STEAM4Climate Worksheet

for students

Project: DIY Wind Turbine for older students

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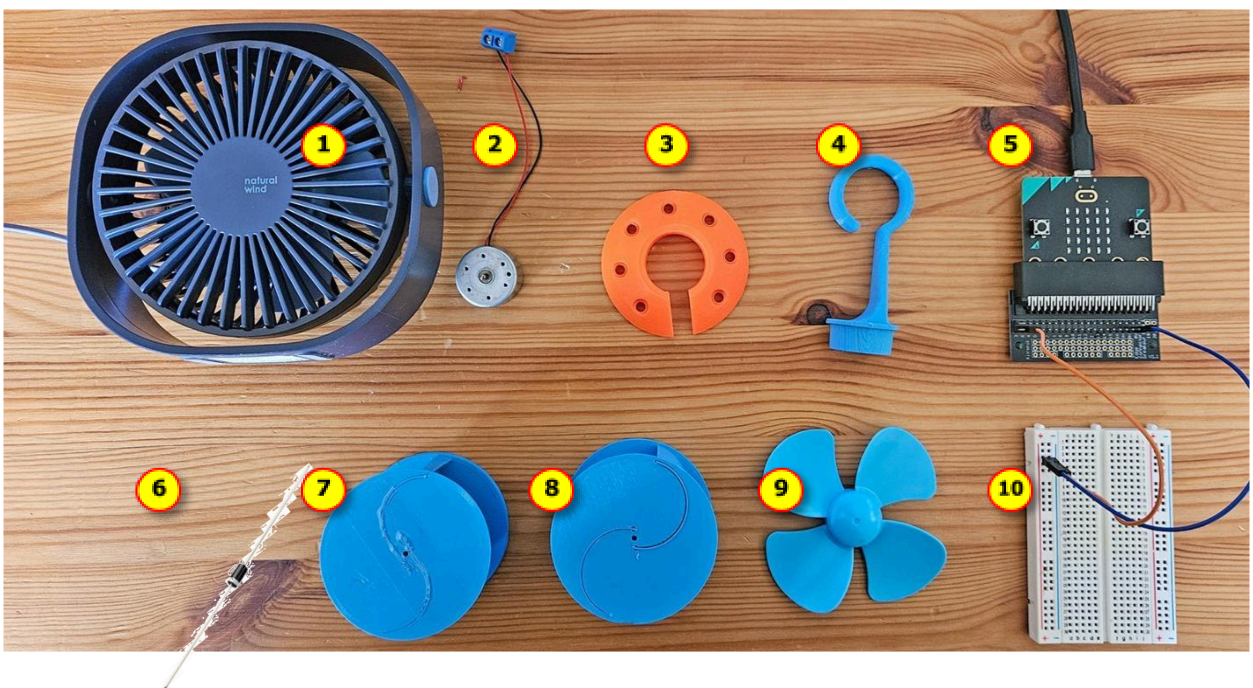
1.9 Wind turbine for older students (technology lessons from grade 9)

A wind turbine is to be built and measured. For this purpose, various wind turbine structures are tested under different conditions:

- What are the different types of turbines?
- What are their advantages and disadvantages?
- What voltage and power do they deliver,
- How easily and quickly they start,
- How does the performance depend on the wind direction,
- What optimization options are there?
- What are the possible applications of all these factors?



USB fan	Mini Generator	Floor slab	Adapter	Microbit

1	2	3	4	5
Schottky Diode (1N5817) 6	Savonius Type1 7	Savonius Type2 8	HAWT rotor 9	Breadboard 10

Tasks to prepare for the experiments:

Clarify the following important terms through research. Create a coherent text from these terms:

- Wind turbine
- generator, production of electrical energy,
- Rotor and typical rotor blades,
- buoyancy runners and resistance runners,
- HAWT (Horizontal Axis Wind Turbine), VAWT (Vertical Axis Wind Turbine),
- Power coefficient, tip speed,
- Darrieus rotors, Savonius rotors

To do this, answer the following questions:

