UNIVERSITY OF CALIFORNIA
Mechanical Engineering Department

E 26 **Three Dimensional Modeling for Design** **Fall 2017**

Faculty: Dr. Ken Youssefi
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Office Hours: TuTh. 11:00 – 1:00
Class website: http://bcourse.berkeley.edu (use CalNet ID and password to login)

Course Description:

Three-dimensional modeling for engineering design. This course will emphasize the use of CAD on computer workstations as a major graphical analysis and design tool. Students develop design skills, and practice applying these skills. A group design project is required. Hands-on creativity, teamwork, and effective communication are emphasized. 2 units, no prerequisite

Lecture: Tuesday 8:10 – 9:00, 120 Latimer

Laboratory:	section 101:	Wed.	12:00 – 2:00	10 Jacobs	GSI - Qian
	section 102:	Th.	9:00 – 11:00	10 Jacobs	GSI - Qiuchen
	section 103:	Fri.	9:00 – 11:00	1171 Etcheverry	GSI - Qian

Graduate Student Instructors (GSI): Qian Zhong qzhong@berkeley.edu and Qiuchen Guo, qiuchen@berkeley.edu

Textbooks:

Recommended,
Lieu, D.K., and Sorby, S.A., Visualization, Modeling, and Graphics for Engineering Design, Cengage Publishers, 2009.

SolidWorks 2016/17, free download with the SDK ID, will be provided in the class

Course Objective

Introduce computer-based solid, parametric, and assembly modeling as a tool for engineering design; enhance critical thinking and design skills; emphasize communication skills, both written and oral; develop teamwork skills; offer experience in hands-on, creative engineering projects; reinforce the societal context of engineering practice; develop early abilities in identifying, formulating, and solving engineering problems.

Semester Project

Wind turbine project: rotor blade and tower design and fabrication (3D print). See project description.

Grading: The final course grade will be based on a normal distribution curve.

- 30% Laboratory work
- 10% Class participation
- 30% Design Project
- 30% Examination

Student Learning Objectives

Upon completion of the course, students shall be able to:

- Create a 3D solid model of a complicated object with high degree of confidence.
- Extract 2D orthographic views from the 3D model for fabrication.
- Specify the proper dimensions, according to industry standards, for parts to be fabricated
- Extract section and auxiliary views.
- Understand the basics of assembly and associative constraints.
- Understand the basics of rapid prototyping, in particular 3D printing
- Understand the engineering design process and the implementation of different design phases.
- Work effectively as a member of a design team.

Weekly laboratory and homework assignments

All labs will be held in room 10 Jacobs. The lab period is 2 hours. During the labs, students will start by doing step-by-step solid modeling tutorials to learn different functionality. Then they will be given the lab assignment where they will apply what they've learned to model new geometries, assemblies, and products. There will be a focus on learning how to build a solid model to capture design intent and meaningful dependencies for ease of subsequent editing. You should be able to finish most of the lab assignment during the lab. If not, you must finish it before coming to the lab the following week (see due dates on syllabus or bCourse). Students will also learn how to set up for a 3D-print build, and 3D-print a geometry they design themselves. Homework problems will cover the theory behind the software, such as constraints and Booleans, and additional modeling problems that build on skills acquired during lab.

Lab assignments are due on Tuesdays by 11 pm. The due dates are indicated in the course syllabus and on bCourse.

Academic Honesty

All students should be familiar with the Code of Student Conduct and know that the general rules and students rights stated in the document apply to this class (see http://uga.berkeley.edu/SAS/osc.htm). With regard to laboratory work and homework assignments, not only are you allowed, but you are encouraged, to discuss the problems and techniques with other students; but each student must do his or her version of the solution. Submitting someone else's work as your own or knowingly allowing someone else to turn in your work as their own will result in a zero grade for the assignment for all involved and will be reported to the Office of Student Conduct. Cheating on the examinations will result in a failing grade in the course and your action will be reported to the Office of Student Conduct for administrative review.

