ELECTRICAL & BIOMEDICAL ENGINEERING
EE 445: Power System Operation with Renewable Energy Sources
Syllabus, Spring 2017

TIME: Tu Th 5:30 PM – 6:45 PM
ROOM: SEM 344 (Scrugham Engineering and Mines)
PRE-REQ: EE 440 Power Systems Analysis
INSTRUCTOR: Mohammed Ben-Idris
   Office: 337 A Scrugham Engineering and Mines
   Email: mbenidris@unr.edu
   Phone: (775) 784-6929
   Website: https://www.unr.edu/ebme/people/ben-idris

OFFICE HOURS & REVIEW SESSIONS:
   Tuesdays: 4:00 pm – 5:30 pm (337 A Scrugham Engineering and Mines)
   Thursdays: 10:00 am – 11:30 am (337 A Scrugham Engineering and Mines)
   or by appointment: These should be arranged by email.

   During the semester there will be several review sessions; the time and location of the review sessions will be announced elsewhere.

COURSE WEBSITE:
   The course website is in the WebCampus Course Management System
   Please point your browser to the following URL: https://webcampus.unr.edu/login/canvas
   and log-in with your UNR NetID and password.

TEXTBOOK:
   Online lecture notes, online handouts and technical papers

REFERENCE:
   • Wood, Wollenberg, & Shebl, Power Generation, Operation and Control, 3rd edition
   • Shahidehpour, Yamin and Li, Market Operations in Electric Power Systems
   • Freris & Infield, Renewable Energy in Power Systems
   • Bergen & Vittal, Power Systems Analysis
   • Exposito, Conejo & Canizares, Electric Energy Systems: Analysis and Operation
COURSE DESCRIPTION:
Renewable energy, distributed generation, impacts of renewable energy based generation on power system operation, electrical energy markets, deregulated power systems, hybrid power generation.

COURSE GOALS AND OBJECTIVES:
This course describes how large-scale interconnected power systems and energy markets are structured and governed in the U.S. The fundamentals of power system operation are introduced. Deregulated power system environment is compared to the previous custom of regulated environments. The advantages and disadvantages of the current deregulated power system industry are discussed. The students are introduced to various energy types for electrical power production and their use in the power system operation. The advantages and disadvantages of different energy sources are summarized and wind, solar, geothermal based power generation are emphasized. The impacts of these unconventional plants on power system operation and energy markets are introduced by analyzing the benefits as well as the challenges in power system operation concurrently. Students are exposed to using MATLAB Power System toolbox as well as programming, state-of-art software packages in electrical power industry such as PSS/E and PowerWorld to analyze the different modes of power system operation while the renewable energy based power generation is present. Main functions of an Energy Management System (EMS) are introduced such as economic dispatch, contingency analysis, security constrained unit commitment and security constrained optimal power flow.

STUDENT LEARNING OUTCOMES (a, k):
This course provides engineering students the opportunity to develop both theoretical and practical skills in power system operation and control. Upon completing the course the student should be able to:

a. Apply knowledge of mathematics, science, and engineering
   • Solve power flow problems in power systems.
   • Solve optimization problems.
   • Compute optimal economic dispatch.
   • Compute optimal power flow.
   • Include unit commitments and ramping rates in optimization problems.
   • Model the uncertainty, intermittency, and variability characteristics of renewable energy sources in power system operation and control.
   • Evaluate the impacts of renewable energy sources on the electricity market.

k. Use the techniques, skills, and modern engineering tools necessary for engineering practice
   • Write and use MATLAB programs to compute the power flow, economic dispatch, and optimal power flow.
   • Sketch and simulate power systems using commercial software packages.

CLASS SLIDES:
Class slides will be uploaded as PDF files to the course website prior to classes.

ATTENDANCE:
Classroom attendance is expected. Solutions to classroom activities and quizzes are not
uploaded to the course website. Missed quizzes and/or classroom activities will result in a zero for the missed assignment.

**GRADING:**
Grading will be based on the following scale. Exams will be out of 100 points. Homework problems (each problem) will be worth 10 points. Classroom Activities & Quizzes (each class) will be worth 10 points. The distribution of the grades on the exams and assignments is as follows:

- Midterm Exam ................................. 25%
- Final Exam (comprehensive) ............. 35%
- Homework .......................................... 15%
- Projects ........................................... 15%
- Classroom Activities ......................... 10%

The grade for any assignment, or problem within an assignment, can be determined by normalizing to the 100 point scale below.

