

Investigation 3

Block Busters

Author

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Subject

Physical Science

Grade Level

4th grade or 1st semester of 5th grade

Driving Question

How is the motion of an object affected when it moves on different types of surfaces?

Abstract

Students use a block of wood and a string to create their own investigation of the different amounts of force it takes to move the block of wood when it is on different surfaces (wood, straws, marbles, dish soap, sandpaper, wax paper).

Michigan Curriculum Framework Science Benchmarks

<http://www.miclimb.net/content/main.html>

Constructing New Scientific Knowledge Benchmarks:

I.1.E1 Generate questions about the world based on observation.

Key concepts: Questions lead to action, including careful observation and testing; questions often begin with, “What happens if...?” or “How do these two things differ?”

Real-world contexts: Any in the sections on Using Scientific Knowledge.

I.1.E2 Develop solutions to problems through reasoning, observations, and investigations.

Key concepts: Observe, predict, collect data, draw conclusions, conduct fair tests; prior knowledge.

Real-world contexts: Any in the sections on Using Scientific Knowledge.

I.1.E3 Manipulate simple devices that aid in observation and data collection.

Tools: Various data collection tools suitable for this level, such as hand lenses, etc.

Real-world contexts: Any suggested in Using Scientific Knowledge benchmarks for which students would design and/or conduct investigations.

I.1.E4 Use simple measurement devices to make measurements and investigations.

Key concepts: Measurement units—milliliters, liters, teaspoons, tablespoon, ounce, cup, millimeter, centimeter, meter, gram.

Real-world contexts: Making simple mixtures, such as food, play dough, papier mache; measuring height of a person, weight of a ball.

I.1.E.6 Construct charts and graphs and prepare summaries of observations.

Key concepts: Increase, decrease, no change, bar graph, data table.

Tools: Graph paper, rulers, crayons.

Real-world contexts: Examples of bar charts like those found in a newspaper.

Reflecting on New Scientific Knowledge Benchmarks:

II.1.E.1 Develop an awareness of the need for evidence in making decisions scientifically.

Key concepts: data, evidence, sample, fact, opinion.

Real-world contexts: Deciding whether an explanation is supported by evidence in simple experiments, or relies on personal opinion.

Using Physical Science Knowledge Benchmarks:

Motion of Objects IV.3.E.2 Explain how forces (pushes or pulls) are needed to speed up, slow down, stop, or change the direction of a moving object.

Key concepts: Changes in motion—speeding up, slowing down, turning. Common forces—push, pull, **friction**, gravity. Size of change is related to strength of push or pull.

Real-world contexts: Playing ball, moving chairs, sliding objects.

Big Ideas

When forces (pushes or pulls) are applied to an object, the object speeds up or slows down (depending on the direction of the force). Friction with the surface slows down the moving object. Different surfaces slow the object more than others, that is, some surfaces provide more friction than others.

Prerequisites For Students

Students should have learned these concepts in previous investigations:

- A force is a push or a pull.
- Forces differ in strength and direction.
- An object at rest can only be set in motion by applying a force to it.
- An external force applied to a moving object is needed to change the object's motion.

Estimated Time Needed

Four classes of approximately 50 minutes

Background Information

People are inherently aware of friction, even if they have not given it much thought. We all know that things slide easily over an icy sidewalk, but the same sidewalk is not at all slippery when dry and clear. A child can slide horizontally across an icy sidewalk on her shoes, but when the sidewalk is dry and clear, those shoes prevent her from sliding. What we are observing is that the amount of force needed to cause the horizontal movement of an object is related to the type of material on which an object is resting.

Motion is a change in an object's position. It can be in a straight line, or the object can change directions. An object can go at a constant speed or it can speed up/slow down. One of the goals

of elementary science is to help students learn to *describe* motion carefully, using references such as the compass directions, right/left/up/down, points of reference in the given context, etc.

Forces are needed to start the motion of an object or change its motion. This includes slowing an object down or making it stop.

Most people usually think that objects stop moving on their own. But in a place where there is no friction, objects continue moving once they've started, with no force needed to keep it moving! Friction is the force that slows down objects when they move over surfaces.

Friction acts on an object when it rubs against another object or material. Friction is involved anytime we try to move an object across a surface. The force needed to move an object in one direction (the push or pull) is opposed by the force of friction in the opposite direction. This means that a force is always needed to keep an object moving if friction is acting on the object.

