Ace in the Hole

Newton's First Law of Motion

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Grade Level	6th – 8th Grade	**Time Frame**	125 minutes
Subject	Science	**Duration**	2-3 class period(s)

Essential Question

How do forces change a projectile's trajectory?

Summary

Students explore projectile motion using Newton's first law of motion.

Snapshot

Engage

Students watch the commercial "Second Chance" and use the I Think/We Think strategy to describe how it relates to inertia and projectile motion.

Explore

Students are given the task of dropping a ball on a target while in motion. Students describe the motion of the ball and sketch a line that describes the motion of the ball.

Explain

Students work together to explain how inertia relates to projectile motion and how gravity and inertia work together to form the projectile's trajectory.

Extend

Students read an article about bombing during World War I and World War II and relate it to projectile motion, or students watch an ICAP video on an attorney and chemical engineer to consider how their careers apply to Newton's law.

Evaluate

Students reflect on the lesson by answering three overarching questions.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD: Interpretation of Data
IOD202: Identify basic features of a table, graph, or diagram (e.g., units of measurement)
IOD302: Understand basic scientific terminology
SIN401: Understand a simple experimental design
EMI301: Identify implications in a model
EMI402: Identify key assumptions in a model
EMI404: Identify similarities and differences between models

Next Generation Science Standards (Grades 6, 7, 8)

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.

Oklahoma Academic Standards (8th Grade)

8.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.

Attachments

- A Drop in the Bucket Handout—Ace in the Hole.docx
- A Drop in the Bucket Handout—Ace in the Hole.pdf
- I Think, We Think T-Chart—Ace in the Hole.docx
- I Think, We Think T-Chart—Ace in the Hole.pdf
- Lesson Slides—Ace in the Hole.pptx

Materials

- Lesson Slides (attached)
- I Think/We Think T-chart handout (one per student, attached)
- A Drop in the Bucket handout (one per student, attached)
- World War II Technology that Changed Warfare (print 1 set per student)
- Poster or easel pad paper (one per group of 4–5)
- Paper (one sheet per student)
- Tape
- Markers
- Sticky notes (several per group)
- Buckets (3 per group of 4–5)
- 3-inch balls (e.g., tennis balls) (1–2 per group of 4–5)

10 minutes

Engage

Use the attached **Lesson Slides** to guide the lesson. Display **slides 3** and **4** to introduce the essential question and learning objectives.

Transition to **slide 5** and show "Second Chance," a seat belt safety commercial that shows the consequences of not wearing a seat belt.

> **Embedded video**
>
> https://youtube.com/watch?v=L62ueMB0E5E

Pass out the **I Think/We Think T-Chart** handout and display **slide 6**. Use the I Think/We Think strategy by instructing students to write down their thoughts in the “I think” column on how the video demonstrates Newton's first law and inertia. After 2–3 minutes, instruct students to pair up and share their ideas to formulate one "we think" statement about the video and Newton's law.

Call on pairs to share their "we think" statements with the class. Use **slides 7** and **8** to share the definitions for Newton’s first law and inertia.

- Newton's first law: An object remains in motion or remains at rest until an unbalanced force is applied to the object, causing it to change its motion or state of rest.
- Inertia: an object's tendency to resist changing its motion or its state of rest.

Address misconceptions and be sure that students know the key term in Newton's first law and can define inertia. Students should also know that this first law can be called Newton's law of inertia.

> **Teacher's Note: Addressing Misconceptions**
>
> Students must understand that the seat belt opposes the inertia of the passenger, while the inertia of the unrestrained driver is not opposed in any way. He continues moving while the car is stopping. Students must not have the misconception that both occupants were at rest in the car. They were moving at the same speed as the car. Use the Explore section to take this idea a step further with a falling object that has an initial velocity.

Display **slide 9** and show the video a second time, and instruct students to sketch the motion of the man on their handout. Students will refer to this sketch later and use it as comparison to another projectile's motion.

30 minutes

Explore

Pre-Setup:

Create 4–5 stations, dependent on your class size. In each station, place three buckets side by side in a straight line on the floor, with about 6 inches of space between them. Label the first bucket "10," the middle "30," and the last "20." (Students will be aiming for the middle bucket.) Provide each station with one ball.