<table>
<thead>
<tr>
<th>Score (out of 100)</th>
<th>Letter Grade</th>
<th>Grade (4.0 scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90.1–100</td>
<td>A</td>
<td>4.0</td>
</tr>
<tr>
<td>87.1–90</td>
<td>A−</td>
<td>3.7</td>
</tr>
<tr>
<td>83.1–87</td>
<td>B+</td>
<td>3.3</td>
</tr>
<tr>
<td>80.1–83</td>
<td>B</td>
<td>3.0</td>
</tr>
<tr>
<td>77.1–80</td>
<td>B−</td>
<td>2.7</td>
</tr>
<tr>
<td>73.1–77</td>
<td>C+</td>
<td>2.3</td>
</tr>
<tr>
<td>70.1–73</td>
<td>C</td>
<td>2.0</td>
</tr>
<tr>
<td>67.1–70</td>
<td>C−</td>
<td>1.7</td>
</tr>
<tr>
<td>63.1–67</td>
<td>D+</td>
<td>1.3</td>
</tr>
<tr>
<td>60.1–63</td>
<td>D</td>
<td>1.0</td>
</tr>
<tr>
<td>57.1–60</td>
<td>D−</td>
<td>0.7</td>
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<tr>
<td>≤ 57</td>
<td>F</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**HOMEWORK POLICY:**
Homework will be due on the dates indicated in the Homework assignments. Homework is due at the start of class. Points will be deducted for late homework as follows:
Homework received 15 minutes after the start of class → 10 points deducted
Homework received after the end of class → 30 points deducted
Homework received one hour or more after class → homework not accepted (score of zero entered)
There will be approximately 12 Homework assignments including problems made by instructor and problems out of reference books. Homework must be neatly written, stapled together, answers must include units and should be boxed or circled. Points will be removed for the above missing components, or for poorly prepared assignments. The top 10 homework assignments will be counted toward your course grade.
CLASSROOM ACTIVITIES POLICY:
Class activities will be given at random times during lectures (beginning, middle, or end of class). These may be individual or team efforts. Class activities will be collected during class. Solutions for classroom activities will be provided during lecture but not uploaded to the course website. There will be approximately 12 classroom activities given in this semester and the top 10 scores will count toward your course grade.

PROJECTS POLICY:
There will be three projects. These may be individual or team efforts. However, each individual should submit his/her own project. Topics and time will be provided during lecture times. All projects will count toward your course grade.

EXAM POLICIES:
Students who do not take the final exam will receive a score of 0.0 in the class. Students who request a rescheduled EE 445 Final Exam based on exams conflict must request rescheduling by sending an email to the instructor. The request must be made prior to the last regularly scheduled class day and approval of the request is based on confirmation of enrollment in the classes having concurrent exams, and consistency of the final exam schedules as listed at: http://www.unr.edu/Documents/academic-central/forms/Fall%202016%20Finals%20Schedule.pdf

Makeup exams will be given for a valid medical excuse, or if arrangements are made prior to the exam. You can find the Medical Excuse Policy at: http://www.unr.edu/shc/files/Note%20Policy.pdf

EXAM SCHEDULE:
One 75-minute midterm exam is held in the classroom during the regularly scheduled class time. There are NO formula sheets, or crib sheets for the exams unless it is provided on the exam. The exam dates are:
Midterm Exam: Tuesday, March 14, 2017
Final Exam: Monday, May 15, 2017 (5:00 pm – 7:00 pm). The Final Exam is also held in the classroom (SEM 344 (Scrugham Engineering and Mines)) and will be comprehensive.

CALCULATORS FOR EXAMS:
Unless stated otherwise, bring a calculator to the exams. You may use any scientific or graphing calculator, unless it has features described on the “Prohibited” list. Note: you may NOT use cell phones during an exam. Prohibited:
- Pocket organizers;
- Handheld or laptop computers;
- Electronic writing pads or pen-input devices;
- Calculators built into cell phones or other electronic communication devices;
- Calculators with a typewriter keyboard (keys in QWERTY format). Calculators with letter keys not in QWERTY format are permitted.

