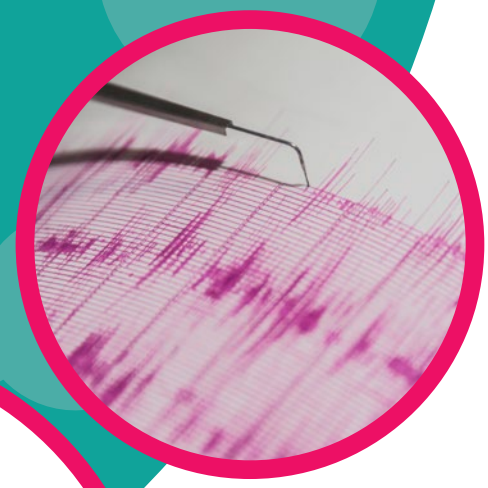
EARTHQUAKE ENGINEERING

GRADE **4**
MODULE **4**

Teacher Edition







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NGSS Framework Alignment

GRADE	NGSS TOPIC ARRANGEMENTS	MODULE	MODULE ANCHOR PHENOMENON	CORE PERFORMANCE EXPECTATIONS
GRADE K 	Interdependent Relationships in Ecosystems	My Big Nature Adventure	Different plants and animals live in different places.	K-LS1-1, K-ESS3-1
	Forces and Interactions; Engineering Design	Marble Run Engineer	What happens when we push, pull, and drop objects? How can we change their speed and direction?	K-PS2-1, K-PS2-2, K–2-ETS1-1
	Weather and Climate; Engineering Design	Be Prepared	How do we observe weather and collect data to describe weather patterns over time?	K-ESS2-1, K-ESS3-2, K-PS3-1, K-PS3-2, K–2-ETS1-1, K–2-ETS1-2, K–2-ETS1-3
	Interdependent Relationships in Ecosystems	I Can	How can I protect the environment from changes that harm it?	K-ESS2-2, K-ESS3-3, K–2-ETS1-1
GRADE 1 	Structure, Function, and Information Processing; Engineering Design	Museum of Leafology	How are all plants alike and how are they different?	1-LS1-1, 1-LS3-1, K–2-ETS1-1, K–2-ETS1-2, K–2-ETS1-3
	Waves; Structure, Function, and Information Processing; Engineering Design	Animal Reporters	How do animals use their body parts, communicate with their young, and make sounds?	1-LS1-2, 1-LS3-1, 1-PS4-1, 1-PS4-4, K–2-ETS1-1, K–2-ETS1-2
	Waves	Shadow Town	Why is the town of Rjukan in a shadow?	1-PS4-2, 1-PS4-3
	Space Systems	Patterns in the Sky	What patterns do we observe in the sky?	1-ESS1-1, 1-ESS1-2
GRADE 2 	Earth's Systems	My Journey West	How can we understand and describe the land and water on Earth?	2-ESS2-2, 2-ESS2-3
	Structure and Properties of Matter; Engineering Design	Master of Materials	How can we describe materials as different from one another and understand how their properties relate to their use?	2-PS1-1, 2-PS1-2, 2-PS1-3, 2-PS1-4, K–2-ETS1-2, K–2-ETS1-3
	Earth's Systems; Engineering Design	Save the Island	How do natural processes shape the Earth?	2-ESS1-1, 2-ESS2-1, K–2-ETS1-1, K–2-ETS1-2
	Interdependent Relationships in Ecosystems; Engineering Design	A Garden for Life	How do living things in an environment depend on one another and what do they need to grow?	2-LS2-1, 2-LS2-2, 2-LS4-1, K–2-ETS1-1, K–2-ETS1-2
GRADE 3 	Forces and Interactions; Engineering Design	The Ultimate Playground	How are objects affected by the forces of push and pull?	3-PS2-1, 3-PS2-2, 3-PS2-3, 3-PS2-4, 3–5-ETS1-1, 3–5-ETS1-2, 3–5-ETS1-3
	Inheritance and Variation of Traits	Welcome to the Biodome	How do plants' and animals' life cycles help them survive?	3-LS1-1, 3-LS2-1, 3-LS3-1, 3-LS4-2
	Interdependent Relationships in Ecosystems	How to Survive an Ice Age	What is the relationship between an organism and its environment?	3-LS3-2, 3-LS4-1, 3-LS4-3, 3-LS4-4
	Weather and Climate	Weather Warning HQ	What is the weather like around the world?	3-ESS2-1, 3-ESS2-2, 3-ESS3-1, 3–5-ETS1-1, 3–5-ETS1-2
GRADE 4 	Energy; Engineering Design	Egg Racers	What happens to energy when objects collide?	4-PS3-1, 4-PS3-3, 3–5-ETS1-3
	Energy; Engineering Design	Sparks Energy, Inc.	How do people produce and transfer energy for their use?	4-ESS3-1, 4-PS3-2, 4-PS3-4, 3–5-ETS1-1, 3–5-ETS1-2
	Earth's Systems	Time-Traveling Tour Guides	How have weathering and erosion sculpted some of Earth's most interesting landscapes?	4-ESS1-1, 4-ESS2-1, 4-ESS2-2, 4-ESS3-2, 3-5-ETS1-2
	Earth's Systems; Engineering Design	Earthquake Engineering	How can we reduce the damage caused by earthquakes?	4-PS4-1, 4-ESS2-2, 4-ESS3-2, 3–5-ETS1-1, 3–5-ETS1-2, 3–5-ETS1-3
	Waves; Structure, Function, and Information Processing	Super Survivors	How do the many parts of my body work together to help me live in the world? Communication involves transferring information through waves or signals.	4-LS1-1, 4-LS1-2, 4-PS3-2, 4-PS4-1, 4-PS4-2, 4-PS4-3, 3–5-ETS1-3
GRADE 5 	Structure and Properties of Matter; Engineering Design	Matter Mysteries Hotline	What is matter made of?	5-PS1-1, 5-PS1-2, 5-PS1-3, 5-PS1-4, 3–5-ETS1-3
	Matter and Energy in Organisms and Ecosystems	Yellowstone: Uncovered	How do matter and energy move through an ecosystem?	5-LS1-1, 5-LS2-1, 5-PS3-1
	Earth's Systems; Engineering Design	H2O Response Team	Why do some places lack fresh water and what can we do to protect it?	5-ESS2-1, 5-ESS2-2, 5-ESS3-1, 3–5-ETS1-1, 3–5-ETS1-2, 3–5-ETS1-3
	Space Systems	Galactic Guidebook	What patterns do we notice when we observe the sky?	5-PS2-1, 5-ESS1-1, 5-ESS1-2
GRADE 6 	Structure, Function, and Information Processing; Engineering Design	BioTech Systems Worldwide	How do human body systems and subsystems work together?	MS-LS1-1, MS-LS1-2, MS-LS1-3, MS-LS1-8, MS-ETS1-1, MS-ETS1-2
	Weather and Climate; Energy; Engineering Design	Destination Everywhere!	Weather and climate vary around the world, but we can use science and past trends to predict them.	MS-ESS2-4, MS-ESS2-5, MS-ESS2-6, MS-PS3-3, MS-PS3-4, MS-PS3-5, MS-ETS1-1, MS-ETS1-3
	Growth, Development, and Reproduction of Organisms	The Red List	How do the environment and genetics affect animals and plants?	MS-LS1-4, MS-LS1-5, MS-LS3-2, MS-ETS1-1, MS-ETS1-2
	Weather and Climate; Human Impacts; Engineering Design	Cities of the Future	How can we reduce harmful impacts on the environment in the places where people live?	MS-ESS3-3, MS-ESS3-5, MS-LS1-4, MS-LS1-5, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

