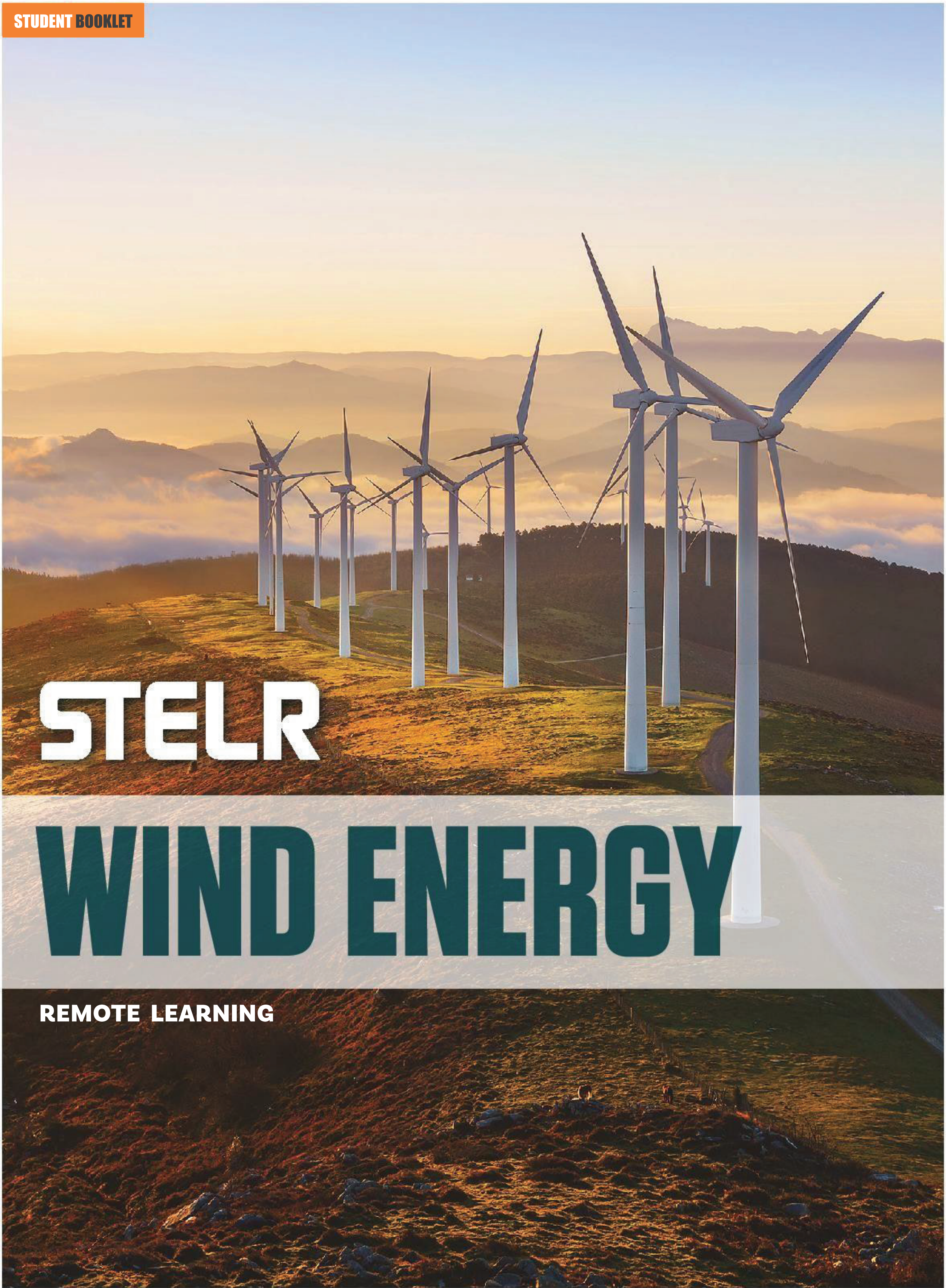
STUDENT BOOKLET



STELR

WIND ENERGY

REMOTE LEARNING

NAME

CLASS

TABLE OF CONTENTS

Wind Energy was written and produced by the STELR project team.

