

△ Guide

Show students the seven filters arranged in the floral pattern and the single filter. Remind them that the seven filters have seven times the mass (or weight) of the single filter, as in the previous demonstration. Tell them again you are going to drop both from the same height at the same time. Ask students to predict and record what will happen and why.

TEACHER TALK

“Now I am going to drop seven filters and one filter again, but this time I’m going to arrange the seven filters so that they are in this flower pattern. The seven filters have seven times the mass of the single filter. I will drop them from the same height at the same time. Which one do you think will reach the ground first? Why?”

After students have recorded their ideas, ask a few students to share their predictions and reasons. This time the demonstration may surprise students. Listen for their ideas about the mass of the objects or if they are also thinking about the surface area. Students do not need to agree now because they will watch the demonstration to see if their predictions were accurate.

Drop the seven floral filters and the single filter from the same height as the previous demonstrations. The single filter should reach the ground first. Because this may surprise students, they may ask to see the demonstration again. Make sure everyone has a chance to see the result. Ask students to record their observations and why they think it happened.

□ Assess

Let students briefly share their ideas or questions about why the seven filters and the single filter reached the ground at different times. Listen for students’ ideas about mass, surface area, and falling objects. Not everyone will reconcile their ideas about falling objects but they should recognize that more than just mass affects how things fall.

Demonstration 3

Floral Pattern of seven Filters vs. Single Filter

In this third demonstration you will drop a single coffee filter and a set of seven coffee filters taped together in a floral pattern. The seven filters have seven times more surface area and mass as the single filter. Here, the heavier object will fall slower.

META NOTES

Students may wonder about the results of the past two demonstrations. They may want to see the seven stacked filters dropped against the floral-pattern filters. The mass is the same but the surface area is different. This is a good example of the effects of surface area.

META NOTES

Some students will have their initial ideas about mass challenged. They learn that mass is not the only factor in how things fall. They should be motivated to learn about why things fall the way they do.

Conference

5 min.

Based on all three demonstrations, have groups compare their predictions and observations, and identify what they think they know and what they still need to know about how objects fall.

META NOTES

During a conference, members of a group discuss their ideas together, in this case their ideas from the three demonstrations. This helps students refine and articulate their ideas to some degree. Later, during class discussions, groups' ideas are further refined, in this case, beginning to think about how things fall.

During each demonstration, you will be asked to do three things:

Predict – Your teacher will explain to you what he or she is going to do during the demonstration. You will predict what you think will happen. Record your prediction on your *Demonstration Notes* page.

Observe – You will observe the demonstration and record your observations.

Compare – After the demonstration, you will compare your predictions to what you observed. Note what you predicted well and what surprised you.

Conference

Share your predictions and observations with your group members. Make sure everybody has a chance to share. Your predictions and observations probably don't match exactly. As a group, see if you understand why the dropped objects behaved the way they did. Discuss what you think you know and what you thought you knew. Discuss what you think you still need to learn to fully understand your observations. Jot down notes so that you will remember what you discussed when you share again with the class. You will have about five minutes, so get started quickly.

Introducing the *Project Board*

When you work on a project, it is useful to keep track of your progress and what you still need to do. You will use a **Project Board** to do that. It gives you a place to keep track of your scientific understanding as you make your way through a unit. It is designed to help your class organize its questions, investigations, results, and conclusions. The *Project Board* will also help you to decide what you are going to do next. During classroom discussions, you will record the class's ideas on a class *Project Board*. At the same time, you will keep track of what's been discussed on your own *Project Board* page.

The *Project Board* has space for answering five guiding questions:

- What do we think we know?
- What do we need to investigate?
- What are we learning?
- What is our evidence?
- What does it mean for the challenge or question?

Project Board:
a space for the class to keep track of progress while working on a project.

Get Going

Introduce students to this conference by pointing out that now that they have recorded their predictions and observations, they need to work together to think about what they know about falling and what they need to explore further. Tell students they will use the ideas from their conference to create a class *Project Board* for everyone to use.