EXCUSED ABSENCES:
Professionalism is part of the education process. At work, absences due to illness have expectations that you contact the company as soon as possible to notify of the absence. A similar
expectation exists for this course. For absences due to illness, please bring a signed doctor’s note to the instructor so arrangements can be made for a makeup or grade adjustment. For absences due to travel and/or interviews, religious holy day observance, etc. you should contact the instructor prior to the absence and make arrangements to turn in any assignment before the due date.

You can find the Medical Excuse Policy at:
http://www.unr.edu/shc/files/Note%20Policy.pdf

You can find the Class Absence Policy at:
http://www.unr.edu/administrative-manual/3000-3999-students/3020-class-absence-policy

OTHER IMPORTANT DATES:
For detailed calendars please refer to the following link:
http://catalog.unr.edu/content.php?catoid=13&navoid=3715#Fall_2015
For final exam schedules please refer to the following link:
http://www.unr.edu/Documents/academic-central/forms/Fall%202016%20Finals%20Schedule.pdf

ACADEMIC HONESTY:
“Cheating, plagiarism or otherwise obtaining grades under false pretenses constitute academic dishonesty according to the code of this university. Academic dishonesty will not be tolerated and penalties can include canceling a student’s enrollment without a grade, giving an F for the course or for the assignment. For more details, see the University of Nevada, Reno General Catalog.”

DISABILITY SERVICES:
“Any student with a disability needing academic adjustments or accommodations is requested to speak with the Disability Resource Center (Pennington Student Achievement Center, Suite 230) as soon as possible to arrange for appropriate accommodations.”

AUDIO and VIDEO RECORDING:
“Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may have been given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.”

ACADEMIC SUCCESS SERVICES:
“Your student fees cover usage of the Math Center (784-4433 or www.unr.edu/mathcenter/), Tutoring Center (784-6801 or www.unr.edu/tutoring-center), and University Writing Center (784-6030 or http://www.unr.edu/writing-center). These centers support your classroom learning; it is your responsibility to take advantage of their services. Keep in mind that seeking help outside of class is the sign of a responsible and successful student.”
### Approximate Course Schedule and Topics:

<table>
<thead>
<tr>
<th>Week</th>
<th>Dates</th>
<th>Topics Covered</th>
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<tbody>
<tr>
<td>2</td>
<td>Jan. 30 – Feb. 3</td>
<td>Power/Load Flow Analysis</td>
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<tr>
<td>3</td>
<td>Feb. 6 – Feb. 10</td>
<td>Power/Load Flow Analysis</td>
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<tr>
<td>4</td>
<td>Feb. 13 – Feb. 17</td>
<td>Economic Dispatch</td>
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<td>5</td>
<td>Feb. 20 – Feb. 24</td>
<td>Unit Commitment</td>
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<td>6</td>
<td>Feb. 27 – Mar. 3</td>
<td>Optimal Power Flow</td>
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<tr>
<td>7</td>
<td>Mar. 6 – Mar. 10</td>
<td>Optimal Power Flow</td>
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<tr>
<td>8</td>
<td>Mar. 13 – Mar. 17</td>
<td><strong>Midterm Exam, (March 14)</strong></td>
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<td></td>
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<td>Power System Control</td>
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<tr>
<td>9</td>
<td>Mar. 18 – Mar. 26</td>
<td><strong>Spring Break</strong></td>
</tr>
<tr>
<td>10</td>
<td>Mar. 27 – Mar. 31</td>
<td>Interchange of Power &amp; Energy</td>
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<tr>
<td>11</td>
<td>Apr. 3 – Apr. 7</td>
<td>Integration of Wind and Solar Based Generation to the Grid</td>
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<tr>
<td>12</td>
<td>Apr. 10 – Apr. 14</td>
<td>Integration of Wind and Solar Based Generation to the Grid</td>
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<tr>
<td>13</td>
<td>Apr. 17 – Apr. 21</td>
<td>Integration of Wind and Solar Based Generation to the Grid</td>
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<tr>
<td>15</td>
<td>May 1 – May 5</td>
<td>Market Operations in Electric Power Systems</td>
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<tr>
<td>16</td>
<td>May 8 – May 10</td>
<td>Review on Tuesday, May 9</td>
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<td>May 11 – May 17</td>
<td><strong>Final Exam</strong> on Monday, May 15 (5:00 – 7:00 p.m, SEM 344 (SEM)). Final exam is comprehensive.</td>
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</table>

Final Exams