Amplify Science

Grade 8

UNIT GUIDE

Force and Motion

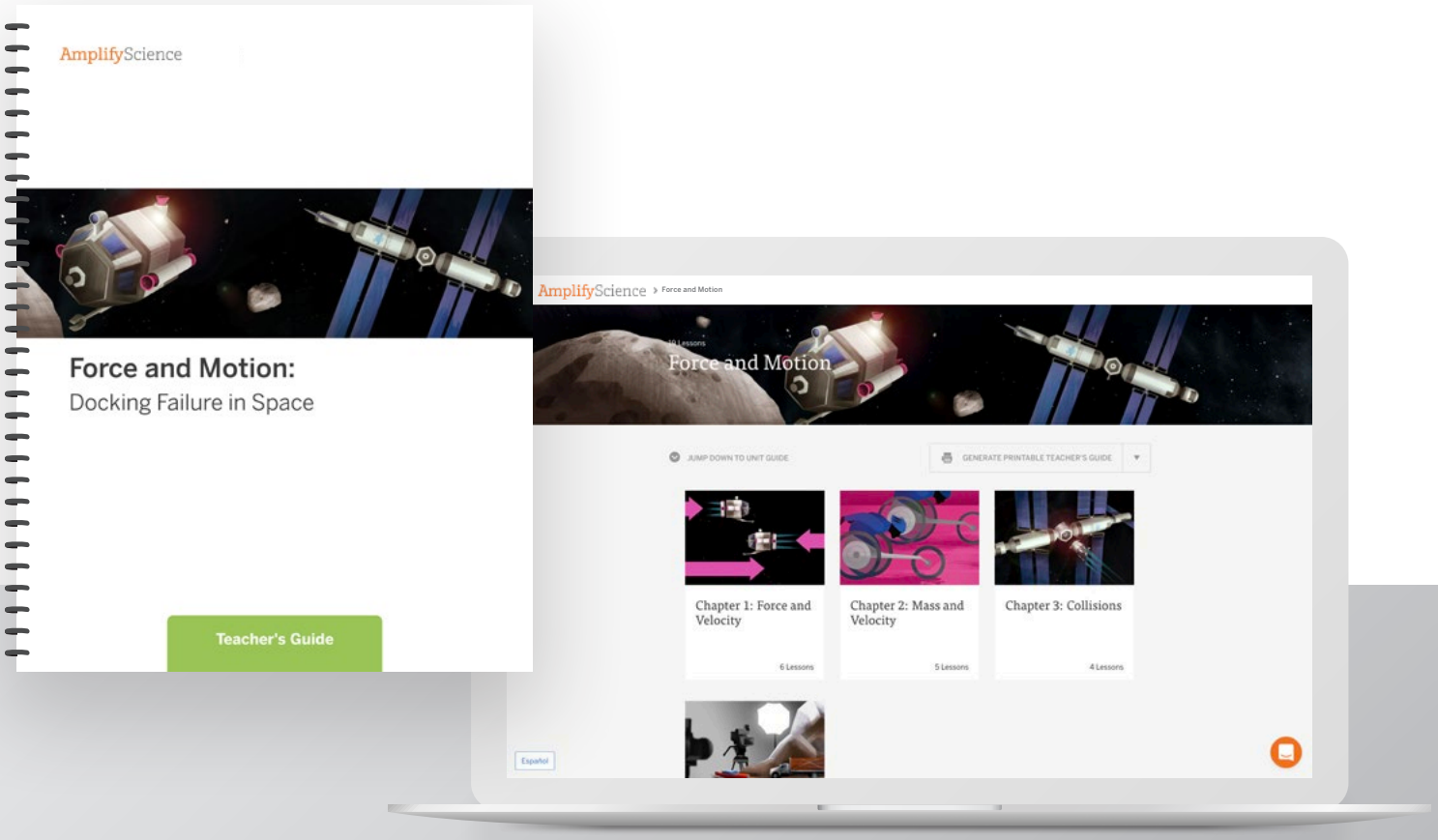


Table of contents

Amplify.

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Welcome to Force and Motion

Most middle school physics units use a series of narrowly defined contexts, such as hockey and billiards, for teaching the concepts of force and motion. In contrast, Amplify Science makes learning more intriguing and relevant by providing students with a broader and more exciting context in which to consider force, motion, and collisions: outer space. What's unique about the setting of deep space is that it allows us to create a scenario where students can think deeply about one-dimensional collisions without the complications of friction or strong gravitational attraction. In addition, this broader context provides them more opportunities to explore the relationship among force, changes in velocity, mass, and the equal and opposite forces exerted during collisions.