Science and Technology Education Leveraging Relevance (STELR) is the key school education initiative of the Australian Academy of Technology and Engineering. www.atse.org.au

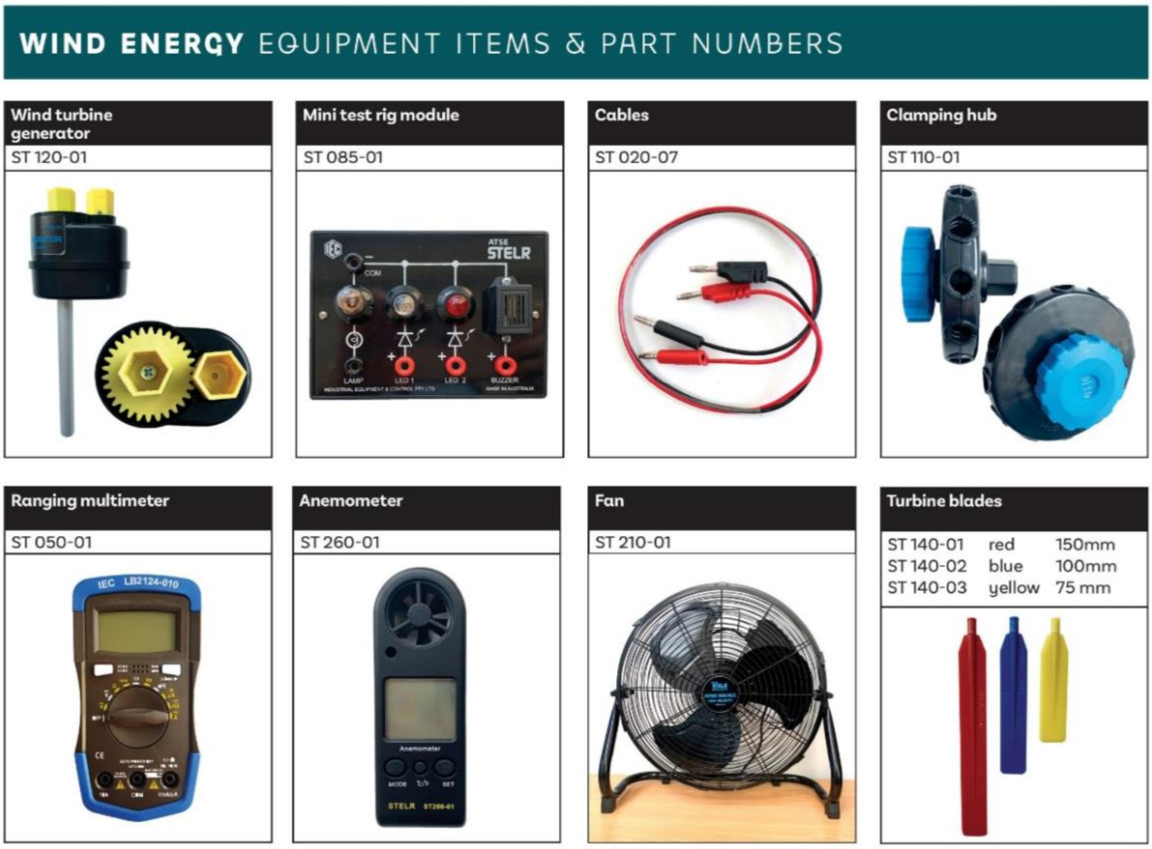
WIND TURBINE INVESTIGATIONS

Introduction

If you wish to transform the energy in the wind into electricity, you want machines that do this as efficiently as possible – at least, within your cost limits.

Many factors contribute to the efficiency of wind turbines. Some factors you can test with the STELR wind energy kit.

Here is what is in the kit.