Guide

Describe to students the task for this conference. First, everyone in the group should compare their observations and predictions. How were they the same? How were they different? What was surprising? Second, each group should make a list of what they think they now know and what they still need to learn to understand what they observed.

Emphasize that scientific ideas must be supported by evidence from observations. Student groups' lists of what they now know should be supported by their observations. When observations don't completely support their ideas, scientists collect more evidence and revise their ideas. Student groups' lists of what they still need to learn will be ideas that their observations did not support.

Emphasize that everyone should participate by sharing ideas and listening to the other students' ideas.

Let students know they should be able to do this quickly so they only have about five minutes.

□ Assess

Listen for questions the students are asking each other and for the places where tensions arise in their discussions. These are good indicators of where an investigative question might be extracted for the *Project Board*.

◇ Evaluate

Also, as groups are conferencing, check that each group has listed what they think they know and what they still need to find out to understand their observations.

○ Engage

Remind students that they were analyzing the demos to get them thinking about their challenge — to design a toy to fall slowly. Help them understand that as engineers and scientists work challenges, they need to keep a record of their ideas so they can monitor their progress. Tell them they will be doing this using a *Project Board*.

△ Guide

TEACHER TALK

“Remember we are working on designing a toy for a cereal box. We are just getting started and we have lots of ideas and things to test before we get to a good design. We will need a way to keep track of our ideas and progress just as scientists and engineers do as they are addressing challenges. We'll do that using a *Project Board*.”

Introduce the *Project Board* and how it is used to students, as this is their first experience using one to record their ideas.

Show students the class *Project Board*. Explain that the *Project Board* is a tool that will be used throughout the course. It is used by the class to organize ideas, questions, and answers when working on a challenge.

META NOTES

As students conference, they share and develop ideas as they listen to the other students' ideas. Conference conversations will include disagreements, which can help students rethink their ideas. This may also be uncomfortable for students who are not used to disagreements or having to justify their ideas. Until students learn how to discuss their different ideas fairly and productively, tensions may develop.

Introduce and Create the Project Board

15 min.

Students are now ready to share ideas about falling with the whole class (so they will be able to address the Whirligig Challenge). At the same time, students need to learn to use a Project Board for monitoring progress on their challenge. Lead a class discussion using the Project Board to record students' ideas about how things fall.

Introduce and Create the Project Board (continued)

Each time you use the *Project Board*, you will record as much as you can in each column. As you work through a unit, you will return over and over again to the *Project Board*. You will add more information and revise what you've recorded. Everything you write in the columns will be based on what you know or what you have learned. In addition to text, you will sometimes want to put pictures or data on the board.

Create the Project Board

To get started on this *Project Board*, identify the important science question you need to answer. To design a better whirligig, you need to understand the answer to this question: *What affects how an object falls towards Earth?* Write this question on your *Project Board*.

The demonstrations you just watched were meant to help you remember what you understand about how things fall. They also helped you think about what you don't understand well enough yet. These are exactly the things that you will record in the first two columns of the *Project Board*.

The Whirligig Challenge				
What do we think we know?	What do we need to investigate?	What are we learning?	What is our evidence?	What does it mean for the challenge or question?

Challenges are big questions that rely on many smaller questions and answers before they can be completed. The *Project Board* helps keep track of it all. Help students understand that the *Project Board* provides a way for the class to work together to plan and keep track of progress during a challenge.

3.1 Understand the Challenge

What do we think we know?

In this column of the *Project Board*, you will record what you think you know. As you just experienced, some things you think you know are not true. Some things are not completely accurate. It is important to record those things anyway for two reasons:

- When you look at the board later, you will be able to see how much you have learned.
- Discussion with the class about what you think you know will help you figure out what you need to investigate.

What do we need to investigate?

