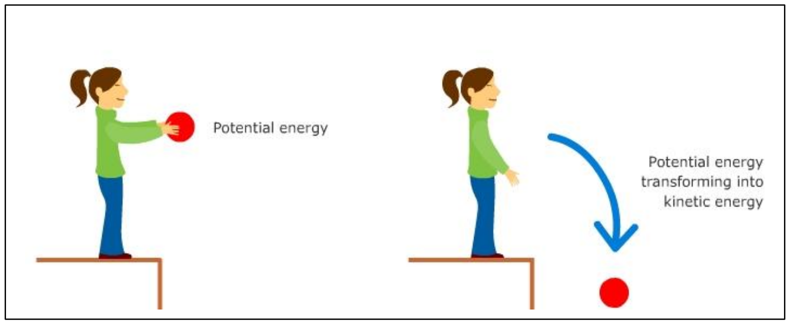
Lesson 4 Physics Experiment (All Series Combined – SS, CS, SS+, CP)

Student Challenge (Lessons 4A & 4B) Classical Physics

OBSERVE:

Look at the world around you. Where do you see moving objects? Where do you see objects "off" the floor or ground, but not moving? What happens if they fall and hit something? Take coconuts in a palm tree, for example.



1. Do coconuts in a tree have **potential energy** because they are off the ground?

Yes, these coconuts have potential energy due to gravity and to the coconut's location above the ground/surface below.

2. Does a coconut falling from a tree have the ability to: a) crack its shell; b) dent a car; c) move/roll after it falls. *If you answered "yes" to any of these, then the coconut has kinetic energy and is doing work. As it changes location, it is doing Work = Force x distance.*

ENERGY – the capacity to do work: Potential (able to do work) Kinetic (moving/working)

Observe the following. Determine whether the object has Potential or Kinetic energy.

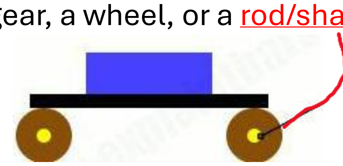
1. A Falling Rock	POTENTIAL	or	KINETIC
2. An Energy or Juice Drink	POTENTIAL	or	KINETIC
3. A Container of Water (elevated)	POTENTIAL	or	KINETIC
4. A Nearby River (flowing)	POTENTIAL	or	KINETIC

All ENERGY forms have the ability to do work or are in the process of "working."

EXPLORE:

Explore simple machines in your world by looking in your own home, garage, nature, and/or books. What makes them capable of doing work? Most will require an energy input from you (your hands, arms, feet, legs) or an energy source like a battery, gasoline, or electricity.

1. Does the simple machine/tool have a lever, a gear, a wheel, or a rod/shaft?
   Most likely, yes.



2. Can you find tools with a wedge or paddle?
   Shovels, ax, oars, fans, pry bars
3. By combining wheels, paddles, and a rod/axle/shaft, many new inventions can be created. Where have you seen paddles or wedges doing work in water or in the air? Windmills, waterwheels, and turbines

These inventions, windmills, waterwheels, and turbines, have saved mankind lots of energy by using readily available energy resources: wind and flowing water/rivers. Most attempts at inventing or "**macgyvering**" are done with one or more simple tools. Knowing how to create new "gadgets" has made survival through time possible.

EXPERIMENT: Determine how waterwheels and windmills "DO WORK."

STEP ONE: Build a framework to hold a wheel-like structure, such as a waterwheel or windmill. Make sure the wheel-like structure rotates.

STEP TWO: Determine whether the **rod/shaft/axle** of the wheel is stationary (**fixed**) to the framework or **free** to rotate with the wheel.

STEP THREE: Answer the following about the **rod/shaft/axle**:

a. Is it fixed or free? Answer depends on construction
b. Is it able to do kinetic work (is the rod/shaft/axle turning)? Answer depends on whether it turns or not
c. Does adding a gear, rubberband, or connecting rod help? Answer depends on construction or changes

STEP FOUR: Experiment by altering the design to switch the center of the wheel from fixed to free or from free to fixed. Does the rod have the potential to turn a gear or drive another rod with a strong rubber band attached? "Tinker" with your design to gain more moving parts.

EXPERIMENT #2: **Kinetic and Potential Energy conversion to Work**

Naturally moving water is the result of elevation change or pressure differences. This experiment demonstrates water's ability to do work (by transferring gravitational potential energy to water). Calories are the original source of energy to "lift" the water and slough.

SUPPLIES: water, measuring cup, wrapping paper tube (slough), cellophane (tape if desired), bottle cap, towel, and oyster crackers.

Determine the distance 10 to 50 mL of flowing water can move an oyster cracker. Start with 10, then continue adding more water as needed to travel the full distance.

STEP ONE: Create a trough or slough (pronounced "slew" meaning a channel) using a wrapping paper tube. Cut in half lengthwise.

STEP TWO: Mark a start position for an oyster cracker at 5 centimeters in from the start. Mark out 1 decimeter (10 cm) increments from start to the end of the tube.

STEP THREE: Line the tube with cellophane. Place the tube on a towel with a bottle cap to elevate it. (Measure the tube angle, if possible.)

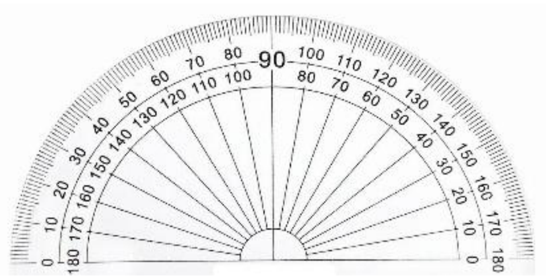
STEP FOUR: Set the oyster cracker on the start position.