The videos and worksheets in this series investigate:

1. what is the best angle for the turbine blades
2. what is the best number of blades, and
3. what is the best length of blade to use

What will happen?

Lee has the STELR wind energy student kit so she will perform the investigations for you.

In each activity, Lee investigates the effect that different combinations of blades has on the voltage output of the STELR wind turbine. The set up for the circuit she uses for all three investigations is shown in Figure 1.

Note how she attaches blades to the hub of the wind turbine and turns them to change the angle of each blade to the direction of the wind.

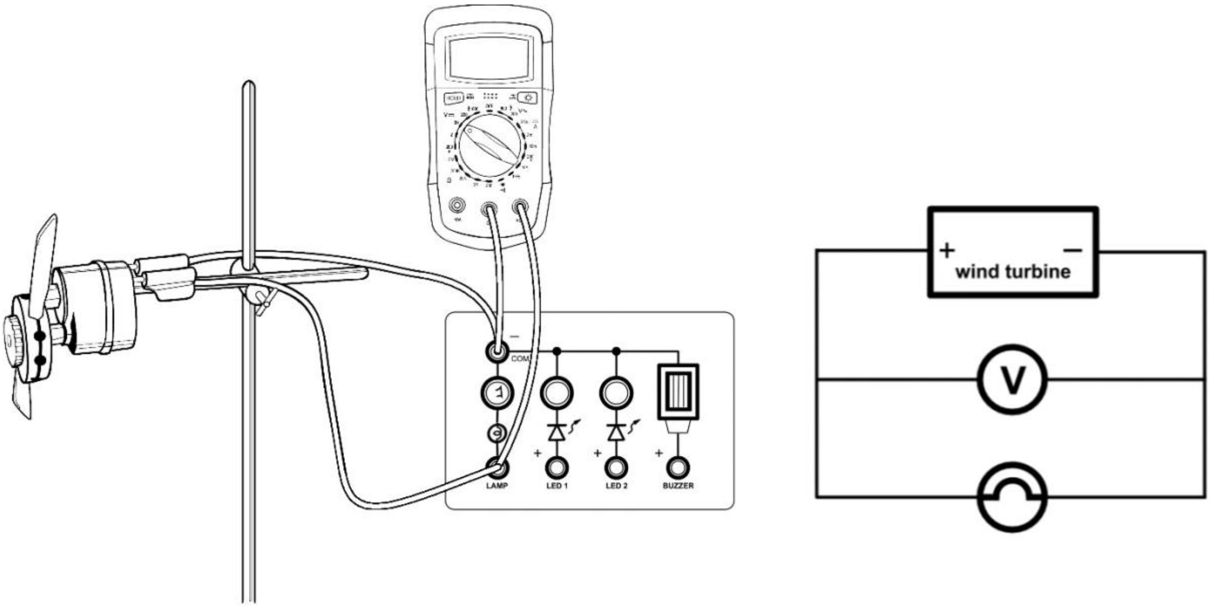


Figure 1. The equipment set up and its circuit diagram

The equipment Lee uses:

- STELR mini testing station
- 1 x STELR multimeter
- Sets of blades, red, blue and yellow
- Turbine hub
- STELR model wind turbine
- Connecting leads
- High-speed electric fan
- Tape measure
- STELR hub protractor

Test 1: Angle of Blades Investigation

Watch the video below and answer the following questions.

STELR Wind Turbine Investigations Part 1: Best Blade Angle
https://stelr.org.au/stelr-modules/wind-energy-remote-learning/

Click on the video: Test 1. Your browser will take you to the STELR video on Australia's Science Channel — How wind turbines are made: Blade angles

Inquiry Question

What is the best angle for the blades on a wind turbine hub that produces the biggest voltage?

Hypothesis

Before you start, predict what you think will happen to the power delivered by the model wind turbine as you change the angle of the blades. Explain why you think this.

Part A – Testing with two blades at 45_o.