> Unlike a typical curriculum, Amplify Science anchors learning by inviting students to take on the role of scientists and engineers.

In this unit, students take on the role of physicists. Their job is to help the fictional Universal Space Agency analyze what went wrong in a space station docking failure. Working together, they figure out what caused an asteroid-sample-collecting pod to collide with the docking station and then, as a result, move away in the opposite direction rather than docking successfully. The unit concludes with a Science Seminar, in which students use what they have learned about force, mass, and velocity to explain why a film student's attempt to recreate a collision scene in a film failed.

Unit Type: Core

Student Role: Physicists

Phenomenon: The asteroid sample-collecting pod failed to dock at the space station as planned.

Core Concept: Understanding how forces can affect the motion of objects

Target Performance Expectations:

- PS2-1: Newton's 3rd Law (Equal and Opposite Forces)
- PS2-2: Sum of Forces
- PS3-1: Kinetic Energy: Mass and Speed

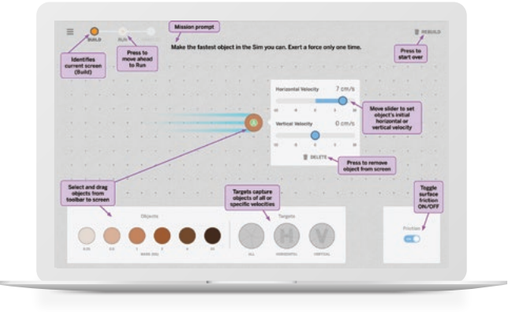
Students figure out the unit phenomenon through the use of a variety of resources.

Student Investigation Notebook

Hands-On Kit

Videos

Digital Tools



About technology in this unit:
All Amplify Science lessons were designed with device sharing in mind, and never assume that every student has a separate device.

In grade 8, student-facing technology includes Practice Tools and digital Simulations. When the use of a digital tool is called for in a lesson, teachers have several implementation options:

If limited student devices are available—teachers can have students do activities in pairs or small groups.

If no student devices are available—teachers can project the digital tool to the class and either "drive" the digital tool themself or invite students to "drive" by using their device.

If internet access is unavailable—teachers can "pre-load" the digital tool on their device for use offline.

Chapter 1:
The storyline begins

What students investigate:

What caused the pod to change direction?

What students figure out:

The pod could have exerted either too little or too much force. A force is required to change the velocity of an object. The type of velocity change depends on the direction of the force on the object. A stronger force can cause a greater change in an object's velocity. Perhaps the pod's thrusters fired more strongly than usual, causing it to reverse rather than stop. Or perhaps the thrusters fired too weakly, causing the pod to hit the station and bounce off.

How they figure it out:

- Exploring ways to change the motion of objects
- Testing the effect of forces of different strength using physical materials (spring-launchers, balls, jar lids) and the Sim
- Reading an article about the direction of friction forces and the effect these forces have on the motion of objects
- Discussing a common confusion—the conflation of force and velocity
- Creating visual models showing possible causes of the pod reversing direction

KEY

- CLASS
- HANDS-ON
- HOMEWORK
- MODELING
- READING
- SIM
- STUDENT-TO-STUDENT DISCUSSION
- TEACHER
- TEACHER-LED DISCUSSION
- WARM-UP
- WRITING

DAY 1 | LESSON 1.1

Pre-Unit Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

Pre-Unit Assessment

DAY 2 | LESSON 1.2

Describing Changes in Motion

- Warm-Up (5 min)
- Video: The Missing Seconds (5 min)
- Discussing What Happened to the Pod (10 min)
- Exploring Changes in Motion (15 min)
- Discussing Changes in Motion (10 min)
- Homework

DAY 3 | LESSON 1.3

Investigating Direction of Force

- Warm-Up (5 min)
- Exploring the Force and Motion Sim (10 min)
- Gathering Evidence About Velocity Changes (25 min)
- How the Pod Changed Its Velocity (5 min)
- Homework

DAY 4 | LESSON 1.4

Explaining Force and Velocity

- Warm-Up (10 min)
- Word Relationships (15 min)
- Investigating Strong and Weak Forces (20 min)
- Homework

On-the-Fly Assessment

DAY 5 | LESSON 1.5

Force Strength and Velocity Change

- Warm-Up (10 min)
- Force Strength and Velocity Change (15 min)
- Modeling Force and Velocity (20 min)

DAY 6 | LESSON 1.6

Evaluating Claims and Thruster Force

- Warm-Up (8 min)
- Modeling Thruster Force (20 min)
- Explaining Thruster Force (17 min)
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

Chapter 2:
The storyline builds

What students investigate:

The thrusters on the ACM pod exerted the same strength force as thrusters on other pods, so why did this pod move differently?

