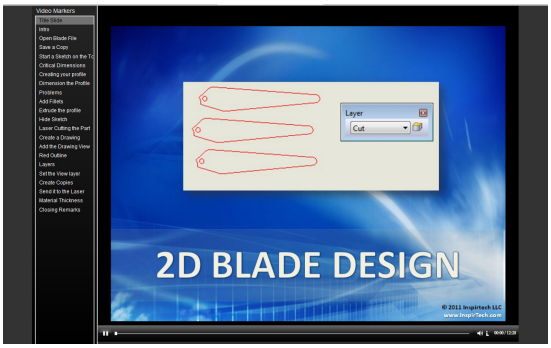
WindPitch Wind Turbine Experiment- Experimenting with Your Own Blades



EXPERIMENT OVERVIEW

This experiment will test short and long custom designed blades that students create with the ***InspirTech "Wind Turbine Blade Design and Performance Kit"*** software along with fabricating the blades on either a 3D printer or laser cutter, as appropriate.

EXPERIMENT OBJECTIVES

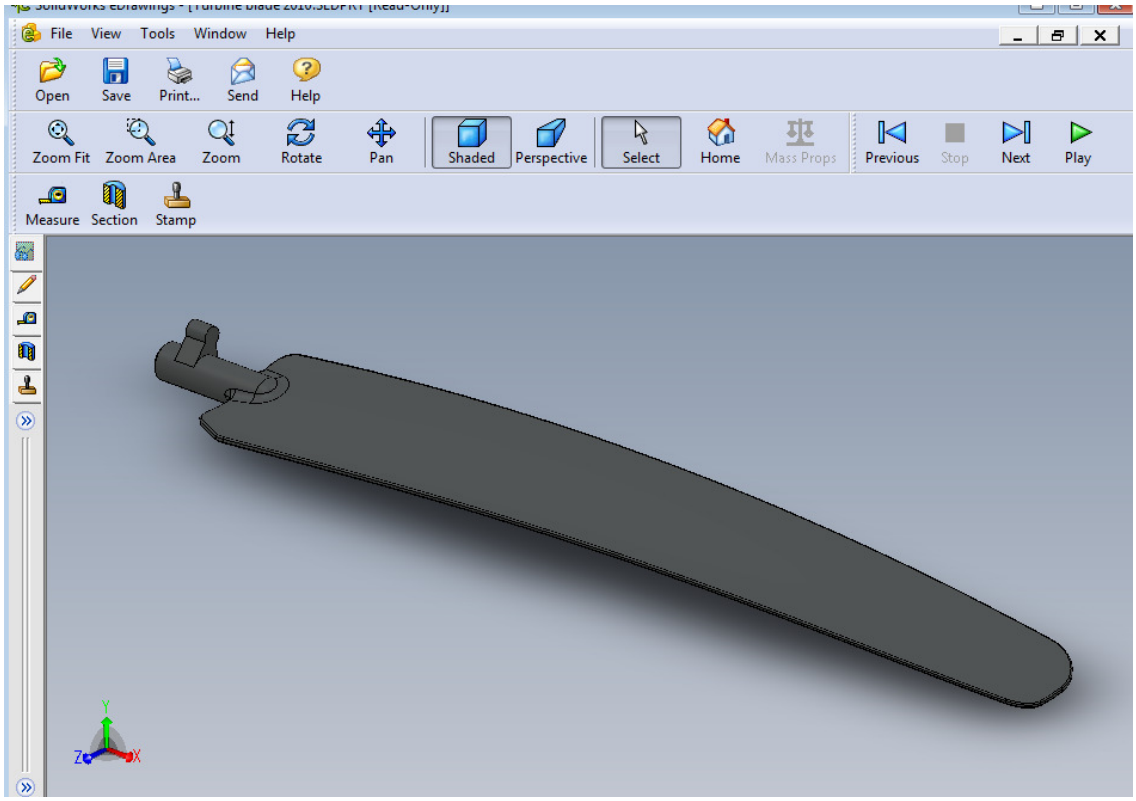
- Students will use the Scientific Process to perform the experiment.
- Students will apply the knowledge they've gained in the previous experiments and apply it to their custom designed blades.
- Students must have successfully completed all the previous experiments using the WindPitch wind turbine and the supplied blades.
- Students must have designed their own short and long 2D or 3D blades.
- Students must have the equipment, or locate same, to fabricate their own custom blades.

