Wind Anemometer Activity: Teacher Worksheet

Level: Intermediate

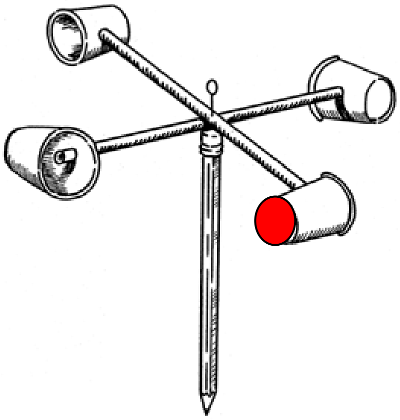
Subject: Geography and Mathematics

Duration: 1 hour

Type: Group hands-on activity

Learning Goals:

- Define an anemometer as an instrument used to measure wind speed
- Calculate the wind speed outside using the cup anemometer
- Compare the calculated wind speed to wind speed from the TAHMO station



Materials per Group:

- (1) pencil with eraser**,** (1) push pin**,** (2) Flexible straws**,** tape or stapler**,** (4) small paper or plastic cups (4)
- (1) timer or clock

Methods:

1. Working in teams of two, build a cup anemometer. Be sure that all of the cups face the same direction when assembled. You may need to tape or staple the straws together to keep them fixed at right angles. Fix the straws to the pencil eraser using the push pin, but make sure the straws can still rotate when the pencil is held still.
2. Mark one cup with a red dot or other mark, you can use this cup as a reference point when counting the rotations in the next step.
3. Go outside in a clear spot, preferably close to the TAHMO weather station. Holding your anemometer in the air, start the timer and count the number of revolutions. Record the time and number of anemometer rotations. Repeat for a total of 3 trials. Determine which direction the wind is coming from (N,E,S,W).
4. Perform the calculations below to compare the velocity from the anemometer to the velocity from the weather station.

Calculations:

We measured the number of revolutions of our anemometer. To calculate the angular velocity, we divide the number of rotations by the time. The angular velocity describes the speed at which a circle is spinning.

# Rotations	/	Time (seconds)	=	Angular velocity (rotations/second)

Now that we have angular velocity, we want to convert it into linear velocities. The speed we drive our cars or walk are both linear velocities. To convert from angular velocity (revolutions per second) to linear velocity (radians per second) we need to use to conversion 1 revolution = 2*π radian ≈ 6.28 radians. A revolution is when the cup completes a circle, traveling 360 degrees, or 2π radians. We now have the angular velocity in rad/sec, to calculate linear velocity we multiply the radius of the wind anemometer by the angular velocity. The radius of our anemometer should be measured from the center of the pencil to the center of cup (shown right), there is a ruler provided on page 1 of the student worksheet.

Angular velocity (rotations/second)	*	Conversion from (rev/s) to (rad/s)	*	Anemometer radius (meters)	=	Linear velocity (meters/second)

Students should fill out the results table on their worksheet with the # of revolutions

To find the average linear velocity of the wind using the cup anemometer, simply add the three calculated linear velocities and divide by 3.

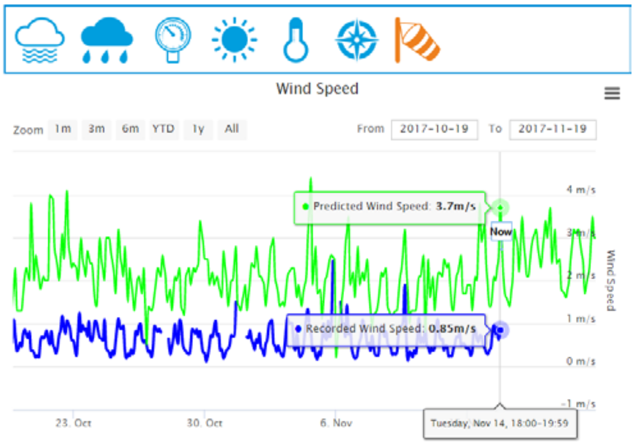
Discussion:

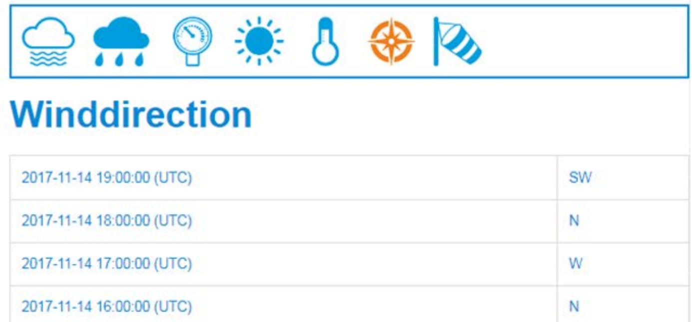
In a weather station, which meteorological variable does an anemometer measure and what are the units?

[Answer: the anemometer measures wind speed which has units of meters per second (m/s)]

What is the recorded wind speed and direction from the TAHMO weather station from the same time that the cup anemometers were tested outside?