Take a ball and drop it vertically from one hand to the next. Ask students to explain what is happening to the ball as you drop it. Display **slide 10** and introduce the ball and target activity.

Place students into groups of four or five and pass out the **A Drop in the Bucket** handout.

Students will explore the concept of inertia further by observing a falling ball from a moving person. Students will run toward three buckets that are placed on the floor. The goal is to drop the object into the middle bucket while other group members watch from the side to determine how the ball falls. Before they begin, have the groups brainstorm and record their ideas about the challenges of getting the ball into the middle bucket.

Display **slide 11**. Students take turns so everyone has a chance. Students may even record the ball drop on a device and watch it in slow replay.

Optional Procedure:

If you want your students to own the entire inquiry process, just give them the goal (to run toward the buckets and release the ball into the middle bucket) and let them devise their own procedure.

Teacher's Note: Expected Outcome

The ball, while it appears to be stationary, is moving at the same speed as the person. Students should find it difficult to get the ball in the bucket and may have to make adjustments to their drop, much like the demonstration in this Ball Dropped video from Weber State University. The ball will travel in a parabolic motion and must be dropped slightly before the bucket is reached. Because of the ball's inertia, it resists changing its horizontal motion, therefore it will not fall straight down, although it may appear to do so.

If the ball bounces out of the bucket, students can still count it as hitting the target.

40 minutes

Explain

Teacher's Note: Defining Trajectory & Projectile

Students may not have a formal definition of trajectory or a projectile. This is also a good place to mention the key terms on **slides 12** and **13** before moving to the analysis questions.

- Trajectory: The path taken by a flying projectile or an object moving based on the action of a given force.
- Projectile: Informally, a projectile is any object that is cast, fired, flung, heaved, hurled, pitched, tossed, or thrown and is influenced by its own inertia and the downward pull of gravity.

When students have finished recording data, display **slide 14** and have students answer the following analysis questions on the handout:

- How is the inertia of the occupants inside the car related to the inertia of the ball in your hand?
- How does your sketch of the man's motion compare to the motion of the falling ball?
- Are both the man and the ball considered projectiles?
- What effect does gravity, paired with inertia, have on the motion of the man and the falling ball?

Student responses:

1. Both the occupants and ball are moving with an initial velocity and resist changing their motion.
2. Both should show a curved path. This curved path shows parabolic motion.
3. Yes, according to the definition of a projectile (see note).
4. Gravity pulls down while the projectile still continues in the horizontal motion causing it to curve rather than fall straight down.

Next, provide each group with poster or easel pad paper, and with markers. Display **slide 15** and introduce the activity. Ask them to create sketches illustrating the car (refer to Engage sketch) and ball scenarios in relation to Newton's first law of motion and inertia. Then, have them summarize how Newton's first law and inertia apply to both scenarios.

Teacher's Note: Timer

Consider providing a timer on the board for your students to reference, to be aware of how much time they have to complete their posters, setting it for 15–20 minutes. You can always move forward if students are all done before the time is up.

Display **slide 16** and use the Gallery Walk strategy to have groups visit each visual presentation and summaries. Give each group enough sticky notes to leave feedback on each poster. Once students have returned to their posters, have them read through the feedback and prepare to share out their understanding or any questions they may still have.

Teacher's Note: Content Feedback

Instruct students to focus their feedback on the content of the poster, not so much about how the poster looks. Challenge them to look for misconceptions and errors in their peers' thinking and offer constructive questions and critiques.

35 minutes

Extend

Display **slide 17** and ask the question: *Beyond the classroom, where might you encounter or see a projectile that has similar motion to the man in the car and the falling ball?* Allow for open, informal discussion. Call on volunteers to answer.

Sample Student Responses

Things students might say: dropping bombs, dropping aid packages, skydiving.

The article, "World War II Technology that Changed Warfare," is an excellent extension of this lesson. Pass out a copy of **World War II Technology that Changed Warfare** to each student. Display **slide 18** and instruct students to read the **introduction and pages 11–15 (Bombsights: The Advancement of Bombsights)** of the reading. Have students use the Stop and Jot strategy with each page to identify the main idea from each section.

Optional: ICAP Activity

The following activity can be used to add a career exploration element to this lesson.