What they figure out:

Data shows that the pod's thrusters fired as usual—neither too strongly nor too weakly. Exerting the same amount of force on two objects with different masses will cause a greater change in velocity for the object with less mass. The pod's mass was greater than usual, so the normal thruster force did not slow the pod as much as usual. It must have hit the station and bounced off.

How they figure it out:

- Testing the effects of changing the mass of an object on which a force acts, in both physical experiments and using the Sim
- Reading an article about how engineers use the relationship among force, mass, and velocity to design the best wheelchairs for different athletic uses
- Making visual models showing what would have happened if the pod were more or less massive than usual

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DAY 7 | LESSON 2.1

Exploring Mass, Force, and Velocity

- Warm-Up (10 min)
- Investigating Forces on Different Objects (20 min)
- Investigating Force and Mass (20 min)

On-the-Fly Assessment

DAY 8 | LESSON 2.2

"Designing Wheelchairs"

- Warm-Up (5 min)
- Reading "Designing Wheelchairs" (25 min)
- Discussing Annotations (15 min)

On-the-Fly Assessment

DAY 9 | LESSON 2.3

Explaining Mass, Force, and Velocity

- Warm-Up (5 min)
- Rereading "Designing Wheelchairs" (20 min)
- Modeling the Effects of Different Masses (20 min)
- Homework

On-the-Fly Assessment

DAY 10 | LESSON 2.4

Critical Juncture Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

Critical Juncture Assessment

DAY 11 | LESSON 2.5

Reviewing Mass, Force, and Velocity

- Warm-Up (5 min)
- Reviewing Key Concepts (10 min)
- Force and Velocity Concepts (20 min)
- Explaining Forces and Velocity Changes (10 min)
- Family Homework Experience (Optional)
- Self-Assessment (Optional)

Self-Assessment

Chapter 3:
The storyline goes deeper

What students investigate:

After the collision, how does the pod's motion compare to the motion of the space station?

What they figure out:

The pod is moving faster than the station is. When two objects collide, a force is exerted on each object. The two forces are in opposite directions but the same strength. Even though the force on each object in a collision is the same strength, the objects will have different velocity changes if their masses are different. The pod is less massive than the station, so the force from the collision affected the velocity of the pod more than it affected the velocity of the station.

How they figure it out:

- Reading an article about the forces produced in collisions and how these affect objects of different masses
- Investigating collisions using balls and with the Sim
- Discussing a common misconception about forces in collisions
- Writing about equal and opposite forces in a collision
- Modeling the effect of the collision between the pod and the space station on each object using the Reasoning Tool

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- WRITING

DAY 12 | LESSON 3.1

"Crash!"

- Warm-Up (10 min)
- Reading "Crash!" (25 min)
- Discussing Annotations (15 min)
- Homework

On-the-Fly Assessment

DAY 13 | LESSON 3.2

Investigating Collision Forces

- Warm-Up (5 min)
- Exploring Direction of Collision Forces (15 min)
- Exploring Strength of Collision Forces (20 min)
- Space Station and Pod Collision Forces (5 min)
- Homework

DAY 14 | LESSON 3.3

Effect of Collisions

- Warm-Up (10 min)
- Rereading "Crash!" (20 min)
- Word Relationships (15 min)
- Homework

DAY 15 | LESSON 3.4

Reasoning About the Pod's Motion

- Warm-Up (10 min)
- Introducing the Reasoning Tool (8 min)
- Reasoning About the Pod (12 min)
- Modeling the Pod's Collision (15 min)
- Explaining the Homework Assignment (5 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

Chapter 4:
Application to a new storyline

What students investigate:

Why did Vehicle 2 fall off the cliff in Claire's test of the collision scene, but Vehicle 2 did not fall off the cliff in the film *Iceworld Revenge*?

What they figure out:

Scientists must communicate how their claims and evidence are supported with reasoning in a convincing scientific argument. In order to convince its reader, written scientific argument needs to state a claim, describe specific evidence, and explain how the evidence supports the claim. A claim can sometimes be supported more effectively if you consider the combination of several different pieces of evidence.

