Electrical Energy Conversion (Devices and Systems)
Syllabus, ELEC 491, Autumn 2011

Instructor: Peter Mark Jansson PhD PE
Office: BRKI 340 **Office Phone:** (570) 577-3398
Email: pmj005@bucknell.edu (use subject: ELEC491)
Class Time: Tuesday and Thursday 9.30-10.52 am in BRKI 065
Laboratory: Tuesday 2:00 – 4:52 pm in DANA 111
Web Page: on MOODLE now (also see my Public drive for class resources)
Office Hours: Tuesdays 11 am-12.30 pm and Wednesdays 10 am -12.30 pm
Prerequisites: ELEC 350 – Electronics I
ELEC 390 – Theory and Applications of Electromagnetics
Textbook: "First Course on Power Systems," Ned Mohan
MNPERE © 2006, ISBN0-9715292-7-2

Additional Texts will be placed On Reserve at the Library during the semester:
"Electric Machinery and Power System Fundamentals," S. J. Chapman ©2002,
"Electric Energy – An Introduction", (2nd Edition) M. A. El-Sharkawi, CRC Press, ©2009,
"Electric Power Systems," (4th Edition), B.M. Weedy and B.J. Cory McGraw-Hill, ©2004,
"Foundations of Electric Power," J.R. Cogdell, Prentice Hall ©1999.
You may find many other helpful books in the library. Search based on the keywords: *power systems, electric motors, electric generators, transformers, energy conversion, power electronics, power distribution and transmission systems.*

Professional and Scientific Journals: EPRI Journal — Power Engineering Journal — Solar Engineering Journal — IEEE Power Engineering Review — IEEE Computer Applications in Power — IEEE/ASME Transactions on Mechatronics — IEEE Transactions on Power Delivery, on Power Systems, on Power Electronics, on Industrial Electronics, on Energy Conversion, and on Magnetics. You can find these journals in paper and/or electronic form at the library and/or library web-page. The content of these journals is usually a bit too advanced for the class, but if you are interested in the field beyond the level of the class then you may study them to learn more about current research in the area.

Key Course Topics: Electrical devices and systems, Electrical Substations, Three phase power circuits, Power transformer circuits, Electric utility deregulation, Distribution and Transmission Systems, End-Use devices, Rotating electric machines and equivalent circuits, Per Unit analysis, Power flow, Synchronous Generators, Interconnected power systems, Economic dispatch, Resource planning, Load management, Power Quality, Voltage regulation, Power electronic switches, Electrical machine dynamics, Motor/generator control, Locational marginal pricing of generation, Smart Grid concepts.

Course Grading*:		
	Homework	10%
	Midterm Exam I	15%
	Midterm Exam II	15%
	Laboratory	30%
	Smart Grid Project	15%
	Final Exam	15%

*NOTE: Extra-credit will be offered for excellent, well-documented, course concept glossaries

Homework Policies:

· Most homework assignments are weekly. Homework will tentatively be due on Thursdays, but **due dates may vary!** Every homework will have its particular due date/time printed on top of the assignment. Be sure to check the due date!

· Every homework assignment has two parts: a mandatory part and an optional part. The mandatory part must be submitted to me on the due date. The optional parts will count as extra credit (if correct). Solutions will be published for only mandatory parts.

· Note that some homework problems will not follow the standard textbook format. They will be testing you on *real world engineering skills.* As such, they may not have a unique and specific solution, they may be design oriented, they may have an economic component, they may not have all underlying assumptions clearly stated (i.e. you will need to fill in with reasonable assumptions of your own), and they are generally more difficult. Some problems may even be deliberately ill posed. Make sure to see me in office hours to discuss such problems **before** you submit your solutions.

· Students are encouraged to consult with each other on the principles involved in solving the homework problems as much as possible. However, they must apply these principles on their own and must hand in assignments that are based solely on their own individual work, their individual abilities, and their individual understanding.

· To be fair to all students, **no late homework** will be accepted. However, you will be able to drop your two lowest homework scores, which gives you some flexibility if you are out of town or sick. Exceptions to this policy will **not** be granted, unless in very extenuating circumstances. Exceptions require approval by Dean Marosi and will only be considered and/or discussed if more than three homework assignments were/will be missed.

· Homework solutions may be handwritten or typed, but may not be machine (e.g. photocopy copies) from other student's work. Make sure that you ***cite everything*** you use from the internet or other library sources!

· You are expected to present your homework solutions in a clear and legible fashion. Solutions with an unnecessarily convoluted structure may receive less or no credit. Remember: It is your job to convince me that you understand the material. If you make it easy for me then I will find it easier to give you full credit! In particular:

– Your name must be on the top of your solutions paper.
– Your paper must be stapled.
– Your solution must be ordered: problem 1 first, problem 2 second, and so forth. (Use a separate piece of paper for each problem, only if necessary).
– Clearly state all assumptions you are making.
– Put a box around your final answers.