SAFETY

Caution must be exercised when using the wind turbine and table fan. Spinning blades can pose a hazard and can cause injury if not careful. DO NOT PLACE YOUR FINGERS, HANDS, ARMS, FACE OR ANY OTHER PART OF YOUR BODY IN THE SPINNING WIND TURBINE OR FAN BLADES!

Wear safety glasses for all experiments

SHORT AND LONG CUSTOM BLADES



- The following experiment use custom blades of two general lengths, short and long, that students design and build, or have built for them.
- The custom blades designed using the "***InspirTech "Wind Turbine Blade Design and Performance Kit"*** software can be of the 2D "flat" or 3D "profiled" variety.
- The experiment is a compilation of the previous WindPitch experiments; therefore, all the previous experiments should have already been successfully performed before this one.
- The experimental results are purposely left general in nature, since the specific blade lengths and other characteristics like shape and type (2D versus 3D) are not known.
- **<u>The student should build "at least" six (6) long and six (6) short blades.</u>**

PREREQUISITES

- Be familiar with the operation of the La Crosse anemometer.
- Be familiar with the operation of the General Technologies tachometer.
- Read and understand the WindPitch Education Kit instructions including:
  - Component Parts
  - Assembly
  - Blade Installation
  - Blade Pitch Adjustment
  - Electrical Connections

EQUIPMENT

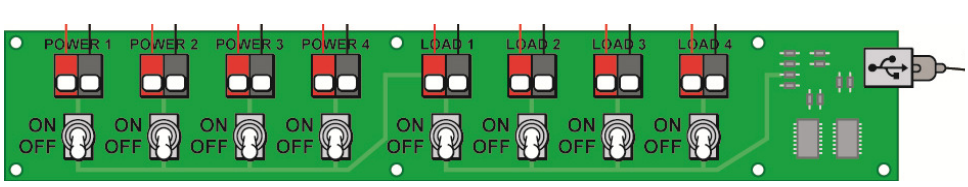
- Control Panel
- Computer running the ecoCAD Real Time Energy Monitoring software
- WindPitch wind turbine with six (6) long and six (6) short custom blades
- Large Table or Floor Fan (at least 16" in diameter with 3 speeds)
- General Technologies model TA105 infrared laser tachometer
- La Crosse model EA-3010U handheld anemometer.
- Two(2) 100 ohm fixed resistors
- Printer

EXPERIMENT SETUP

1. The Control Panel should be connected to the computer with the graphic software running to perform the experiment. All the switches should be OFF.

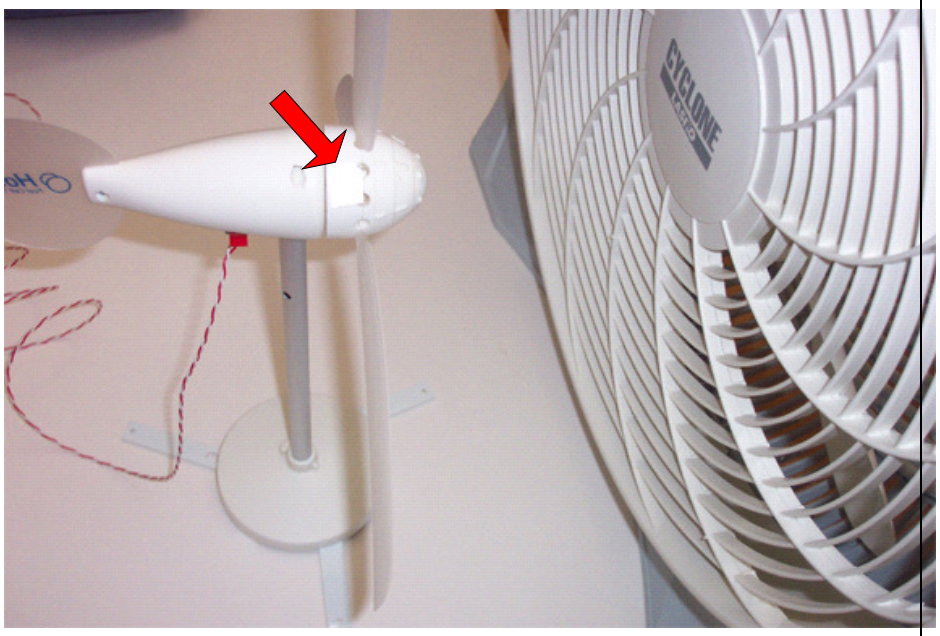
2. Insert a 100 ohm resistor into both the **Load 1** and **Load 2** terminals. Polarity does not matter.