How they figure it out:

- Reviewing available evidence to make an argument
- Engaging in oral argumentation in a student-led discourse routine called a Science Seminar
- Writing final arguments

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DAY 16 | LESSON 4.1

Using Physics on Movie Sets

- Warm-Up (5 min)
- Playing the Video About Friction
- Introducing Movie Sets and Claire's Problem (10 min)
- Analyzing Evidence from the Film Student (15 min)
- Coordinating Claims and Evidence (15 min)

On-the-Fly Assessment

DAY 17 | LESSON 4.2

Discussing Physics and Movie Sets

- Warm-Up (5 min)
- Preparing for the Science Seminar (15 min)
- Introducing the Science Seminar (5 min)
- Participating in the Science Seminar (20 min)
- Homework

DAY 18 | LESSON 4.3

Writing a Scientific Argument

- Warm-Up (10 min)
- Using the Reasoning Tool (10 min)
- Organizing Ideas in the Reasoning Tool (10 min)
- Writing a Scientific Argument (15 min)
- Investigating Kinetic Energy, Mass, and Velocity (20 min)
- Homework
- Self-Assessment (Optional)

Self-Assessment

DAY 19 | LESSON 4.4

End-of-Unit Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

End-of-Unit Assessment

All students. All standards.

Rather than treating the standards simply as a list of topics to cover, we designed Amplify Science to allow for truly in-depth and integrated coverage of the disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). Unlike other programs, however, ours makes the NGSS' vision of "all students, all standards" a reality by creating a unit-specific learning progression for every unit called a Progress Build.

Each Progress Build defines several levels of understanding of the unit's anchoring phenomenon, with each level integrating and building upon the knowledge and skills from lower levels. In this way, each Progress Build provides a clear roadmap for how students' understanding of the phenomenon is expected to deepen and develop with each successive chapter and lesson.

What's more, the program's system of assessments is also tied to these Progress Builds. This carefully crafted integration provides teachers with credible, actionable, and timely diagnostic information about student progress toward the unit's learning goals and grade-level performance expectations. Armed with this powerful data, teachers have the ultimate flexibility to decide when to move on and when to slow down and dive deeper.

Force and Motion Progress Build

The Progress Build in this unit consists of three levels of understanding. At each level, students add new ideas and integrate them into a progressively deeper understanding of how forces can affect the motion of objects.

Progress Build Level 1:
A force causes a change in an object's velocity.

Progress Build Level 2:
An object's mass determines its velocity change for a given force.

Progress Build Level 3:
When two objects collide, both experience the same strength of force, but in opposite directions.

Examples of differentiation in this unit

In addition to providing unit-specific Progress Builds that break learning goals into smaller, more achievable levels of understanding, Amplify Science makes learning accessible for all students through a variety of scaffolds, supports, and differentiation strategies for every lesson. **For a complete list of strategies, see the Differentiation section of every Lesson Brief**.

Below are a few examples of strategies embedded in this unit.

For English learners:

Reading and extracting important information (Example from Lesson 4.1)
English learners may benefit from additional support in interpreting the information in the Science Seminar Evidence Cards. Consider going over each piece of evidence as a class before students sort the cards. Prompt the class to look at a specific piece of evidence. Ask students to first summarize the information provided on the evidence card and share any questions about the information. Then, ask them how it relates to the claims or to the key concepts that have been presented. After they understand what is shown on each card, they can begin sorting. You could also adjust the activity so that partners work with only one or two Science Seminar Evidence cards at a time and then share and discuss as a class.

For students needing more support:

Provide more guidance with determining change in velocity (Example from Lesson 2.1)
Students will plan an investigation where they exert the same size force on different objects to determine how they could be affected differently. Students may need additional support in determining the change in velocity of their objects. During Activity 2, you will suggest that they will start with stationary objects so that the object's final velocity is equal to the change in velocity and you will model how to calculate velocity. Students may need additional modeling and explanation individually or in small groups as they plan their investigations and then as they calculate velocity.

For students ready for a challenge:

Answering an additional question with the Word Relationships cards (Example from Lesson 1.4)
Students who need more challenge can use the Word Relationships cards to generate additional explanations for different questions. Invite students to use as many of the words as possible to explain how the thrusters of the pod normally cause the pod to dock at the space station. You can generate different scenarios that students must explain using the cards.

3-D Statements

In order to help teachers recognize the three-dimensional structure of every unit, chapter, and lesson, each unit contains a 3-D Statement document that makes the integration clear.

Making the 3-D statement document all the more effective, the three dimensions are color-coded for easy recognition.