· Some homework (and lab) assignments will involve MATLAB, PSCAD/EMTDC, *PowerWorld* and PSpice programming. A working knowledge of MATLAB and PSpice is prerequisite for the class, PSCAD and *PowerWorld* tutorials are provided with the text and on the text website - http://www.mnpere.com/PSbook.htm. The student copies of PSCAD/EMTDC and *PowerWorld* are provided in the CD-ROM accompanying your text. If you purchased a text without the CD-ROM it is your responsibility to download the required labs and programs from the MNPERE text website above. Corrections to the 2006 text are also provided on the text website and should be reviewed as you read each assigned chapter. Access to relevant manuals will be available via the class web page. We will only spent a limited time in class on programming related issues.

Exam Policies: · All exams will be *in-class* exams with closed book and closed notes. You will be allowed to bring:

1. All handouts from the web-page that are contained in the course folder Exam Relevant Handouts.
2. One sheet of self-prepared notes (8-1/2" × 11") to the first midterm exam, two sheets to the second midterm exam, and three sheets for the final exam.
3. Pocket calculators may be permitted (watch out for announcement in class). Laptop computers and laptop-like pocket calculators are not permitted! Nor is any access to the internet allowed at any time during graded exams.

· All midterm exams will take the full class time (82 minutes).

· Make-up exams and missing class may be granted in cases of emergencies and for reasons such as job interviews, and so forth provided advanced notice is given to me. Make-up exams require the expressed approval of Dean Marosi.

· Requests for regrades of exams must be submitted **in writing within two weeks of the exam's return.** All questions may be regraded.

· You are expected to present your exam solutions in a clear and legible fashion. Solutions with an unnecessarily convoluted structure may receive less or no credit.

· Exam scores will be determined based on a scaling procedure that converts accumulated points into a corresponding percentage.

Lab Policies: · There will likely be twelve (12) laboratory assignments throughout the autumn 2011 semester. These labs will vary from Field Learning Labs (3-4 labs) through Lab Bench Measurement and Testing Labs (2-3 labs) to Computer Simulation and Modeling Software Labs using MATLAB, PSCAD/EMTDC, *PowerWorld* and P-Spice (6-8) labs). The due dates of each assignment will be printed on top of the laboratory assignment sheet.

· Always be sure to abide by the **lab safety rules** when working in the lab. The lab safety rules will be covered in our first lab session. One of the most important safety rules is that **you may not work alone in the lab at any time!**

· In the lab you will work in a group with 2 students each. Every group will submit a lab report (one per team). Your lab grade will be solely based on your lab report and the (successful) demonstration of your work in accomplishing the laboratory learning outcomes.

The grading criteria for laboratory reports are generally as follows:

* Design:	20%
* Data Collection/Analysis:	20%
* Writing Effectiveness	20%
* General Formatting:	15%
* Completeness:	15%
* Does It Work(?) or What Did you Learn:	10%

More specific expectations for the Field Learning Lab reports will be discussed as those lab sessions are introduced.

· The labs are designed to become increasingly complex as you learn multiple aspects of the electric power system and its component devices difficult. The early assignments will simply require you to very observant and learn nomenclature and take detailed notes of how the elements of the system are interconnected. As we progress you will take lab and field measurements and analyze circuits and devices. Later assignments will delve more into the *design and evaluation* aspect of engineering as we learn to simulate aspects of the power system and its components. Note that you may not always be able to complete the assignment within the allotted lab time so you may require additional time to complete your work. Please make every attempt to get any critical lab measurements done during the lab period provided.

· I recommend that you maintain a lab notebook/journal with your field notes, observations, circuit designs, experimental procedures, and relevant data to help your team write an excellent lab report. Lab notebooks themselves are not graded.

· Not all labs will count the same number of points towards the final lab grade. As the demand for more effort on your part increases with lab difficulty your amount of points will also increase. (Each lab handout will indicate the number of points available)

Lab Attire: For all laboratory exercises students are required to wear appropriate attire for the planned activity. If we are going on a Field Learning/Training Tour rugged shoes or sneakers are to be worn and shorts are prohibited. If we are meeting with utility and/or other professional groups the students should also be dressed appropriately for these meetings. We are currently planning to visit an electric utility substation, coal fired power plant, Bucknell's cogeneration facility, and walk a distribution feeder on-campus or in the Lewisburg area. Photographic technology is encouraged for each lab team on these trips to collect images to assist in the presentation of their lab report/findings/observations.