The force of friction depends on several factors: the weight of the object; the type of contact surface; whether the object is sliding or rolling. The force needed to overcome friction is far less for a rolling object than it is for a sliding object. It is also greater when starting motion than it is when maintaining motion.

In this lesson, students will have the opportunity to discover several of these concepts. At this point, they do not need to know what coefficients of friction are, but they will learn that different surfaces have different forces of friction. They do not need to know how to calculate the amount of force needed to move their wooden blocks, but they may observe that it is less when the block is placed on rolling surfaces, like marbles or cut-up straws laying on their sides. They may even be able to grasp how the force of friction depends on gravitational force, with adequate discussion.

This lesson gives each student group a chance to design and conduct an investigation to answer the question, "How do different surfaces affect the amount of force needed to move a block over the surface?" Students develop and test hypotheses, collect evidence, draw conclusions and then present their results.

Teacher Page 3-1 gives a sample of how a student group might fill out Student Page 3-1, involving investigation design. Teacher Page 3-2 is an example of a Research Methods page. Teacher Page 3-3 gives an example of the group's Data Collection, and Teacher Page 3-4 is a sample Conclusion. These are meant to be used as examples, not as instructions for any group's investigation.

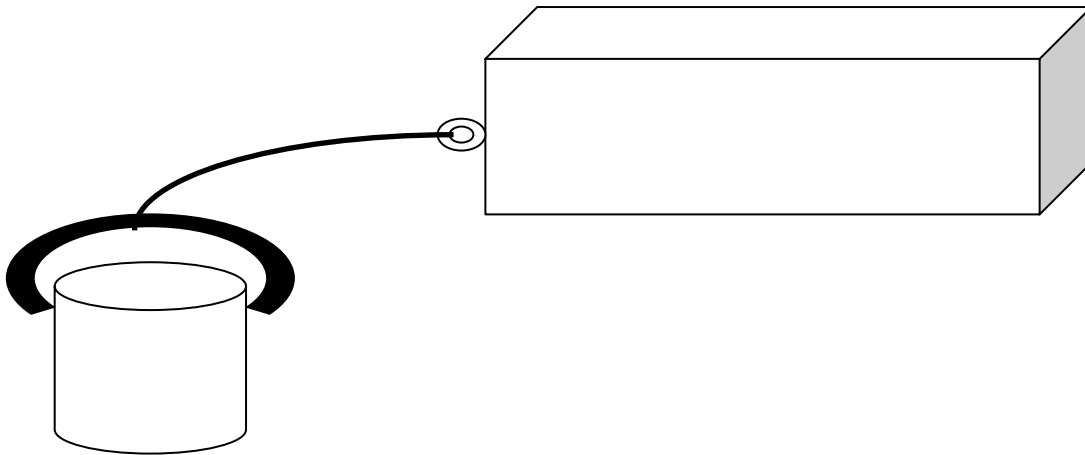
Student groups may come up with many other investigations besides the example given, such as counting the number of washers that can be put on the block to prevent its movement over different substances when the cup is weighted with a certain number of washers. Students may have completely different ideas about how to design an investigation. This is to be encouraged.

Materials List***For each student group of 3 or 4***

- 1 block of wood with sand paper on one side and an eyehook on its end
- 1 plastic cup with handle
- 1 piece of string, 1 meter long
- 1 piece of wax paper
- 2 wide rubber bands
- 40 washers
- 1 roll masking tape
- 1-meter stick
- 1 pair of scissors
- 4 marbles
- 10 straws
- dish soap
- different grades of sand paper
- stopwatch (optional, if requested by students)
- 1 copy each of Student Page 3-1 and Student Page 3-2 (have extras on hand)

Advance Preparation

Attach the string to the eyehook on the block. Using the pipe cleaners, make a handle on each plastic cup by poking two holes near the top of the cup. Attach the other end of the string to the pipe cleaner handle.



Procedure

Part 1: Student Exploration (Day 1)

1. Tell the following story to the students: Elena wanted to move a big, heavy box from her room to another room, which was down the hall and around a corner. She tried pushing on it but could only move it a couple inches. She found a friend to help her, but even with the two of them working together, it was hard to move.

