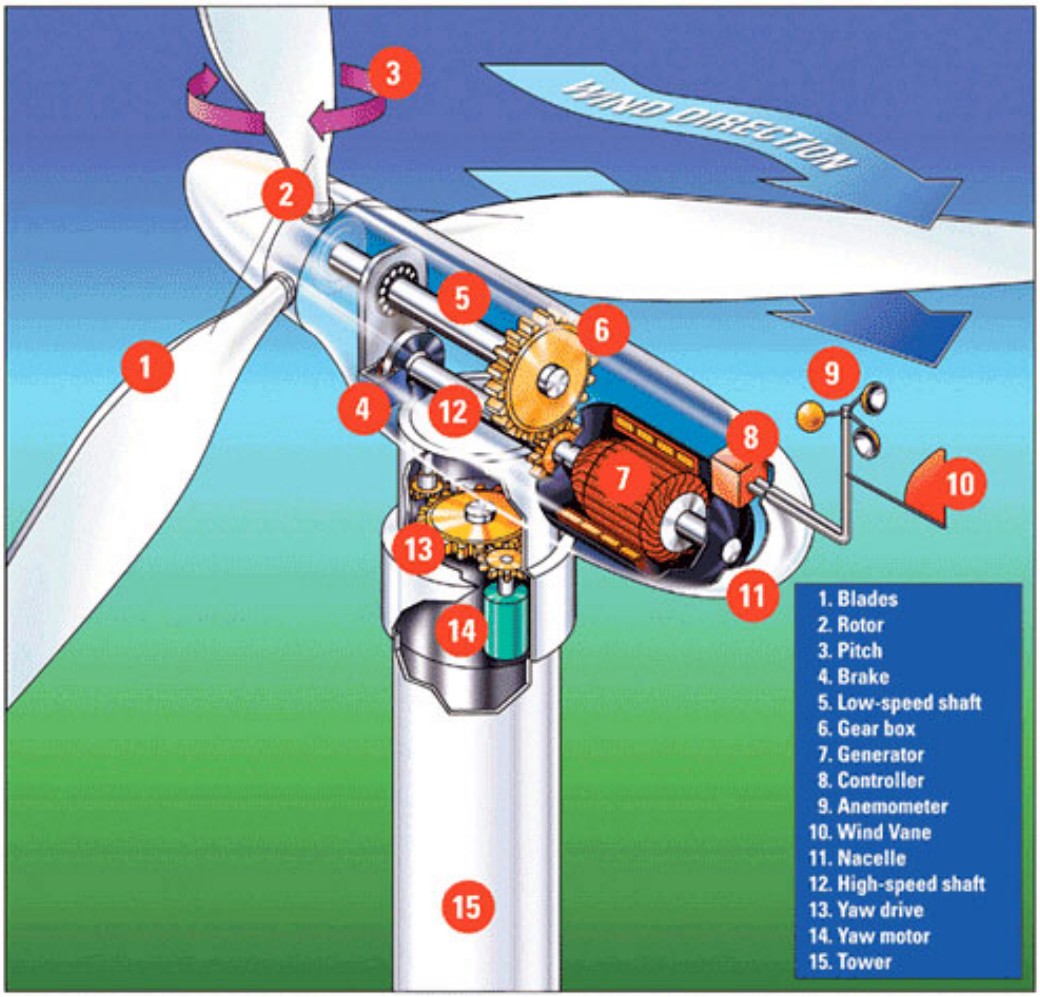
58:164 – Fundamentals of Wind Turbines

(ME:4164:0001)

Syllabus



P. Barry Butler
111 Jessup Hall
The University of Iowa
Iowa City, IA

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Spring 2012
58:164 – Fundamentals of Wind Turbines

Instructors: P. Barry Butler
111 Jessup Hall
319-335-3565 (patrick-butler@uiowa.edu)

Time: 4:30 – 6:00 pm, MW

Place: 2217 Seamans Center

Text: Wind Energy Handbook (John Wiley and Sons)
Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi

Grades:

Homework	20%
Midterm Project	40%
Final Project	40%

Course Description:

The goal of this course is to learn how to apply fundamental principles of thermodynamics, fluid mechanics and mechanical systems to wind turbine engineering. Fundamentals of horizontal-axis wind turbines will be emphasized: wind energy conversion to useful work; wind turbine aerodynamics; performance; design of wind turbine components. An overview of wind resource and historical development of wind turbines and introduction of wind turbine installation and wind farm operation will also be covered. Team-based projects are an integral part of this course: students will form 3 or 4 member teams and conduct term projects that apply fundamental principles to wind turbine operations and wind farm siting.

Course Outline

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1 - Introduction

- 1.1 Historical Development (BC – 20th Century)
- 1.2 Historical Development (20th Century – 1980s)
- 1.3 Recent Developments (1980s – present)
- 1.4 Wind Energy Potential
- 1.5 Offshore Wind Energy
- 1.6 Modern Wind Turbines

2 - The Wind Resource

- 2.1 The Nature of the Wind
- 2.2 Geographical Variation in the Wind Resource
- 2.3 Long-term Wind-speed Variations
- 2.4 Annual and Seasonal Variations
- 2.5 Synoptic and Diurnal Variations
- 2.6 Turbulence
- 2.7 Gust Wind Speeds
- 2.8 Extreme Wind Speeds
- 2.10 Turbulence in Wakes and Wind Farms
- 2.11 Turbulence in Complex Terrain

3 - Aerodynamics of Horizontal-axis Wind Turbines

- 3.1 Introduction
- 3.2 The Actuator Disc Concept
- 3.3 Rotor Disc Theory
- 3.4 Vortex Cylinder Model of the Actuator Disc
- 3.5 Rotor Blade Theory
- 3.6 Breakdown of the Momentum Theory
- 3.7 Blade Geometry
- 3.8 The Effects of a Discrete Number of Blades
- 3.9 Calculated Results for an Actual Turbine

4 - Wind-turbine Performance

- 4.1 The Performance Curves
- 4.2 Constant Rotational Speed Operation
- 4.3 Comparison of Measured with Theoretical Performance
- 4.4 Variable-speed Operation
- 4.5 Estimation of Energy Capture
- 4.7 Wind-turbine Performance Measurement
- 4.10 Aerodynamic Performance Assessment

6 - Conceptual Design of Horizontal Axis Wind Turbines

- 6.1 Introduction
- 6.2 Rotor Diameter
- 6.3 Machine Rating
- 6.4 Rotational Speed
- 6.5 Number of Blades
- 6.7 Power Control
- 6.8 Braking Systems
- 6.9 Fixed-space, Two-speed or Variable-speed Operation
- 6.10 Type of Generator

7 - Component Design

- 7.1 Blades
- 7.2 Pitch Bearings
- 7.3 Rotor Hub
- 7.4 Gearbox
- 7.5 Generator
- 7.6 Mechanical Brake
- 7.8 Yaw Drive
- 7.9 Tower
- 7.10 Foundations

9 - Wind-turbine Installations and Wind Farms

- 9.1 Project Development
- 9.2 Visual and Landscape Assessment
- 9.3 Noise
- 9.4 Electromagnetic Interference
- 9.5 Ecological Assessment
- 9.6 Finance