3. Attach the WindPitch electrical output terminals to the **Power 1** terminals on the Control Panel. You will need to acquire a length of 2 conductor wire to make the connection between the WindPitch and the Control Panel. Wire the Red terminal on the WindPitch to the Gray or Red terminal on **Power 1** and the Black terminal on the WindPitch to the Black terminal on **Power 1**.



DOING THE EXPERIMENT

1. Set the table or floor fan as close as possible to the wind turbine blades. **MAKE SURE THAT THE WIND TURBINE BASE IS SECURE AND CAN'T MOVE. USE A BOOK OR OTHER OBJECT TO HOLD IT IN PLACE BEFORE TURNING THE FAN ON.**



2. Cut a ½" square section of reflective tape and apply it to the side of the WindPitch blade hub just behind the blades.

3. Using the anemometer measure and record the wind speed in meters / second where the WindPitch will be placed in front of the fan.

Part 1 – Short Blades

2 Short Blades

4. Setup the WindPitch wind turbine with two short blades opposite one another on the hub.

5. Adjust the blade pitch angle to $15^{0.}$

6. Set the table or floor fan as close to the wind turbine blades as possible. **MAKE SURE THAT THE WIND TURBINE BASE IS SECURE AND CAN'T MOVE. USE A BOOK OR OTHER OBJECT TO HOLD IT IN PLACE BEFORE TURNING THE FAN** ON.

7. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

8. Set the fan to its highest speed setting.

9. Aim the tachometer at the reflective tape and push the Measurement Button on the side. A red dot will appear on the rotating hub and RPM reading should appear on the display.

10. Measure and record the RPM.

11. Clear the computer screen by clicking on the Trash can icon.

12. Click the Screen Capture icon to record the voltage, current and power being consumed by the 50 ohm resistor load.

13. Stop the fan.

3 Short Blades

14. Setup the WindPitch wind turbine with three (3) short blades in a triangular pattern.

15. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

16. Aim the tachometer at the reflective tape and push the Measurement Button on the side. A red dot will appear on the rotating hub and RPM reading should appear on the display.

17. Measure and record the RPM.

18. Clear the computer screen by clicking on the Trash can icon.

19. Click the Screen Capture icon to record the voltage, current and power being consumed by the 50 ohm resistor load.

20. Stop the fan.

4 Short Blades

21. Setup the WindPitch wind turbine with four (4) short blades opposite one another to form a 12, 3, 6 and 9 o'clock pattern.

22. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

23. Aim the tachometer at the reflective tape and push the Measurement Button on the side. A red dot will appear on the rotating hub and RPM reading should appear on the display.

24. Measure and record the RPM.

25. Clear the computer screen by clicking on the Trash can icon.

26. Click the Screen Capture icon to record the voltage, current and power being consumed by the 50 ohm resistor load.

27. Stop the fan.

6 Short Blades

28. Setup the WindPitch wind turbine with six (6) short blades.

29. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

30. Aim the tachometer at the reflective tape and push the Measurement Button on the side. A red dot will appear on the rotating hub and RPM reading should appear on the display.

