Waterwheel (adapted from Teach Engineering) Teacher's Guide

Subject (Body of Knowledge): Science (Physical Science)

Big Idea (topics): Work and Power

Summary: Students will build and test waterwheels made from two-liter soda bottles

Objective(s): After completing the field lab, students will be able to:

1. Build and test a water wheel
2. Measure Work (W = Fd)
3. Measure Power (P = W/t)

Ecosystem(s): Rivers or streams

Equipment:

- Water wheels
- String (1.5 meter sections)
- Weight (1 Newton)
- Tape Measure
- 2 x Meter Sticks
- Dowel Rod (1/2 inch)
- Packing Tape
- Scissors
- Graduated cylinder
- Bucket with hole & cork
- Stopwatch
- Calculator

Background (Pre-field Classroom Activity):

- **Equipment Training**: none
- **Vocabulary**: Work, Force, Newton's, Joules
- **Reference material**: Teach Engineering: http://www.teachengineering.org/view_activity.php?url=http://www.teachengineering.org/collection/cub_/activities/cub_energy/cub_energy_lesson02_activity1.xml
- **Advanced Preparation**: Build waterwheels in advance!

Procedures (Engage; Explore; Explain; Elaborate; Evaluate):

1. **Engage**. Give the students a liter of water and ask them how they might use it to lift a 100 gram item 0.5 meters off of the ground. Let them discuss various methods they might use.
2. **Explore**.
   a. Tell the students they will use a water wheel to do "work." Explain that work is done when a force on an object causes that object to move a certain distance in the direction of the force.
   b. Students should make three different water wheels – each with a different number of fins (5, 7, 9)
   c. Have students prepare their water wheel as shown in the diagram. A 100 mg weight should be tied to a 0.5 meter string connected to one neck of the water wheel. A 2 liter soda bottle should be held about 0.5 meters above the water wheel and hold 1 liter of water to flow onto the wheel.
   d. With the string fully extended and the weight on the ground, release the water onto the waterwheel and measure the height of the weight at the highest point reached. Record the time it took to lift the weight to this point.
3. **Explain**.
   a. Answer and discuss the assessment questions as a group and allow each student to record an answer.
   b. Review the key concepts (items on pre/posttest).
   c. If time permits, explore additional ways to set up the water wheel in existing water bodies. Be careful around any water body especially deep or swiftly moving water.

Sunshine State Standards:

Science: SC.912.P.10.3; **Mathematics**: MA.8.G.5.1; **Language Arts**: LA.6.4.2.2; **Social Studies**: SS.7.G.5.1

Waterwheel (adapted from Teach Engineering) Student Data Sheet

General Information

Full Name:		Date:	
School (teacher):		Time:	

Student Hypothesis and Rationale

If there are more paddles on a waterwheel, then my waterwheel will do (more/less) Work, because . . . .

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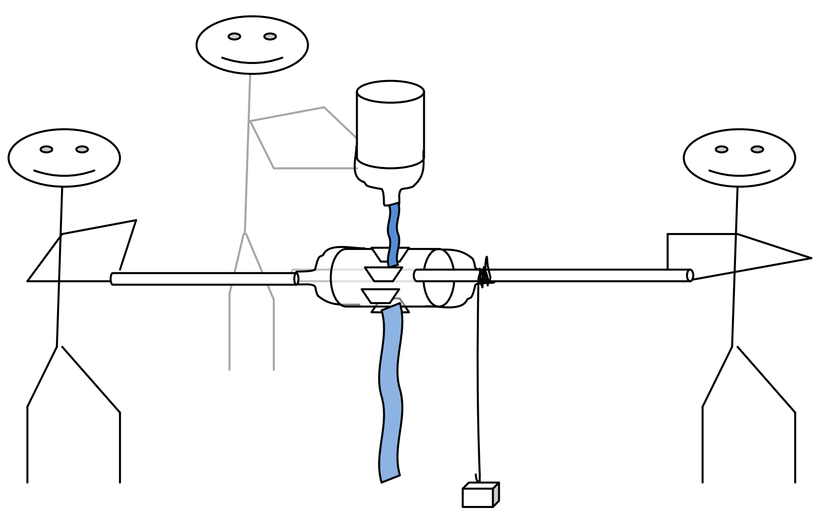
Field Observations/Measurements

# of Paddles		Force (kg x 10 = Newtons	Distance (meters)	Work (Newtons x meters=Joules)	Time (sec.)	Power* (J/s or W)
5	Trial 1					
5	Trial 2					
5	Trial 3					
7	Trial 1					
7	Trial 2					
7	Trial 3					
9	Trial 1					
9	Trial 2					
9	Trial 3					

* optional

Water Wheel Set-up:



Waterwheel (adapted from Teach Engineering) Assessment

1. Which water wheel (5, 7, or 9 paddle) did the most work?

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2. What was the difference between the most effective waterwheel and the least effective water wheel?

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3. Did your data support your hypothesis? If not, why?

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4. How would doubling the amount (and doubling the height) of water being poured on the water wheel affect the amount of work done?

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5. How could people ensure that a river had sufficient water available to run a water wheel?

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6. Based on what you learned in this lab, write a new question about something you'd like to learn more about?

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Waterwheel (adapted from Teach Engineering) — Assessment

Imagine you were given the task of building the most powerful waterwheel. What factors would be involved in making the waterwheel powerful. Describe how you would design the wheel to be as powerful as possible.

Waterwheel (adapted from Teach Engineering) Reference

Equations

Acceleration (a)	=	change in velocity (m/s) time taken for this change (s)	a =	$v_f - v_i$ $t_f - t_i$
Average speed (v)	=	distance time	v =	d t
Density (D)	=	mass (g) Volume (cm^3)	D =	m V
Percent Efficiency (e)	=	Work out (J) Work in (J) × 100	%e =	W_{out} W_{in} × 100
Force (F)	=	mass (kg) × acceleration (m/s^2)	F =	ma
Frequency (f)	=	number of events (waves) time (s)	f =	*n* of events t
Momentum (p)	=	mass (kg) × velocity (m/s)	p =	mv
Wavelength (λ)	=	velocity (m/s) frequency (Hz)	λ =	v f
Work (W)	=	Force (N) × distance (m)	W=	Fd