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Course Schedule

Week	Dates	Topics	**Lab. work** Assignments
1	8/23	Wednesday	No lab this week
2	8/29	Introduction to the course Introduction to design project	Lab. work #1 – due Tu. 9/5 by 11:00 pm Sketching & Extrusion
3	9/5	Introduction to 3D modeling Parametric modeling, feature-based modeling, Design Intent	Lab. work #2 – due Tu. 9/12 by 11:00 pm Extrusion & Revolve
4	9/12	Solid modeling commands: Sketching, Extrusion , Revolve, fillet, pattern, …	Lab. work #3 – due Tu. 9/19 by 11:00 pm Sweep
5	9/19	Solid Modeling: reference geometry Sweeps and Lofts	Lab. work #4 – due Tu. 9/26 by 11:00 pm Loft
6	9/26	Aerodynamics of wind turbine Rotor blade design, angle of attack, profile,…	Work on the blade design as a group and turn in 2-3 pages of your concept designs (sketches) at the end of the lab.period (10 pts)
7	10/3	Wind turbine tower structure design Stiffness and strength consideration	Lab. work #5 – due Tu. 10/10 by 11:00 pm Wheel and screwdriver design
8	10/10	Assembly modeling; Top-down and bottom-up Mates in assembly, exploded view	Lab. work #6 – due Tu. 10/17 by 11:00 pm Assembly
9	10/17	Extracting 2D views from the 3D solid model. Dimensioning standards and conventions	Lab. work #7 – due Tu. 10/24 by 11:00 pm Shop drawing
10	10/24	Introduction to Rapid Prototyping Three Dimensional printing	Work on the tower design, as a group, turn in 2-3 pages of your concept designs (sketches) before leaving lab (10 pts)
		Blade design due by Th. 10/26 midnight, upload to bCourse	
11	10/31	3D printing: FDM, STL, laser, .. Material: liquid and solid polymer, powder, paper, metal, ceramic,…Advantages and limitations	Lab. work #8 – due Tu. 11/7 by 11:00 pm Auxiliary and Section views
12	11/7	Engineering analysis with SolidWorks Introduction to Finite Element Analysis	Lab. work #9 – due Tu. 11/14 by 11:00 pm Finite element problem
		Wind turbine design structure due by Fri. 11/10 midnight, upload to bCourse	
13	11/14	Finite Element Analysis (FEA) cont. Project discussion	Fusion 360 presentation Lab. work #10 – due Tu. 11/21 by 11:00 pm Part modeling (spring)
14	11/21	Stress and deflection of the wind turbine tower Simulation using SolidWorks	**Thanksgiving holiday** **No labs this week**
15	11/28	Engineering Design Process: Concurrent Engineering Design	Fusion 360 presentation Lab. work #11 – due Tu. 12/5 by 11:00 pm Assembly modeling
16	12/5	Reading/Review/Recitation (RRR) week - no class	
		Wind turbine testing is scheduled for Tu. Dec. 5 from 9-12 and 1-4 in Hesse Hall basement	

Final Exam (SolidWorks) – Th. Dec. 14, 12:00–2:30, 3:00–5:30 and 6:00–8:30pm, 10 Jacobs

Project Report (One report per group)–Due Wed. Dec. 14 at the final exam

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Motor specs.

26 mm

45 mm

Power generation

Tower deflection

Stiffness test

Project Report Guidelines (One report per group)

Due Wed. Dec. 14 at the final exam

- **Cover (title) page - picture (color)** of your wind turbine, **the title** of the project (descriptive and specific), the **entity** for which the report was written, i.e., University of California, Mechanical Engineering Dept. E26, names of the **team members**, group number, name of the instructor, and the date of submission.
- **Project Summary** section succinctly and specifically states: **The objective(s) of the project**, **the outcome/results** (as per project guideline requirements), **summary of all the "performance data."** This section should consist of three to five paragraphs, and be about one page long. A figure (or a photograph) that provides a good visual summary of your project is appropriate for this section, but no more than one. Remember, each figure should be numbered and have a caption.