They thought that maybe it would be easier to push the box once it was into the hall, because the hall did not have carpeting. But they still couldn't get it that far!

2. Ask students to brainstorm ways that Elena and her friend might move the box more easily. Allow any suggestions. Keep track of students' suggestions on the board.

Student suggestions will include getting additional people to help, using some kind of machine or ropes, perhaps putting it on a cart. Ask them to think about ways to move the box without additional people, and without machines. Steer them toward thinking about how the carpet makes it hard to move the box, and what they might do about that. Help them focus on the surface on which the box slides.

(This is also a good scenario for developing investigations about ropes and pulleys – a simple machine that can exert more force on the box than the individuals pushing on it. However, the investigation below is designed to help students learn about friction, so if students want to conduct investigations with pulleys, have them do that another day.)

3. Divide the class into groups of three or four students. Review students' ideas about the surface that the box slides on and friction. Tell them that they are going to explore how friction works, to help them find a solution for Elena.
4. Ask the students to rub their hands together and describe what they observe. Encourage the students to describe their observations to each other in small groups using their own terms.
5. Ask the students to rub their hands over the surface of the desk and describe their observations to each other.
6. Distribute four marbles to each group. Ask the students to place the marbles under the palm of their hands and move their hand in a rubbing motion on the desk. Have them discuss and describe their observations within their groups.
7. Place one to two teaspoons of dish soap on the surface of the desk and have students rub their hands on the desk where the soap is. Have students wash their hands, then let students discuss and describe their observations in their small groups. Wipe off dish soap.
8. As a whole class, discuss and describe student observations of the different things they tried. Record their ideas on newsprint. Save this piece of newsprint to revisit at the end of the

activity. (Students should have observed that it gets easier to move their hands over each new surface. Some students might ask why this is; if so, you can ask them how each surface was different from the previous one. Look for descriptions about smoothness or roughness, or about how some substance allowed their hands to move more freely.)

9. Review what the students have learned about motion and forces from previous activities. Ask them to describe how their hands moved and what force made them move (the force was a push from the muscles in their arms). Make sure there is student understanding that motion is a change in an object's position, and that a force is needed to start an object in motion or change the way an object moves.

Part 2: Question or Statement

1. Ask students to suggest questions about their experiences with moving their hands over different surfaces and substances. Shape the discussion so that students begin to ask about forces and slipping – questions like “Does it take less force to move an object over a slippery surface?” or “How much more force would it take to move an object over the table than over marbles?” As they propose questions, re-state their questions by showing them the block moving over different surfaces. That is, if they say “Does it take less force to move your hand over marbles,” re-state the question by showing them the block moving over marbles and saying “So the question is, ‘Does it take less force to move an object over marbles than over the bare table.’” Write testable questions generated by students (and re-stated by you) on the board.

Notes: Re-stating the questions in terms of a block is important because investigating the motion of blocks is easier than investigating the motion of hands. A method will be developed to apply a certain amount of force to a block, where it is more difficult to apply a measured force to one's hand.

Students may also develop questions such as “Does the block move faster over marbles than over the bare table when a certain amount of force is applied?” These kinds of questions (about the speed of the block) can also be investigated. The sample Research Methods page shows an outline for determining the different amounts of force needed to start moving a block over surfaces with different amounts of friction, but the question of speed can also be written up and tested. To test the speed of the block, students first need to find an amount of force that will get the block moving over the surface with the most friction, then use that same amount of force with the other surfaces. They will need to hold the block in place while they place the given amount of washers in the cup, then let it go. They may want to use a stopwatch to time the block, and they need to make a starting line and finish line on the table to make the distance the same for each trial. If they conduct this kind of investigation, they will be finding the average speed of the block, since it speeds up while it moves. What they are really finding is the time it takes to move a certain distance.

2. Have students choose one of the questions to be tested in their small groups. There should be at least two small groups investigating the same question, so that data can be averaged across the groups. Usually the questions are something about the amount of force needed to move

an object over different surfaces, or the speed at which the block moves over different surfaces with different forces. Students should compare at least *three* different surfaces.

