

Chapter 6



Donna Calder: Marbles At Work

I am a science teacher in Chicago Public Schools. I have been teaching for 9 years and it has been a very challenging and rewarding experience. In the laboratory, students engage in hands-on activities that help them better understand the world around them. Students become scientists through exploration, questioning, and experimentation. I continue to be a learner by participating in quality professional development that helps me master my craft. As the world is always changing, so does our approach to teaching. It is crucial to stay current and creative to engage students in problem-solving techniques like questioning new situations by applying acquired knowledge. Children are naturally inquisitive so critical thinking skills are practiced as the student's work through different problems. I encourage students to look at their world through a different lens and think about what they see.

Marbles At Work

Grade Level: 4-8

Content Area Topic: Science(Energy)

Content Area Standard(s):

- MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- MS-PS3-2: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Learning Objective(s): SWBAT

- Learn how potential energy transforms to kinetic energy
- Be able to explain work in a scientific context
- Manipulate variables and test hypotheses

Suggested Time Allotment: 45 minutes

Sequence in Learning: Students have received an introduction to energy. Energy can take on many different forms (e.g. thermal, sound, mechanical, etc.), but it can neither be created nor destroyed. Most forms of energy are a type of kinetic or potential energy. Kinetic energy, or moving energy, is the energy something has because of its motion—the energy a marble has when it is rolling on the floor. Potential energy is the energy that comes from the position of one object relative to the position of another—the energy a marble has when it is being held at the top of a ramp. In a scientific context, we do work when we apply force on an object and that object moves in the direction of the force you exert on it. For instance, when you push a marble and roll it across the floor, you are doing work which equals the change in kinetic energy of the marble—the marble moves!

Below is the formula for gravitational potential energy (in joules), where m is the mass of an object in kilograms, g is the acceleration due to gravity (9.8m/s^2), and h is the height of the object above the surface:

Gravitational potential energy = mgh

The amount of gravitational potential energy an object has depends on its mass, and its height above the Earth's surface—the greater the height and the mass, the more gravitational potential energy the object has.

The kinetic energy of an object depends on the mass of an object (m) and its velocity (v):

$$\text{Kinetic Energy} = 1/2 mv^2$$

The greater an object's mass and velocity, the greater the kinetic energy

Students will understand that mechanical energy allows objects to do work, which is a way of transferring energy from one place or form to another. Through these activities, students will realize that mechanical energy is all around them.

Materials & Resources Needed:

- Per Group:
- A couple of thick books
- 3 marbles
- 1 ruler (ramp)
- 1 paper or Styrofoam cup,
cut in half lengthwise
- Tape
- Stopwatch
- Vocabulary List
- Worksheet

Lesson Activities & Sequence:

WARM UP (5 minutes)

Ask students if they can define what the word work means. Students will likely come up with definitions that correspond to the everyday use of the word work - "I worked really hard on that project" or "my parents went to work today". Explain that the definition of the word work in the context of science is different: in science, work is when we use a force to move an object. Give students a few seconds to think about this while you write the definition on the board. Now push really hard to move an object that won't move (like a wall). Ask students if you did work. If they say yes, point to the definition on the board and ask if the wall moved. Now take a pencil and push it so that it rolls across a table. Did you do work that time? Explain that energy was transferred from you to the pencil. The pencil got kinetic energy — energy of motion — from you and moved: you did work!

Students will prepare for group work and check poster for job assignments for that month. Groups of four at each table have assigned animals based off of classification. Students will determine what job they are responsible for based off the poster. For example a picture of a bat will look for the mammal assignment for that month. It could be the leader, getter, recorder, or the clean machine (each job is defined in a poster that has already been established in class)

Leader runs the activities/Getter retrieves all supplies/recorder completes activity sheet and reports out/ clean machine times the activity and cleans and puts materials back in proper locations. **5 minutes**

Activity

Part I Explore (3 minutes)

1. Place one of the half cups on its side on a smooth, level surface, so that it makes a cave with an opening on one side.
2. Take turns to roll a marble into the open end of the cup, and observe what happens when...
 - ... the marble hits the back of the cup
 - ... the marble is rolled at different speeds
 - ... the marble is rolled from different distances of the cup

Part II: Height (5 minutes)