[Answer: Answers will vary. Go to https://school2school.net/stations/ and select your TAHMO weather station. Select the wind speed variable and read the most recent wind speed measurement (this can be done by zooming to the 1 month view and then hovering your mouse over the most recent data point on the observed blue line shown in the picture below. Be sure the time of the data is the same as time that the students were taking data). Next choose the wind direction icon and record the most recent wind direction measurement- be sure the time corresponds to the time that the students were outside taking their measurements.]





Winddirection

2017-11-14 19:00:00 (UTC)	SW
2017-11-14 18:00:00 (UTC)	N
2017-11-14 17:00:00 (UTC)	W
2017-11-14 16:00:00 (UTC)	N

What was your estimated wind direction from step 3? How does this compare with the recorded wind direction from the TAHMO station?

[Answer: Wind direction changes frequently and since the data from the School-2-School website records hourly averages it may be different than the estimated wind direction from step 3.]

How does the TAHMO wind speed value compare to the calculated linear velocity from the wind anemometer? What is the percent error between the two values? To calculate percent error subtract the calculated average linear velocity from the TAHMO wind speed then divide by the TAHMO wind speed.

[Answer: Our anemometer measured wind using a physical instrument that turned in the wind, while the TAHMO weather station uses a sonic anemometer to measure wind speed. A sonic anemometer operates by measuring the time it takes for a pulse of sound to travel between two transducers, and comparing that to the speed of sound, thus making sonic anemometers extremely accurate. While answers to this question will vary, it is likely that the calculated velocity is not the same as the TAHMO recorded wind speed.]

What errors are involved with measuring velocity with an anemometer?

[Answer: There are multiple sources of error when measuring wind velocity from an anemometer, here are a few: Cup anemometers are affected by friction, so at very low wind speeds they might not rotate. Because of the design, cup anemometers won't rotate if the wind direction isn't blowing directly into one of the cups. There are also small errors associated with converting an angular velocity into a linear velocity.]

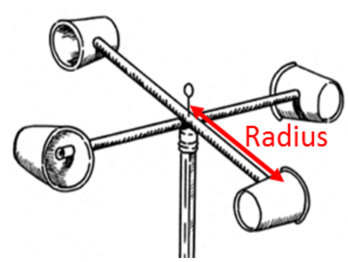
Wind Anemometer Activity: Student Worksheet

1. Working in teams of two, build a cup anemometer. Be sure that all of the cups face the same direction when assembled. You may need to tape or staple the straws together to keep them fixed at right angles. Fix the straws to the pencil eraser using the push pin, but make sure the straws can still rotate when the pencil is held still.
2. Mark one cup with a red dot or other mark, you can use this cup as a reference point when counting the rotations in the next step.
3. Go outside in a clear spot, preferably close to the TAHMO weather station. Holding your anemometer in the air, start the timer and count the number of revolutions. Record the time and number of anemometer rotations. After you have completed a total of three trails, determine which direction the wind is coming from (North, East, South, or West).
4. Perform the calculations below to compare the velocity from the anemometer to the velocity from the weather station.
5. Answer the 4 discussion questions at the end of the worksheet.

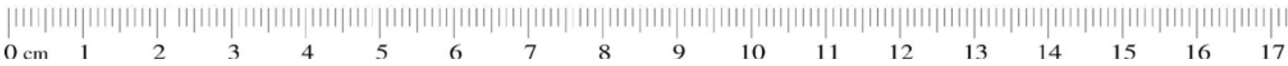
We measured the number of revolutions of our anemometer. To calculate the angular velocity, we divide the number of rotations by the time. The angular velocity describes the speed at which a circle is spinning.

# Rotations	/	Time (seconds)	=	Angular velocity (rotations/second)
_________	/	_________	=	______________

Now that we have angular velocity, we want to convert it into linear velocities. The speed we drive our cars or walk are both linear velocities. To convert from angular velocity (revolutions per second) to linear velocity (radians per second) we need to use to conversion 1 revolution = 2*π radian ≈ 6.28 radians. A revolution is when the cup completes a circle, traveling 360 degrees, or 2π radians. We now have the angular velocity in rad/sec, to calculate linear velocity we multiply the radius of the wind anemometer by the angular velocity. The radius of our anemometer should be measured from the center of the pencil to the center of cup (shown right), be sure to record your measurement in meters. You may use the ruler provided at the bottom of this page or use your own.



Angular velocity (rotations/second)	*	Conversion from (rev/s) to (rad/s)	*	Anemometer radius (meters)	=	Linear velocity (meters/second)
______________	*	2 * π	*	___________	=	_____________



Results:

To find the average linear velocity of the wind using the cup anemometer, simply add the three calculated linear velocities and divide by 3.

Trial #	Time (s)	Revolutions	Linear velocity (m/s)
1			
2			
3			
Average	------------	----------------	

Discussion:

In a weather station, which meteorological variable does an anemometer measure and what are the units?

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What is the recorded wind speed and direction from the TAHMO weather station from the same time that the cup anemometers were tested outside?

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What was your estimated wind direction from step 3? How does this compare with the recorded wind direction from the TAHMO station?

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How does this value compare to the calculated linear velocity from the wind anemometer? What is the percent error between the two values? Hint: % error= (TAHMO wind speed - average linear velocity from the table above)/(TAHMO wind speed).

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What errors are involved with measuring velocity with an anemometer?

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