twig Science | NEXT GEN Grade 4 Scope and Sequence

MODULES	MODULE ANCHOR PHENOMENON	STORYLINE	PERFORMANCE EXPECTATIONS (*PEs that integrate traditional science content with engineering through SEPs or DCIs)
1: Egg Racers **NGSS Topic Arrangements: Energy; Engineering Design** 	What happens to energy when objects collide?	Crash! Bang! Wham! Students learn about collisions, impacts and safety when they design and build their own race cars with a little help from our cartoon friend, Egg. But can they design and build a car that is safe enough to crash without breaking the egg inside? To do that, students will first have to understand what happens to energy when objects collide, what kinetic energy is, and how shock absorption works.	**4-PS3-1** Use evidence to construct an explanation relating the speed of an object to the energy of that object. **4-PS3-3** Ask questions and predict outcomes about the changes in energy that occur when objects collide. **3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
2: Sparks Energy, Inc. **NGSS Topic Arrangements: Energy; Engineering Design** 	How do people produce and transfer energy for their use?	This is a newsflash! Sparks Energy, Inc. is recruiting intrepid reporters to investigate the energy needs of the United States and beyond. While working as science journalists, students learn about energy sources, discover how people use energy, and find out what impact this has on the environment. They work in teams to research the facts and figures, carry out investigations and interviews, and update their reports as new information comes in. The module ends with students using their knowledge and expertise to write an exclusive article for the Sparks Energy, Inc. website.	**4-ESS3-1** Obtain and combine information to explain that energy and fuels are derived from natural resources and their uses affect the environment. **4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* **3–5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3–5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
3: Time-Traveling Tour Guides **NGSS Topic Arrangements: Earth's Systems** 	How have weathering and erosion sculpted some of Earth's most interesting landscapes?	What would you see if you traveled millions of years back in time? In this module, students become Time-Traveling Tour Guides and, with the help of videos and 360-degree imagery, discover how the Grand Canyon was formed. They observe fossils, investigate the effects of wind and water erosion on the landscape, use maps to look at patterns in the Earth's features, and study the course of the mighty Colorado River.	**4-ESS1-1** Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. **4-ESS2-1** Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. **4-ESS2-2** Analyze and interpret data from maps to describe patterns of the Earth's features. **4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* **3–5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
4: Earthquake Engineering **NGSS Topic Arrangements: Earth's Systems; Engineering Design** 	How can we reduce the damage caused by earthquakes?	Earthquakes can strike without warning, bringing massive destruction, but knowing where they happen can help reduce the damage caused. Students use an interactive to explore the Earth and investigate where earthquakes happen, collecting and analyzing data to identify patterns. Students find out what makes a strong and stable structure, and use this knowledge to design and build their own earthquake-proof buildings. Using an earthquake shake table, they test their structures and, like real civil engineers, refine their designs before the final build.	**4-PS4-1** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. **4-ESS2-2** Analyze and interpret data from maps to describe patterns of Earth's features. **4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* **3–5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3–5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
5: Super Survivors **NGSS Topic Arrangements: Waves; Structure, Function, and Information Processing** 	How do the many parts of my body work together to help me live in the world? Communication involves transferring information through waves or signals.	Can you run as fast as a cheetah, hear as well as an Arctic fox, or see as far as a peregrine falcon? Through a series of videos, informational texts, and hands-on activities, students investigate the incredible world of plants and animals, and find out how they use their amazing structures and systems to survive. Building on their knowledge of information processing, students are then challenged to design a long-distance communication device. Can they use waves, digitization, and binary code to survive on a ship lost at sea?	**4-LS1-1** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. **4-LS1-2** Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. **4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. **4-PS4-1** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. **4-PS4-2** Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. **4-PS4-3** Generate and compare multiple solutions that use patterns to transfer information.* **3–5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

ASSESSMENT All modules include: Pre-Exploration, Formative Assessment, Performance Task, Multiple Choice Assessment, and Benchmark Assessment

NGSS

CROSS-CURRICULAR CONNECTIONS

Row 1

Crosscutting Concepts
CCC-2 Cause and Effect
CCC-4 Systems and System Models
CCC-5 Energy and Matter

Disciplinary Core Ideas
PS3.A Definitions of Energy
PS3.B Conservation of Energy and Energy Transfer
PS3.C Relationship Between Energy and Forces

Engineering, Technology, and the Applications of Science
ETS1.A Defining Engineering Problems
ETS1.B Developing Possible Solutions
ETS1.C Optimizing the Design Solution

Science and Engineering Practices
SEP-1 Asking Questions and Defining Problems
SEP-2 Developing and Using Models
SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-6 Constructing Explanations and Designing Solutions
SEP-7 Engaging in Argument from Evidence
SEP-8 Obtaining, Evaluating, and Communicating Information

Common Core English Language Arts
RI.4.1 Key Ideas and Details
SL.4.1 Comprehension and Collaboration
SL.4.4 Presentation of Knowledge and Ideas
W.4.2 Text Types and Purposes
W.4.8–9 Research to Build and Present Knowledge

WIDA English Language Development
Standard 1: Social and Instructional Language
Standard 2: The Language of Language Arts
Standard 3: The Language of Mathematics
Standard 4: The Language of Science

English Language Proficiency Domains
Speaking, Listening, Reading, Writing

Common Core Math
4.MD.A Solve problems involving measurement and conversion of measurements
MP6 Attend to precision

Row 2

Crosscutting Concepts
CCC-2 Cause and Effect
CCC-4 Systems and System Models
CCC-5 Energy and Matter
CCC-6 Structure and Function

Disciplinary Core Ideas
PS3.A Definitions of Energy
PS3.B Conservation of Energy and Energy Transfer
PS3.D Energy in Chemical Processes and Everyday Life
ESS3.A Natural Resources

Engineering, Technology, and the Applications of Science
ETS1.A Defining Engineering Problems
ETS1.B Developing Possible Solutions
ETS1.C Optimizing the Design Solution

Science and Engineering Practices
SEP-1 Asking Questions and Defining Problems
SEP-2 Developing and Using Models
SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-5 Using Mathematics and Computational Thinking
SEP-6 Constructing Explanations and Designing Solutions
SEP-7 Engaging in Argument from Evidence
SEP-8 Obtaining, Evaluating, and Communicating Information

Environmental Principles and Concepts
Principle I People depend on natural systems
Principle II People influence natural systems
Principle IV There are no permanent or impermeable boundaries that prevent matter from flowing between systems
Principle V Decisions affecting resources and natural systems are complex and involve many factors

Common Core English Language Arts
L.4.4 Vocabulary Acquisition and Use
RI.4.1–3 Key Ideas and Details
RI.4.4, 5 Craft and Structure
RI.4.7, 8 Integration of Knowledge and Ideas
SL.4.1, 3 Comprehension and Collaboration
SL.4.5 Presentation of Knowledge and Ideas
W.4.2 Text Types and Purposes
W.4.4, 5 Production and Distribution of Writing
W.4.7, 9 Research to Build and Present Knowledge

WIDA English Language Development
Standard 1: Social and Instructional Language
Standard 2: The Language of Language Arts
Standard 3: The Language of Mathematics
Standard 4: The Language of Science

English Language Proficiency Domains
Speaking, Listening, Reading, Writing

Common Core Math
4.NBT.A Generalize place value understanding for multi-digit whole numbers
4.G.A Draw and identify lines and angles, and classify shapes by properties of their lines and angles
4.NF.B Build fractions from unit fractions
4.NF.C Understand decimal notation for fractions, and compare decimal fractions

Row 3

Crosscutting Concepts
CCC-1 Patterns
CCC-2 Cause and Effect
CCC-3 Scale, Proportion, and Quantity
CCC-4 Systems and System Models
CCC-7 Stability and Change

Disciplinary Core Ideas
ESS1.C The History of Planet Earth
ESS2.A Earth Materials and Systems
ESS2.E Biogeology
ESS3.B Natural Hazards

Engineering, Technology, and the Applications of Science
ETS1.B Developing Possible Solutions
ETS1.C Optimizing the Design Solution

Science and Engineering Practices
SEP-1 Asking Questions and Defining Problems
SEP-2 Developing and Using Models
SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-5 Using Mathematics and Computational Thinking
SEP-6 Constructing Explanations and Designing Solutions
SEP-8 Obtaining, Evaluating, and Communicating Information

Environmental Principles and Concepts
Principle III Natural systems change in ways that people benefit from and can influence
Principle V Decisions affecting resources and natural systems are complex and involve many factors

Common Core English Language Arts
L.4.4 Vocabulary Acquisition and Use
RI.4.1 Key Ideas and Details
RI.4.4, 5 Craft and Structure
RI.4.7–9 Integration of Knowledge and Ideas
SL.4.4, 5 Presentation of Knowledge and Ideas

WIDA English Language Development
Standard 1: Social and Instructional Language
Standard 2: The Language of Language Arts
Standard 3: The Language of Mathematics
Standard 4: The Language of Science

English Language Proficiency Domains
Speaking, Listening,

Common Core Math
4.MD.A Solve problems involving measurement and conversion of measurements
4.MD.B Represent and interpret data
4.MD.C Geometric measurement: understand concepts of angle and measure angles
4.NBT.A Generalize place value understanding for multi-digit whole numbers
4.NF.C Understand decimal notation for fractions, and compare decimal fractions
4.OA.A Use the four operations with whole numbers to solve problems