Lee uses two red blades. They are 15 cm long. She makes sure the blades are tight in the hub of the turbine and are both at 45_o to the face of the hub, like those in Figure 2 on the next page.

She secures the STELR wind turbine to the retort stand and makes sure that the hub is fitted tightly in the correct socket of the hub.

Figure 2. These blades have been set into the hub at the same angle (45^{0}).

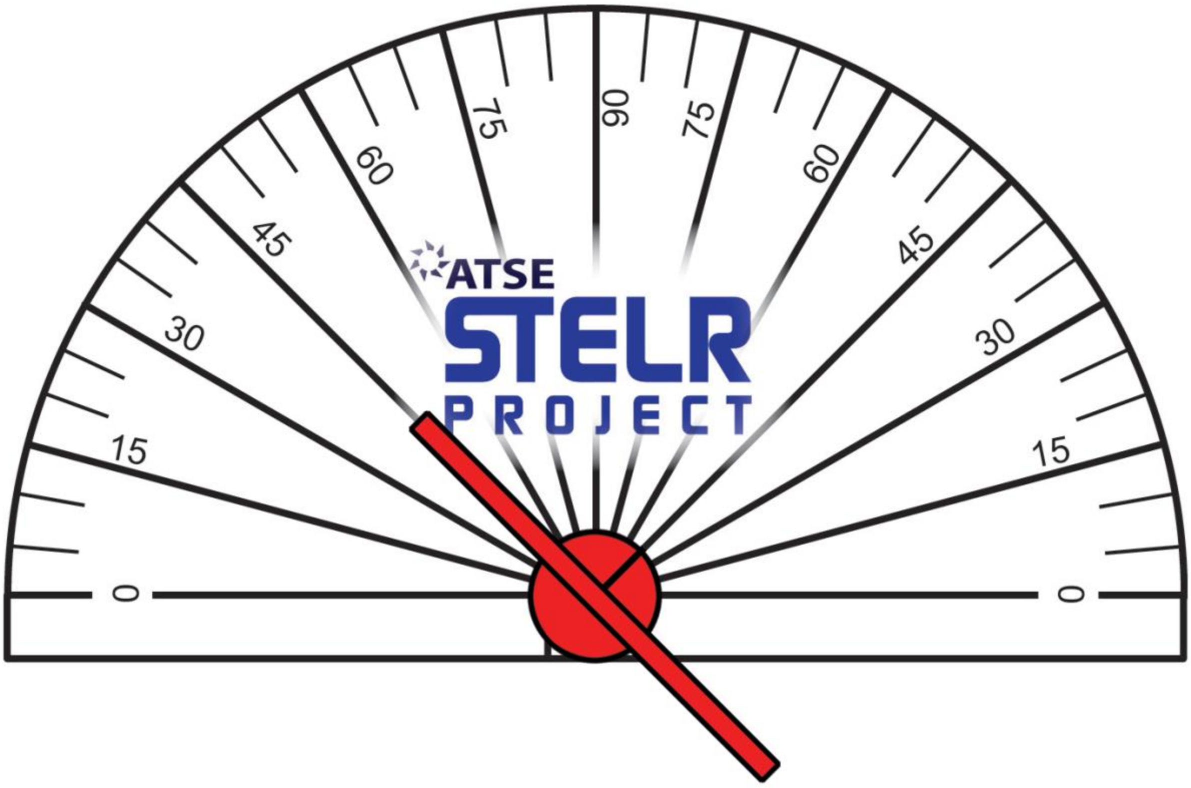
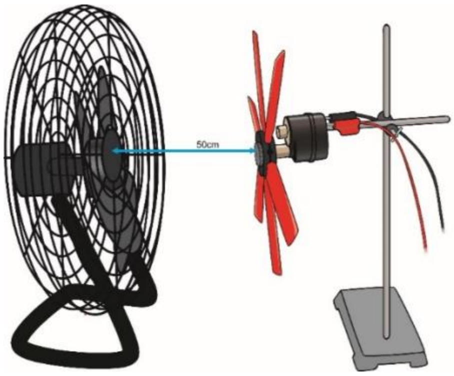


Figure 3. Using the STELR protractor to set the blade angle

She sets up the circuit as shown in Figure 1 on page 5.