In this column, you will record the things you need to learn more about. During your group conference, you probably came up with questions about how to explain what happened in the demos. You might have figured out some things you are confused about too. And you might have found that you and others in your group disagreed about your predictions. This second column is designed to help you keep track of things that are confusing. Record what you don't understand well yet, and that you disagree about. These are the things you will need to investigate. They will be important for achieving your challenge (designing a better whirligig).

Sometimes you are unsure about something but don't know how to word it as a question. One of the things your class will do together around the *Project Board* is to turn the things you are curious about into questions that you can investigate.

Later in this unit, you will return to the *Project Board*. For now, work as a class and begin filling in the first two columns.

Messing About

Messing About is an exploratory activity. It gives you a chance to become familiar with the materials you will be using. It also lets you figure out how a product you will be designing should work. At this stage, you aren't ready to do a formal investigation or test. When you *mess about*, you explore in a way that will help you do that later.

Next, describe the five columns. Explain that the third and fourth columns go hand in hand (the third basically lists the claims and the fourth lists the evidence that backs up those claims based on observations and information from experts), and the fifth explains how it is connected with the challenge or a bigger question.

Emphasize that the class will be filling out the first two columns (*What do we think we know?* and *What do we need to investigate?*) today and that they will add to all the columns as they work on the challenge.

You may want to distribute the student *Project Board* pages at this time. Let students know that they should be keeping a personal copy of the class *Project Board* that they can refer to as needed and that you will be keeping the class *Project Board* and recording the class's ideas and questions on it until the end of the Unit.

META NOTES

Students may be surprised that the first column is called *What do we think we know?* instead of *What do we know?*

◇ Get Going

Begin students on the *Project Board* by starting with the question: *What affects how an object falls toward Earth?* Describe that they need to answer this question to design a slow-falling whirligig. Write this question across the top of the *Project Board* or have a student volunteer. Note that you will later want to write another question across the top: *How can we design a slow-falling whirligig?* Also, leave room for that and for a question that will arise in *Learning Set 4*.

TEACHER TALK

“Over here I have set up our class *Project Board* for the *Whirligig Challenge*. We’ll begin by recording what we think we know about how things fall and questions we have about how things fall. Our *Project Board* will help us organize our ideas and questions as we work on this challenge. It will allow us to remember what questions we have already addressed and which ones we still need to find answers to. It will also help us keep track of what we are learning.”

META NOTES

Students do not think about science or engineering as dynamic processes that change as new information becomes available. They may be surprised to hear that they will be returning to the *Project Board* and updating it over time.

META NOTES

The student text has *The Whirligig Challenge* written across the top. It would be better to write questions across the top rather than the name of the challenge.

META NOTES

It is helpful to keep track of the date items that were posted. That way, students can monitor changes in their ideas and their progress on the challenge.

△ Guide

Now it is time to help students post ideas and questions in the first two columns of the *Project Board*. This will require helping them share with each other what they’ve discussed in their conferences about the demos. To guide students in this discussion, ask questions such as:

- What did you list as things you think you know?
- What did you talk about in your group that everyone agreed on?
- What do you know about falling from the first demonstration with the book and paper?
- What do you know about falling from the second demonstration with the coffee filters? Did that demonstration agree with your ideas from the first demonstration?
- What did you list as things you need to investigate?
- What did you talk about that not everyone agreed on?
- Did the third demonstration with the flower-shaped coffee filters agree with your ideas about falling from the first or second demonstration?

As students share their ideas and questions with the class, record their ideas on the *Project Board*. Use the first column to record their current ideas. There is no need to figure out right now if these ideas are right or wrong.

Use the second column for their questions. This includes questions about ideas students don't agree on or have a hard time accepting. Students will disagree about some of the items in the first column. These are indications of questions that need to go in the second column. Things students are surprised by should go in the second column as well.

◆ Evaluate

With students, look over the ideas and questions on the *Project Board*. Make sure everyone has had the opportunity to contribute and that their ideas are represented. Also make sure ideas or questions about mass (heaviness) and surface area (shape or spread) are included. Don't expect students to be experts at this point.