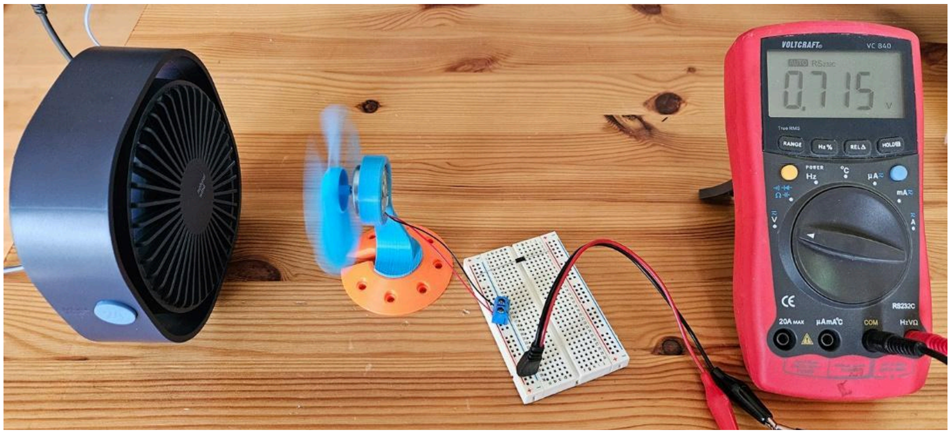
A) What is a HAWT turbine as opposed to a VAWT turbine?

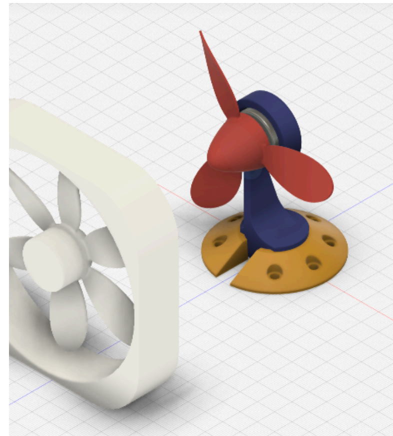
B) What do the rotor blades look like on Darrieus and Savonius rotors?

C) To which types did HAWT, Darrieus and Savonius belong: buoyancy or resistance runners? Justify in keywords.

D) What is the so-called power coefficient? Why is it important?

Experiment 1: Measurement setup with HAWT turbine and multimeter





A) Create the experimental setup shown. Work with a multimeter first (if possible), because a wrong polarity is not bad here.

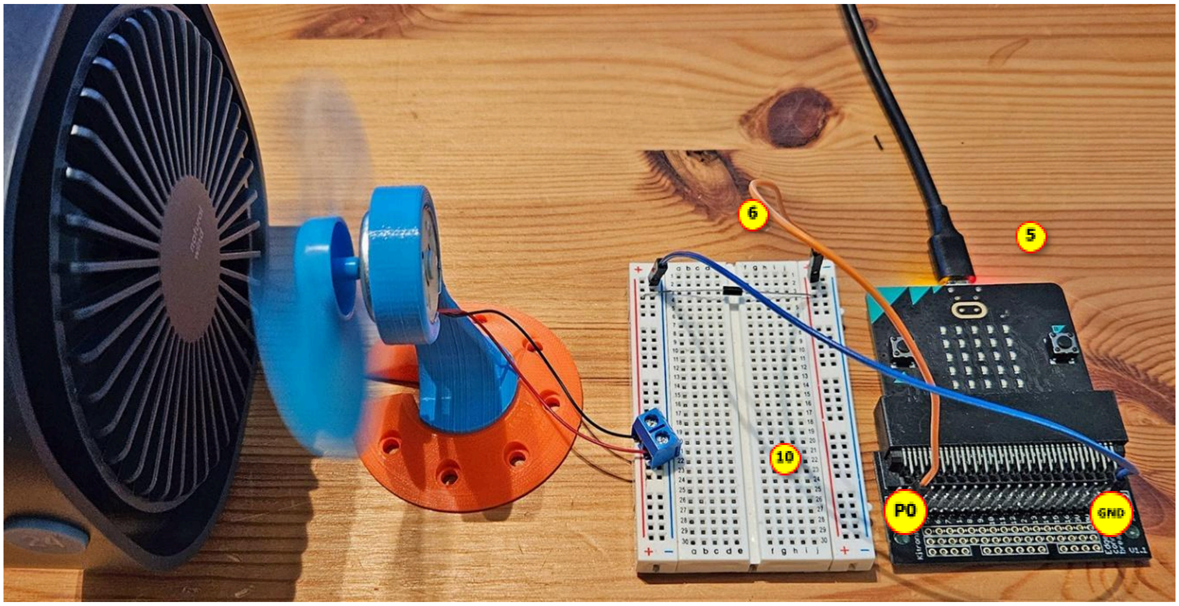
B) How are measured voltage and wind strength related? Try different distances from fan to wind turbine and different fan speed settings.