1. Stack 3 books on a level surface (a desk or the floor). Lean the ruler on the books so it makes a ramp. The ruler should be placed so that the lower numbers are at the base of the ramp. Fix the ruler in place with tape so it will not move from one experiment to the next
2. Place a half cup at the base of the ramp so that a marble rolling down the ramp will enter the cup and push it.
3. Position one marble at the top of the ruler (30 cm) and let it go.
4. How far did the cup move? Measure from the base of the ramp to where the cup came to rest. (NOTE: the cup may be at an angle to the ramp, so measure from a line that crosses the midpoint of the cup edge—see image on the next page)
5. Repeat the experiment 2 more times, so that you will have 3 measurements. Average your 3 measurements.
6. Now release the marble from $\frac{3}{4}$ of the way up the ramp (at 22.5cm), halfway up the ramp (15 cm), and $\frac{1}{4}$ of the way up the ramp (7.5 cm). Be sure to release the marble three times from each position on the ramp, and calculate an average.
7. Record all your measurements on the Student Worksheet table.

Part III: Mass (5 minutes)

1. Repeat the experiment above releasing 2 marbles together, instead of just 1. Place the marbles one behind the other on the ruler, making sure that the lead marble is at the correct spot on the ramp (i.e. 30, 22.5, 15, and 7.5 cm).
2. Record all your measurements on the Student Worksheet table.

Part IV: Velocity (5 minutes)

1. Take away the cup from the ramp setup.
2. Measure a distance of 1 meter from the base of the ramp. Mark that distance with tape.
3. Use a stopwatch to time how long it takes for a marble to go from

the base of the ramp to the 1-meter mark. Release the marble from the top (30cm), 3/4 of the way up (22.5 cm), half way up (15 cm), and 1/4 of the way up (7.5 cm). Make sure that you repeat the experiment 3 times at each ramp height.

4. Record all your measurements on the Student Worksheet table.
5. Calculate the average time of all three trials.

Proficiency:

10 minutes: Exit slip is completed worksheet. Student groups that complete 80% of the worksheet meet the level of success.

Some possible misconceptions:

Objects that are dropped do not have motion energy. For example, a dropped object doesn't have motion energy because gravity is just pulling it down.

Energy is associated mainly with human beings, not inanimate objects.

A lighter object has more motion energy than a heavier object because lighter objects move faster than heavier objects.

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Additionally, students should complete the following task:

5 minutes: Each group will have to report by answering two of the five questions

1. Which marble has the most kinetic energy—one moving fast or one moving slowly? The one moving fast has the most kinetic energy.
2. How did you measure the amount of energy a rolling marble has? By measuring how far the marble(s) pushed the cup or measuring how long it took the marble to reach the one meter mark.
3. How did the height from which the marble was released on the ramp affect how much the cup moved? The cup moves a longer distance when the marble is released from a higher point
4. How did the number of marbles (mass) released from the ramp affect how much the cup moved? The more marbles we used, the cup moved a longer distance.
5. Which marble moves faster (has the greatest velocity) - one released from the top of the ramp, or one released from the middle of the ramp? The marble that is released from the top of the ramp.

Feedback

Teachers As Learners:

I really like the sequence of these investigations.

After every part, bring it back together whole group, journal, etc. allowing students to connect it back to energy. Helps adjust for

misconceptions. Usually time is a restraint so maybe I could break into two lessons. Kids need that prompting to figure out what are they doing with these marbles. As the groups are working the teacher is facilitating by visiting each group and probing with questions regarding the vocabulary related to energy. I often forget when doing big inquiry lessons, that you need to bring it back together, so that kids don't get carried away. Very important to time activities and circulate around the classroom to keep students on task.

Elements of Pretty Good Practice:

- Guided Inquiry allows students to question and test building knowledge to what they already know.
- Hands-on gives student to exposure of doing.
- Collaboration provides students opportunity to teach and learn through their peers.

Modifications and Adaptations:

I also like the idea of having a community space to write/post summaries of each section. This is excellent. I will create this space for the beginning of year. I wonder if you use a spring so you can exert the accurate amount of force for each trial run, to reduce the amount of error. Differentiated Instruction:)

Questions Arisen:

- How does this relate to energy?
- Why don't we stop at each part to make sure students understand each part of inquiry?
- What is gravitational potential energy?

Bibliography:

Barry, P. (n.d.). Museum of Science and Industry | Home. *Welcome to The Museum of Science and Industry*. Retrieved July 12, 2014, from <http://www.msichicago.org/>

Related Resources/Ideas:

- Museum of Science and Industry Exhibits
- Science Storms
- Jolly Ball
- Student Worksheet