</td>
<td>6.9 6.11</td>
<td>PV handout</td>
</tr>
</tbody>
</table>

<sup>1</sup>The value of the resistor in part a is incorrect. Use a value of 0.052 ohms.

<sup>2</sup>The answers in the back of the book are incorrect. Use a.) 1705.2 W b.) 3270.8 W c.) 93.8%
ET 332a
Laboratory Activities and Experiments

1.) **Using Spreadsheets in Laboratory Calculations**
   (Handouts)
   The Excel spreadsheet is introduced and used to produce graphs that are commonly found in technical reports. Linear graphs are produced. Semi-log plots are created by using a log function to reduce the range of the data and by using the scaling abilities of the spreadsheet. Embedding the results into reports is also demonstrated. The Microsoft Equation Editor is demonstrated. A student activity uses the developed skills to make plots and produce professional solutions to technical problems.

2.) **Power Laboratory Safety and Work Procedures/Resistance of DC machines**
   (Hampden Experiment 1)
   Students are instructed in high voltage laboratory safety rules. Avoiding electric shock and other safety hazards encountered in the power lab are covered. The basic operation of the fractional-horsepower motor lab equipment will be covered. The class will perform a simple experiment to determine the dc resistance of the field and armature coils of a typical dc motor.

3.) **Saturation Curve of a Generator**
   (Hampden Experiment 2)
   The main object of this lab is to obtain the necessary data to plot a saturation curve of a separately excited dc generator. The shape of this curve is a scaled representation of a machine’s B-H curve. The effects of saturation on the output of a generator are observed.

4.) **Counter EMF Force**
   (Hampden Experiment 16)
   The counter EMF force of a dc machine will be observed. The laws of induction and force on a conductor will be verified using a dc machine.

5.) **Load Characteristics of a Separately-Excited Shunt Generator**
   (Hampden Experiment 6)
   The load level Vs terminal voltage characteristic of a separately-excited shunt generator is developed. The voltage output capabilities of the machine are examined at the rated speed and field current of the device.
6.) **Shunt Motor Characteristics**  
(Hampden Experiment 18)  
The speed-torque characteristic of the shunt dc motor is determined experimentally. The speed regulation of the machine will be found. The relationship between the load torque and the armature current is examined.

7.) **Efficiency and Losses in a Dc Shunt Motor**  
(Hampden Experiment 21)  
The operating efficiency of a shunt dc machine will be determined by lab tests. The sources of losses in dc machines are identified and measured. These losses can be divided into fixed and load-variable components.

8.) **Series Motor Characteristics**  
(Hampden Experiment 19)  
The speed-torque characteristic of the series dc motor is determined experimentally. The speed regulation of the machine will be found. The relationship between the load torque and the armature current is examined.

9.) **Compound Motor Characteristics**  
(Hampden Experiment 20)  
The speed-torque characteristic of the compound dc motor is determined experimentally. The speed regulation of the machine will be found. The relationship between the load torque and the armature current is examined.

10.) **Shunt Generator Output Polarity and Voltage Build-up**  
(Hampden Experiment 3)  
This experiment covers the correct procedures for preparing a shunt generator to for operation. The voltage build-up process is examined. The proper connections for voltage build-up are given.

11.) **Field Resistance Vs Generator Voltage Build-up/Motor Control Simulator**  
(Hampden Experiment 4)  
This lab examines the affects of field resistance on generator voltage build-up. The lab demonstrates the effect of excessive field resistance on terminal voltage. The second section introduces ladder diagrams and motor control with an animated, computer-based simulator.

12.) **PV Array Economics Report**

Students survey the Web and other technical resources to determine the cost and feasibility of utilizing solar power in a grid-tied residential application. A short report summarizes the findings.
Lab Reporting Format

The laboratory procedure will be handed out approximately a week before it will be performed. Reading the lab prior to lab makes the performance of the experiment more efficient. All data collected in lab must be initialed and dated by the lab instructor. All reports submitted without instructor verification will receive a zero.

The experiments for this course will be reported in an abbreviated format. The laboratory handout has an experiment objective and procedure included. There is no need to restate these sections in another report. To fully document the results of the experiment, all questions, problems and graphs required by the laboratory handout must be completed. Also, a discussion of the topics covered in the experiment and how they relate to the lecture material should be completed. This discussion should be at least one page type written and double-spaced.

The report should have the following sections:

1.) Cover page that is like the one attached to this document
2.) All the pages from the laboratory handout that have questions, problems, tables, graphs.
3.) Discussion

It is permissible to answer the questions/problems on a separate sheet, but the questions and problems must be numbered and all the answers typed. Some of the lab handouts have places to make graph in them. It is also permissible make graphs using software packages such as Excel instead of using this page. If a graph is made on a separate sheet it must have:

1.) A title
2.) Labels on each axis
3.) Units on each axis
4.) A legend if more than one curve is on the same axis. This identifies each curve on the graph.

The graphs should be scaled to show the data in the most meaningful way. Change the graph limits so the curve covers most of the axis.

Hints for Good Reports

1.) Follow the format. If you are not sure about how something should be done, ask the lab or lecture instructor.
2.) Use computer tools whenever possible. (Word processors, drawing tools, spreadsheets) If you have never had any experience with some of these tools or have a question about how to perform a function using the common software tools ask the lab or lecture instructor.
3.) Spell-check the document.
4.) Proof-read the document at least once.

