In collaboration with:

TEACHERS' TOOLKIT

Learning wind energy in **primary schools**

MODULE 2

CONSTRUCTING AN ANEMOMETER AND TAKING MEASUREMENTS

OVERVIEW

Students can learn how to measure wind speed by building a simple cup anemometer. A cup anemometer like the one below is used to measure wind speed. The cup anemometer has a vertical axis and three cups that move with the wind. A sensor keeps track of how many spins per minute the cup anemometer makes. A computer uses that information to estimate how fast the wind is blowing.

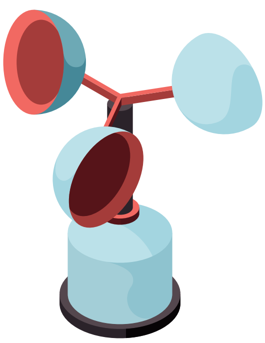
A wind turbine can only work if it knows how fast the wind is blowing, and the faster the wind blows the more electricity the wind turbine produces. That's why it needs to measure the speed of the wind and for this it needs to be equipped with an anemometer.

Imagine a wind turbine producing electricity, and the wind speed is 5 metres per second. Imagine that the wind speed doubles, from 5 to 10 metres per second. With the new wind speed, the wind turbine will generate eight times as much electricity as before.

GRADES

5-6th Primary (10-12 yo)

FIG. 9
Anemometer



TIME

- Two (50-minute) classes to build the anemometers
- Two (50-minute) classes to take measurements

SUBJECTS

- Physics
- Geometry
- Maths

LEARNING OBJECTIVES

At the end of this module, students will have acquired the following knowledge and competences:

Knowledge

- How to measure length
- Velocity -> Wind velocity
- The circumference and area of the circle: learning new formulae
- Discovering and understanding the concept of Pi (π)

Competences

- Planning and designing a project in 3D
- Comparing results and organising them in a double entry table
- Discovering and using the scientific method
- Thinking rationally when faced with a challenge and identifying possible solutions using available evidence
- Presenting this reasoning to the group

LESSON PLAN

MATERIALS

- Wooden shafts
- Wooden arms
- Empty yoghurt pots
- A mechanism to make the arms turn

METHOD

On a windy day, ask the students how can they measure the speed of the wind?
Answer -> An anemometer!

STEP 1
Constructing an anemometer

- In teams of three, students come up with a plan to build an anemometer, by answering these three questions:
  - How many arms does it need?
  - What type of cup can be used?
  - How big is each part of the anemometer?
- Each team makes a scale diagram of their anemometer (Fig 10)
- Based on the drawing, each team builds their anemometer using wood for the vertical shaft and the arms, yoghurt pots for the cups and a mechanism to make the arms turn

TABLE 4
Examples of sizes of the anemometers each team can build

TEAM	Size of the base	Size of the vertical shaft	Size of the horizontal arms
1	9 x 9 cm	20 cm high	15 cm long
2	15 x 15 cm	40 cm high	15 cm long
3	12 x 12 cm	30 cm high	14 cm long
4	18 x 18 cm	15 cm high	15 cm long
5	20 x 20 cm	40 cm high	10 cm long
6	15 x 15 cm	30 cm high	15 cm long
7	20 x 20 cm	25 cm high	20 cm long

FIG. 10
Example scale diagram with the different components: base, vertical shaft, horizontal arms.

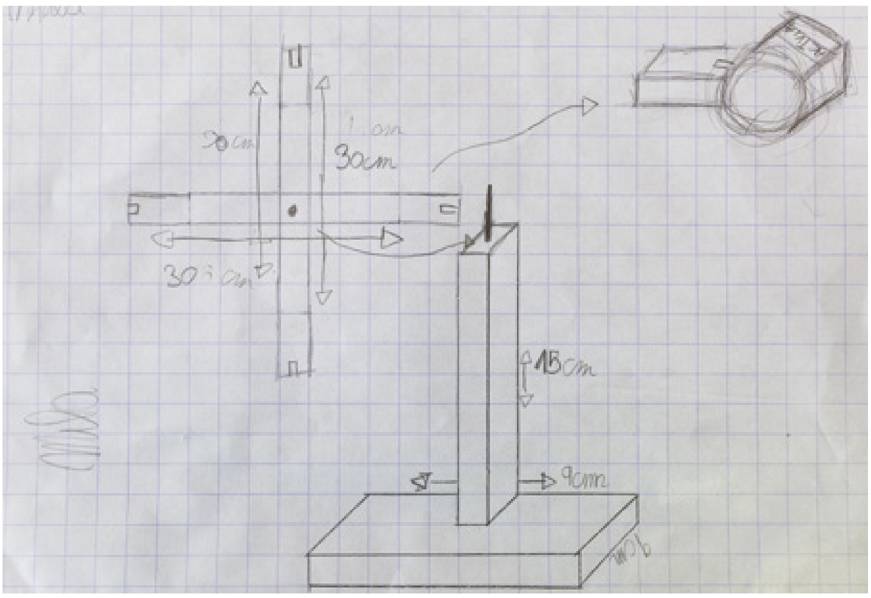


FIG. 11
Students place the horizontal arms on the vertical shaft of the anemometer

