University of Illinois at Urbana-Champaign

COURSE OUTLINE

This proposal is for: [X] A new course Proposed effective date: Spring 2006
[ ] A revised course Proposed effective date:

1. College/School: Engineering Department: Nuclear, Plasma and Radiological Engineering

2. Rubric and course Number: NPRE 478 Title: **Wind Power Systems**

a. If revision involves change of number or title, give number and title of existing course:

b. In this course replaces existing course (which should be dropped), indicate number and title: NPRE 498WP, Wind Power Systems, Special Topics.
https://netfiles.uiuc.edu/mragheb/www

c. If course is to be cross-listed, indicate department(s) and course numbers):
To be submitted for review for possible cross listing to: Aerospace Engineering.
d. If cross-listed, indicate controlling department responsible for scheduling and staffing:
Nuclear, Plasma and Radiological Engineering

3. Catalog description: (Include special requirements, such as field trips, special equipment, etc.)

This course is presented as a cross disciplinary fundamental coverage of wind power systems, providing an insight into the energy and power content of the wind, operating principles, theory of wind machines, Betz's equation, site selection, components of wind machines, and wind turbine design. The topics covered include properties of the wind, USA and global wind energy resources and status, wind energy converter concepts, wind generators history, historical wind generator machines, system design, control of wind turbines, and the aerodynamic and mechanical design of modern wind turbines. Issues of structural towers, fatigue failure, annual power production, economics and finance, and environmental considerations, licensing policy and legal issues are treated. The elastic interaction of the blades with the wind flow around them using the methods of Computational Fluid Dynamics (CFD) is addressed. The types of electrical generators used, energy storage options, electrical grid coupling and power transmission considerations will be covered. Alternative wind energy systems including offshore wind farms, small wind generators, and hydrogen production from wind electricity will be considered. A field trip to a wind farm will be organized.

4. Prerequisites:

Adequate mathematical background: Differential Equations (Math 285 or equivalent), Junior-Senior or graduate standing, and computer programming experience (CS 101 or equivalent), or consent of instructor.

5. Credit: SEMESTER HOURS: 3 UNITS: ¾-1
Summer credit. SEMESTER HOURS: 3 UNITS: ¾-1

5. Credit (continued)

a. Restrictions on credit:

1. May this course be repeated in separate semesters? No If so, when appropriate, please complete the following:

May be repeated to a maximum of hours or units.

2. May students register in this course more than once in the same term? (This is called "duplicate registration." No If so, for how many total hours and/or units?

Hours Units

3. Other restrictions on credit? If so, specific. (Example: "Students may not receive credit for both (this course) and _______.")

b. For a graduate course permitting variable credit, e.g. ½ or 1 unit, specify the additional work required for the higher credit.

Graduate students enrolled in this course for 1 unit will be required to complete more advanced assignments and/or carry out an individual study project documented by a term paper or report, to earn the extra ¼ unit of credit.

c. For 300-level courses only 1 unit is normally considered the equivalent of 4 semester hours of undergraduate credit. If for example, 1 unit is to be equivalent to 3 semester hours in this course, explain why the graduate credit is not ¾ unit.

6. For revised courses, summarize the nature of the changes and the reason for them.

7. Purpose of the course:

a. Prerequisite for:

b. Required in the following curricula for majors:

c. Required in the following areas: Any.

d. Meets the general education requirements (for 100- through 300- level courses);

7. Purpose of the course: (continued)

For 300- and 400- level courses, describe the following:

1. Course Objective.
2. How the course relates to the overall pattern of courses in your department and/or other courses in the area of specialization.
3. Justify a new course in terms of deletion of other courses, new subject matter, and evidence of course need, e. g. enrollment in special topics offering, enrollment increase, expand staff, etc.
4. Justify why this course should award graduate credit in terms of level of content, previous knowledge required, relevance to current research, methodology, etc. (See Graduate College statement of criteria for judging graduate courses.)

1. This course provides motivation and sets directions for further study and research for many undergraduate and graduate students in different fields of engineering, by emphasizing the cross disciplinary nature of Wind Power Systems. As an emerging new technology, a wind turbine with propeller blades is currently the favored engine for wind power generation. It converts the mechanical fluid energy of the wind into electrical energy. The electricity generated by a wind turbine farm can then be harvested, stored in the form of hydrogen or sent directly through pipelines or transmission lines to the power consumption sites. Modern windmills are large sophisticated engineered structures requiring the interaction of engineers from the fields of structural engineering, fluid dynamics, control systems, power conversion, power transmission, and in the future, hydrogen energy and superconductivity.

The course is a contribution to the College of Engineering Dean's initiative on the establishment of an Energy Systems Institute bringing together the different areas of expertise at the College of Engineering level.

