WHITNEY RELAY GRADES 3 – 5

The Eli Whitney Museum Whitney Relay program can be used to serve science curriculum goals in the area of force and motion and/or to provide an opportunity for students to develop creative thinking and problem-solving skills.

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

- Use the student sheet to assess your students' ability to apply formal science concepts to the Whitney Relay machines.
- Have students describe their experience in writing. See the student sheet for a possible prompt.
- Conduct investigations using the ramps and marbles. See Investigations with Ramps for a possible series of investigations.
- 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

Using the student sheet encourages students to apply the terms that are part of a force and motion unit to the experience they've had with the Whitney Relay. Depending on the needs of your class, you might have students analyze the details, set up the same switch and test it or have them complete the questions using the photograph as a guide.
Students with a developed understanding should realize the gravity is always an important force, not just when the marble is moving down a ramp. The force of gravity can be considered before Eli lets go of the marble and in the motion of the block that acts as a trigger.

Students' experiences building the machines are often emotionally rich and provide opportunities to explore aspects of problem solving, including frustration, satisfaction, the excitement of new ideas, tinkering until something works, and recognizing and building off others' interesting ideas. Asking students to discuss and write about this experience gives them an opportunity to consider and reflect on the process of invention and problem-solving.

Sample Correct Responses to Content Questions

1. Before Eli lets go, the marble is not moving. The force of gravity is pulling it down, but Eli is holding it up.

2. When he lets go, it moves faster and faster because of gravity. (Students may mention that the force of friction as a force acting against the motion, however, it is the less significant force at play.)

3. When Marble 1 hits the block, the block will fall. Marble 1 exerts a force on it when it hits it. Also, the force of gravity will cause the block to fall once it is pushed a little.

4. The block will hit the marble and the marble will start moving. Students should notice that the second ramp is flat. Therefore the marble will slow down after it starts moving, because of the force of friction. It may even stop before it reaches the end of the ramp.

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Investigations with Ramps

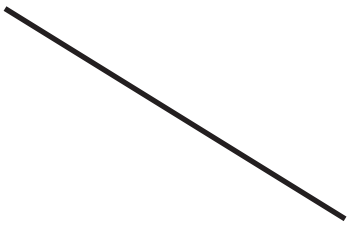
We have designed the project below to provide an opportunity for students to develop inquiry thinking skills as they use their Whitney Relay materials and further explore force and motion. In this investigation, students are asked to think about whether the height of the ramp matters. We have based our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

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 Investigations

Materials Needed: Students' Whitney Relay kits, rulers or other measuring tools
Time: At least two or three 45-60 minute class periods

1. Ask students: *Do you think that the slope of the ramp (how steep it is) matters? Will a marble going down Ramp 1 push another marble with more force than a marble going down Ramp 2?*

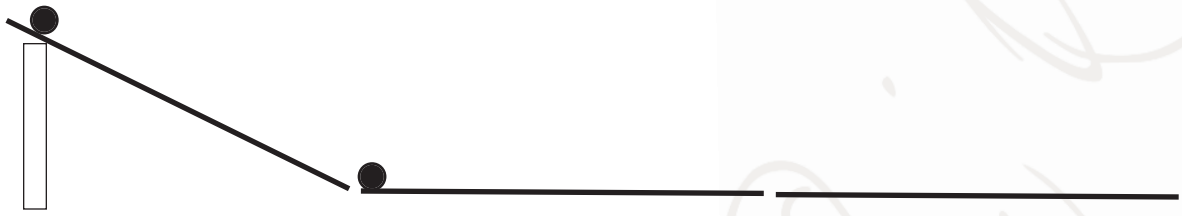


Ramp 1

Ramp 2

2. Help students plan an investigation to test out their predictions.

- If students need help to structure their thinking, we suggest showing them a setup like the following using two marbles and three ramps. The motion of Marble 2 will be slowed by friction. Students can estimate the amount of force applied to the marble by how far it travels before it stops.



- Have students brainstorm ways to have the first marble push the second. Some possibilities might be: pushing it directly, using a pusher made of a dowel and two circular pieces of wood, and using a domino. It is helpful if you test out these ideas ahead of time – there are some results which may be surprising.

Investigation 1: Marble 1 Hits Marble 2

1. Have all students plan an investigation where Marble 1 hits Marble 2 directly.
- Ask students to think about how they will change the angle of Ramp 1. How will they keep track of how high it is?
- Ask students how they will keep track of how far the marble travels.

2. Have students record their planned procedure in their notebooks
- You might want to ask students to write the materials they will use, describe their procedure, and construct a data table to record results.

Sample Data Table

Height of Ramp 1	How far Marble 2 travels

3. Have students carry out their investigations in teams and record their findings.

4. As a class, share results and discuss any surprises or discrepancies in the data.

Investigation 2: Using a Trigger

1. Have students decide on one of their triggers (the domino, a pusher, etc) to test.

2. Ask them to predict whether they will see exactly the same results with this trigger.

3. Discuss which variables they will want to keep constant (the heights they test, using 2 ramps at the end, etc.

4. Have students record their planned procedure and a data table in their notebooks.

5. Have students carry out their investigations in teams and record their findings.

6. As a class, share results and discuss any surprises or discrepancies in the data.

Notes:
This is an investigation that can be structured as much or as little as you want, depending on the needs of your class. Some interesting possibilities include:
- Placing a ruler, other system for measuring, along the second track and recording the distance the second marble travels.
- Agreeing on the ramp heights to test so that results can be easily compared. Deciding on a shared system for measuring ramp height.
- Comparing results when Marble 1 hits Marble 2 with different triggers; Marble 1 hits a dowel pusher; Marble 1 hits a domino etc. and discussing why each investigation produces different results.
- Discussing the importance of controlling variables.

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