Row 4

Crosscutting Concepts
CCC-1 Patterns
CCC-2 Cause and Effect
CCC-5 Energy and Matter
CCC-6 Structure and Function

Disciplinary Core Ideas
PS4.A Wave Properties
ESS2.B Plate Tectonics and Large-Scale System Interactions
ESS3.B Natural Hazards

Engineering, Technology, and the Applications of Science
ETS1.A Defining Engineering Problems
ETS1.B Developing Possible Solutions
ETS1.C Optimizing the Design Solution

Science and Engineering Practices
SEP-1 Asking Questions and Defining Problems
SEP-2 Developing and Using Models
SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-6 Constructing Explanations and Designing Solutions
SEP-7 Engaging in Argument from Evidence
SEP-8 Obtaining, Evaluating, and Communicating Information

Environmental Principles and Concepts
Principle III Natural systems change in ways that people benefit from and can influence
Principle IV There are no permanent or impermeable boundaries that prevent matter from flowing between systems
Principle V Decisions affecting resources and natural systems are complex and involve many factors

Common Core English Language Arts
RI.4.1–3 Key Ideas and Details
RI.4.4 Craft and Structure
RI.4.7, 9 Integration of Knowledge and Ideas
SL.4.1–2 Comprehension and Collaboration
SL.4.4–6 Presentation of Knowledge and Ideas
W.4.2, 3 Text Types and Purposes
W.4.4 Production and Distribution of Writing
W.4.7–9 Research to Build and Present Knowledge
W.4.10 Range of Writing

WIDA English Language Development
Standard 1: Social and Instructional Language
Standard 2: The Language of Language Arts
Standard 3: The Language of Mathematics
Standard 4: The Language of Science

English Language Proficiency Domains
Speaking, Listening, Reading, Writing

Common Core Math
4.MD.A Solve problems involving measurement and conversion of measurements
4.NBT.B Use place value understanding and properties of operations to perform multi-digit arithmetic

Row 5

Crosscutting Concepts
CCC-1 Patterns
CCC-2 Cause and Effect
CCC-4 Systems and System Models
CCC-5 Energy and Matter
CCC-6 Structure and Function

Disciplinary Core Ideas
LS1.A Structure and Function
LS1.D Information Processing
PS3.A Definitions of Energy
PS3.B Conservation of Energy and Energy Transfer
PS4.A Wave Properties
PS4.B Electromagnetic Radiation
PS4.C Information Technologies and Instrumentation

Engineering, Technology, and the Applications of Science
ETS1.A Defining Engineering Problems
ETS1.B Developing Possible Solutions
ETS1.C Optimizing the Design Solution

Science and Engineering Practices
SEP-2 Developing and Using Models
SEP-3 Planning and Carrying Out Investigations
SEP-4 Analyzing and Interpreting Data
SEP-5 Using Mathematics and Computational Thinking
SEP-6 Constructing Explanations and Designing Solutions
SEP-7 Engaging in Argument from Evidence
SEP-8 Obtaining, Evaluating, and Communicating Information

Common Core English Language Arts
RI.4.1–3 Key Ideas and Details
RI.4.4, 5 Craft and Structure
RI.4.7–9 Integration of Knowledge and Ideas
RI.4.10 Range of Reading and Text Complexity
SL.4.1–3 Comprehension and Collaboration
SL.4.4, 5 Presentation of Knowledge and Ideas
W.4.2 Text Types and Purposes
W.4.4, 5 Production and Distribution of Writing
W.4.7, 9 Research to Build and Present Knowledge
W.4.10 Range of Writing

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Standard 3: The Language of Mathematics
Standard 4: The Language of Science

English Language Proficiency Domains
Speaking, Listening, Reading, Writing

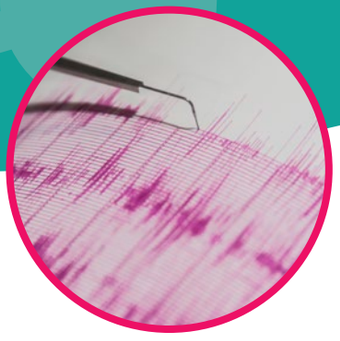
Common Core Math
4.G.A Draw and identify lines and angles, and classify shapes by properties of their lines and angles
4.MD.A Solve problems involving measurement and conversion of measurements
4.NBT.B Use place value understanding and properties of operations to perform multi-digit arithmetic

Earthquake Engineering

Module Anchor Phenomenon: How can we reduce the damage caused by earthquakes?

GRADE **4**
MODULE **4**






As cities get bigger, buildings get taller, and bridges get longer, they all have to be able to withstand whatever our planet throws at them...

Welcome to the Twig Science Earthquake Engineering module!

Earthquakes can strike without warning, bringing massive destruction.

But what causes earthquakes, and how can we prepare for them?

Movements inside our planet create mountains and release incredible forces of nature. Over the next few weeks, we'll peel back the Earth's surface to help your students explore what's inside—right under their feet!

Just like real engineers, students will travel around the world to map real-life earthquakes as they happen, investigate how to minimize the damage caused by natural disasters, and use that knowledge to design and build their own earthquake-proof buildings.

Are you ready to rumble?

Twig Education, Inc.

Teacher Edition
Earthquake Engineering
Grade: 4
Module: 4

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Imperial College London

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Earthquake Engineering
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Driving Question 1 — 1
How are waves involved in earthquakes?

Performance Expectations: 4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move; **3–5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Students investigate and model wave motion, amplitude, and wavelength. Using an interactive, they explore how waves move objects. Students then make connections between wave amplitude and earthquake magnitude.

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Resources and Assessments			3
Differentiated Instruction			4
Lesson 1	My House Collapsed!		6
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Lesson 4	Rocks and Ducks		28
Lesson 5	How Big Was That Earthquake?	3-D	34

Driving Question 2 — 43
How can patterns help us predict where earthquakes and volcanoes will occur?

Performance Expectation: 4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.

Students collect and interpret data from the Earth Explorer interactive to make sense of core ideas about patterns in the location of tectonic plates, volcanoes, and earthquakes.

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Driving Question 3 — 93
How can building materials and shapes affect the severity of earthquake damage?

Performance Expectations: 3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost; **3–5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem; **3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Through a series of investigations, students build understanding of how the shape, structure, and properties of materials affect buildings' ability to withstand forces.

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Lesson 1	Overloaded	3-D	98
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Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Reading for Evidence · 3-D Assessment · Video Investigation

GRADE 4
MODULE 4

Driving Question 4 — 123

How can our understanding of earthquakes and materials help us build safer buildings?

Performance Expectations: 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans; 3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost; 3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem; 3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Students design, build, and test their first earthquake-resistant structures.

Overview			124
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Differentiated Instruction			126
Lesson 1	Back to the Drawing Board		128
Lesson 2	Let's Build It!		134
Lesson 3	Rumble and Shake! It's an Earthquake!	3-D	140

Driving Question 5 — 145

What can we learn from engineers that will help us revise our designs?

Performance Expectation: 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Students discuss and make sense of observations and information obtained from their investigations with physical models, as well as informational texts and videos that explore real engineering solutions from around the world.

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Find the Multiple Choice Assessment for this module online. 3-D

Driving Question 6 — 179

How can we redesign our buildings to make them safer during earthquakes?

Performance Expectations: 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans; 3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost; 3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem; 3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

In the final presentation of their engineering designs, students explain how decisions about building characteristics, such as materials' flexibility, shape, and symmetry, address the Module Investigative Problem.

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Lesson 5	Presenting Our Work	3-D	202

Leveled Reader Lessons: Shake, Rattle, and Roll

Chapter 1 — Spark Curiosity	**The Curious Scientist** This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend informational text.		208
Chapter 2 — Career Focus	**STEM Career: Meet a Seismologist** This chapter focuses on the career of a seismologist. It includes an optional micro-lab in which students explore how energy is stored and released during an earthquake.		214
Chapter 3 — Why Care?	**Earthquake-Proofing: What's the Cost?** This chapter focuses on applying science standards to students' lives, and examines engineering approaches to earthquake-proof buildings.		220



Welcome to twig Science | NEXT GEN

Are you ready to celebrate plants by curating your own Museum of Leafology? How about designing the Ultimate Playground after learning about playground forces?