C) How does the wind turbine react if the fan does not blow from the frontal direction, but from the side?

D) Now place the fan behind the wind turbine. It should start up again with some trial and error. What value do you read from the multimeter? Pay attention to the omen!

E) Explain your observation D) What consequences does this have on the construction of a wind turbine?

Experiment 2: Measurement setup with HAWT turbine and microbit



(6) Schottky diode, protects the P0 pin of the microbit against incorrect polarity (if + and – are reversed). The diode points with the small gray circle to the orange microbit cable.

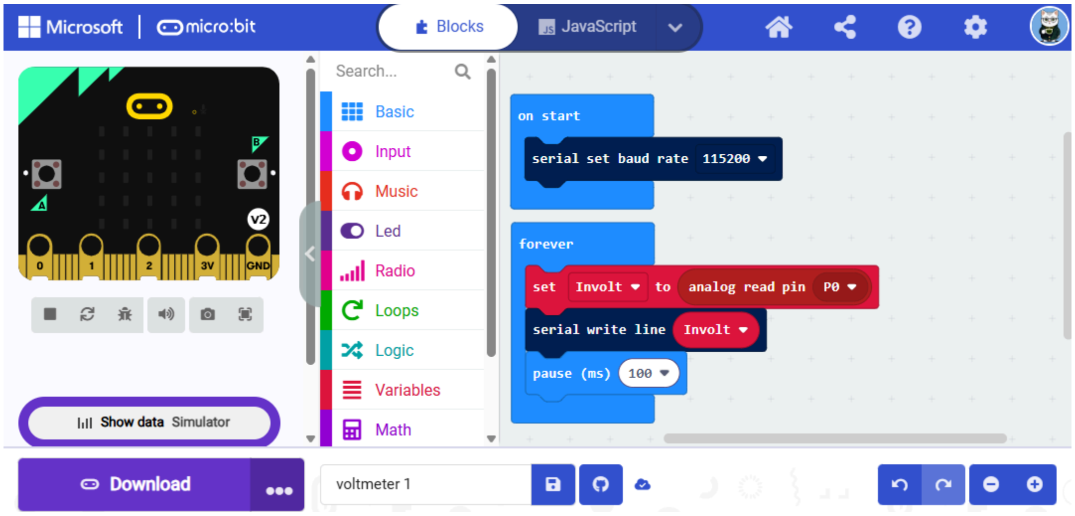
(5) Microbit switched as a voltage meter.

(P0) The P0 input of the Microbit is a so-called "analog input": It can measure values between 0 and 3.3 volts and translates this into a value range from 0 to 1023.

(GND) In order to create a closed circuit, there must be a negative terminal (referred to here as a "ground").