  Think of the Project Summary section as the 'Reader's Digest' version of your report. The Project Summary gives the **key aspects** of the project in a concise form. It must include a summary of the performance data (**weight, height, maximum power, and stiffness**) and should include the outcome of your project (Did it successfully achieve the design objectives? Were there significant failures?) The rest of the report will elaborate on what you did, how you did it, and what happened.
- **Table of Contents**: Number report pages starting with page 1 as the Introduction page. Title page has no number and other pages before Introduction can be numbered i, ii, iii, etc. The **Table of Contents** should include all the sections / subsections headings with the starting page number for each. It comes after the Project Summary.
- **Introduction:** This section describes relevant background information. (2 to 4 pages). It describes what the project was about, first in general, but then *specifically*, presenting the *specific* objectives that your design addresses. This section should be at least two pages long. Make sure that you include sufficient sketches, drawings, and/or photographs and verbiage to clearly explain to someone unfamiliar with this project what it is all about. You may use sketches from the Project Guidelines, but <u>cite your source</u>.
- **Theory:** Describe briefly the theory(ies) that apply to your project, including any applicable formulas.
- **Design – Build - Test:** Give a description of your turbine blade and structure design including:
  i. Relevant **sketches, drawings, pictures.**
  ii. **Type**, **shape** and **dimensions** (and possibly cost if known) of the materials used
  iii. Name/describe the **major tools** used during the "Build" cycle
  iv. Describe the **type of tests** performed on the project, the **purpose of each test** and its **outcome.**
  v. Name/describe the **major tools/measuring equipment** used during testing
  vi. Include data plots for the following parameters and briefly discuss the performance.
     1. Turbine Stiffness
     2. Voltage vs. Current
     3. Power vs. Current
  vii. Compare the actual power generated versus the theoretical power, and calculate the efficiency.

Consider putting performance results in tables. Create a graph of your load and deflection data, and use Excel curve fitting techniques to determine the stiffness. **You will have achieved success in writing this section if a peer could take what you have written, and referring to it alone, be able to reproduce your device and perform both tests (power and stiffness).**

- **CAD drawings –** 3D assembly drawing of the wind turbine, exploded view of the tower, 3D drawings of all 3D printed parts
- **Conclusions** SUMMARIZE the work done, what was learned, and the outcomes of the project, such as how well it worked or didn't work. How did the efficiency of your turbine compare with the efficiency of typical turbines in use today?
- **Recommendations for Future Work:** Include some recommendations of what you would do if you had more time to improve the design or what you might have done differently knowing what you know now. Here you want to make sure to give *specific* recommendations for improvements or further work. For example, a poorly written recommendation might say something like, "… we would make the turbine blade go faster." A better one might read, "… we would use four blades instead of three to develop more power."
- **Reference** section. Any references listed should be cited in your report. Examples of how to cite references can be found in:

  http://www.lib.nus.edu.sg/lion/s/citeapa.html

  http://www.lib.nus.edu.sg/lion/s/apastyle.ppt

  Note that the reference list must be alphabetized. Remember that any material you include in your report that you did not create by yourself or that is common knowledge, ***must be*** cited as reference, or else you are committing the ethical violation of plagiarism.
- **Appendices** contain any other information that, in your judgment, might be a big help to someone trying to do a similar project (data sheets, catalog pages, etc.).

  Required appendix elements

  - **Appendix A** - Original data sheet (raw data) used during testing

Peer Evaluation:

No written evaluation is needed if everyone on the team contributed equally. Email me your evaluation and score the individual(s), from 0 – 20, that did not contribute to the team as you expected. I expect to receive emails from other members of groups that have issues.

Grading:

Turbine performance (100 pts)

Power generation (35%), 25-35
Stiffness (30%), 20-30
Weight (20%), 16-20
Meeting specs (5%)
Creativity (10%)

Written report (100 points)

Bonus points: 5 points for the highest power generation
5 points for the highest ratio of stiffness to weight

