Course Number and Title

NAU: ME 535 Wind Energy Engineering
TTU: WE5300 Advanced Technical Wind Energy I
UMass: MIE 573 Wind Energy Systems Engineering

Effort: 3-credits, semester

Prerequisites:
Graduate student status or approval on instructor. The content of this class is best suited for students with an undergraduate degree in engineering. Students with a background in the sciences or math may also be sufficiently prepared for the course content, provided their studies included mathematics through differential equations and exposure to the fundamental equations of motions including conservation of mass, momentum, and energy. An exposure to statistics and experience using a computer programming language is recommended. For each major topic addressed in the course, background material and reference resources will be provided for review. For example, a brief presentation of the basic equations of fluid mechanics necessary to understand derivation of the Betz limit will be presented for those students with the math and science background described above, but not with a background in fluid mechanics.

Textbook / Resources:
Wind Energy Explained, 2nd ed., by J.F. Manwell, J.G. McGowan, A.L. Rogers, John Wiley & Sons, 2009.

Numerous resources from other sources will be available via the online course interface. E.g., LBNL Wind Turbine Market Report, US DOE Wind Vision, excerpts from other textbooks, journal papers, magazine online articles, manufacturers information, etc.

Course content will be supplemented by guest lectures from experts in industry and the national labs.

Course description:
The purpose of this course is to develop an understanding of the engineering principles underlying the design and operation of modern wind energy conversion systems (WECS), with a focus on horizontal-axis turbines that dominate the industry. The course begins with an overview of the wind industry and how wind power fits into the electrical power system. Students will become familiar with the vernacular and many of the key aspects of WECS, including wind turbine architecture, hub height, costs, capacity factor, cost of energy, power coefficient, power curve, wind shear, and more. Technical study of wind energy will begin with the source of the energy itself, the wind, its origin, the magnitude of the resource available, and its statistical description. Wind turbines capture the energy in the wind using their rotor blades, and therefore the basic principles governing rotor blade performance will be described, including derivation of the Betz limit on efficiency. Rotor blade aerodynamic design will be covered in detail, with students learning how to design a Betz-optimum rotor blade shape. Rotor blade performance will be studied using blade element momentum (BEM) theory, and students will write their own simple BEM computer codes and use them to predict the performance of a typical wind turbine blade design.

Following this in-depth description of the wind and how turbines capture the energy available in the wind, the course will provide an introductory survey of several of the most important aspects of WECS, including:

- Mechanics and dynamics: wind turbine loads, moments, and natural frequencies

- Electrical power generation: generator topologies and characteristics, and interconnection to the grid
- Materials and components
- Wind turbine control
- Wind turbine design and testing
- Wind power plant design
- Environmental and regulatory considerations
- Wind energy economics

For each of these survey topics, the governing principles, concepts or equations will be described (not derived) and their important consequences and/or results presented. Students will become familiar with the meaning and importance of key parameters and equations and be able to perform straight-forward calculations. Upon completing the course, students will understand the salient aspects of wind turbine performance and design and will have the background necessary for advanced study of wind turbine design, wind power plant design, and wind power development.

Learning Outcomes:

The following list contains the learning outcomes for the course. As a graduate-level course covering a very broad topic, many outcomes are anticipated.

1) an understanding of the breadth of topics necessary to understand wind energy conversion systems (WECs)
2) an understanding of the key terms and concepts used in the wind industry
3) an ability to identify and describe the main components of a horizontal-axis wind turbine, and of a wind power plant
4) an understanding of the impact of wind energy in a global/societal context; in this case how WECs fit into societies energy needs and clean energy solutions
5) an ability to apply mathematics, science and engineering principles to WECs
6) an ability to design the shape of rotor blades for a horizontal-axis wind turbine within realistic constraints, and to identify other system components consistent with the rotor design
7) an ability to identify, formulate and solve problems related to wind energy conversion systems
8) a recognition of the need for and an ability to engage in life-long learning, as related to sustainable energy and wind energy
9) a knowledge of contemporary issues related to WECs
10) an ability to use the techniques, skills and modern engineering tools necessary for engineering practice as applied to WECs. (e.g. creating or using computer-implemented solutions in wind turbine design and/or performance prediction)
11) an ability to communicate effectively the technical results of the WECs project design

Topics:

Introduction; Overview of WECS, wind turbine applications, topology, and design
Wind resource analysis
Introduction to aerodynamics of wind turbines
Aerodynamics & ideal blade planform
Blade element momentum technique
Blade design and performance prediction
Electrical aspects of wind turbines
Wind turbine controls
Mechanics and dynamics of wind turbines

Wind turbine design and testing
Policy and regulation related to wind energy
Utilities and wind energy
Grid integration and transmission Wind Turbine Materials, Components, Control
Wind energy economics, project development, siting and design
Environmental impacts of wind energy and wind turbines

Assessment:
Students will be assessed via the traditional measures: performance on homework, exams and project-related work. The exact method of assessment will depend upon the faculty instruction the course. For the bulk of the assessment, some instructors may use homework and exams, and others projects and applied problems.