Experience the phenomena-based Pre-K–6 science program created for the three-dimensional Next Generation Science Standards (NGSS)—ensuring all students have an interwoven understanding of scientific ideas (DCIs), practices (SEPs), and concepts (CCCs).

Our unique instructional design challenges students to experience real-world STEM roles as they become creative problem solvers, making sense of engaging phenomena and deepening their knowledge, skills, and confidence.

Whether in print or digital, Twig Science Next Gen is flexible and fun, providing teachers with a system of support to bring the wonders of science and the motivation to learn to every student.







Collaborative Think Tank

Meet the team or, as we like to call ourselves, the Twig Science Collaborative Think Tank.

The development of Twig Science has been guided by our collective commitment to making science accessible to all. We do this through our engaging, phenomena-based storylines and flexible range of captivating resources. We'd like to thank the thousands of teachers, students, and administrators who have generously taken time to advise, review, revise, and trial Twig Science.

Imperial College London

Imperial College London is one of the world's leading universities. The College's students and researchers are expanding the frontiers of knowledge in science, medicine, engineering, and business, and translating their discoveries into benefits for society.

SCALE
Stanford Center for Assessment, Learning, & Equity

SCALE (Stanford Center for Assessment, Learning, & Equity) has a mission to improve instruction and learning through the design and development of innovative, state-of-the-art performance assessments and by building the capacity of schools to use these assessments in thoughtful ways to promote student, teacher, and organizational learning.

Alan Spivey



A professor of chemistry at Imperial College London, Alan leads the scientific review team. He is a committed educator, spearheading the implementation a new learning and teaching strategy, an ambitious and exciting project designed to establish the College as a global leader in STEM education and active learning.

Natasha Stillwell



An acclaimed broadcast-science journalist, Natasha Stillwell hosted and produced Discovery Channel's award-winning science and technology show Daily Planet. Natasha has a powerful gift for storytelling and engaging young learners, and she brought these talents to the development of award-winning international online classroom resources for Twig Education.

Cathy Zozakiewicz



Cathy provides technical consulting and support through Stanford Center for Assessment, Learning, and Equity (SCALE). Cathy develops innovative, educational, and state-of-the-art performance assessments for evaluating student learning.

Wiley Blevins



Wiley has written several books on reading instruction and teaching students to read informational texts. He is a cross-curricular expert with extensive experience in English Language Arts and English Language Development, including graduate work in education at Harvard University, elementary classroom teaching, and professional development in the United States, Latin America, and Asia.

K–6 Program Components

Print and Digital, English or Spanish

Teacher Editions

Modular Teacher Editions with flexible pacing, including options for Fast Track. Comprehensive lesson planning for phenomena-based investigations, with three-dimensional instruction, scaffolds for differentiation, and language routines.

Student Twig Books

Colorful, all-in-one text and investigation student books, for modeling, annotation, sketching, and unpacking Driving Questions—with text-to-speech functionality and English/Spanish toggling.



Print and Digital, English or Spanish

Leveled Readers

High-interest, magazine-style, and phenomena-based leveled readers.
Chapter 1: Exploring Phenomena
Chapter 2: STEM Career Focus and Hands-On Micro-Lab
Chapter 3: Real-World Connection



Recommended Trade Books

Use our recommendations—or replace with your own trade books—to provide expert writing models, prior knowledge, and content vocabulary.



3-D Assessment Suite

Formative and Summative Assessments measure students' abilities to meet all aspects of Performance Expectations (PEs). Rubrics provide clear guidance on how to assess students of all skill levels. Flexible options to monitor student progress are included.



Hands-On Lab Kits

Twig Science Module Lab Kits are clearly labeled, simply organized, and available for each module, ensuring you have all you need to roll out amazing hands-on investigations. Replenishment kits for consumable items are available. In Grades 3–6, Science Essentials kits provide high-value, multipurpose equipment that is used across the grade.



Digital Pathway (for all device types)

Twig Science (English or Spanish)

An intuitive, collaborative, and interactive online platform with 24-7 access to student and teacher pathways, components, songs, and engaging videos. The award-winning media suite brings phenomena to life in the classroom—it includes a presentation view for instant display of interactive lesson content and optional integration with LMS or Google Classroom.



Designed for 3-D NGSS: Foundations

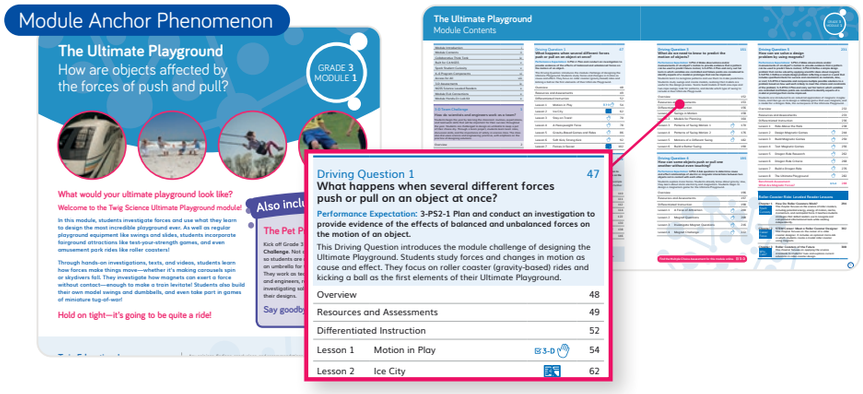
Explore Phenomena/Problems

Module Phenomena or Anchoring Phenomena

Every Twig Science module has an engaging storyline, designed to inspire students to think about STEM roles. It connects to an overarching Module Anchor Phenomenon that drives student learning.

Driving Questions and Investigative Phenomena

Through each module, students follow a sequence of Driving Questions to figure out Key Investigative Phenomena, problems, or design challenges. These build in complexity, spiraling and scaffolding students' acquisition of the three dimensions required to master the Module Anchor Phenomenon.



NGSS Framework Alignment

Every Teacher Edition contains the NGSS Framework Alignment, setting out a clear and logical sequence for the PEs across Twig Science. A grade-specific Scope and Sequence clearly identifies the sequence of the modules and unpacks the PEs into their respective DCIs, SEPs, and CCCs. Cross-curricular connections are included to help find and save time for science integration.

twig Science | NEXT GEN

NGSS Framework Alignment

GRADE	NGSS TOPIC ARRANGEMENTS	MODULE	MODULE ANCHOR PHENOMENON	CORE PERFORMANCE EXPECTATIONS
GRADE K 	Interdependent Relationships in Ecosystems	My Big Nature Adventure	Different plants and animals live in different places.	K-LS1-1, K-ESS3-1
	Forces and Interactions; Engineering Design	Marble Run Engineer	What happens when we push, pull, and drop objects? How can we change their speed and direction?	K-PS2-1, K-PS2-2, K–2-ETS1-1
	Weather and Climate; Engineering Design	Be Prepared	How do we observe weather and collect data to describe weather patterns over time?	K-ESS2-1, K-ESS3-2, K-PS3-1, K-PS3-2, K–2-ETS1-1, K–2-ETS1-2, K–2-ETS1-3
	Interdependent Relationships in Ecosystems	I Can	How can I protect the environment from changes that harm it?	K-ESS2-2, K-ESS3-3, K–2-ETS1-1
GRADE 1 	Structure, Function, and Information Processing; Engineering Design	Museum of Leafology	How are all plants alike and how are they different?	1-LS1-1, 1-LS3-1, K–2-ETS1-1, K–2-ETS1-2, K–2-ETS1-3
	Waves; Structure, Function, and Information Processing; Engineering Design	Animal Reporters	How do animals use their body parts, communicate with their young, and make sounds?	1-LS1-2, 1-LS3-1, 1-PS4-1, 1-PS4-4, K–2-ETS1-1, K–2-ETS1-2
	Waves	Shadow Town	Why is the town of Rjukan in a shadow?	1-PS4-2, 1-PS4-3

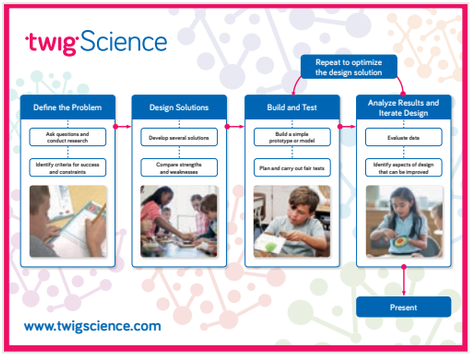
Three-Dimensional Learning

Students develop their mastery of the three dimensions using claims, evidence, and reasoning to connect prior knowledge to new skills, concepts, and ideas.