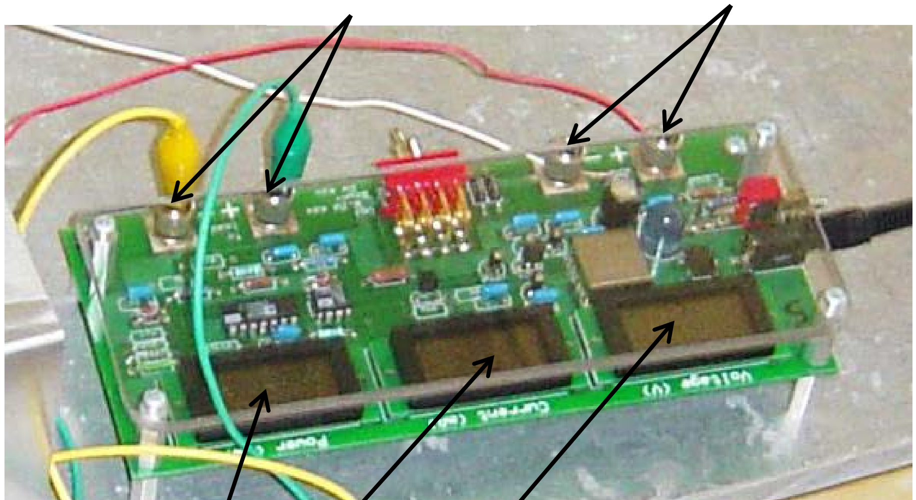
Testing - Power generation and stiffness measurements

Power measurement

Power measurement involves two main components: electrical meter to measure current, voltage and power, and a load box to draw power.

Power Meter
The meter is connected to the generator (motor) and to the load box as indicated.

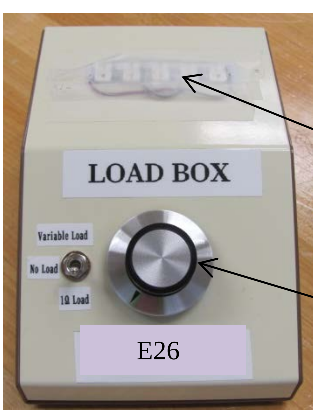
Load box **Generator (motor)**



Power, Current, and Voltage digital display

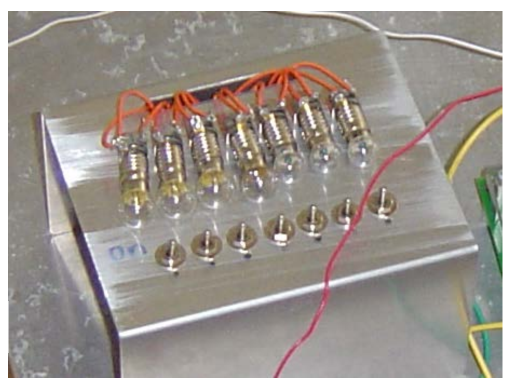
Load Box (potentiometer)

The load box consists of a potentiometer and a bank of LEDs. By turning the potentiometer clockwise more power is drawn from the wind turbine and the LEDs become brighter.



LEDs

Potentiometer



Different layout using switchs bulbs

Electrical power sources (wind turbine generator) can provide maximum power under certain loading condition. Whether this maximum power is fully utilized (or drawn) from the generator depends on the loading condition. In a real wind turbine, a computer controlled power unit constantly adjusts the loading condition based on the wind speed in order to achieve the maximum possible power production under all conditions at all time.