2. The course is a response to a College of Engineering Faculty meeting where recommendations were advanced about enlarging the scope of the Department of Nuclear, Plasma, and Radiological Engineering into the broader energy field. It is a response to a mandate by the College of Engineering towards the development of an energy systems studies and research option. It complements another course developed on Fuel Cells and hydrogen systems technology. This builds upon existing expertise in the teaching of methodologies in the field of Computational Fluid Dynamics covered as part of a course on the Safety Analysis of Nuclear Reactor Systems (NPRE 457 / CSE 462) and on the use of the Monte Carlo Direct Simulation method for Fluid Dynamics as part of a Monte Carlo Simulations course (NPRE 490M), both taught by the instructor.

3. Wind power is recently blooming all over the world, particularly in the European Community, as an answer to the problems of fossil fuels depletion, greenhouse gases emissions, global warming considerations and adherence to the Kyoto Treaty. Advanced engineering, science and technology are propelling the expansion of wind energy. Germany, Spain and Denmark have the largest installed base of global wind generators with nearly 60 percent of the total worldwide wind power capacity of 47 gigawatts electrical (GWe) in 2005. In the USA wind power is advancing, supported by the national energy policy encouraging the development of renewable energy resources. Educating our national as well as international students in this nascent field places the College of Engineering and the University of Illinois at the leading edge of the development of a technology technology both in terms of teaching and research.

4. This course is advanced material for both majors and non-majors, and is thought suitable for graduate credit. Students continuing for graduate research in the fields of Mechanical, Electrical, Civil and Environmental Engineering, Aeronautical and Astronomical Engineering as well as General Engineering would identify research topics in their respective fields from the intended broad coverage in this course. Business, Economics, Physics, Architecture, Agricultural

Engineering, Environmental Engineering and Law School majors would also benefit in their future research from the topics covered in this course.

8. Overlap with other courses. Identify and justify duplication or overlap of content with other courses, either in your department or other departments. If overlap with a course in another department has been identified, please attach letters from that department's representative indicating appropriateness of overlap.

Some three hours of background will be developed in Computational Fluid Dynamics with the NPRE 457 / CSE 462 (Safety Analysis of Nuclear Reactor Systems), where the coverage is related to the fluid dynamics of nuclear reactors under accident conditions with the overlap quickly dissipating when specialization to wind turbines propellers will be considered. Simulations of fluid systems using the Direct Simulation Monte Carlo technique, will also overlap within 2 hours with the NPRE 498MC course on "Monte Carlo Simulations" A more specialized course AE481: Wind Power Technology, requiring fluids, electrical and mechanics courses as prerequisites is listed by Aerospace Engineering, but is no longer being taught due to the retirement of the instructor. The course has been submitted for possible cross listing with Aerospace Engineering. Specialization to wind energy systems will minimize other overlaps with more advanced specialized courses in controls, structural design, aerodynamics, power systems, etc. that the students will be steered toward taking, to gain an expanded and thorough knowledge in these areas according to their specialization and interest in pursuing graduate studies and research.

9. If the course will serve students in other departments, summarize discussions with other departments.

The course is a contribution to the College of Engineering Dean's initiative on the establishment of an Energy Systems Institute bringing together the different areas of expertise at the College of Engineering level.

The course is a response to a College of Engineering Faculty meeting where suggestions about enlarging the scope of the Department of Nuclear, Plasma, and Radiological Engineering into the broader energy field.

The course outline will be submitted for review for possible cross listing to: Aerospace Engineering, Civil and Environmental Engineering, Computational Science and Engineering, Electrical Engineering, General Engineering, Industrial Engineering, Mechanical Engineering.

Discussion about the advisability of development and of possible cross listing with General Engineering was discussed with Prof. Enrique Reis, and with Aerospace Engineering.

10. For both new and revised courses, list the principal topics covered in this course, including minor headings as well. The topics outline should be specific enough to make the contents of the course clear to an outsider. Include examination and total the number of contact hours. If available, attach the complete topics outline from the syllabus for the course.)