Students apply their understanding through a rich variety of learning experiences, including:

- Hands-on, video, and digital investigations
- Research, close reading, and writing
- Engineering design challenges

The Report and Reflect sections provide opportunities for students to have peer discussions, ask and answer questions, make explicit connections to the DCIs, SEPs, and CCCs, and reflect on their learning.





Access for All

The tools you need to allow every student to experience the wonders of science in the classroom...

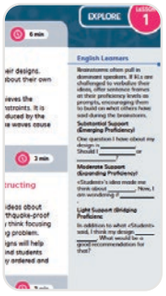
Equitable Access

Text-to-speech is provided for all digital assets. Assessments are multimodal throughout the program, allowing students with different learning styles and different learning needs to demonstrate their achievements.



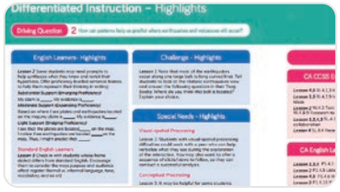
English Language Learners and Language Development

- English Language Learner scaffolds for substantial, moderate, and light support toward language proficiency
- Speaking, listening, reading, and writing language domains
- Linguistic frames, tiered vocabulary support, and Stanford UL-SCALE language routines



Cultural Connections

Links to cultural contexts to promote equitable, inclusive, and safe learning environments.



Special Needs

Modifications to accommodate students with light to moderate special needs (fine motor skills, physical disability, conceptual processing, executive functioning, social-emotional functioning, visual-spatial processing, and expressive and receptive language).



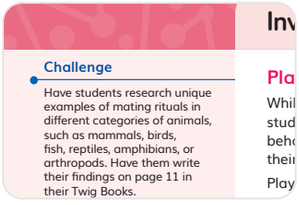
Family Outreach

Editable letters to extend STEM beyond the classroom and make school-to-home connections in multiple languages.



Challenge

Additional tasks online and in print to challenge advanced and gifted students at Depth of Knowledge Levels 3 and 4.



Cross-Curricular Connections

Helpful links to ELA, WIDA, Math, and Arts, increasing the impact and understanding of science in different contexts.



Designed for 3-D NGSS: Teacher Support

Unpack the NGSS Framework with on-demand professional learning, model lesson videos, and easy-to-use Teacher Editions.

Every module kicks off with a short introduction video, giving an overview of the Module Anchor Phenomenon or Investigative Problem, the sequence of learning, and how the PEs are addressed.

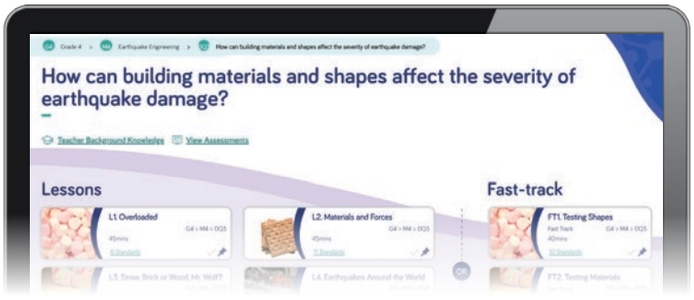
Our professional learning materials include background information, unpacking the science in bite-sized chunks, and a digital guide to the SEPs and CCCs.



Full Course and Fast Track

Twig Science gives you flexibility to teach the Full and Fast Track Courses—targeting 3-D NGSS Performance Expectations via a variety of multi-modal investigation types.

While the Full Course is recommended for mastery of the PEs, the Fast Track Course delivers NGSS at an accelerated pace.



In-Person and Webinar Training



Twig Science's specialist team is here to provide support in person and online for technical, implementation, and science-topic training.

Model Lesson Videos



Short videos that demonstrate teaching three-dimensional investigations.

Teacher and Administrator Observations



Built into every Teacher Edition, Look Fors support educators in understanding what success with the NGSS looks like in the classroom.



Supports Dual-Immersion and Bilingual Programs



More Spanish Resources than Any Other Program

Spanish resources include:

- Digital platform
- Teacher Editions
- Student Twig Books
- Readers
- Family Outreach Letters
- 1,300+ videos to bring phenomena to life
- Prior-Knowledge Read-Alouds



Twig Science: Pre-K

Spark, Investigate, and Reflect

A phenomena-rich science curriculum with hands-on and digital investigations, videos, interactives, songs, posters, and vocabulary cards.

Modules are aligned to Head Start standards and the NGSS, and include the following adventures:

- Senses Safari
- How to Build a Human
- Ultimate Games Day
- Weather Explorers
- Shipwreck Island
- Life on a Farm
- Ocean Deep
- Space Race



HEAD START PROGRAM & NGSS ALIGNMENT

FOCUS ON WIDA STANDARDS & LANGUAGE ACQUISITION

CROSS-CURRICULAR CONNECTIONS



Additional Resources

twigScience | TOOLS

Tools to Refresh and Extend 3-D Background Knowledge

Review for state assessments and extend learning opportunities with thousands of new investigations and videos.

Search by NGSS, topic, or grade and be confident that your classroom meets expectations.

Including:

- **950+ short videos**
- **700+ videos in Spanish and Mandarin**
- **100 lessons**
- **700+ activities**
- **1,500+ visuals**

Deliver personalized learning to every student!



www.twigsciencetools.com

twigScience | REPORTER

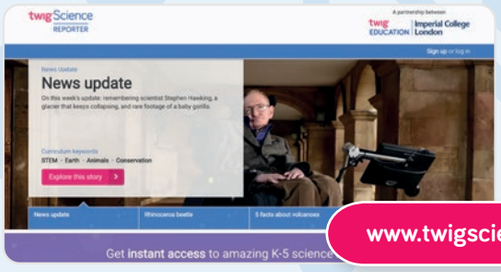
Research and Evidence Sources

Real-world topical STEM news focused on the latest science, technology, and engineering phenomena.

From wild weather to trending technology, topical science news from around the world puts SEPs into action!

- **Inquire about current news stories**
- **Build connections between textbook topics and real-world wonder**
- **Explore real-life causes and effects**
- **Explain and demonstrate the importance of science in everyday life**

Spark the imagination of the next generation of students with today's topical science.



SCIENCE ROCKS!

www.twigsciencereporter.com

Grade 4
Phenomena Tracker

Earthquake Engineering

Blue: SEP **Orange:** DCI **Green:** CCC

Module Anchor Phenomenon: How can we reduce the damage caused by earthquakes?

SUMMARY	PERFORMANCE EXPECTATIONS	KEY INVESTIGATIVE PHENOMENA	I CAN... STUDENT LEARNING OBJECTIVES
1. How are waves involved in earthquakes?			
Students investigate and model wave motion, amplitude, and wavelength. Using an interactive, they explore how waves move objects. Students then make connections between wave amplitude and earthquake magnitude.	**4-PS4-1** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move **3–5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost	• Waves cause objects to move. • Earthquakes are caused by waves of energy called seismic waves. • The amount of energy in waves can be measured by recording their amplitude. Waves of a bigger amplitude have more energy.	• Explore the phenomena of waves • Watch a demonstration and draw a diagram to understand how waves form when an object is dropped in water • Use a rope model to show how the wavelength and amplitude of waves is affected by energy transfer • Use an app and read a text to understand that earthquakes release energy in the form of waves.
2. How can patterns help us predict where earthquakes and volcanoes will occur?			
Students collect and interpret data from the Earth Explorer interactive to make sense of core ideas about patterns in the location of tectonic plates, volcanoes, and earthquakes.	**4-ESS2-2** Analyze and interpret data from maps to describe patterns of Earth's features	• Earthquakes occur in patterns along the boundaries between tectonic plates. • Identifying patterns in information helps scientists predict future earthquake events. • Areas near plate boundaries are at higher risk of experiencing earthquakes.	• Explore the phenomenon of plate tectonics • Use an interactive to explore earthquakes and volcanoes, and interpret data to understand the relationship between earthquakes and tectonic plates • Read and analyze informational texts about earthquakes, and use gathered data to produce a news report.
3. How can building materials and shapes affect the severity of earthquake damage?			
Through a series of investigations, students build understanding of how the shape, structure, and properties of materials affect buildings' ability to withstand forces.	**3–5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost **3–5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem **3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved	• Engineers design, build, and test earthquake resistant structures. • Some materials are better at withstanding earthquakes than others.	• Explore the phenomena of loads and forces • Build different model buildings and test their stability by applying different forces and loads • Watch a video and read informational texts to compare and contrast the effects of earthquakes in different locations.