Force and Motion 3-D Coverage

SEPs
Science and Engineering Practices

DCIs
Disciplinary Core Ideas

CCCs
Cross-Cutting Concepts

Unit Level

Students plan and conduct investigations with physical materials, use digital models, and obtain information from science texts to investigate the relationships between force, change in velocity, and mass and discover the equal and opposite forces exerted during collisions (cause and effect). They construct visual models and explanations about what happened during a collision between a pod and a space station.

Chapter Level

Chapter 1: Force and Velocity

Students conduct investigations with hands-on materials and analyze data from a digital model to discover ways that a force can affect an object's velocity (cause and effect) and that an object's motion remains stable unless it is changed by a force (stability and change).

Chapter 2: Mass and Velocity

Students investigate the relationship between force, mass, and velocity (cause and effect) by planning and conducting physical experiments, conducting tests with a digital model, and using mathematical thinking to make sense of their results. They also obtain information by reading an article about designing wheelchairs for different purposes.

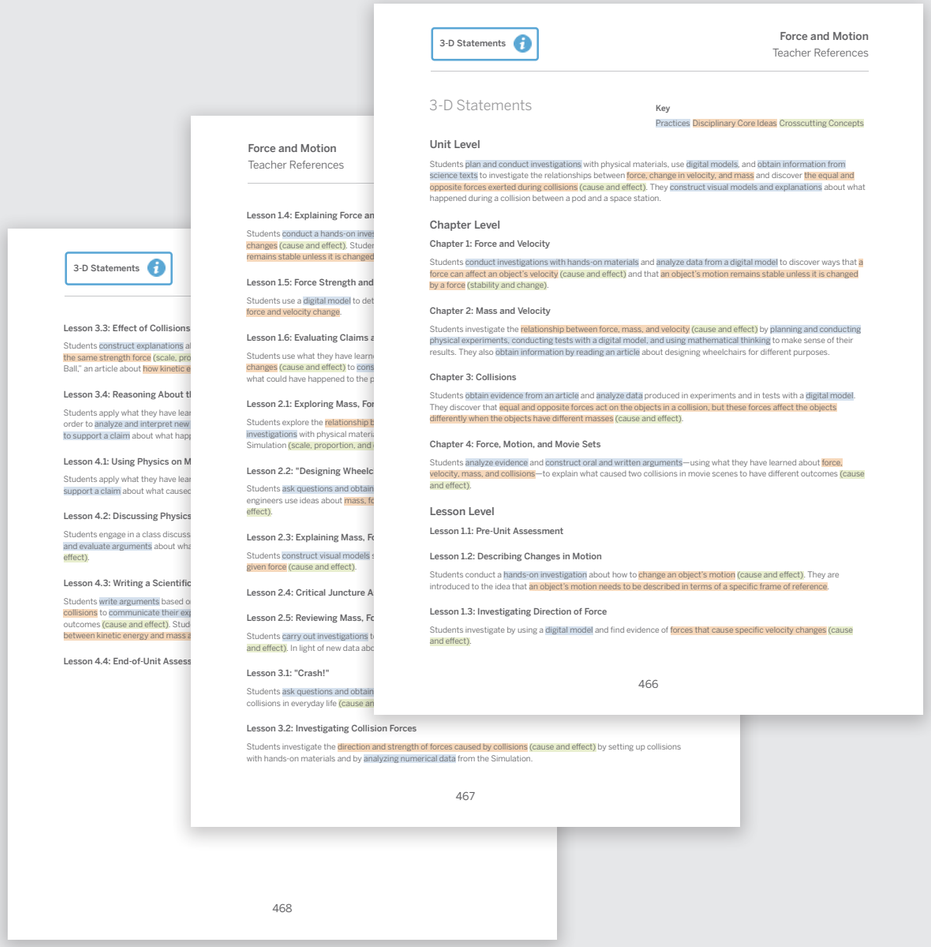
Chapter 3: Collisions

Students obtain evidence from an article and analyze data produced in experiments and in tests with a digital model. They discover that equal and opposite forces act on the objects in a collision, but these forces affect the objects differently when the objects have different masses (cause and effect).

Chapter 4: Force, Motion, and Movie Sets

Students analyze evidence and construct oral and written arguments—using what they have learned about force, velocity, mass, and collisions—to explain what caused two collisions in movie scenes to have different outcomes (cause and effect).

To review the 3-D Statements at the lesson level, see the Lesson Brief section of every lesson.



Notes

Notes

For more information on Amplify Science, visit **amplify.com/science**.

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