Southern Illinois University at Carbondale
ET 332
Lab Report Grading and Attendance Policies

Grading

The following table shows the point distribution and items that will be graded in the ET 332 lab report. If all listed items are included and correct, then the maximum grade is received.

Only include the pages from the lab handout that show data and have answers to questions. This includes both the De-Briefing and Quick Quiz sections. All graphs should be generated using a computer program such as Excel. Include the graphs required by the lab procedures and any additional ones specified by the lab instructor.

Late labs will have point totals reduced by 5 points per working day. After one week, late labs will not be accepted.

Attendance

Students are expected to be seated in the lab at the scheduled starting time. An attendance sheet will be circulated at the beginning of the lab period. Everyone is responsible for signing this sheet. Anyone entering the lab after the scheduled starting time will be considered late and the work that they are intending to hand in will be considered late by one day. The lab instructor will be available before the lab period begins to answer questions and assist in experimental setups.

Pre-lab Online Presentations

Each lab has an online audio/video presentation describing major technical points and details of the procedure. Students should view these lab presentations before attempting to perform the experiments. The lab instructor may give pop quizzes based on these presentations to test basic knowledge. Students can reference these presentations while writing their experimental discussions.

<table>
<thead>
<tr>
<th>Item</th>
<th>Points</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Title Page</td>
<td>5 pts</td>
<td>The title page must follow the given format exactly to receive credit. See the examples in the syllabus and from the lab T.A.</td>
</tr>
<tr>
<td>De-Briefing Questions</td>
<td>20 pts</td>
<td>Complete all short answer questions correctly and completely. Print question responses clearly. Unreadable responses will be considered wrong. Use complete sentences and good grammar. Graphs are sometimes included in this section. Always use a computer program to generate these plots. Additional tables of the collected data can be included with the graphs, but are not required.</td>
</tr>
<tr>
<td>Experimental Results</td>
<td>10 pts</td>
<td>All data tables must be filled and contain reasonably accurate values. The values should be written clearly. The data tables must be signed by the T.A. before leaving lab. Unsigned data will receive no credit.</td>
</tr>
<tr>
<td>Quick Quiz</td>
<td>20 pts</td>
<td>Correctly answer all multiple choice questions listed in the lab handout. Include these pages in the report.</td>
</tr>
<tr>
<td>Discussion</td>
<td>45 pts</td>
<td>To receive maximum credit for the discussion section, each topic on the discussion point handout must be included and thoroughly explained. The discussion can be up to three pages in length. It must be typed with no greater than a 12 point font and double spaced.</td>
</tr>
</tbody>
</table>
IMPORTANT DATES *
Semester Class Begins .............................................. 08/18/2014
Last day to add a class (without instructor permission): ........ 08/24/2014
Last day to withdraw completely and receive a 100% refund: .. 08/31/2014
Last day to drop a course using SalukiNet: ........................ 10/26/2014
Last day to file diploma application (for name to appear in Commencement program): ........................................... 10/31/2014
Final examinations: .................................................. 12/8–12/12/2014

Note: For outreach, internet, and short course drop/add dates, visit Registrar’s Academic webpage: http://registrar.siu.edu/

FALL SEMESTER HOLIDAYS
Labor Day 09/01/2014
Fall Break 10/11—10/14/2014
Veterans Day 11/11/2014
Thanksgiving Vacation 11/26—11/30/2014

WITHDRAWAL POLICY ~ Undergraduate only
Students who officially register for a session may not withdraw merely by the stopping of attendance. An official withdrawal form needs to be initiated by the student and processed by the University. For the proper procedures to follow when dropping courses and when withdrawing from the University, please visit http://registrar.siu.edu/pdf/ugradcatalog1314.pdf

INCOMPLETE POLICY ~ Undergraduate only
An INC is assigned when, for reasons beyond their control, students engaged in passing work are unable to complete all class assignments. An INC must be changed to a completed grade within one semester following the term in which the course was taken, or graduation, whichever occurs first. Should the student fail to complete the course within the time period designated, that is, by no later than the end of the semester following the term in which the course was taken, or graduation, whichever occurs first, the incomplete will be converted to a grade of F and the grade will be computed in the student’s grade point average. For more information please visit: http://registrar.siu.edu/grades/incomplete.html

REPEAT POLICY
An undergraduate student may, for the purpose of raising a grade, enroll in a course for credit no more than two times (two total enrollments) unless otherwise noted in the course description. For students receiving a letter grade of A,B,C,D, or F, the course repetition must occur at Southern Illinois University Carbondale. Only the most recent (last) grade will be calculated in the overall GPA and count toward hours earned. See full policy at http://registrar.siu.edu/pdf/ugradcatalog1314.pdf

GRADUATE POLICIES
Graduate policies often vary from Undergraduate policies. To view the applicable policies for graduate students, please visit http://gradschool.siu.edu/about-us/grad-catalog/index.html

DISABILITY POLICY
Disability Support Services provides the required academic and programmatic support services to students with permanent and temporary disabilities. DSS provides centralized coordination and referral services. To utilize DSS services, students must come to the DSS to open cases. The process involves interviews, reviews of student-supplied documentation, and completion of Disability Accommodation Agreements. http://disabilityservices.siu.edu/

PLOPOLICY
Undergraduate only

INCOMPLETE POLICY
Undergraduate only

REPEAT POLICY
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