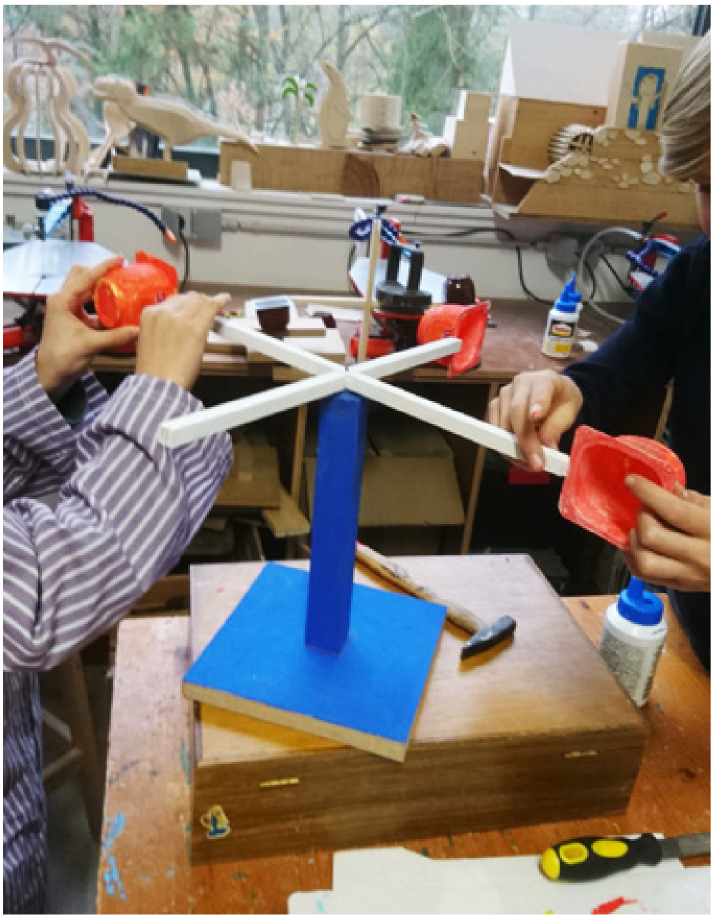


FIG. 12
Students attach the cups (empty yoghurt pots) to the horizontal arms of the anemometer.

STEP 2
Using an anemometer to measure wind

Once the anemometers are built, they need to be tested.

- On a windy day, in a well-ventilated area of the school playground, each team counts the number of spins their cups make over a 30 second period, by placing a coloured marker on one of the cups to help with the counting

- A member of the team records the number of spins on a table and compares the results with the other teams

- The more spins, the faster the wind is blowing and the higher the wind speed!

STEP 3
Doing experiments with the anemometer

- As a group, the students should discuss why the number of recorded spins is different from one team to another

Do sizes of the anemometer arms have an influence on the number of spins?

- To answer the question, students should carry out the following experiment in the classroom:

Material:

- 3 anemometers of different sizes for the base, the vertical shaft and arms made by the students (see table above)
- 1 fan
- 1 chronometer

Hypothesis:

The students put forward their own hypothesis: the anemometer that has the longest arms will rotate the fastest.

Experiment:

- The students turn on the fan facing the anemometer
- Try different fan speeds and distances until the anemometer starts spinning
- For each anemometer, students count the number of revolutions over a 30 second period
- Students notice that the anemometer that spins the most is the one with the shortest arm length

Conclusions:

The class arrives at the same conclusions:
- The shorter the arms of the anemometer, the faster the anemometer spins
- The longer the arms, the fewer spins the anemometer makes
- The cups of the anemometer move in a circle
- The "length of the circle" made by the rotation of the cups is shorter when the blades are shorter

This comparison does not take into account the size of the cups. The influence of the size of the cups on the number of spins could be part of the discussion with the students.

STEP 4
Measuring the circumference and area of the circle made by the anemometer

Up until now, the students saw that the anemometer cups moved in a circle.

Maths challenge:

- Ask the students to solve this challenge individually:

How to measure the circumference of the circle their anemometer makes when it rotates?

