Lesson 9.8 Acceleration due to gravity

Recommended teaching time for this lesson: 1 x 60 minute period

• 30 minutes of explicit teaching

• 30 minutes of suggested classroom activities

• 50 minutes homework

Getting started

Key ideas

* For acceleration due to gravity, the upwards direction is regarded as positive.
* Objects near the surface of Earth have a free-fall acceleration due to gravity of –9.8 m $s^{-2}$.

Curriculum links

Science understanding

* Interpret experimental data to determine the value of acceleration due to gravity on the Earth’s surface.

Advice for teaching this lesson

Things to know before you start teaching

This lesson is an extension of what has been taught in the previous lesson but instead has students dealing with systems where acceleration will always be an assumed value rather than a given component of the *suvat* equations.

The three types of questions presented in the worked solutions all use the same approach, just different initial conditions, however Worked solution 9.8C is the most complex as it involves small chunked scenarios. Students should be encouraged to tackle these questions in either full single equation approaches, or by modelling each small component depending on which approach they find makes more sense.

The starter activity requires students to drop pieces of paper and books to compare falling rates. Small textbooks make excellent tools for this activity.

Common misconceptions

* Students will often accept blithely that gravitational acceleration is the same for all objects, but not actually believe it due to common experiences. The starter activity is a great way to help them confront that cognitive belief and deepen their understanding of physical systems.

Differentiation strategies

Encourage diagramming out questions with clear labelling. This will benefit all students at the start of their learning but significantly improve the ability of lower level students to engage with this content.

Starter activity: Falling to the ground

Approximate time: 10 minutes

**Activity placement:** Place directly after Lesson overview

**Activity summary:** A small hands on activity to observe that gravity is the same, it’s the air that’s the problem.

Notes for the teacher

This activity requires some simple equipment. If your students do not have ready access to scrap paper and books due to being a laptop heavy school consider providing some so they can engage with this.

Instructions for students

Step 1: Collect two pieces of paper and a book. A textbook is good, however a simple notebook you write in is perfectly fine.

Step 2: Scrunch up one piece of paper into a ball.

Step 3: Hold both the ball of paper and the flat piece of paper at eye height.

* 1. Predict which piece of paper will hit the ground first.

Step 4: Drop both pieces of paper and observe.

Step 5: Hold the book and ball of paper at eye height.

* 1. Predict whether the ball of paper or book will hit the ground first and then drop them.

Step 6: Hold the book and flat piece of paper at eye height.

* 1. Predict whether the book or piece of paper will hit the ground first and then drop them.

Step 7: Place the piece of paper on top of the book and drop it. Observe what happens.

* 1. Suggest an explanation for what you observed with Step 7.

Answers

1. Student answers will vary. Students generally predict that the ball of paper hits the ground first.
2. Student answers will vary. Students generally predict that the book will hit the ground first.
3. Student answers will vary. Students generally predict that the book will hit the ground first.
4. The reason the flat piece of paper falls with the book is that the book pushes the air out the way, this allows you to see gravity pull both with the same acceleration.

Classroom activity: Brian Cox vacuum chamber

Approximate time: 10 minutes

**Activity placement:** Place directly above “What effect does dropping or throwing an object down have?”

**Activity summary:** A video demonstrating the effect of a vacuum chamber.

Notes for the teacher

The video is an excerpt from a Brian Cox special hosted at: <https://www.youtube.com/watch?v=E43-CfukEgs>. You may need to play it for your class depending on your school’s permissions.

Instructions for students

Step 1: Watch the following video. The first important moment begins at time stamp 1:08. Pause after 1:55.

https://www.youtube.com/watch?v=E43-CfukEgs Brian Cox – The world’s biggest vacuum chamber

1. Describe what air resistance did to the motion of the feathers compared to the bowling ball?
2. Infer what air resistance did to the acceleration of the feathers.

Step 2: Skip forward to timestamp 2:40. You can close the video after 3:50. The information at the end will be revisited in your studies of special relativity.

1. Compare how the feathers fell without any air with your previous observations.

Answers

1. The feathers fell to the ground slower than the bowling ball.
2. The acceleration was reduced.
3. The feathers fell motionless. They did not ripple or bend as they fell. They hit the ground at the same time as the bowling ball – slightly earlier because they are longer.

Classroom activity: Graphs of gravity

Approximate time: 10 minutes

**Activity placement:** Place directly above “Check your learning 9.8”

**Activity summary:** An activity to consider the displacement of falling objects under gravity.

Notes for the teacher

Students do not need to calculate values, just to sketch the rough forms.

The activity in Lesson 9.5 with different shaped graphs for different accelerating systems may assist here.

Instructions for students

Step 1: In Lesson 9.5 you saw that acceleration causes displacement-time graphs to be curved, and you may have done an activity comparing the shapes of different displacement-time graphs to the movement of objects. The end of Lesson 9.8 demonstrates velocity-time and acceleration-time graphs for an object being thrown up. Sketch graphs for the following scenarios. You do not need numerical values, but you should consider the shape of the graphs.

1. An object being thrown up and returning to the same height.
2. An object being dropped from the top of a tall building.

Helpful hints

* Recall that the gradient of a displacement-time graph is equal to the velocity. Figure 6 shows the velocity of an object being thrown up and returning down.

Support activity

Notes for the teacher

This version provides some more explicit instruction on what to consider at the start.

Instructions for students

Step 1: In Lesson 9.5 you saw that acceleration causes displacement-time graphs to be curved, and you may have done an activity comparing the shapes of different displacement-time graphs to the movement of objects. The end of Lesson 9.8 demonstrates velocity-time and acceleration-time graphs for an object being thrown up. Sketch graphs for the following scenarios. You do not need numerical values, but you should consider the shape of the graphs. Use the following questions to help you consider what the graph will look like. Consider the following before answering questions a and b.

* How will the velocity of the object behave at the start? This determines the steepness of your line.
* How will the velocity of the object behave in the middle? What about at the end?
1. An object being thrown up and returning to the same height.
2. An object being dropped from the top of a tall building.

Challenge activity

Notes for the teacher

This version asks students to consider a system that bounces.

Instructions for students

Step 1: In Lesson 9.5 you saw that acceleration causes displacement-time graphs to be curved, and you may have done an activity comparing the shapes of different displacement-time graphs to the movement of objects. The end of Lesson 9.8 demonstrates velocity-time and acceleration-time graphs for an object being thrown up. Sketch graphs for the following scenarios. You do not need numerical values, but you should consider the shape of the graphs.

1. An object being thrown up and returning to the same height.
2. An object being dropped from the top of a tall building and bouncing twice when it hits the ground.

Answers

1. 
2. Student answers will vary depending on where they assign the 0 value for displacement and what direction they assign positive. The example below has 0 displacement as the ground, and downwards being the negative direction.


Support activity

1. 
2. Student answers will vary depending on where they assign the 0 value for displacement and what direction they assign positive. The example below has 0 displacement as the ground, and downwards being the negative direction.


Challenge activity

1. 
2. Student answers will vary depending on where they assign the 0 value for displacement and what direction they assign positive. The example below has 0 displacement as the ground, and downwards being the negative direction. The two bounces should be of decreasing magnitude in displacement.