STEP FIVE: Pour about 10 mL of water into the tube at the first 5 centimeters location.

STEP SIX: Measure the cracker's location change between the start and the finishing location. Try using more water to get the cracker all the way to the end.

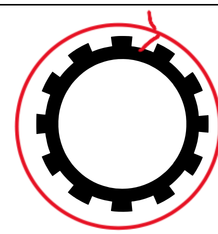
ANALYZE (add angles – elevate your slough - giving more potential to move the cracker):

Potential Energy (Gravitational) equals greater ability to do WORK. Try adding different angles to see the ACCELERATION DUE TO GRAVITY as it applies to moving your oyster cracker.
Gravity is a force. When combined with moving water, work is possible W = Fd. So, the greater the elevation, the faster the cracker should move.



Basic (SS)

Math Skills



Count RPM's

1. Try spinning a wheel (like your tinkertoy/project wheel). Count the number of full revolutions you see it make.
2. Next use a timer. See how long it takes your wheel to stop spinning (start the timer at the same time you spin your wheel). Stop the timer when your wheel stops.
3. Your answer may be something like:

   4 revolutions in 2 seconds or 3 revolutions in 3 seconds
   That's Cool. You are discovering a rate or the speed of your wheel!

Advanced (CS)

Math Skills – Codes to Know

RPM's and **rps** are code words for a rate or frequency. Revolutions per minute (rpm) or per second (rps) indicates how fast a gear, rod, cylinder, or wheel (anything that can make a 360 degree turn) is turning.

1. One important code word is **PER**. Per generally indicates **division**. Similar to how many parts per whole, a rate will give how many "________" per unit of time (minute, second, hour).
2. MPH or miles per hour is commonly used". If a car is traveling 50 mph, that means 50/hr. Therefore **"PER = /"** or "÷" with the number of miles on top and the time on the bottom.
3. If the revolutions of a wheel were 4 revolutions in 2 seconds, the rps or r/s is 4/2 or 2 revolutions per second shown as rps = 2/sec.

Match the following codes:

/	**Δ (delta)**
Per	**÷**
Change in	**=**
Product	**-**
Difference	**+**
Sum	**x or ***
Equals	

Applied (SS+)

With a vertical or 90 degree drop, water's force can easily be measured (no need to figure angular components). It's ability to work would be equal to the Force (ma) x Height (aka distance).

Problem #1: If 100 kilograms of water is released/dropped under the acceleration due to gravity (9.8 m/s^2rounded to 10 m/s^2) its force is:

Force = ma

F = 100kg x 10 m/s^2

F = 1000 kgm/s^2 or 1000 Newtons

ANSWER: 1 x 10^3 N or simply 10^3 N

Problem #2: If this 100 kilograms of water drops two meters downward into a water wheel, it is doing work (on the waterwheel). To calculate its energy/work, we need to include the distance it drops (2 m) times its force.

Work = Fd

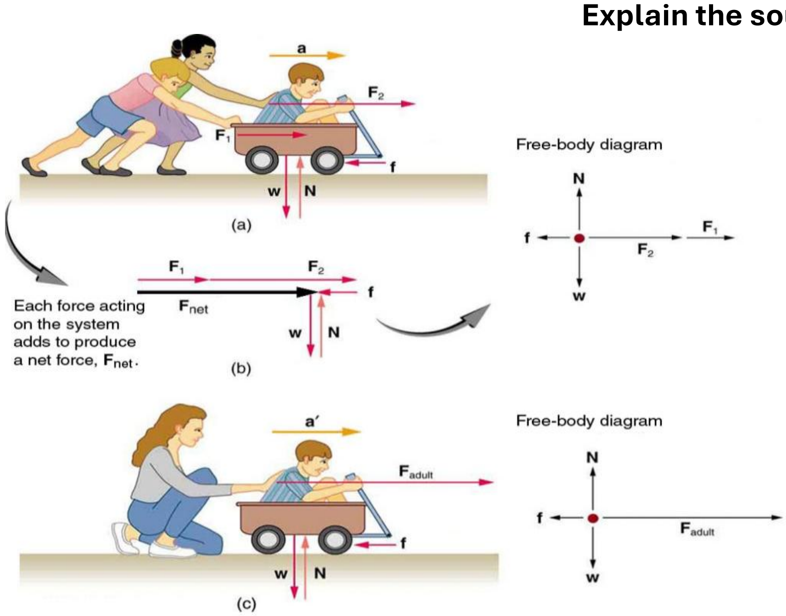
W = 1000 kgm/s^2 x 2 m

W = 2000 kgm^2/s^2

ANSWER: 2 x 10^3 Nm (Newton meters) or in Energy 2 x 10^3 J (Joules)

Compute (CP) Work Done based on Net Force Applied

Study the diagram below. Based on your understanding of forces, try to explain net forces: F = Force; W = Weight; N = normal force (Newton's Laws of equal and opposite force); a = acceleration; f = friction; F1 & F2 force applied.



Explain the source of:

1. **F1** child's (ma = force)
2. **F2** adult's (ma = force)
3. **W** weight of child/wagon
4. **a** combined acceleration
5. **N** upward push
6. **f** wheel friction/contact

Note the primary difference between the illustration and the Free-body diagram is aligning the force vectors to XY axis and a 0 (zero) origin.