She places the high-speed fan on the bench so that the front of the fan is 50 cm from the front of the hub on the wind turbine.



Lee does not change the distance between the fan and the turbine over the course of the experiments.

Lee then turns the fan onto the highest speed setting.

Results

The results are recorded in *Table 1* below.

Angle of turbine blades	Voltage produced (V)
0_o	0
15_o	3.2
30_o	2.1
45_o	1.2
60_o	0.8
90_o	0

Draw a graph of the voltage produced at different angles of the blades

Graph

Discussion

What do you think would have happened to the voltage produced by the turbine if the fan had been set at the medium setting instead of the high setting?

Question 1

Was the prediction you made at the start of this experiment correct? Were you surprised with the results for this model turbine? Suggest a reason why the prediction was or was not correct.

Question 2

Identify at least two sources of error for this experiment, which would help account for any differences in the results.

Question 3

List the variables that Lee kept the same as she performed the investigation.

Conclusion

What is your answer to the inquiry question?

What is the best angle for the blades on a wind turbine hub to produce the highest voltage?

Test 2: Blade Length Investigation

Watch the next video below and answer the following questions.

STELR Wind Turbine Investigations Part 2: Best Blade Length
https://stelr.org.au/stelr-modules/wind-energy-remote-learning/

Click on the video: Test 2. Your browser will take you to the STELR video on Australia's Science Channel — How wind turbines are made: Blade lengths

Inquiry Question

Which blade length, of the three lengths supplied, delivers the biggest voltage for the STELR wind turbine generator?

Hypothesis

What blade length do you think will give the biggest voltage? Why?

Results

Draw a graph of Lee's results on the graph grid below.

Blade colour	Blade length (cm)	Voltage produced (V)
Yellow	7.5	2.2
Blue	10.0	1.7
Red	15.0	1.2

Graph

Question 1

How reliable do you think Lee's results are? Discuss.

Question 2

Did your findings surprise you? Can you suggest an explanation for what you discovered?

Conclusion

Of the three lengths supplied, what is the best blade length for the STELR model wind turbine when using the fan?

Test 3: Number of Blades Investigation

Watch the video below and answer the following questions.

STELR Wind Turbine Investigations Part 3 Best Number of Blades
https://stelr.org.au/stelr-modules/wind-energy-remote-learning/

Click on the video: Test 3. Your browser will take you to the STELR video on Australia's Science Channel — How wind turbines are made: How many blades?

Introduction

In this activity, Lee investigates the effect that different numbers of blades has on the voltage produced by the STELR wind turbine.

Inquiry Questions

1. What voltage can be delivered by a STELR wind turbine with 6 blades?
2. What is the relationship between the number of blades on the STELR wind turbine and the voltage it delivers?
3. How many blades give the greatest voltage?

Hypothesis

Before you start, predict what you think will happen to the power delivered by the model wind turbine as you change the number of blades. Explain why you think this.

___

___

Part A – Testing with six blades:

Lee makes sure the six blades are tight in the hub of the turbine and are all at 45^0 to the face of the hub, like those in Figure 2 below. She sets up the equipment, turns on the fan and notes the voltage on the multimeter.

Figure 2. These blades have been set into the hub at the same angle (45^0).

Part B – Testing with other numbers of blades:

Lee next tries different numbers of blades in the hub. First, she uses the red blades set at 45$_{o}$. She then tried blue blades at 45$_{o}$ and then yellow blades at 45$_{o}$.

Results

Table 2: Voltage produced by the wind turbine with different numbers of red and blue blades.