Unhide and go to **slide 19.** Tell students: "Today, we are going to learn about two professions that need to understand the physics of car crashes, but from two vastly different angles." Invite students to watch a video to introduce these professions. Ask students to consider, as they watch, what kind of research they would need to do on Newton's laws in order to be successful at these jobs.

For students to answer this question as they watch, you can use either of the following methods.

Open-Ended Questions: After watching each video, ask students one of the questions below as instructed.

Mentimeter: To use Mentimeter, you will need to visit the site and create an account (or log in) and create two open-ended questions in advance. The K20 Mentimeter tech tool has instruction on how to use it. Prepare the questions below.

1. What kind of evidence related to Newton's laws would Mr. Marshall need to take into consideration in a case concerning a car crash?
2. Describe, in three sentences or less, how Ms. Schneberger uses her degree in chemical engineering to make cars safer and to decrease the momentum of an object in a car collision.

First, play the video "ICAP - Buckle Up" through YouTube.

Embedded video
https://youtube.com/watch?v=3OBNpJQxQrs

Pause the video at the 2:47 mark and have students answer open-ended question #1 (using a class discussion format or using Mentimeter). Resume the YouTube video. Once the video is over, have students answer open-ended question #2 in the same way.

Once students have watched the video and answered the questions, unhide and go to **slide 20.** Ask students to think of a job they are interested in pursuing or that they find fascinating. Highlight how that occupation institutes safety procedures to reduce momentum on an object and explain why those safety precautions are essential to that job. If a student chooses an occupation without clear safety procedures (an artist, for example), you can give an example that focuses on a peripheral part of the job (using the example of an artist choosing safe packaging to transport a work of art).

Then move on to the activity below.

10 minutes

Evaluate

Display **slide 21** and give students time to think before answering the following questions on a sheet of paper. Instruct students to use key terms from the lesson.

- How are the man, the ball, and the bombs from WWI and WWII all related?
- Before bombsight technology and radar, what factors would have to be considered to get the falling projectile (the bomb) to hit its exact target?
- In what situations is a projectile launched but the effect of gravity on the path is not easily observed, only its own inertia?

Student Responses:

1. They are all projectiles with their own inertia, subjected to gravity's pull, displaying a parabolic curve.
2. Some answers may include: time to fall, distance from target, altitude, initial velocity of the plane/bomb.
3. When the distance is minimal. Examples might include throwing a dart at a dart board or shooting a gun at a close-range target.

Optional: ICAP Activity

If you completed the ICAP activity instead, then unhide and go to **slide 22**. Have students answer the following questions. Instruct students to use key terms from the lesson.

- How are the man and the ball related?
- What factors would have to be considered to get a falling projectile, such as the ball, to hit its exact target?
- In what situations is a projectile launched but the effect of gravity on the path is not easily observed, only its own inertia?

Resources

- Demonstrations in physics. (n.d.). Newton's first law of motion. https://physics.weber.edu/amiri/physicsvideos/part1/laws_of_motion/first_law/default.asp
- Foley, S. (February 2011). World War II technology that changed warfare - radar and bombsights. *Academic Symposium of Undergraduate Scholarship 8*. https://scholarsarchive.jwu.edu/cgi/viewcontent.cgi?article=1011&context=ac_symposium
- K20 Center. (n.d.). Gallery walk / carousel. Instructional Strategies. https://learn.k20center.ou.edu/strategy/118
- K20 Center (2020, December 14). K20 ICAP - Attorney & chemical engineer - Buckle Up. YouTube [Video]. https://youtu.be/3OBNpJQxQrs
- K20 Center. (n.d.). I think / we think. Instructional Strategies. https://learn.k20center.ou.edu/strategy/141
- K20 Center. (n.d.). K20 timer - 00:00:00 https://timer.k20center.ou.edu/
- K20 Center. (n.d.). Mentimeter. Tech Tools. https://learn.k20center.ou.edu/tech-tool/645
- K20 Center. (n.d.). Stop and jot. Strategies. https://learn.k20center.ou.edu/strategy/168
- U.S. Department of Transportation National Highway Traffic Safety Administration. (2015, May 8). *Second chance* [Video]. YouTube. https://www.youtube.com/watch?v=L62ueMB0E5E
- Weller, M. (2024, April 11). Newton's cradle (99/365). Flickr. https://www.flickr.com/photos/edtechie/6683410305