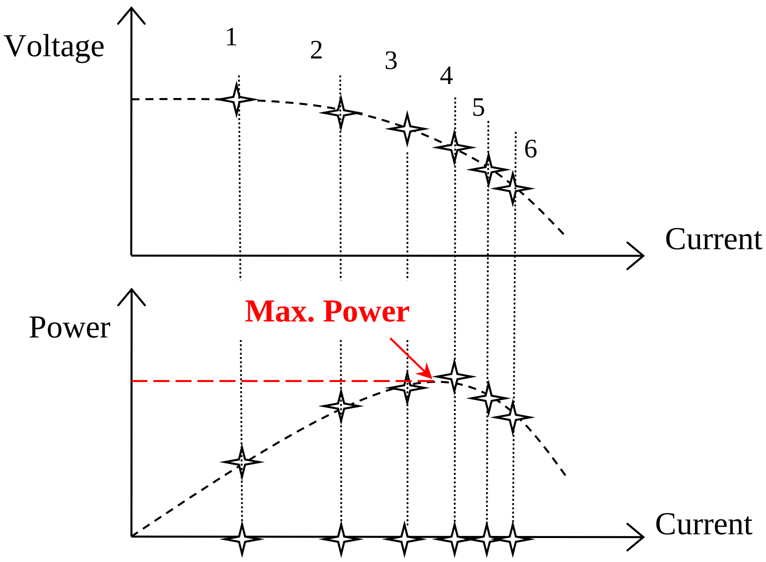
Wind speed measuring meter

Tachometer - measures the speed of the rotor

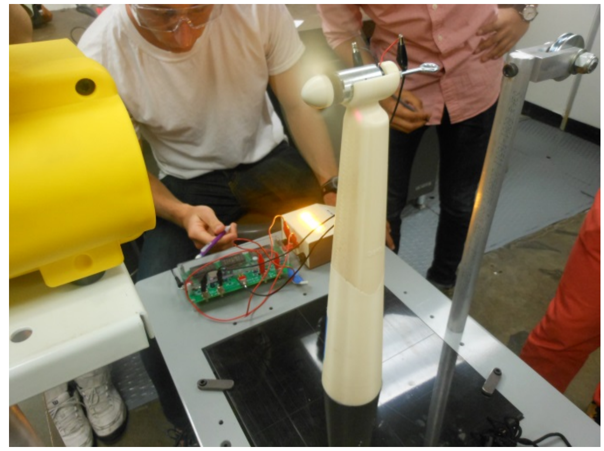
You are asked to determine the maximum output power of your wind turbine generator. **To do so, you must search for the best loading condition by varying the resistance on the circuit**. For a wind turbine generator, the best loading condition varies with wind speed (we do not explore this relationship).

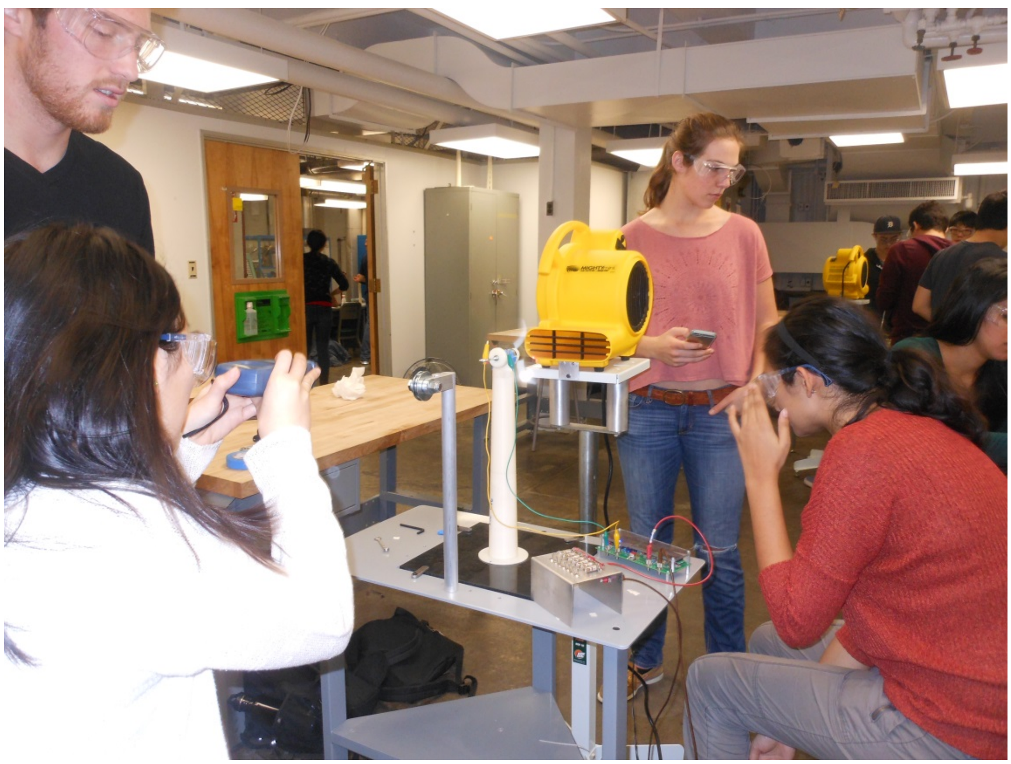
Testing procedure

- Secure the wind turbine to the testing platform and position the blower so the **wind velocity is 25 mph**.
- Turn the blower off and connect the generator and the load box to the power meter.
- Zero the potentiometer (turn all the way ccw). Switch to variable load and turn the blower on.
- Turn the potentiometer nub clockwise small intervals at a time and for each step record the current, voltage and power. Your power should peak at a certain current and then drop as shown below. Obtain a plot of power vs current to determine the maximum power generated by your wind turbine.