Earthquake Engineering

Blue: SEP **Orange:** DCI **Green:** CCC

Module Anchor Phenomenon: How can we reduce the damage caused by earthquakes?

SUMMARY	PERFORMANCE EXPECTATIONS	KEY INVESTIGATIVE PHENOMENA	I CAN... STUDENT LEARNING OBJECTIVES
4. How can our understanding of earthquakes and materials help us build safer buildings?			
Students design, build, and test their first earthquake-resistant structures.	**4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans **3–5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost **3–5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem **3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved	• Engineers apply what they know about waves and the properties of materials to design earthquake-resistant structures.	• Work in a team to plan and build an earthquake-resistant structure, and test it using an earthquake simulator.
5. What can we learn from engineers that will help us revise our designs?			
Students discuss and make sense of observations and information obtained from their investigations with physical models, as well as informational texts and videos that explore real engineering solutions from around the world.	**4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans	• Engineers apply what they know about waves and the properties of materials to design earthquake-resistant structures. • Earthquakes can harm structures and people.	• Further explore the phenomena of natural hazards • Identify earthquake hazards • Read texts and watch a video to learn how engineers solve problems and make their buildings safer.
6. How can we redesign our buildings to make them safer during earthquakes?			
In the final presentation of their engineering designs, students explain how decisions about building characteristics, such as materials' flexibility, shape, and symmetry, address the Module Anchor Phenomenon.	**4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans **3–5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost **3–5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem **3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved	• Engineers use models to test their designs and make improvements.	• Use what I have learned in previous lessons to build a new and improved earthquake-proof model • Present my model and use what I have learned about earthquakes and engineering to explain my design.

Earthquake Engineering

NGSS Science Leveled Readers

Focus on navigating informational text, text structures, text features, vocabulary strategies, and building science content knowledge.

Chapter 1 The Curious Scientist.
Chapter 2 STEM Career: Meet a Seismologist.
Chapter 3 Earthquake-Proofing: What's the Cost?



		Guided Reading	ATOS
OL	On-Level	S	4.9
AL	Above-Level	U	6.2
BL	Below-Level	N	3.2
EL	English Learners	S	4.9

Leveled Reader Lesson Routines

First Read

- Introduce Informational Text
- Preview the Text
- Prepare
- Vocabulary Routine
- Read
- Build Content Knowledge
- Ask Text-Dependent Questions
- Assess Conversations

Second Read

- Revisit the Text
- Focus on Text Feature or Structure
- Focus on Vocabulary
- Connect to Writing—Read Across Texts
- Use Graphic Organizers

Additional Strategies

- Make Word Banks
- Use Pictures and Texts to Build Meaning
- Micro-Labs
- Extend the Conversation
- Focus on Fluency
- Synthesize Information
- Monitor English Language Proficiency

Already use another ELA program in your class? No problem! Each Twig Science module is aligned to Workshop Models and McGraw-Hill Wonders©. Benchmark Advance™ available online.

ELA CONNECTIONS

Workshop Models

RI.4.1–3 Key Ideas and Details
RI.4.4 Craft and Structure
RI.4.7, 9 Integration of Knowledge and Ideas
SL.4.1–2 Comprehension and Collaboration
SL.4.4–6 Presentation of Knowledge and Ideas
W.4.2, 3 Text Types and Purposes
W.4.4 Production and Distribution of Writing
W.4.7–9 Research to Build and Present Knowledge
W.4.10 Range of Writing

McGraw-Hill Wonders©

Unit 1, Week 3 Thinking It Through
Leveled Reader Landscapes
Student Anthology Earthquakes

Hands-On Lab Kit

Hands-on activities are designed for collaborative group work and can be adapted to suit different group sizes, making efficient use of all kit materials, whatever your class size.

From Grade 4 Science Essentials Kit

- ☐ Safety goggles
- ☐ Meter sticks
- ☐ Stopwatch

Earthquake Engineering Module Lab Kit

- ☐ 10 jump ropes
- ☐ 400 pipe cleaners
- ☐ 32 resealable plastic bags
- ☐ 5 lb sand
- ☐ 7 lb modeling clay
- ☐ 1 ball of string
- ☐ 1 pack of straws
- ☐ 1000 craft sticks
- ☐ 90 cardboard pieces
- ☐ 1 roll aluminum foil
- ☐ 100 foam sheets
- ☐ 250 toothpicks
- ☐ 200 paper clips
- ☐ 1 roll masking tape





GRADE **4**
MODULE **4**

EARTHQUAKE ENGINEERING

Module Anchor Phenomenon:
How can we reduce the damage caused by earthquakes?

Driving Question 1
How are waves involved in earthquakes?

Performance Expectations: 4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move; 3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Students investigate and model wave motion, amplitude, and wavelength. Using an interactive, they explore how waves move objects. Students then make connections between wave amplitude and earthquake magnitude.



Overview: **Full Course**

Driving Question 1 How are waves involved in earthquakes?

	FULL COURSE			
	LESSON		PAGE	SUGGESTED PACING
ENGAGE	1	**My House Collapsed!** Students watch a video to engage them in thinking about natural disasters and then construct as tall a building as they can out of newspapers. The Module Investigative Problem is introduced, and students listen to a text to activate prior knowledge.	6	45 min
EXPLORE	2	**Making Waves** Students learn about waves to prepare them for understanding seismic waves. They observe a teacher demonstration and a video about waves, then draw and write explanations of what they observed. They share, discuss, and revise their visual models.	12	45 min
EXPLAIN	3	**Learning the Ropes** Students look at images of waves and discuss their similarities and differences before learning the abstract concepts of amplitude and wavelength by shaking ropes.	20	45 min
ELABORATE	4	**Rocks and Ducks** Students review what they have learned about waves, wavelength, and amplitude in previous lessons. They use an interactive to explore the connection between wave amplitude and amount of energy transfer, then discuss and explain their observations.	28	45 min
EVALUATE	5 3-D	**How Big Was That Earthquake?** Students observe a demonstration that illustrates the concept that earthquakes transfer energy to the ground as waves. They then read an informational text to learn about the size or magnitude of earthquakes and fill in a magnitude scale chart.	34	45 min

Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · 3-D Assessment

The Full Course is recommended for mastery of the Performance Expectations.
The Fast Track Course delivers the Next Generation Science Standards at an accelerated pace.

Overview: **Fast Track Course***

Driving Question 1 How are waves involved in earthquakes?

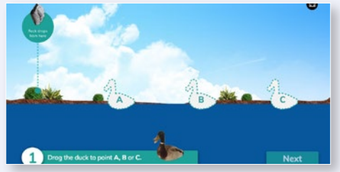
RESOURCES	MATERIALS	
	TEACHER	TWIG SCIENCE LAB KITS
• Family Outreach Letter 1 • Natural Disasters video • Optional: Natural Disasters visual • Criteria and Constraints 1 visual • Earthquakes, Tsunamis, and Volcanoes Prior-Knowledge Read-Aloud • Earthquake Engineering Trailer video	• Newspaper • Tape • Scissors • Optional: Camera	
• Raindrop video	• Plastic tub to hold water • Water • Rock • Optional: Computer or tablet for each student	• Safety goggles
• Waves visual • Waves Summary visual		• Jump ropes • Meter sticks • Masking tape
• Making Waves interactive	• Computer or tablet for each pair	
• Earthquake Patterns Progress Tracker	• Seismometer 6 app, installed on a smartphone or tablet	