META NOTES

Linking items in different columns that are related to each other with arrows helps the students see how ideas and questions are connected.

META NOTES

During the discussion, listen for students' ideas about how things fall and their reasoning.

The Whirligig Challenge				
What do we think we know?	What do we need to investigate?	What are we learning?	What is our evidence?	What does it mean for the challenge or question?

Mess About with the Whirligig

15 min.

Let students explore the whirligig materials to become familiar with the materials and think about how to make the whirligig fall more slowly.

Messing About: an exploratory activity that gives you a chance to become familiar with the materials you will be using or the function of the product you will be designing.

structure: the way the parts of an item are put together. (This is a different definition of structure than the one you saw while making your book support.)

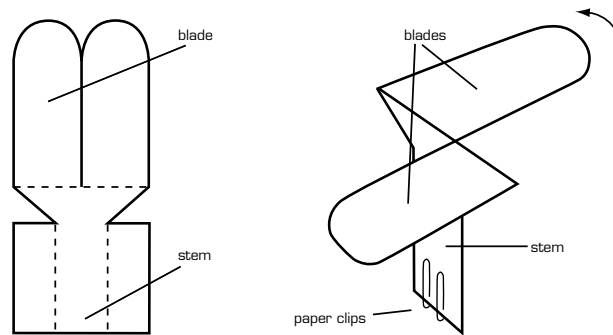
mechanism: the way the parts of an item connect and move.

Mess About with the Whirligig

To help you think about how to achieve your challenge, you will begin by **messing about** with the whirligig. You will use the basic whirligig that now appears on the back of the cereal boxes.

You will get a template (pattern) of a whirligig. It will look like the one shown below. The whirligig has several parts: blades, paper clips, and a stem. If you call them by those names when you talk about the whirligig, everyone will know what you are talking about.

Cut out the template. To form the whirligig, fold the cutout template. Attach two paper clips to the stem.



As you *Mess About* with the whirligig, explore how it works. Think about what it is capable of doing. While *Messing About*, see if you can answer the questions below. This will help you identify more about what you still need to learn and help you figure out what investigations to do.

- What is the **structure** of the item I'm working with? (Structure means the way the parts are put together.)
- What are its **mechanisms**? (Mechanism refers to how the different parts connect to each other or move with each other to make the object behave the way it does.)
- How is this item supposed to behave? What might I change in the item to affect that behavior?

Engage

Remind students that they have now thought about what affects how objects fall toward Earth. Now they can begin thinking specifically about why and how the whirligig falls toward Earth and how to make it fall more slowly. Show students the whirligig again and how it falls and remind them of the goal (to figure out a way to make a whirligig fall as slowly as possible to the ground). Remind them that the questions they need to investigate on their *Project Board* will help them find a way to solve the *Whirligig Challenge*.

3.1 Understand the Challenge

You will have about five minutes to construct and drop your whirligig several times. Watch it carefully. Try dropping it in different ways. Try changing some of the parts. Notice the effect these changes seem to have on the whirligig's fall. Discuss the observations you make with your group. Use *Messing-About Observations* pages to record your observations, ideas, and questions.

Messing-About Observations	
Name _____	Date _____
Top view	Description (structure, behavior, mechanism)
Side view	What happened?

Update the Project Board

After you complete a small-group activity, your class will get together to review what you found out and what you were thinking about. This time, you will discuss the behavior of the whirligigs. Update the *What do we think we know?* and *What do we need to investigate?* columns based on your *Messing About* experience.

Mess About with the Whirligig (continued)

TEACHER TALK

“With the *Project Board* we have been thinking about what affects how objects fall toward Earth. Now it is time for us to think about the whirligig specifically. What affects how the whirligig falls toward Earth and what affects how slowly the whirligig falls? Let’s look back at the things you need to investigate. This will help you think about what things you might change about the whirligig to make it fall more slowly.”

Mess About with the Whirligig (continued)

Next, tell students they will explore these features as they *Mess About* with the whirligig materials. They will get to try out all their ideas about what can be changed on the whirligig that might make it fall slowly.