Number of red blades	Voltage (V) red blades	Number of blue blades	Voltage (V) blue blades	Number of yellow blades	Voltage (V) yellow blades
0	0	0	0	0	0
2	2.2	2	1.3	2	2.2
3	2.4	3	1.9	3	3.1
4	2.5	4	1.5	4	2.6
6	2.7	6	1.5	6	2.9
8	2.4	8	1.8	8	2.8
12	2.3	10	1.5	10	2.9
		12	1.8	12	2.8

Draw a graph of Lee's results, using different colours for the different blades, on the graph grid below.

Graph

Discussion Questions

Question 1

Was the prediction you made at the start of this experiment correct? Were you surprised with the results in Part B for this model turbine? Suggest a reason why your prediction was or was not correct.

Question 2

List the variables that were kept the same as Lee performed each investigation.

Question 3

Do you think the results would have been the same if the set of blades had been shorter than the sets Lee used in this experiment? Discuss.

Question 4

Do you think the results would have been the same if the blades had been set at different angles to the angle used in this experiment? Discuss.

Question 5

Suggest two reasons why large wind turbines usually have three blades.

Conclusion

What are your answers to the three inquiry questions?

1. What voltage can be delivered by a STELR model wind turbine operating with six blades?

2. What is the relationship between the number of blades on the STELR model wind turbine and the voltage it delivers?

3. How many blades give the greatest voltage?

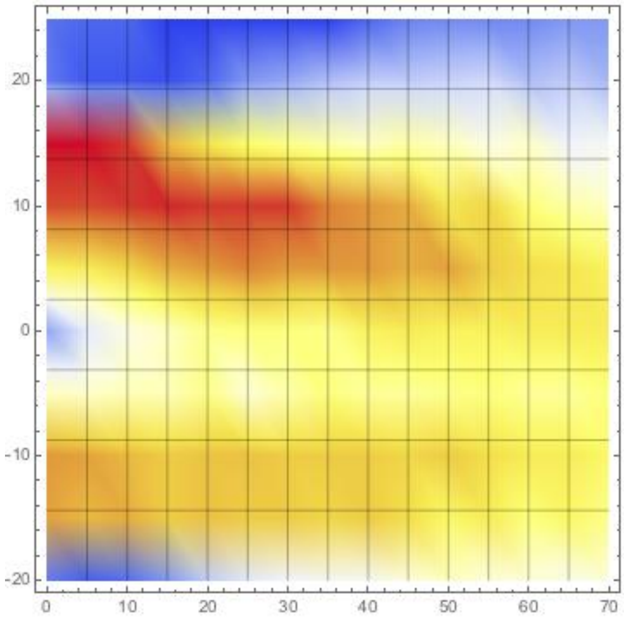
Unexpected results?

The wind produced by fans is not at the same speed everywhere in front of the fan.

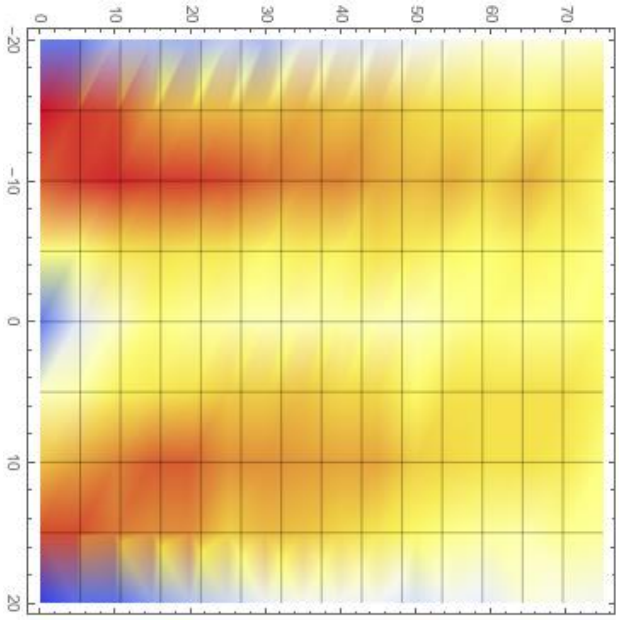
Fans produce a swirling stream of air.