Part 3: Method for Gathering Data

1. Tell students that they need to develop a method for applying different forces on a block, so they can accurately compare the forces needed to move the block over different surfaces. Show them one of the blocks with the string attached, and show them how to pull it over a surface using the string – but do not show them how to place washers in the cup to produce different forces: Some of the students might like to figure this out. Distribute the following material to each group of 3-4 students:
 - 1 block of wood with sand paper on one side and an eyehook on its end, tied to the cup with the handle
 - 1 piece of string, 1 meter long
 - 1 piece of wax paper
 - 2 wide rubber bands
 - 40 washers
 - 1 roll masking tape
 - 1-meter stick
 - 1 pair of scissors
2. Ask the students to take a few minutes to examine the materials on the table with their groups. Tell them they may try different things with the materials to produce different forces on the block that will get it started moving over each different surface or material. Circulate around the room as they look over the materials and help them figure out how to use the washers in the bucket to produce different forces on the block. Facilitate the groups' activities by listening to their dialogue and asking questions such as:
 - What are you thinking?
 - What did you observe that makes you think that?
 - What have you discovered so far?
3. If groups are struggling to come up with a usable set-up, invite them to ask other groups what they are doing. Allow the students to learn and explore with each other until they develop the set-up shown in the picture above. (This set-up allows students to place different numbers of washers in the bucket, hanging it over the side of the table so that it exerts different forces on the block. The force is measured in “number of washers” but the force is actually the weight of the washers.)

Students often discover that a certain number of washers will make the block move if the block is tapped lightly to start it moving. That is, once it is tapped, it continues moving with the force of the washers. What this indicates is that the force of friction on the stationary block is more than the force of friction on the moving block. They may want to add “give the block a little tap to see if it starts to move” to their procedure, which they write up in Part 5.

Part 4: Prediction

1. Develop a prediction with the whole class. It should be something like: If the surface that the block moves on is more slippery, then it will take fewer washers to start it and keep it moving. Write the prediction on the board. There could be more than one, if students design additional, related investigations or state their question in terms of the speed of movement of the block.
2. Distribute the Investigation Design student pages and have students fill them out in groups. See Teacher Page 3-1 with sample student responses.

Part 5: Research Details

1. Have each group write down the steps they will take to perform their investigation in a step-by-step process on a page they create and title "Research Methods." A sample is provided at the end of the investigation.
2. Review the groups' Research Methods and Investigation Design pages to determine if their investigations are feasible given time and resources. Check to make sure that the Research Methods will result in measurable data that may support or not support the prediction. Give guidance as you review the materials, but try not to dictate specific changes. This is best done by asking critical questions such as, "How will you measure that?" and "What things will you keep the same?" Then groups can come up with changes that answer your questions and critiques.
3. **(Day 2)** Return the Student Pages and Research Methods with your comments and let groups re-design or alter them if needed.
4. Many times the observations and results of an open inquiry activity drive the next step in an investigation. Tell students that this is OK. If student groups add steps or change things as they perform their investigation, they should write these down, too. Have extra copies of Student Page 3-1 available, in case students want to make major changes.

Part 6: Data Collection

1. Review with the entire class what they will be measuring (the force needed to move the block when there are different surfaces, for example) and what units they will use for the measurements (the number of washers added to the bucket). Have each group design a data collection page (see Teacher Page 3-3 for a sample). Make sure there is room on the page for additional surfaces if they decide to test other materials.
2. Let each student group perform their investigation as they have written it. If they make changes as they go, they should reflect this on their written methods. They should record their results on their data collection page.

3. As student investigations progress, add these additional materials: straws, marbles, dish soap, and different grades of sand paper. Have students continue to record their results.

Part 7: Data Analysis, Data Use and Communication of Results

1. Have each group share its data tables with the class. Discuss similarities and possible discrepancies between groups that have conducted the same investigation. Ask whether the different research groups support each others' conclusions.

Have each group look at its results and determine what they show. Help each group determine whether the data supports its prediction, and what the answer would be to their initial question.

