ME490/ME555 Wind Turbine Design and Analysis

Instructor:
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Prerequisites: ME 321L Mechanical Analysis for Design, ME 336L Fluid Mechanics.
Corequisite: ME421L Mechanical Design.

Text:
Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi. Wind Energy Handbook, Second Edition. Wiley & Sons, Ltd. 2011. ISBN 9780470699751.

Additional Resources:

- IEC 61400-1:2019. Wind Energy Generation Systems – Part 1: Design Requirements.
- IEC 61400-2:2013. Wind Turbines – Part 2: Small Wind Turbines.
- IEC 61400-3-1:2019. Wind Energy Generation Systems – Part 3-1: Design Requirements for Fixed Offshore Wind Turbines.
- IEC 61400-3-2:2019. Wind Energy Generation Systems – Part 3-2: Design Requirements for Floating Offshore Wind Turbines.
- NREL OpenFAST. https://github.com/OpenFAST/openfast.

Couse Content:
An introduction to the design and analysis of horizontal-axis wind turbines. Topics include wind as a resource, economics of wind power generation, aerodynamics of horizontal axis wind turbines, actuator disk, rotor disk, and rotor blade theories, performance of fixed-speed and constant tip speed ratio turbines, yaw and pitch control, breakdown of momentum theory, Prandtl tip loss factor, blade geometry, lift and drag of aerofoils, stall delay, unsteady flows, ultimate strength analysis using partial safety factors, fatigue analysis using Marin derating factors and Minor's rule rain-flow cycle counting, and solid mechanics of composite materials.

Analysis of wind turbine systems according to IEC 61400-1 and 61400-2 standard Design Load Cases (DLC) 1.1-1.5 Power production (ultimate strength and fatigue analyses), DLC 2.1-2.4 Power production plus occurrence of fault (ultimate strength and fatigue analyses), DLC 3.1-3.3 Start up (ultimate and fatigue analyses), DLC 4.1-4.2 Normal shut down (ultimate strength and fatigue analyses), DLC 5.1 Emergency shut down (ultimate strength analysis), DLC 6.1-6.4 Parked still or idling (ultimate strength and fatigue analyses), DLC 7.1 Parked with fault condition (ultimate strength), and DLC 8.1-8.2 Transport, assembly, maintenance, and repair (ultimate strength).

Use of software analysis tools including Finite Element Analysis (FEA) for component mode shape and frequency analysis, FEA generation of 6x6 Timoshenko blade element stiffness matrices, XFoil and XRotor generation of turbine blade lift-drag polars, NREL FAST v8/OpenFAST whole-turbine time-domain aeroelastic analysis of Design Load Cases.

Grading/Evaluation Methods:
Homework and in-class assignments, team-based assignments, Python programming assignments, final project in lieu of a final exam.

The graduate version of this course (ME555) will include at least two additional out-of-class assignments and an additional requirement for the final project. These additional assignments will include nonlinear finite element analyses of composite blade layup schedules and fatigue analyses.

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