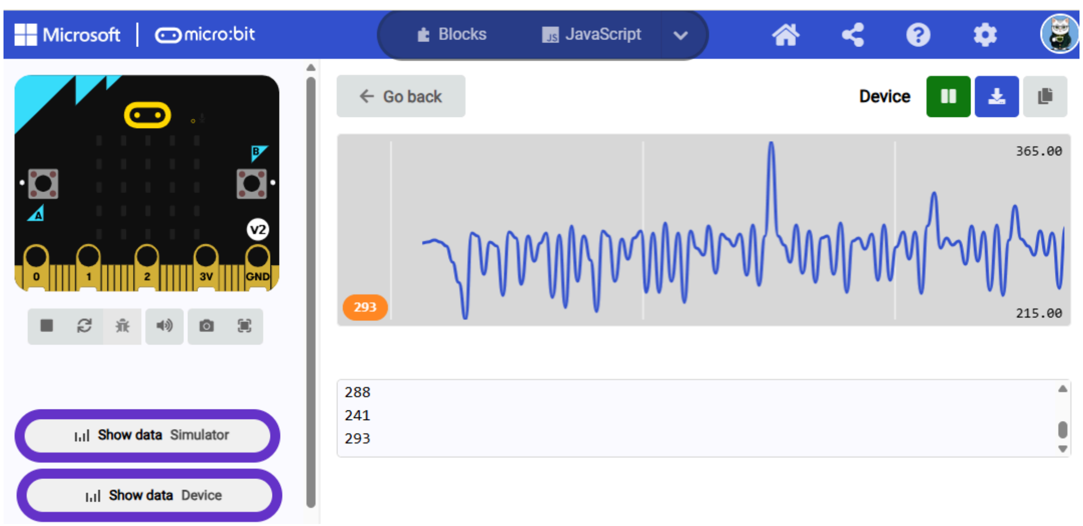
(10) On the breadboard are connected to each other: generator, Schottky diode and two cables to the microbit: One from GND to generator minus and one from P0 to Schottky diode.

Program structure:



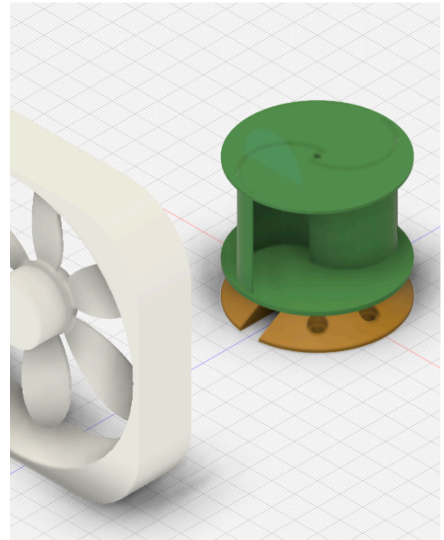
Measured values of the microbit at about 250

*(corresponds to approx. 3.3 volts * 250/1023 = 0.8 volts)*



- What measurements do you get at different wind speeds?
- Convert these readings to volts

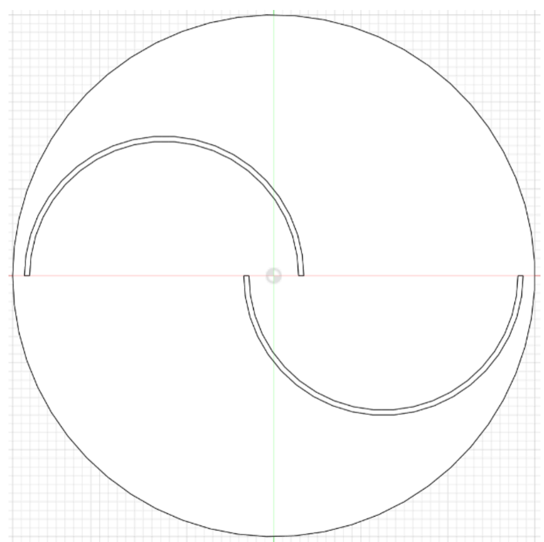
Experiment 3: Measurement setup with Savonius turbine



A) Replace the HAWT rotor with one of the different Savonius turbines.

B) Before you connect it to the breadboard: Blow against it and compare the different Savonius designs. What are the differences?