PRE-EXPLORATION

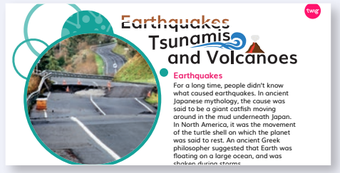
Resource Highlights



Earthquake Engineering Trailer video



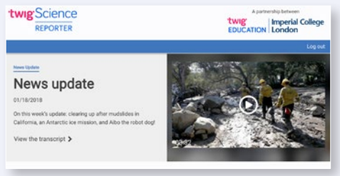
Making Waves interactive



Earthquakes, Tsunamis, and Volcanoes Prior-Knowledge Read- Aloud



Professional Learning



Topical science news, features, and careers

twig Science REPORTER

*Fast Track lessons/activities are identified by

FAST TRACK COURSE		
BLOCK	SUGGESTED PACING	LESSONS/ACTIVITIES
1	10 min	**Sections from My House Collapsed!** • Introduce the Module • Formative Assessment
	40 min	**Sections from Making Waves** • Discuss the KLEW Charts • Demonstrate Waves—Drop a Rock in Water • Observe the Video • Introduce the Activity • Draw a Wave Model • Share Models and Explanations • Connect Today's Learning to SEP-2—Developing and Using Models
2	25 min	**Sections from Learning the Ropes** • Introduce the Activity • Create Waves • Discuss Observations
	25 min	**Sections from Rocks and Ducks** • Explore Waves with the Interactive • Discuss the Interactive • Discuss Findings • Formative Assessment
3 3-D	30 min	**Sections from How Big Was That Earthquake?** • Demonstrate the Seismometer 6 App • Introduce the Close Reading • Close Read • Connect Today's Learning to the Driving Question • Pre-Exploration • Use the Pre-Exploration

Scientist and Engineer Investigation Experience:
Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · 3-D Assessment

Leveled Readers and ELA Connections

These high-interest, magazine-style leveled readers give students the opportunity to explore the ideas covered in the module in greater depth and meet real-world scientists and engineers. Available in 4 levels, they can be used in differentiated small-group reading time. On-Level lessons that accompany the readers are provided in the Teacher Edition. Above-Level, Below-Level, and English Learner lessons can be found online at www.twigscience.com.



		Guided Reading	ATOS
OL	On-Level	S	4.9
AL	Above-Level	U	6.2
BL	Below-Level	N	3.2
EL	English Learners	S	4.9

Shake, Rattle, and Roll

Chapter 1: The Curious Scientist

This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend informational texts while reading independently.

Chapter 2: STEM Career: Meet a Seismologist

This chapter focuses on the career of a seismologist. It includes an optional micro-lab in which students learn how energy is stored and released during an earthquake.

Chapter 3: Earthquake-Proofing: What's the Cost?

This chapter focuses on applying the science standards to students' lives, and examines different ways that engineers earthquake-proof buildings.

Already use another ELA program in your class? No problem! Each Twig Science module is aligned to Workshop Models and McGraw-Hill Wonders©. Benchmark Advance™ available online.

ELA CONNECTIONS

Workshop Models

RI.4.1–3 Key Ideas and Details
RI.4.4 Craft and Structure
RI.4.7, 9 Integration of Knowledge and Ideas
SL.4.1–2 Comprehension and Collaboration
SL.4.4–6 Presentation of Knowledge and Ideas
W.4.2, 3 Text Types and Purposes
W.4.4 Production and Distribution of Writing
W.4.7–9 Research to Build and Present Knowledge
W.4.10 Range of Writing

McGraw-Hill Wonders©

Unit 1, Week 3 Thinking It Through
Leveled Reader Landscapes
Student Anthology Earthquakes

Lift foldout for Fast Track information

Differentiated Instruction—Highlights

Driving Question 1 How are waves involved in earthquakes?

English Learners

Lesson 1 Students may need support with some of the vocabulary in the text, such as *originate*, *epicenter*, *tilt*, *split*, and *landslides*. Read the text aloud without interruption and model using context to decode unfamiliar words, as many are explained or their meaning expanded in the text itself.

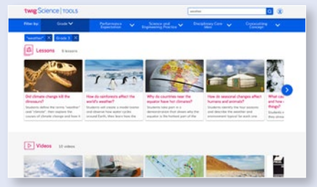
As you introduce the Module Investigative Problem, ensure that ELs know what an *engineer* is and that *engineering* is what engineers do. Some may not recognize the word as a verb.

Lesson 5 Preview the ELA text prior to whole group reading to highlight vocabulary and content. This will help English learners to more fully participate in the lesson. Focus on key science terms. Say each word and have students repeat. Correct or confirm pronunciations. Use sentence stems to help students use each new word.

Extension Activities

NGSS-mapped resources to help extend and enrich learning for students of all abilities.

twigScience TOOLS
www.twigsciencetools.com



Challenge

Lesson 2 Ask students what they would see if raindrops fell in exactly the same place once every second.

Lesson 4 Divide students into groups and ask them to think of one extra question that they would like to test and investigate. **Note:** It's fine if students make claims that can only be tested outside the interactive. Examples of student-generated testable claims could include:

- Does the weight/volume/density of the rock affect the amplitude/wavelength of the wave? How?
- What happens when two rocks are dropped?

Special Needs

Fine Motor Skills

Lesson 1 Allow students with fine motor skill challenges to dictate some of the physical actions of the build to a peer who will enact what they are saying (e.g., cutting the paper in a particular shape). However, ensure they engage with the portions of the build that they can do.

Conceptual Processing

Lesson 2 If possible, provide access to at least one computer so that students can watch the video again at their own pace during the activity. They may wish to pause and watch sections of the video again.

Social-Emotional Functioning

Lesson 5 Consider which students work better when paired with peers for reading. Allow pairs to sit away from others and read aloud.

Time Savers

CCSS English Language Arts

Lesson 1–5 SL.4.1 Comprehension and Collaboration

Lesson 3 W.4.3 Text Types and Purposes

Lesson 5 RI.4.1 Key Ideas and Details; RI.4.4 Craft and Structure

Lesson 5 W.4.8 Research to Build and Present Knowledge

WIDA English Language Development

Lesson 1, 2, 3, 4
Standard 1: Social and Instructional Language

Lesson 3
Standard 3: The Language of Mathematics

Lesson 1–5
Standard 4: The Language of Science

CCSS Mathematics

Lesson 3 4.MD.A Measurement and data

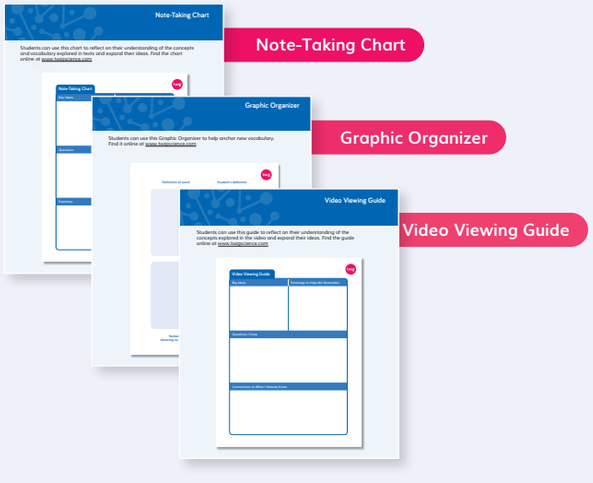
Lesson 3 MP1 Make sense of problems and persevere in solving them; MP6 Attend to precision

Access to Science Literacy and Vocabulary

Word Wall

Driving Question 1	**natural disaster, earthquake, tsunami, volcano, energy transfer, waves, point of impact, amplitude, wavelength, seismic waves**
Driving Question 2	ocean, Pacific Ocean, Atlantic Ocean, Ring of Fire, elevation, mountain range, belt, pattern, tectonic plates, fault, fault line, latitude, longitude
Driving Question 3	dead load, live load, horizontal load, compression (squeezing), tension (stretching), torsion (twisting), bending
Driving Question 4	-
Driving Question 5	civil engineer, structures, forces, mistakes, materials, engineering design process (problem, criteria and constraints, brainstorm, design, build a model, test, refine, share), hazard, safety, revise
Driving Question 6	fair test, data, budget

Additional Differentiated Support



See our full range of vocabulary support tools online.

My House Collapsed!

OVERVIEW

Spark	**9 min**	Students watch and discuss a video which shows different natural disasters.
Investigate	**15 min**	Student teams build the tallest structures they can using newspaper and tape.
Report	**5 min**	Student teams discuss their structures and explain the choices they made.
Connect	**10 min**	Students listen to a read-aloud about earthquakes, tsunamis, and volcanoes, and watch a video that introduces them to the module's Performance Task, the Engineering Design Challenge.
Reflect	**6 min**	As a formative assessment, students complete the "Know" and "Wonder" columns of the KLEW Chart.