The stream of air moves faster in the middle and slower at the edges. This is like water in a river. It moves faster in the middle of the river where the water is deeper. The water at the edge is shallower and moves slower.

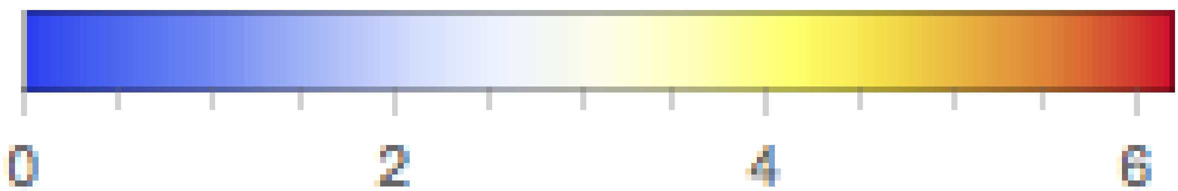
These diagrams use different colours to show the speed of air in front of a STELR fan in two planes: vertical and horizontal.



Air speed versus distance in front of the fan as viewed from the side (in a vertical plane).



Air speed versus distance in front of the fan as viewed from above (in a horizontal plane).



Speed of the air measured in m/s

The diagrams show that shows that the tips of longer STELR blades are affected by slow moving air when they are placed 50 cm in front of the fan. All of the shorter yellow blades are in fast moving air.

This is why scientists use wind tunnels to test their wind turbines.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Students from South Oakleigh College (VIC) using the STELR Wind Energy kit

STELR Wind Energy — Curriculum Resources

stelr.org.au/stelr-modules/wind-energy

See what we're up to online

YouTube > STELR Project

Facebook > STELR

australiascience.tv > STELR Project

The Australian Power Insititute (API) proudly supports science, technology, engineering and maths education in Schools.

ENGINEERING THE FUTURE

Engineers in the Energy Industry help to:

- Provide the "bridge" between science & community
- Take up climate change challenges
- Address technological challenges
- Transition to a renewables future
- Implement energy efficiency initiatives
- Continue providing essential service to community
- Raise living standards & tackle poverty in developing countries.

ABOUT API

The API is a not for profit organisation established by the energy industry companies in Australia to facilitate the provision of tomorrow's technical leaders equipped to deliver Australia's energy future through initiatives such as:

- API Bursary Program to support students at university study engineering and technology courses
- Support for programs to encourage young female students to study STEM and pursue engineering and technology careers.

API SOLAR CAR CHALLENGE

As API is committed to improving STEM education, API provides part funding for STELR, which is an initiative of The Australian Academy of Technological Sciences & Engineering (ATSE). API supports this program by providing class sets of re-usable model solar car kits to over 250 schools Australia wide using the Science and Technology Education Leveraging Relevance (STELR) Renewable Energy Module.

API also encourages involvement between university undergraduate engineering students by sending an API Bursary Holder to a participating high school to deliver a presentation about careers related to the renewable energy and power industry. During these visit the young undergraduate engineers also assist with solar car construction, judge the cars, and award prizes. The API, the high school teachers and students consider the Solar Car Challenge a great program to be invlolved in!

API BURSARY PROGRAM

As The API is constantly working to support the education and professional development of engineers & technologists in the energy industry across Australia, API offers scholarships to engineering & technology students with an interest in areas of engineering relevant to the electric power industry. The bursaries provide financial assistance over 4 years plus the opportunity where available for paid employment with member companies during the univeristy summer vacations.

Applications open February-May 2020 via API website.

