WindPitch Wind Turbine Experiment- Voltage, Wind Speed and RPM

EXPERIMENT OVERVIEW

This experiment is designed to show the relationship among wind speed, blade revolutions per minute (RPM) and the wind turbine's voltage output at three different fan speeds – fast, medium and slow.

EXPERIMENT OBJECTIVES

- Students will use the Scientific Process to perform the experiment.
- Students will learn about the relationship between wind speed, blade RPM and output voltage.
- Students will be shown how to manually plot wind speed against voltage and RPM in graph form.

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

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 3 BP-28 profile blades
- Student built flat or profiled blades where available
- 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.
- Printer

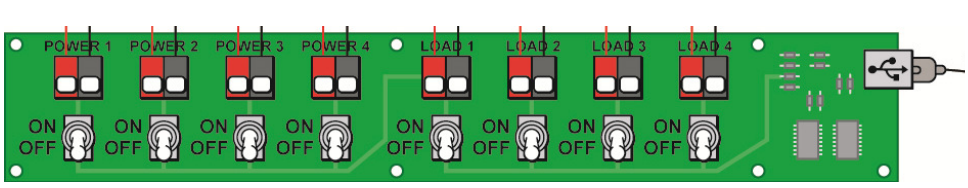
EXPERIMENT SETUP

- Setup the floor fan with the WindPitch in front of it.

- Adjust the La Crosse anemometer to measure wind speed in meters per second (m/s). Refer to a previous experiment for information.

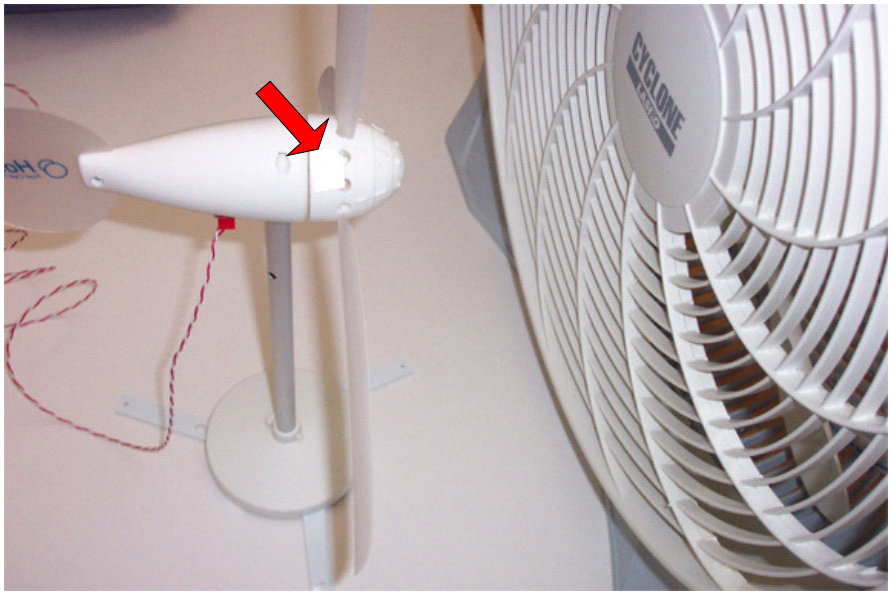
- The Control Panel should be connected to the computer with the graphic software running to perform the experiment. All the switches should be OFF.

- 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.

Fast Speed

3. Switch ON the wind turbine (**Power 1**).
4. Set the fan to its highest speed setting.
5. Clear the computer screen by clicking on the Trash can icon.

6. Click the Screen Capture icon to record the voltage reading.

7. Measure and record the wind speed in meters/second.
8. On the tachometer set the RPM / TOT button to RPM.
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.

Medium Speed

11. Switch ON the wind turbine (**Power 1**).
12. Set the fan to the medium_speed setting.
13. Clear the computer screen by clicking on the Trash can icon.
14. Click the Screen Capture icon to record the voltage reading.
15. Measure and record the wind speed in meters/second.
16. On the tachometer set the RPM / TOT button to RPM.
17. 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.
18. Measure and record the RPM.

