Course Number and Title

UMass: MIE 673 Wind Turbine Design

Effort: 3-credits, semester

Prerequisites:

MIE 573 or equivalent or permission of instructor. Graduate student status. Students should be familiar with the basics of wind energy, particularly blade element momentum theory. Students should have experience with MATLAB or another programming language.

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, particularly regarding the wind as an external design condition, aerodynamics, design standards and mechanics.

Course description:

The goal of this class is to become proficient in wind turbine technology and wind turbine design. This will be accomplished via a semester long wind turbine design project, which will utilize modern wind turbine design and analysis codes, including those of the National Renewable Energy Laboratory, such as *TurbSim*, *Aerodyn*, *BModes* and *FAST* as well as ancillary codes written in Excel, VBA or MATLAB. Students will learn about the theory behind these codes as well as how to develop the input files, run the codes and analyze the results. A technology review assignment will also be required for students to acquaint themselves with one particular technology in detail.

This class operates similar to a seminar. There will be lectures on specific topics, but there will also be open discussions during class times. There will be a significant amount of reading assignments, from a variety of sources, to help introduce the various topics and as well as "traditional" homework problems. Students will be expected to learn somewhat independently; that is, the assignments and design project are not straightforward repetition of topics covered in class lectures. Instead, lectures are used to introduce a topic and then the students must use that knowledge to complete the assignment. The design project includes of a sequence of linked assignments. This is a design class, so there will be a certain amount of trial and error.

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 design a wind turbine
2) an ability to use computer codes needed to evaluate the performance of a wind turbine in terms of energy production and structural loads
3) familiarity with wind turbine design standards, particularly the fundamental standard of the International Electrotechnical Commission, IEC 61400-1
4) familiarity with the important design considerations, including ultimate and fatigue loads, turbulence in the wind, airfoil performance, tower and blade vibrations, aeroelastic behavior structural reliability, application of statistics to the design process
5) an understanding of what is required in the design of a modern wind turbines and what that would imply for developing new designs

Topics:

Introduction
Review of Blade Element Momentum Theory
Considerations of rotor design: aerodynamics and structure
Turbulence in the wind
Fourier transforms and power spectra
Theory of simulating turbulent wind
Use of *TurbSim* for synthesizing turbulent wind
Principles of airfoils
Use of *XFOIL* for analysing airfoils
Use of *Aerodyn* for assessing rotor aerodynamic performanc
Wind turbine vibrations
Vibrations of continous elements: towers and blades
Use of *BModes* for predicting natural frequencies and mode shape
Principles of structural reliability in relation to wind turbine design
Assessment of fatigue, rainflow cycle counting, damage equivalent loads
Principles of rotor dynamics
Linearized dynamic model of rotor
Control of pitch regulated, variable speed turbines
Wind turbine design standards
Principles of aeroelastic turbine analysis
Introduction to NREL's *FAST* aeroelastic code
FAST: input files, operation, analysis of outputs
Wind turbine component scaling
Design of gearboxes
Electrical components
Design of support structures
Soils and foundations
Overall turbine design
Design of unconventional wind turbines
Special topics as time allows:
Hydrodynamics of offshore wind turbines
Offshore support structures (fixed or floating)
Grid integration
Energy storage

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.