Topic (Hours)

1. Introduction, global wind power status, USA wind energy resources. (1 hour)
2. Wind generators history, historical wind machines. (1 hour)
3. Properties of the wind, energy and power content of the wind. (2 hours)

4. Theory of wind machines, Betz's equation (3 hours)
5. Components of wind machines. Wind energy converters concepts. (2 hours)
6. Modern wind generators. Small wind generators (1 hour)
7. Control of wind turbines. Stall, pitch and variable speed wind turbine controls. (4 hours)
8. Structural towers design and construction. Fatigue failure. (4 hours)
9. Siting: Wind farms siting. Wind velocity distribution. Atmospheric boundary layer and turbulence. Terrain Influence. (2 hours)
10. Environmental considerations. (2 hours)
11. Economics, licensing legal and policy aspects. (3 hours)
12. Computational Fluid Dynamics of wind turbine systems. Discretization of the fluid flow equations for a wind propeller and their numerical solution. (3 hours)
13. Direct Monte Carlo Simulation of fluid flow. (3 hours)
14. Mechanical and Structural aspects: Structural aspects of aerodynamic and inertial loads. Fatigue loading. (3 hours)
15. Electrical aspects: Electrical energy generators and connected converters. Standalone wind generators and grid connections. (3 hours)
16. Energy storage, hydrogen production and transmission. Superconductor transmission lines. (2 hours)
17. Safety features and risk assessment of wind installations (1 hour)
18. Offshore wind farm installations. (1 hour)
19. Alternative wind turbines designs for small and large scale applications. (1 hour)
20. Field trip to visit an existing wind farm in Illinois, e. g. Paw Paw wind farm, will be organized (Weekend, one day)
21. Two midterms and a final (3 hours)

Total hours (45 hours)

11. Basic texts: Complete list of texts (give author, title, year of publication): If a long bibliography of articles or chapters from books is to be used, attach the complete list and indicate required and recommended articles.
(All sources are recommended only)

Recommended texts:

1. M. Ragheb, Lecture Notes on: "Wind Power Systems," Univ. of Illinois at Urbana-Champaign, 2005. https://netfiles.uiuc.edu/mragheb/www
2. Thomas Ackerman, Ed. " Wind Power in Power Systems," John Wiley and Sons, 2005.
3. John F. Walker and Nicholas Jenkins, "Wind Energy Technology," John Wiley and Sons, 1997.

Web Links:

World Wind Energy Association: http://www.wwindea.org/default.htm
American Wind Energy Association: http://www.awea.org

Danish Wing Energy Association: http://www.windpower.org/en/core
British Wind Energy Association: http://www.bwea.com
European Wind Energy Association: http://www.ewea.org
The Canadian Wind Energy Association: http://www.canwea.ca
The Australian Wind Energy Association: http://www.auswea.com.au
The Irish Wind Energy Association: http://www.iwea.com
General Electric Wind Energy:
http://www.gepower.com/businesses/ge_wind_energy/en/index.htm
US Department of Energy Wind and Hydropower Program:
http://www.eere.energy.gov/windandhydro/
Finnish Wind Power Association: http://www.tuulivoimayhdistys.fi/
Minnessota Wind Energy Information Index Page:
http://www.me3.org/issues/wind/
Centre for Renewable Energy Sources, Greece:
http://www.cres.gr/kape/index.htm
Energy Research Centre of the Netherlands: http://www.ecn.nl/
German Wind Energy Institute: http://www.dewi.de/
National Wind Technology Center, USA: http://www.nrel.gov/wind/
Risø National Laboratory, Denmark: http://www.risoe.dk/
The European Renewable Energy Centres Agency, Brussels:
http://www.eurec.be/

12. Additional comments:

Teaching will be web based. Lecture notes will be posted by the instructor on the web. Textbooks are recommended.

Interested instructors from other departments will be invited to co teach the course as a nucleus for a future seminar and a wind energy program within the proposed College of Engineering Energy Systems Institute. Prof. Cliff Singer kindly agreed to cover the topic of Economics of Wind Systems, and Prof. James Stubbins the topic of Fatigue Failure of Components.

Tests and grades:

Two midterms and one final exam: 60 percent
Homeworks, quizzes, term paper or project: 40 percent
To obtain a full 1 unit credit, graduate students are expected to present a term paper or a project for a ¼ unit on an advanced topic related to the course.

APPROVALS
(Signatures required unless otherwise specified)

Request prepared by:	M. Ragheb, 223 NEL, (217)333-6569 ____________________________ (Print or type. Signature not required)	Date: 8/16/2005 ________
Faculty member who Will teach the course:	M. Ragheb and other interested Faculty. ____________________________ (Print or type. Signature not required)	Date: 8/16/2005 ________
Department approval	____________________________ (Head of Department)	Date: ________
School Approval (if applicable)	____________________________ (Director of School)	Date: ________
Department Approval	____________________________ (Head of Department)	Date: ________
Undergraduate College approval	____________________________ (Dean of College)	Date: ________
Graduate College approval ((if applicable)	____________________________ (Dean of Graduate College)	Date: ________
Approved by the Chancellor	____________________________ (Assistant Vice Chancellor for Academic Affairs)	Date: ________

<u>IMPORTANT:</u> If a course is to be CROSS-LISTED, the written approval (or signatures thereof) of all concerned departments, schools, and colleges must be obtained.