Voltage
1
2
3
4
5
6
Current
Power
Max. Power
Current



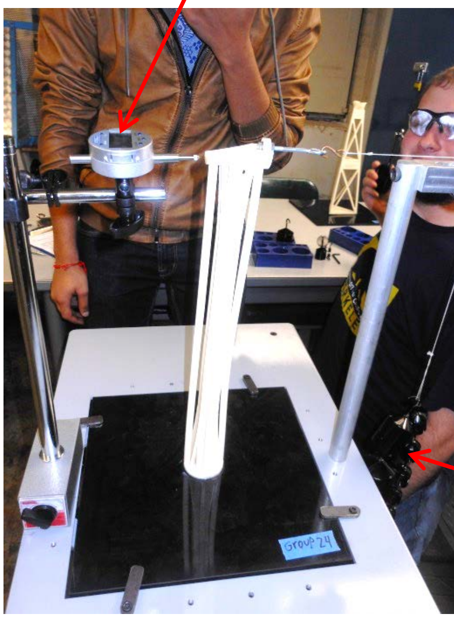


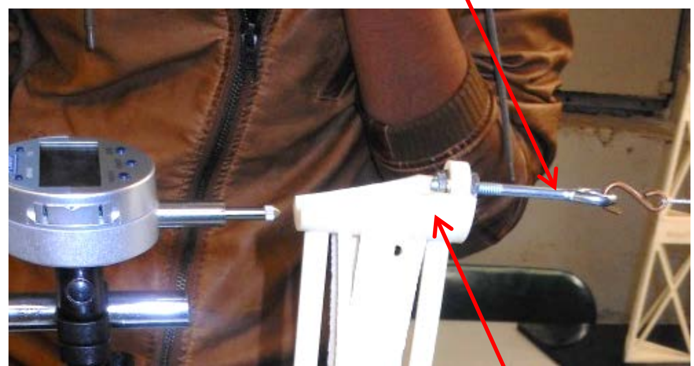
Stiffness measurement

The deflection (stiffness) of the tower is measured by loading the top plate supporting the motor as shown in the picture. A string attached to the back of the top plate, pulled over a pulley with weights hanging from it.

Dial indicator to measure deflection

Eyebolt





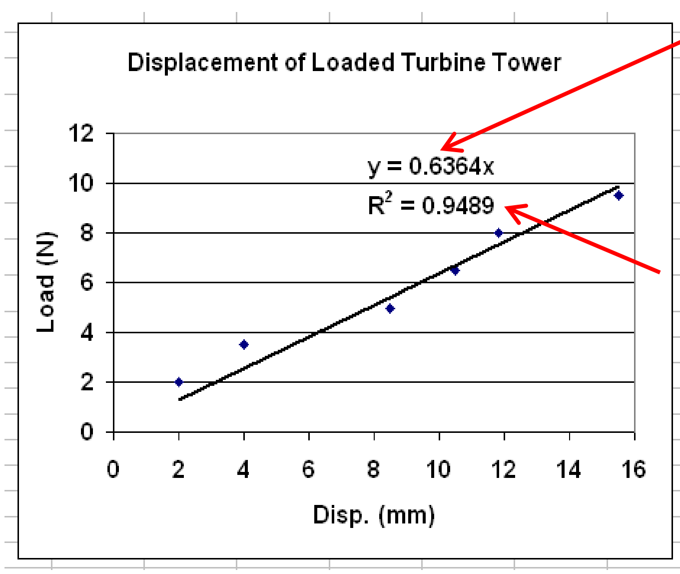
Motor housing

Load

Testing procedure

- Secure the wind turbine to the testing platform
- Attach a string to the back of the top support plate using an eyebolt (provided), pull it over the pulley
- Position the dial indicator and zero it.
- Add weight and measure the deflection.
- Plot load vs. deflection as shown, fit a curve (straight line) to the data and determine the stiffness of the wind tower.

Stiffness k = .6363 N/mm



Correlation factor, R^2 = 94.9%

ky