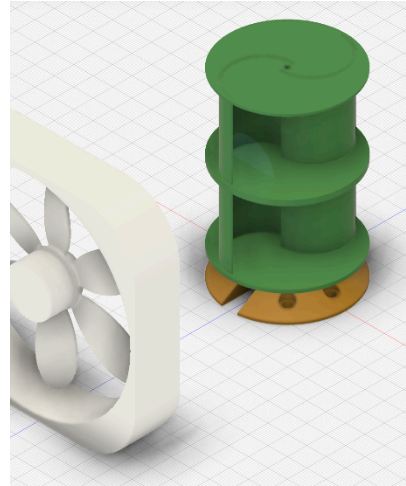
C) Can you explain these differences? Keep in mind that Savonius rotors are resistance rotors. Which path does the wind take? Draw its path through the rotor:



D) Compare the performance of HAWT and Savonius. Weigh the pros and cons against each other.

E) How to improve the disadvantages of the Savonius rotor?

Experiment 4: Measurement setup with two Savonius turbines



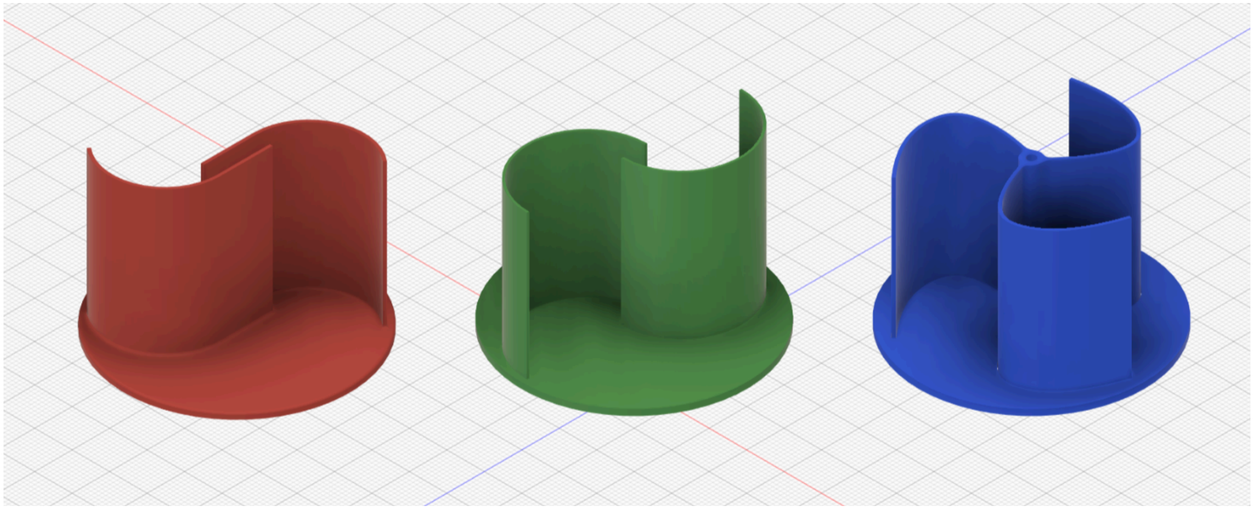
F) Fix two Savonius rotors on top of each other with scotch tape. They do not have to be strongly attached to each other.

G) Repeat the measurements from experiment 2 and compare them with each other.

H) What about the start-up ability, i.e. the willingness to start the rotational movement from a standing start?

I) Is it possible to improve this run-up ability even further? Note: Either both turbines are aligned exactly the same or they are rotated 90 degrees to each other. Which is better and why?

Experiment 5: Comparison of the Savonius Turbines



A) In the drawing above, you can see three Savonius types, all of which are the subject of current research.

B) You have already learned a lot about them from your experiments. How do they behave? Summarize these behaviors in keywords.

C) Make a drawing of the three different Savonius types as in Experiment 3.

D) Draw the path of the wind through the rotor. The rotor type on the far right is generally considered to be close to optimal. How do you judge this type?

E) The three-bladed rotor is considered the optimal type of the Savonius rotor with three blades. What does this say about the optimal number of sheets?