Measurements:

- To measure the circumference, students are free to use the materials they want. Ideally, they could use a piece of string to cover the length of their circle
- The students write down the ''length'' of their circle = the **circumference (C)**
- The students also measure the **diameter (D)** and the **radius (r)** of their circle and write them dow.

Comparison and observation:

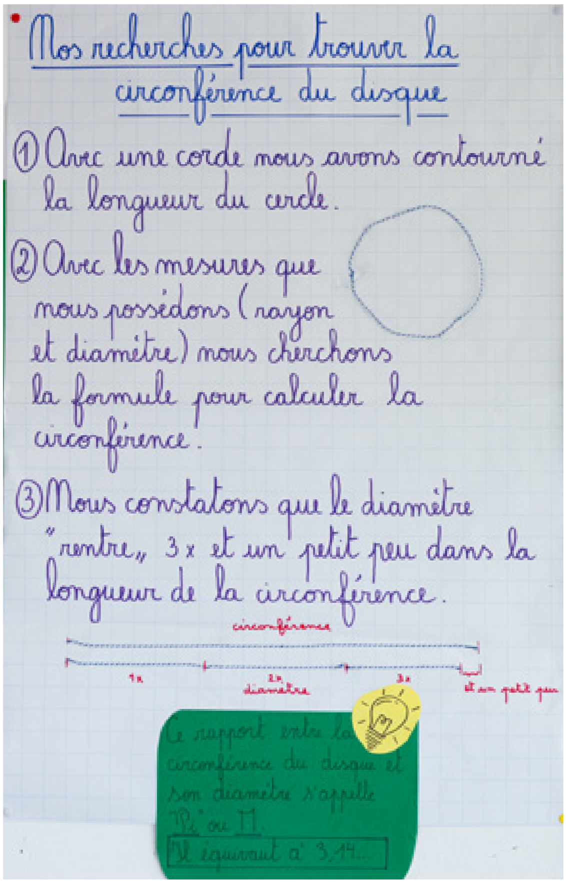
- Ask the students to compare the **diameter** of their circle with the circumference of their circle
- Students will observe that the circumference adds up to slightly more than **3 times** the diameter of the circle

Conclusions:

The teacher introduces the number Pi (π) and the formulae for calculating circumference and area:

- The ratio of the circumference of the circle to its diameter is called **Pi (π)**
- **Pi (π)** equals **3.14**
- The formula for calculating the circumference of the circle is **C = π x D**
- The formula for calculating the area of the circle is **A = π x r x r**

FIG. 13
Students take down their conclusions in a notebook



1. We put a string around the length of the circle
2. With the measurements of the radius and the diameter, we came up with the formulae for calculating the circumference of the circle made by the anemometer arms;
3. We observed that the circumference adds up to slightly more than 3 times the diameter of the circle.

SUPPORT MATERIAL FOR THE TEACHER

This Toolkit offers support material for the teacher to help implement the curriculum. It was prepared by wind energy experts and is meant to inform the teacher about the subject area of each module. This will help the teacher to plan out his/her lesson and to help them pass on this knowledge to the students. Activities in this material should make use of recycled and affordable material.

The support material contains the following and can be downloaded here

Theoretical aspects

- The concept of energy, its types and forms
- The concept of aerodynamics, how it explains the shape of wind turbine blades and their interaction with wind
- The concept of air and atmospheric pressure
- The European Wind Atlas
- How do we measure wind?
- Basic components of a wind turbine

Classroom activities & experiments

- Forms of energy
- Energy transformation
- Atmospheric pressure and wind formation

Classroom discussions

- Renewable versus non-renewable sources of energy; their advantages and disadvantages

YouTube videos

- Virtual tours inside and outside a wind turbine

Step-by-step guides and instructions

- Building a cup anemometer and taking measurements
- Building a wind turbine and making it spin
- Making a wind vane and finding the wind direction

To find out more you can use the following resources:

School resources:

- Wind with Miller
- Alliant Energy Kids
- Energy student resources
- NEED Curriculum Resources
- Wind for Schools

WindEurope LearnWind free resources:

- **Let the wind blow** book & video
  Explains climate change & wind energy

- **When I Grow up** book
  Inspires young adults to consider a career in clean energy

- **Wind Energy Basics** animation
  Teaches users about wind energy technology

- **Offshore Wind 4 Kids** workshops
  Demonstrates how offshore wind turbines work

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If you are interested in distributing or translating this Toolkit, contact yamina.guidoum@windeurope.org

If you are a teacher implementing this plan in your school, we would be happy to receive your feedback at yamina.guidoum@windeurope.org.

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