31. Measure and record the RPM.

32. Clear the computer screen by clicking on the Trash can icon.

33. Click the Screen Capture icon to record the voltage, current and power being consumed by the 50 ohm resistor load.

34. Stop the fan.

Part 2 – Long Blades

2 Long Blades

35. Setup the WindPitch wind turbine with two long blades opposite one another on the hub.

36. Adjust the blade pitch angle to $15^{0.}$

37. Set the table or floor fan as close to the wind turbine blades as possible. **MAKE SURE THAT THE WIND TURBINE BASE IS SECURE AND CAN'T MOVE. USE A BOOK OR OTHER OBJECT TO HOLD IT IN PLACE BEFORE TURNING THE FAN** ON.

38. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

39. Set the fan to its highest speed setting.

40. Aim the tachometer at the reflective tape and push the Measurement Button on the side. A red dot will appear on the rotating hub and RPM reading should appear on the display.

41. Measure and record the RPM.

42. Clear the computer screen by clicking on the Trash can icon.

43. Click the Screen Capture icon to record the voltage, current and power being consumed by the 50 ohm resistor load.

44. Stop the fan.

3 Long Blades

45. Setup the WindPitch wind turbine with three (3) long blades in a triangular pattern.

46. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

47. Aim the tachometer at the reflective tape and push the Measurement Button on the side. A red dot will appear on the rotating hub and RPM reading should appear on the display.

48. Measure and record the RPM.

49. Clear the computer screen by clicking on the Trash can icon.

50. Click the Screen Capture icon to record the voltage, current and power being consumed by the 50 ohm resistor load.

51. Stop the fan.

4 Long Blades

52. Setup the WindPitch wind turbine with four (4) long blades opposite one another to form a 12, 3, 6 and 9 o'clock pattern.

53. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

54. Aim the tachometer at the reflective tape and push the Measurement Button on the side. A red dot will appear on the rotating hub and RPM reading should appear on the display.

55. Measure and record the RPM.

56. Clear the computer screen by clicking on the Trash can icon.

57. Click the Screen Capture icon to record the voltage, current and power being consumed by the 50 ohm resistor load.

58. Stop the fan.

6 Long Blades

59. Setup the WindPitch wind turbine with six (6) long blades.

60. Switch ON the wind turbine (**Power 1**) and both 100 ohm resistors (**Load 1 and Load 2**). Since the resistors are in parallel this makes a 50 ohm load.

61. Aim the tachometer at the reflective tape and push the Measurement Button on the side. A red dot will appear on the rotating hub and RPM reading should appear on the display.

62. Measure and record the RPM.

63. Clear the computer screen by clicking on the Trash can icon.

64. Click the Screen Capture icon to record the voltage, current and power being consumed by the 50 ohm resistor load.

65. Stop the fan.

STUDENT EXERCISES

1. Which number of blades produced the most power overall?

2 short	2 long
3 short	3 long
4 short	4 long
6 short	6 long

2. Which number of blades produced the least power overall?

2 short	2 long
3 short	3 long
4 short	4 long
6 short	6 long

3. Which number of blades produced the most RPM?

2 short	2 long
3 short	3 long
4 short	4 long
6 short	6 long

4. Which number of blades produced the least RPM?

2 short	2 long
3 short	3 long
4 short	4 long
6 short	6 long

5. Did you expect to see more blades or fewer blades produce the most power? Explain your answer.

6. Did your expectation prove correct or incorrect? Explain why in either case.

7. Would decreasing the fan's wind speed produce more power for specific blade numbers and length? Explain why you think so (or not).

TEACHER NOTES - ANALYZING THE RESULTS

- Most of the material for this experiment has been covered in previous experiments.
- Refer to the previous experiments for background on how to advise the students on their results.
- Ask the students what changes they would make to their custom blade designs to create more power from the WindPitch wind turbine.
- Use this and the other experiments to continually test and validate new results.