△ Guide

Explain to students that *Messing About* is an opportunity for them to become familiar with the materials. It assists students in figuring out what they know and what they need to learn about the whirligig and how it falls. Emphasize that this session is not about playing. The purpose is to explore how the whirligig works, what the parts are like (structure, i.e., size, shape, heaviness), and the way the parts are put together and move (mechanism, i.e., how the parts interact).

TEACHER TALK

“The purpose of *Messing About* is for you to explore the materials you will use to make the whirligig. This way you will get familiar with the materials being used, how the whirligig falls, and what might affect the time it takes to fall. While exploring the whirligig, you should think about the structure (what the parts are like) and on the mechanism (how it is put together and moves).”

◇ Get Going

Let students know that they will be constructing their whirligig and then dropping it three or four times and in different ways to figure out what affects the whirligig and how it falls. Let students know that they may also change the parts of the whirligig.

Observe and your observations. questions.

Messing-About Observations	
Name _____	Date _____
Top view	Description (structure, behavior, mechanism)
Side view	What happened?

Describe what type of information is needed on the *Messing-About Observations* pages. Students should draw what the whirligig looks like in the top and side view boxes for each variation of the whirligig they use and label it as variation 1, 2, 3, or 4. In the description box they should describe the structure (what the parts are like), mechanism (how it is put together and moves), and its behavior when it falls (twirls, tumbles, etc.) for each variation and label it as variation 1, 2, 3, or 4. In the *What happened?* box, students should describe the time it took the whirligig to fall to the ground for each variation and compare them.

Tell students how much time they have to make their observations. Groups should take between five and ten minutes. Take no more than ten minutes for this and move on as soon as students seem to be off-task.

□ Assess

As students are working, observe what they are trying and note their ideas. These can be discussed when the class returns to the *Project Board*. Students may try changing how the blades are angled, or how the paper clips are situated on the stem. If anyone has tried dropping the whirligig with no paper clips, they may note that the whirligig tips sideways and falls rapidly. This idea will be addressed later in the *Learning Set* and should not be a focus of this section.

◇ Evaluate

Make sure students have recorded at least three variations for dropping their whirligig and using that they are using the *Messing-About Observations* pages as described above.

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Update the Project Board

10 min.

Lead students in updating the Project Board with information they obtained while exploring the whirligig.

Update the Project Board

After you complete a small-group activity, your class will get together to review what you found out and what you were thinking about. This time, you will discuss the behavior of the whirligigs. Update the *What do we think we know?* and *What do we need to investigate?* columns based on your *Messing About* experience.

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DIVING INTO SCIENCE

Engage

Remind students that the challenge is to figure out a way to make a whirligig that fits on a cereal box and falls slowly and that they have just explored the whirligig and materials. Remind them that when they started the *Project Board*, they were considering what they know about how things fall. Now they are going to fill out the first two columns — *What do we think we know?* and *What do we need to investigate?* — focusing on the whirligig which they have just explored.

TEACHER TALK

“Remember our challenge is to figure out a way to make a whirligig that fits on a cereal box and falls slowly. You’ve had a chance to explore the whirligig a bit and think about how it falls and what might affect how it falls. Now we are going to fill in the first two columns of the *Project Board* — *What do we think we know?* and *What do we need to investigate?* — based on your experience with the whirligig.”

Guide a Class Discussion

Ask each group to contribute their ideas to the first two columns of the *Project Board*. Students may not be sure which items should go in the *What do we need to investigate?* column. You could ask what parts of the whirligig affect how it falls. You should guide students to discuss how the structure (what the parts are like) and mechanism (the way the parts connect or move) of the whirligig affects how it falls. During the discussion, record and edit the class’s *Project Board* as needed.

Examples for the *Project Board*: These examples are provided to give you a sense of what students may say. It is O.K. if the class has a different set of ideas and questions listed.