CONTACT US

www.api.edu.au info@api.edu.au

VIDEO PROFILES OF WOMEN IN STEM CAREERS AND ENTREPRENEURSHIP

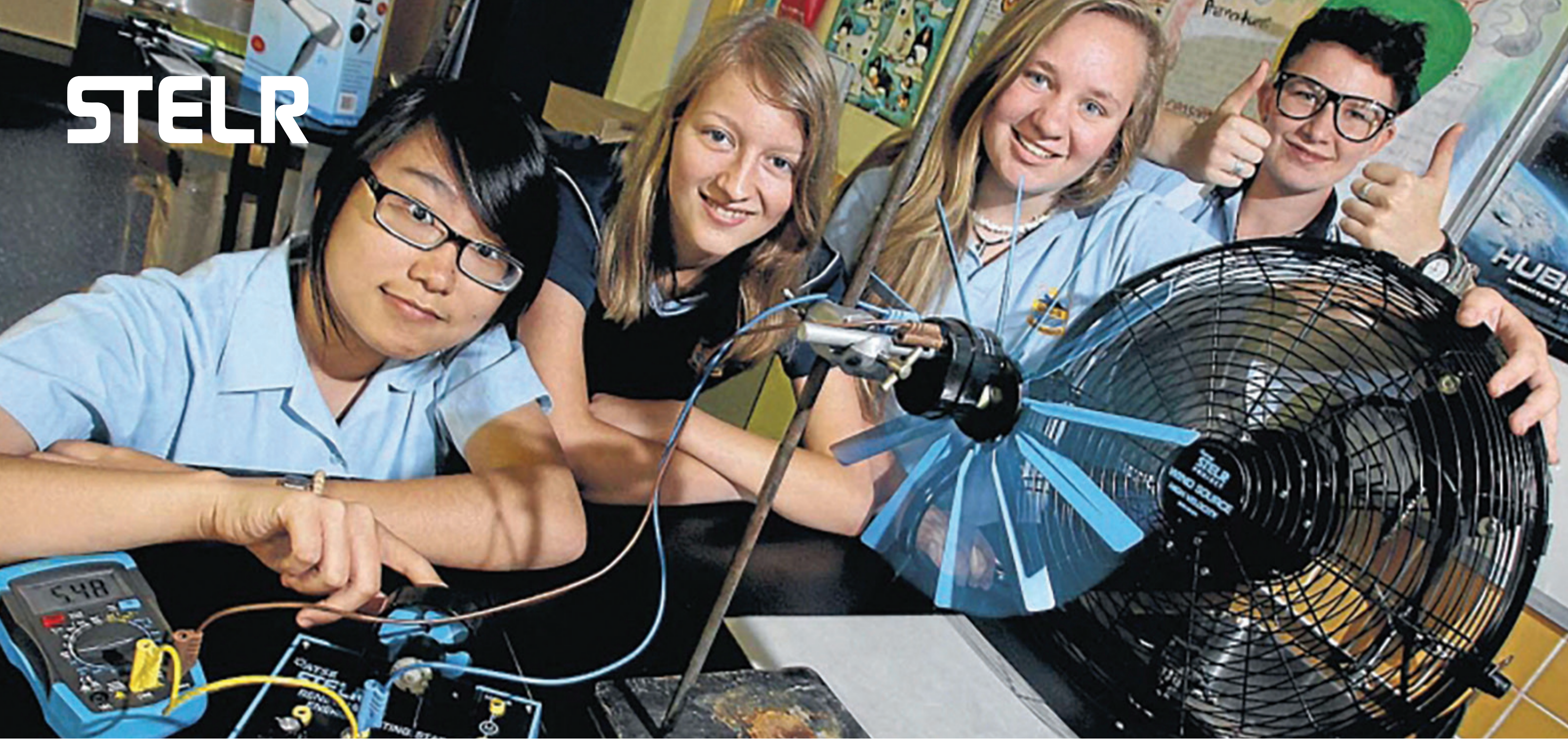
View them all at www.stelr.org.au/WomenInSTEM

#WomeninSTEM #BeAChangemaker #DoSTEMMakeChange

STELR

An initiative of the Australian Academy of Technology and Engineering

This project received grant funding from the Australian Government



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