

Teacher Materials

The Eli Whitney Museum Whitney Relay program can be used to serve science curriculum goals or to provide an opportunity for students to develop creative thinking and problem-solving skills. For older students, you might adapt your discussion of the program to focus either on energy or force & motion, depending on your current unit of science study.

As a follow-up to the **Whitney Relay** program, you might:

- Use the student sheets to assess your students' ability to apply formal scientific terms to the Whitney Relay machines.
- Conduct investigations using the ramps and marbles. See Investigations with Ramps (pages 2&3) for a possible series of investigations.
- Have students identify the simple machines used in the project (inclined planes and in some cases levers) and plan how they could add simple machines to a complex machine using the Whitney Relay parts.
- Have your students continue to add parts to create more complex machines (see our website, <http://www.eliwhitney.org/schoolprograms/marble.htm>, for videos showing interesting projects using the Whitney Relay parts and other common materials).

Using the student sheets with your students

Encourage students to be as specific and detailed as possible. In both the case of force & motion and energy, there are important details that students may overlook at first glance and can be challenged to find and include.

Example answers for Force and Motion Study

Point 1: Before the finger touches the marble, the forces on it are balanced and it is still. The force of gravity pulls the marble down the ramp, but the craft stick exerts a force against it and prevents it from moving. The finger exerts a force on the marble and pushes it over the craft stick. Then there is no force to act against gravity and the marble accelerates down the ramp.

Point 2: Before the marble hits the block, the forces on the block and the second marble are balanced and both are still. When the marble hits the block, it starts to tilt. Then gravity continues to pull it downward and it falls. It hits the second marble. When the marble moves over the craft stick, the forces on it are unbalanced because there's nothing pushing against gravity. The marble will accelerate down the ramp.

Example answers for Energy Study

Point 1: Before the finger touches the marble, it has potential energy because it is above the ground. When the finger pushes it over the craft stick, its energy is transformed to kinetic energy and it moves faster and faster, but some of its energy is transformed into heat because of friction.

Point 2: Before the first marble hits the block, the block and the next marble have potential energy. When the marble hits the block, it transfers its energy to the block. Also, the block's potential energy is transformed into kinetic energy. When it hits the marble, the block's energy is transferred to the marble, which gets it moving over the craft stick. So it has kinetic energy from the block but also gains more kinetic energy as its potential energy is transferred into kinetic energy. Some energy is also transformed into heat because of friction.

Investigations with Ramps

We have designed the project below to provide an opportunity for students to develop inquiry thinking skills as they use their Whitney Relay materials to further explore motion and the transformation and transfer of energy. We have based our investigation on the Curriculum-Embedded Performance Task model. In this investigation, students are asked to think about whether the height of the ramp is important.

As with other investigation experiences, we expect that students will need support to structure their exploration, investigation, and writing. We encourage you to adapt the investigation below to fit your classroom routines and students' needs.

Student Investigation

Do you think that the slope of the ramp (how steep it is) matters? Does a marble going down Ramp 1 have more energy than a marble going down Ramp 2? Does it transfer more energy to another marble?



Conduct investigations to find out whether the slope of the ramp is important in your machines.

Materials: three ramps, two marbles, different sized blocks to put in the notches under the ramps.

Investigation 1:



1. Set up Track 1 with one with a medium block under one end. Set up Track 2 and 3, so that they are completely level and continuous. Place a marble directly over the notch at the start of Track 2. Construct a pushing trigger from a dowel and two circular pieces of wood and place it against the marble with its other edge resting at the bottom of Track 1.
2. What do you think will happen when you release a marble from the top of Track 1? Why?
3. Release Marble 1 from the top of Track 1. What happens?
4. What do you think would happen if you changed how steep Track 1 is? Would a steeper or a less steep track cause a difference in the motion of Marble 2?

5. Design an investigation that will help you find out whether the angle of Track 1 matters. Identify your independent and dependent variables, as well as variables that you will want to keep constant.
 - How will you know whether the angle of Ramp 1 is important to the motion of Marble 2? What will you measure?
 - What will you need to keep the same as you conduct your investigation? How will you make sure to keep these variables constant?
 - Will you need to conduct more than one trial with each ramp height?
5. Write your procedure, including enough detail so that someone else could repeat your experiment.
6. Create a data table so that you can record your results in an organized way.
7. Do your experiment and record your results.
8. Analyze your data. Does it seem consistent? Do you need to conduct more trials? How can you best present your data so that others can quickly understand whether the height of Track 1 matters?
9. Interpret your data. What conclusions can you draw about the height of Track 1?
10. Present your findings and conclusions.

Investigation 2:



If you use a block as a trigger, would you expect the same effect of ramp height that you found in Investigation 1?

Conduct an investigation that would allow you to answer this question. Design a procedure, conduct your investigation, and analyze and present your findings.

Investigation 3:

What question do you have that the ramps and marbles can help you answer? Design your own experiment to answer your question.