- **Column 1:** *What do we think we know?* The whirligig flutters as it falls to the ground. Sometimes it turns sideways and falls rapidly;

TEACHER TALK

“**First column:** What did you observe about how the whirligig falls? What do you think you know about how the whirligig falls based on what you observed? What parts of the whirligig did you change to affect how it falls? How did it affect the whirligig’s fall, for example, did it take more time, less time, or the same time? Does the way the parts are connected or the way they move affect how the whirligig falls? In what way? What did you observe?”

Second column: Were there any groups that had different observations when trying the same thing (like adding more paper clips)? If so, this is something we should investigate. How should we write it up on the *Project Board*? Are there other things we are not sure about or that groups disagree on? These are things we should write in the second column of our *Project Board*? How should we write these?”

when I put more paper clips on it, it takes less time to reach the ground (like the book and piece of paper — the heavier it is, the faster it falls).

- **Column 2:** *What do we need to investigate?* How does adding the paper clips (adding mass) affect the whirligig? Does it matter where we put the paper clips? How does the blade size/length/width affect how the whirligig falls? How does the stem length affect how the whirligig falls?

◇ Evaluate

There should be many questions on the *Project Board*. Make sure that something like the following two questions are on the *Project Board*.

1. How does the length of the whirligig’s blades affect the time it takes the whirligig to fall to the ground?
2. How does the number of paper clips on a whirligig’s stem affect the time it takes the whirligig to fall to the ground?

If students have not suggested these two questions, continue eliciting their ideas, guiding them toward these two questions. Remember students’ responses may be worded differently.

TEACHER TALK

“Did anyone try using a different number of paper clips? If not, let’s try it now. Did anyone try changing the length of the blade? If not, let’s try it now.”

What's the Point?

10 min.



What's the Point?

In your previous challenge, you identified the criteria and constraints to help you understand the challenge. In this challenge, you were given the criteria and constraints. To help you understand this challenge, you tried to find out what you need to learn more about to be successful.

You made some predictions and observations about several demos. Then you compared your observations with your predictions. You may have found some surprises.

You started a *Project Board* to help track what you understand. You also added questions about how things fall. The *Project Board* is a space to help the class work together to understand and solve problems. Using it will help you have good science discussions as you work on a project.

You *Messed About* with a basic whirligig. You became familiar with how a whirligig moves and acts. This led to identifying more investigations you might do.



META NOTES

It is important for students to be able to figure out what they need to know when they are working on a challenge so that they can figure out what to investigate to solve the challenge.

Students should have a sense of the importance of understanding what it is they need to learn and how the demonstrations, *Project Board*, and *Messing About* were all helpful in forming their ideas and questions. Ask students why it is important to be able to identify what they need to know and how this connects to the challenge.

Assessment Options

Targeted Concepts, Skills, and Nature of Science	How do I know if students got it?
<p>Scientists often work together and then share their findings. Sharing findings makes new information available and helps scientists refine their ideas and build on others' ideas. When another person's or group's idea is used, credit needs to be given.</p>	<p>ASK: students if they can give an example from what they did today of how scientific ideas and methods change.</p> <p>LISTEN: to students describe how the demonstrations, <i>Project Board</i>, and <i>Messing About</i> all added to their understanding of what they know and what they need to investigate.</p> <p>ASK: students how working in a group and presenting their group's work to the class helped them figure out what they know and what they need to know.</p> <p>LISTEN: to students describe how their group and class discussions helped them realize what they know and what they need to know.</p> <p>ASK: students if any other group or student influenced or changed their thinking.</p> <p>LISTEN: to students acknowledge that their thinking has been influenced by something they hear another student or group say during the discussions.</p>

Teacher Reflection Questions

- What difficulties did students have in constructing the whirligig? What help will they need when it comes time to build the whirligig for the experiment?
- What was difficult or easy for students in coming up with experimental questions? What guidance will they need to improve their ability to describe experimental questions?
- What worked well in *Messing About*? What will you change the next time students *Mess About*?