Attendance: · Attendance is generally expected for the class and the lab. Excused absences are only approved when I am notified in advance. You will receive a zero for unexcused absences from labs (report) and lecture learning exercises if you have not made a reasonable attempt to notify the instructor in advance.

Other Policies: · I tend to read **email** regularly throughout the normal working day. I will try my best to reply to your emails within 24 hours. Please note, though, that I do not believe it beneficial to student learning to *teach-through-email* and, therefore, may choose to answer your email questions with: "I cannot answer your question over email. Please

come and see me in person...". Also: always be sure to include ELEC491 in your subject line.

· I am generally available for consultation on Tuesdays and Wednesdays 10 am -12.30 pm and will endeavor to make myself available at other convenient times to meet your needs. I have another course I am responsible for on Wednesdays 2-5 pm when I will not be available during the Autumn 2011 semester. I spend significant time consulting on Fridays and Mondays, or may be out of town working with other colleagues or on my research. However, with advanced scheduling, I can surely set aside time for students whose schedules do not enable them to take advantage of my normal office hours.

Tentative Course Calendar (Autumn 2011):

First Class:	Thursday, 25 Aug
Midterm Exam I:	Thursday, 22 Sep
Fall Recess:	Monday & Tuesday, 10-11 Oct
Mid-Semester Grades:	Wednesday, 12 Oct
Midterm Exam II:	Tuesday, 1 Nov
Final Project/Research Approval:	Thursday, 10 Nov
Thanksgiving Recess:	Wednesday through Friday, 23-25 Nov
Last Class/Lab:	Tuesday, 6 Dec
Final Exam:	(TBA during Exam Week 8-15 Dec)

Course Learning Outcomes:

At the end of the semester the students are expected to:

· demonstrate competence and understanding of how the electric power system functions as a whole (from end-use customer loads, through delivery and transformation, to generation types and fuels).

· be able to calculate and measure electrical power, efficiency, voltage regulation, and power factors associated with electrical systems and devices.

· be able to calculate/model power flow in a power systems network, and simulate (via models) critical operational characteristics of the power grid including: voltage stability, reactive power control and economic dispatch

· be able to analyze balanced and unbalanced three phase circuits connected in both delta and wye configuration.

· be able to determine the equivalent circuit model for a transformer.

· have experienced first-hand (via tours, visits. models and lab work) what it would be like to work in, design, maintain and operate an actual power system.

· understand the technology options for providing electricity to society via a Smart Grid and the features of energy use (load profiles, load duration curves, end-use load shapes).

· know the theoretical basis for the design and operation of the electric power grid.

· understand the changing landscape of the power industry under deregulation.

· understand key parameters of transformers, synchronous generators and AC / HVDC transmission lines and the roles they play in the power system.

· understand the key factors affecting power quality and the basis for maintaining acceptable levels of service to customers.

Tentative Course Schedule:

Week 1

general introduction – review of course syllabus, and power system fundamentals including end-uses, load profiles, load duration curves, load factor, the changing landscape of the current electric power industry.

Weeks 2 + 3

Review of basic electric circuits and electromagnetic concepts - definitions. power factor, real and reactive power, 3-phase circuits, phasors, apparatus ratings (base and per-unit values), line and phase voltages/currents, delta and wye connections, energy efficiency of equipment, electromagnetic concepts, Faraday's law of induction and energy conversion.

Weeks 4 + 5

Electric energy and the environment, fossil-fueled steam power plants, hydropower, combined cycle units, cogeneration systems, distributed generation, resource planning, climate change issues and carbon taxation implications, overhead AC transmission lines and underground cables, transmission line parameters, HVDC systems.

Weeks 6 + 7

Ideal and non-ideal transformers, 3-phase transformer connections, harmonics in transformers, transformer models, transformer efficiency and equivalent circuits in power systems, regulation in transformers, auto-transformers, taps, turns ratios and phase shifting.

Weeks 8 + 9

introduction to distribution systems, loads and power quality, load management, power system pricing (locational marginal prices on PJM by utility operations areas), Smart Grid concepts, technologies and case studies

Weeks 10 + 11

Synchronous generators, induced EMF in the stator windings, field excitation control to adjust reactive power, automatic voltage regulation.

Weeks 12 + 13

Voltage regulation and stability in power systems, radial systems, voltage collapse, transient and dynamic stability of power systems

Weeks 14 + 15

Control of interconnected power system and economic dispatch, final project presentations and research summaries

Week 16

Final project presentations and research summaries, course wrap-up and review

Course Letter-Grade Distribution:

A-Range	above 90% of total course score
B-Range	below 90% but above 80% of total course score
C-Range	below 80% but above 70% of total course score
D-Range	below 70% but above 60% of total course score
F-Range	below 65% of total course score