2. **(Day 3)** Ask students if a graphic representation of their data (a bar graph, a line graph, a pie chart or a labeled diagram) might help them and others better interpret their results. For example, could they tell from a graph of their data what surfaces required the most force to move the block?
3. Have each group develop a graphic representation of its data: a chart, line graph, bar graph, or diagram explaining the results. A bar graph with the number of washers it takes to move the block on the Y axis, and different materials under the block on the X axis would work for some investigations. A sample is provided on the sample student data collection page (teacher page 3-3).
4. Give each group Student Page 3-2. Have each group discuss each question.
5. Write the following parts of a conclusion on the board, and as you write each one, ask one student from one of the various groups to answer it. This will help clarify what is being asked for:
 - What was the purpose of the investigation?
 - What did you find out?
 - Was the prediction supported by the data?
 - How can you explain what you found out?
 - Why was it important to keep certain things the same during the different trials?
 - What else would you like to do with this investigation, and how would you make it better?
6. After the class discussion, have each individual student write a conclusion that incorporates answers to each question.
7. **(Day 4)** Have each group present its question, prediction, research methods, graphic representation of data, and conclusion to the class. Every group member should have a part in the presentation. Presentations should include these parts (write them on the board):
 - The group's question
 - The full prediction
 - The research methods

- The data, presented as graphs, charts, or drawings
- The conclusion
- Participation by each group member

If most or all of the groups conduct the same investigation, you might draw straws to see which group will present their investigation. Multiple presentations of the same investigation can become boring. You might ask one or more of the groups to make presentations of their investigations at other times, such as parent nights or school board meetings, or they can make posters that present their investigations and display them in the school.

8. Have students turn in all Student Pages, the Research Methods, and the Data Collection pages for assessment purposes.

Part 8: Guided Questions for Reflection

1. Ask each group:
 - What did you find out?
 - Does it support your prediction?
 - What evidence supports it?
2. Discuss the following questions with the whole class to review what they have learned:
 - How does friction affect the motion of the block? (it slows it down)
 - How is motion affected by the friction of different types of surfaces? (different surfaces provide different amounts of friction)
 - How could Elena move the box more easily? (she could put rollers or wax paper or other types of surfaces under the box that would provide less friction)
 - What other examples of friction can you think of?
 - When do we want as little friction as possible in everyday life? (moving things, including moving parts in machines such as cars, motors, etc.)
 - When would we want to *increase* friction? (walking across icy sidewalks – put down sand; keeping glasses from sliding on moving boats or planes; in the bathtub, so you don't slip when it's wet)
 - What exactly *is* friction? (friction is a force acting between the surface and the block to slow down its motion)
3. Help students understand the concepts about friction that are explained in the teacher background that

Part 9: Student questions for additional inquiry

1. Ask students:
 - What additional questions do you have?
 - How could you find the answers to them?
2. If possible, do the subsequent investigations students suggest.

3. Have students do research with books and/or the internet to learn if their conclusions were correct, and to find out what other scientists have found out about friction.

Assessment

Group assessment can be made by ranking proficiency in each of the parts of the final presentation: the prediction, the Investigation Design page, the step-by-step Research Methods, the graphic presentation of the data collected, the conclusion, and, finally, the participation of all members. Student Pages 3-1 and 3-2 can be assessed as well.

For final, individual assessment, write this on the board: “Friction is a force that acts on an object when it rubs against another object or material. Friction is involved anytime you try to move an object across a surface.” Then ask students to write down their answers to these questions:

- What effect does friction have on the force necessary to start an object in motion?
- What effect does friction have on the force necessary to stop an object in motion?
- What is one question you still have about friction? How would you find the answers to this question?

Names _____

Investigation Design

1. What is our question?

2. What do we know? – How does the block act when it is pulled?

3. What will we do? – How will we change things to affect how the block moves?

4. What data will we collect? – How will we measure the response of the block to what we change?

5. What is our prediction? – **If** we change the surface that the block slides on by

(#3) _____,

then (#4) _____ will change by

6. The things we keep the same on purpose are:

Names _____

Conclusion

Answer all of these questions in your conclusion:

1. What was the purpose of the investigation?
2. What did you find out?
3. Was the prediction supported by the data?
4. How can you explain what you found out?
5. Did other researchers come to the same conclusions?
6. Why was it important to keep certain things the same during the different trials?
7. What else would you like to do with this investigation, and how would you make it better?

Names (sample student responses)

Investigation Design

1. What is our question?
What amount of force is required to move a block of wood when it is on different kinds of surfaces?
2. What do we know? – How does the block act when it is pulled?
It moves.
3. What will we do? – How will we change things to affect how it acts?
We will make different surfaces for the block to move on.
4. What data will we collect? – How will we measure the response of the block to what we change?
We will measure how many washers it takes to get the wood to move.
5. What is our prediction? If we change the surface that the block slides on by (#3): putting different surfaces under it, then (#4) the number of washers needed to move it will change by decreasing when the material under the wood is more slippery.
6. The things we keep the same on purpose are:
The block, string, and cup set-up, and the washers.