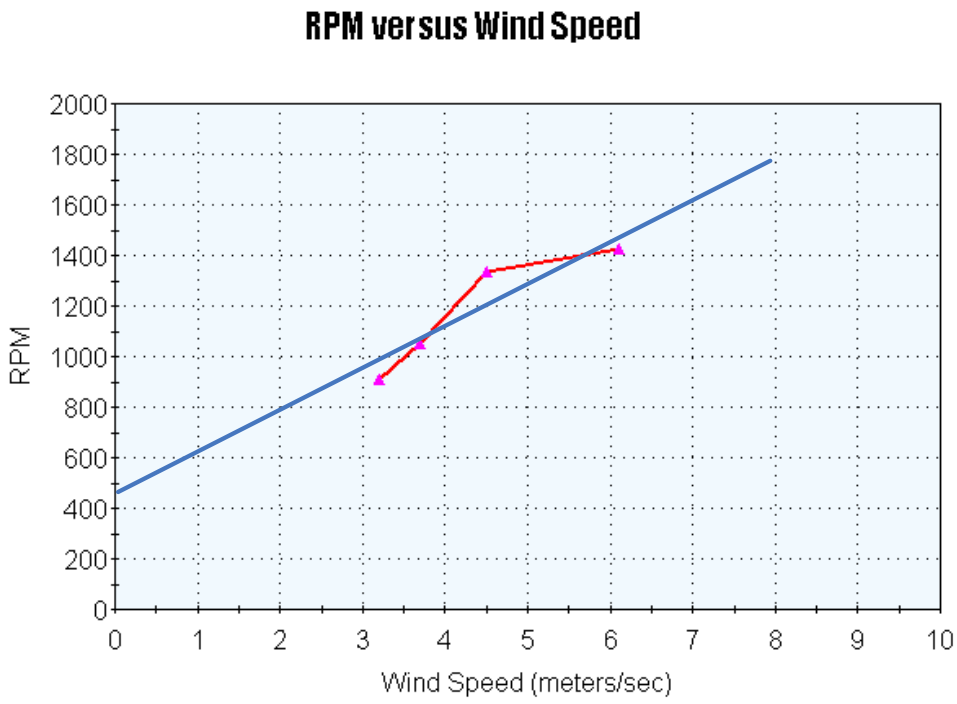
Slow Speed

19. Switch ON the wind turbine (**Power 1**).
20. Set the fan to the slow_speed setting.
21. Clear the computer screen by clicking on the Trash can icon.
22. Click the Screen Capture icon to record the voltage reading.
23. Measure and record the wind speed in meters/second.
24. On the tachometer set the RPM / TOT button to RPM.
25. 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.
26. Measure and record the RPM.
27. Turn off the fan.

Analysis

Based on the collected data the following table was constructed so that corresponding graphs can be generated from it – your data will be similar but different.

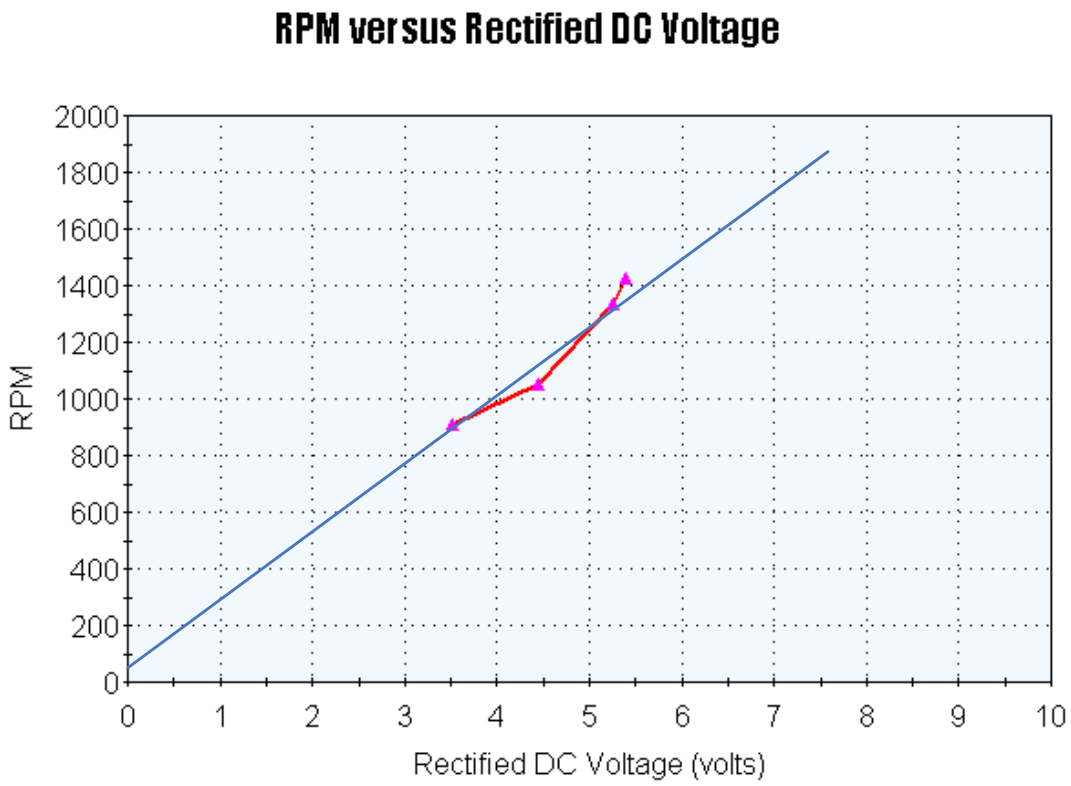
Wind Speed (meters/sec)	RPM	Voltage
6.1	1428	5.391
4.5	1333	5.254
3.7	1052	4.444



As can be seen by the graph the relationship between wind speed and RPM can form a trend line (blue) when the wind is blowing at a reasonable rate of speed, which means that a linear equation can be developed to convert RPM into wind speed as in:

Y = mx + b where **Y** is the RPM value (Y axis)
m is the slope of the line
x is the wind speed (X axis)
b is the RPM value where it intersects the Y axis where the value of wind speed (x) is zero

The same can be done with respect to RPM versus rectified DC voltage by substituting voltage for wind in the x axis.



Certain approximations for wind speed versus RPM as well as RPM versus DC rectified voltage were made to form these graphs. These assumptions **may not** extend well to lower or higher wind speeds; however, the analysis was done in order to approximate the wind turbine's voltage outputs under the measured wind speeds and RPM, and to show how it can be done.

Listed below are two websites that can help explain the above equations in more detail:

http://id.mind.net/~zona/mmts/functionInstitute/linearFunctions/lsif.html

http://www.math.com/school/subject2/lessons/S2U4L2GL.html