GENERATION**GENIUS**
ALWAYS QUESTION. ALWAYS WONDER.

LESSON PLAN

WHAT IS SCIENCE?
GRADES 6-8

SUMMARY

Students will engage in science and engineering practices as they plan and carry out an investigation to explain how a Slinky falls when it is held by one end and then released.

NEXT GENERATION SCIENCE STANDARDS CORRELATION

MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Science & Engineering Practices	Connections to Classroom Activity
Asking Questions and Defining Problems	• Students make observations and ask questions after watching a slow motion video of a Slinky being dropped after it is suspended from one end.
Planning and Carrying Out Investigations	• Students develop hypotheses about why the Slinky falls the way it does and then plan and carry out investigations to support an explanation about how the Slinky falls.

Disciplinary Core Ideas	Connections to Classroom Activity
PS2.A: Forces and Motion The motion of an object is determined by the sum of the forces acting on it. If the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	• Students use ideas about balanced and unbalanced forces to explain how the Slinky falls. The lesson builds toward this core idea, but it is not intended to fully develop student understanding.

All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.	
Cross Cutting Concepts	**Connections to Classroom Activity**
Stability and Change **Cause and Effect**	• Students analyze the behavior of the falling Slinky as the forces on it change, and they determine the causes for these changes and the resulting motion of the Slinky.

DURATION

90 min.

MATERIALS

- Slinky (1 or 2 per group)
- Masking tape
- Meterstick (1 per group)
- String
- Weights

ENGAGE

Ask students if they have ever played with a Slinky, and show them the toy. Tell them you have an interesting phenomenon to share with them that involves the Slinky. Show students the "Slinky Drop" video. Have students write down their predictions on a slip of paper or sticky note. Poll the class to determine how many students committed to each prediction. If students write their predictions on sticky notes, then you can use those to make a bar chart on a wall, poster, or whiteboard to display the predictions. Have students share their prediction and reasoning with a partner. Then, have one student representing each prediction share his or her reasoning with the class. Tell students to label the top of a sheet of paper with "Observations." Tell them to write down their observations as they watch the Slinky drop. Perform the Slinky drop as a live demonstration, and ask students to share their observations. Tell them they will now have a chance to see the demonstration in slow motion to help them make additional observations. Tell students to make as many observations as they can while they watch the video. Play the "Slinky Drop Answer" video (this is a follow-up to the first video), but be sure to stop the video at 0:55 min., before Dr. Cross begins to explain the phenomenon. Replay the video as needed. Have students share their observations with the whole class.

Have students label the next section of their page *Questions* and write down questions they have based on their observations. As students write their questions, circulate around the room to read them. Select a few examples (or think of some questions similar to your students') of stronger and weaker scientific questions. Write those on the board. Tell students that the questions on the board represent the types of questions they are writing down and that you will use them to talk about what makes a good scientific question. Lead a discussion with students with the goal of coming to consensus that scientific questions should ask how or why something happens and should be answerable based on evidence that can be collected through an investigation. Have students revisit their initial questions and revise or replace any questions that do not meet these criteria. Have students share revised questions with a partner and then with the class. After students share, ask whether the class agrees that the driving question they have is "Why does the bottom of the Slinky remain stationary until the top of the Slinky reaches it?"

Have students write an initial answer to this driving question. Students' initial answers should describe what happens to the Slinky and explain why or how they think it is happening. Tell students that this initial answer is a *hypothesis*, or a proposed explanation that can be tested, and you need to test your hypothesis.

EXPLORE

Tell students they will now work in small groups to plan and carry out an investigation to test their hypotheses. Show students the materials they have available: Slinkys, masking tape, meter sticks, string, and weights. Tell students to think about the following questions as they plan their investigation:

- What do you think is causing the Slinky to fall the way it does?
- What variable could you change that would test this idea?
- If your explanation is correct, then how should the Slinky behave if you change that variable?

Students might drop the Slinky in different ways, attach weights to the Slinky before dropping it, use the tape or string to prevent the Slinky from stretching out, or manipulate the Slinky in other ways.

Once you approve their investigation plan, have students carry out the investigation and record their data. Have students use the Claim-Evidence-Reasoning (CER) framework to interpret the results of their investigations. Students can set up their CER explanation on paper, a poster, or a whiteboard. Share the following prompts to help students complete the CER explanation.

- Question: Why does the bottom of the Slinky remain stationary until the top of the Slinky reaches it?
- Evidence: Present the analyzed data from your investigation, along with your interpretation of the data.
- Claim: Answer the question in a complete sentence.
- Reasoning: Use science ideas to explain how your evidence supports your claim.

End of Day 1

EXPLAIN

Have students perform a gallery walk to see the findings from other groups. Lead the class in a discussion to build understanding of the investigations and findings. Prompt students to use science ideas about forces (pushes and pulls) to explain the Slinky's behavior. Use the following questions to guide the discussion:

- Why do things move? Why do things stay still?
- What forces were acting on the top of the Slinky? ...the bottom?
- How did the forces change at different points in the fall?

The goal of this discussion is to make sense of the investigations and build some initial understanding of the idea that the motion of an object is determined by the sum of the forces acting on it. This core idea is addressed more completely in a separate video and lesson. After the class discussion, you can show students the rest of the "Slinky Drop Answer" video, where Dr. Cross gives a simple explanation of the phenomenon.

ELABORATE

WATCH THE GENERATION GENIUS WHAT IS SCIENCE? VIDEO AS A GROUP

Discuss with students which science practices they engaged in to make sense of the Slinky phenomenon (asking questions, planning and carrying out investigations, analyzing and interpreting data, constructing explanations) and how the remaining practices might help them in figuring out more or communicating about why the Slinky falls the way it does. You can also use the After Discussion questions to review the content of the video.

EVALUATE

There are multiple ways to assess your students' understanding of this topic. The Exit Ticket is an opportunity for students to use the science ideas they built in the lesson in a new context. Alternatively, you can use the Kahoot! quiz (which provides downloadable scores at the end of the game), and/or the paper quiz. All these resources are located right below the video in the assessment section.

EXTENSION

- Although students can develop a simple explanation of the Slinky fall based on classroom investigations, the physics concepts behind this phenomenon are quite complex and have attracted the attention of several professional physicists. Students could do online research to learn more about how physicists have used mathematical modeling to explain this phenomenon more fully.

- Tell students that you want them to use the science practices they learned about in this lesson to make sense of a phenomenon that they find outside of school. Give students the following instructions.
    - Find a process or phenomenon anywhere that you spend time outside of school. Make some initial observations of the phenomenon.
    - Develop a how or why question that you would like to answer about the phenomenon.
    - Make at least three more observations about your phenomenon.
    - Develop an initial answer to your how or why question, and write it down. This is your hypothesis.
    - Think about an investigation you could carry out to test your hypothesis. You can use this sentence stem to think through this: "If I change ______, then ______ will happen, because ______."
    - If possible, carry out your investigation and determine whether your results support your hypothesis.