Names (sample student page)

Research Methods

1. Hang the cup over the edge of the desk and put the block on the desk. The block is attached to the cup by a string.

(Student drawing would go here.)

2. Add washers until the block of wood moves on its own (we may have to tap the block lightly from behind to see if it will move).
3. Write down the number of washers used.
4. Turn the block of wood over to the sandpaper side, and do it again.
5. Tape wax paper on the desk under the block, and do it again.
6. Put cut-up straws lying on their sides under the block and do it again.
7. Record the data in a chart and make a graph of the data.

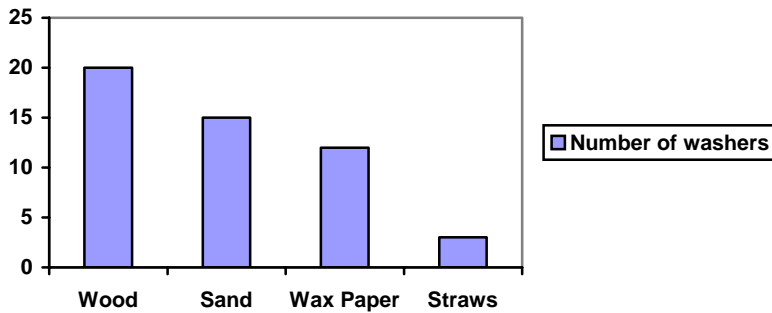
(Students may try it with different or additional surfaces.)

Names (sample student responses)

Data Collection

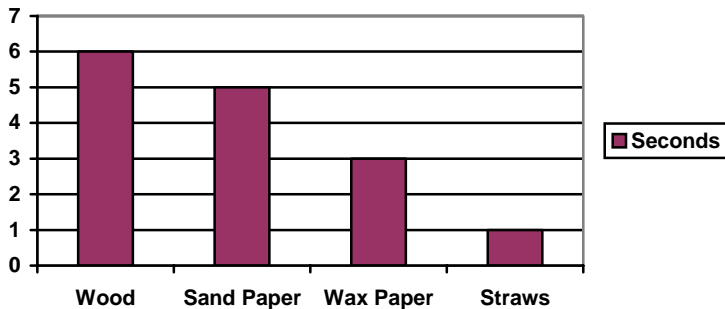
Sample data collection table and chart

Type of surface	Number of washers needed to move the block
Wood	20
Sand paper	15
Wax paper	12
Straws	3



Data table for alternative question about the speed of the block with a fixed amount of force

Type of surface	Number of seconds from starting line to finish line using "15 washers" of force
Wood	6
Sand paper	5
Wax paper	3
Straws	1



Names (sample student responses)

Conclusion

Answer all of these questions in your conclusion:

1. What was the purpose of the investigation?
2. What did you find out?
3. Was the prediction supported by the data?
4. How can you explain what you found out?
5. Did other researchers come to the same conclusions?
6. Why was it important to keep certain things the same during the different trials?
7. What else would you like to do with this investigation, and how would you make it better?

Conclusion: The purpose of our investigation was to see how different surfaces changed the amount of force it took to move a block of wood. We found out that less force was needed to move the block when slippery or rolling materials were under the block.

Our prediction was: If we put different surfaces under the block, then the number of washers need to move it will change by decreasing when the material under the wood is more slippery. Our data supported our prediction.

When we changed the block by putting different surfaces under it, then the number of washers need to move the block did change. We needed fewer washers to move the block when the material under the wood was more slippery. Other researchers in our class found the same thing.

What happened makes sense to us because we know that things that are slippery move more easily, like when we put soap on our hands and moved them back and forth. This is because there is less friction when the surface is more slippery. Friction is a force that slows down the motion of objects, so less friction allows them to move with less force.

We kept certain things the same during each trial, including using the same block, keeping the distance the same that the block had to move, and using the same length of string. It was important to use the same block during each trial, because if we used blocks with different weights, that might affect the amount of friction.

It would be good to try this investigation with pancake syrup. We could improve the investigation by not dropping the washers too hard into the cup, because sometimes that made the block move a little.