STANDARDS

NGSS

PE — **3–5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

DCI — **ESS3.B** Natural Hazards
ETS1.A Defining Engineering Problems
ETS1.B Developing Possible Solutions

SEP — **SEP-1** Asking Questions and Defining Problems
SEP-3 Planning and Carrying Out Investigations

CCC — **CCC-7** Stability and Change

CETAS — Influence of Engineering, Technology, and Science on Society and the Natural World

CROSS-CURRICULAR CONNECTIONS

EPC — **Principle V** Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

CCSS ELA — **SL.4.1** Comprehension and Collaboration

WIDA — **Standard 1:** Social and Instructional Language (Listening, Speaking)
Standard 4: The Language of Science (Listening, Speaking)

3-D LEARNING OBJECTIVES

Students will:

- Discuss and ask questions about natural disasters (earthquakes, tsunamis, volcanic eruptions) and their impact on humans
- Build a structure using design criteria and constraints.

Driving Question 1
How are waves involved in earthquakes?

LESSON 1

RESOURCES

Digital

- **Family Outreach Letter 1**
- **Natural Disasters video**
- Optional: **Natural Disasters visual**
- **Criteria and Constraints 1 visual**
- **Earthquakes, Tsunamis, and Volcanoes Prior-Knowledge Read-Aloud**
- **Earthquake Engineering Trailer video**

Student

For the class:

- Optional: Camera

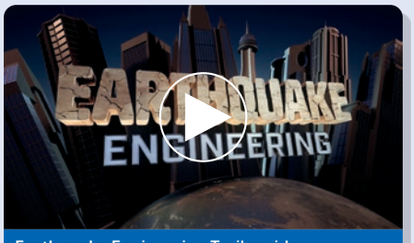
For each team of 4:

- Clear tape
- Newspaper
- Scissors



Natural Disasters video

Observe erupting volcanoes, earthquakes, and tsunamis, and learn about their devastating effects.



Earthquake Engineering Trailer video

An introduction to the Earthquake Engineering module, in which students learn about earthquakes, then design an earthquake-resistant structure.

LESSON PREPARATION

- Print out the **Family Outreach Letter 1** (1 per student) to give to students at the beginning of class. You may also email a copy to parents or guardians.

  This letter provides families with an overview of the module's core science ideas, gives general suggestions for how families can connect student learning to experiences outside the classroom, and includes an optional form for parents or guardians to indicate availability to volunteer in the classroom, and/or provide materials for the module.
- Either prepare to distribute the newspapers or have a stack that students can take from.
- Make the Interesting Earthquake Fact Board using a large piece of chart paper, and display in the classroom. Before each lesson, you or a student will add a new fact about earthquakes to the board.
- Gather materials for making the academic word wall, e.g., poster paper, pens, etc. This will be referred to throughout the module to develop students' academic language. Determine a place for it in the classroom.

Word Wall

- natural disaster
- earthquake
- tsunami
- volcano

Spark

9 min

Fact Board

Earthquake Fact of the Day:

- We think the fires that ensued after the 1906 San Francisco Earthquake caused more damage than the earthquake itself.

English Learners

Use visuals to support students during the discussion.

Substantial Support (Emerging Proficiency)

Replay the video and pause it at images of an earthquake, tsunami, and volcano as you discuss the questions. Also project the Natural Disasters visual to support students' ability to describe what is viewed.

Moderate Support (Expanding Proficiency)

Write *earthquake*, *tsunami*, and *volcano* on the board. Guide students to connect each word to an image on the Natural Disasters visual prior to the discussion.

Light Support (Bridging Proficiency)

Show the Natural Disasters visual. Guide students to name and describe each image prior to the discussion. Add vocabulary, as needed.

Cultural Connection

Be aware that some students may have personally witnessed or experienced natural disasters, and that some of the images shown could spark emotions or connections to other memories. During the discussion, if students want to briefly share something personal, invite them to do so. Offer reassurance that in this module they will learn important facts, as well as ways that we can safeguard against some of these challenges through the power of engineering.

Discuss the Video



Without introducing its content, play the **Natural Disasters video**, which shows footage of earthquakes, volcanoes, and tsunamis, and their impact on people.

Ask students to describe what they observed in the video.

Expect them to use such words as *volcanoes*, *waves*, and *destroyed buildings*.

If students do not suggest that they observed things that are the result of natural disasters (earthquakes, tsunamis, volcanoes), you can ask the following prompts:

- ***What natural events might have destroyed those buildings?***
- ***What could cause large waves?***
- ***What questions can you ask about these natural disasters and their impact on humans?***

Guide students to use the vocabulary words (*natural disaster*, *earthquake*, *volcano*, and *tsunami*) and add these to the academic word wall. You can add an illustration beside *earthquake*, *volcano*, and *tsunami*.

Connect Today's Learning to CCC-7—Stability and Change

Ask students if they think the after-effects of the natural disasters (e.g., destroyed buildings) occurred immediately, or if they took longer to occur. Remind them that it took millions of years for the Grand Canyon to become what it is today (Module 3) and make a comparison with time scales of natural disasters.

Introduce the Interesting Earthquake Fact Board

Point to the Interesting Earthquake Fact Board. Explain that each day either you or a student will add an interesting fact about earthquakes or their impact on people.

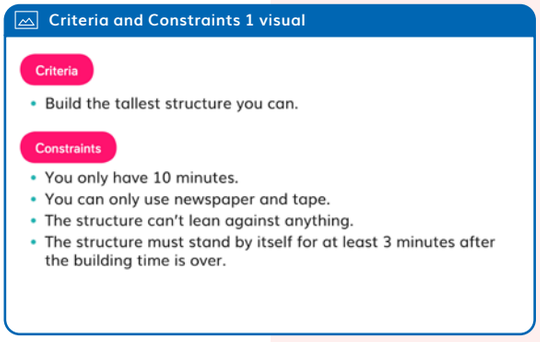
Investigate

15 min

Introduce the Activity

Today, students will work in teams of 4 to create a structure using newspaper and tape.

Display the **Criteria and Constraints 1 visual**, and read aloud the information. Point out that the information is also given on page 3 in the Twig Book.



Review the terms with the class:

- *criteria*: conditions that engineers must meet with their design
- *constraints*: limits engineers must adhere to when designing (e.g., limits on materials and time)

Let students know that this task is experimental and should be enjoyable—it's OK if the design doesn't work, as this will help them understand why buildings fail.

Build Structures

Divide students into teams of 4 and give each team the resources they will need to build their structures—newspaper, clear tape, and scissors. Let students know that they may cut the newspaper to build their structures.

Have teams begin building their structures using the resources provided.

You do not need to formally assess students during the activity; however, circulate and take notes about how each team constructs their buildings. For example, you might take notes on:

- The overall designs created (e.g., built with walls, columns, floors)
- The variety of the structures' shapes
- The shape of the structures' bases
- The number of floors in the structures
- The stability of the structures—which ones worked and which didn't
- The types of reinforcements made to stabilize the structures
- The structures that were stable during the activity, but you anticipate would not remain stable under earthquake-stress conditions (i.e., shaking).

Ask students to make drawings or take photos of their structures. Keep your notes, so that you can refer back to them during the course of the module. For example, when working on shapes in Driving Question 3, Lesson 1, you might ask students to think back to the triangular shapes they used in this lesson.

Prepare for the Report

Identify a few teams to describe their structures. If possible, select teams that used different shapes or different construction ideas, and teams that had stable structures as well as teams whose structures collapsed.

Safety

Remind students to handle scissors with care.

Special Needs

Fine Motor Skills

Allow students with fine motor skill challenges to dictate some of the physical actions of the build to a peer who will enact what they are saying (e.g., cutting the paper in a particular shape). However, ensure they engage with the portions of the build that they can do.

Report

5 min

Discuss Structures

Have the teams you selected explain why they built their structures the way they did. Allow students to use informal vocabulary. Remember that most students have no, or limited, background knowledge about forces and materials and the stability of different shapes, so don't expect correct answers—just get them thinking.

- ***What shape did you use to build your structure?***
- ***Why did you choose this shape?***
- ***What did you do to strengthen your structure?***
- ***What shape is the base of your structure?***
- ***Did your structure collapse? Why?***

Connect

10 min

Read Aloud

Display the **Earthquakes, Tsunamis, and Volcanoes Prior-Knowledge Read-Aloud**. Before you read, guide students to preview the text:

Step 1: Read the title of the article. It explains its topic.

Step 2: Read the introduction and any headings. These relate to the main ideas of the text. Think about what the main ideas may be.

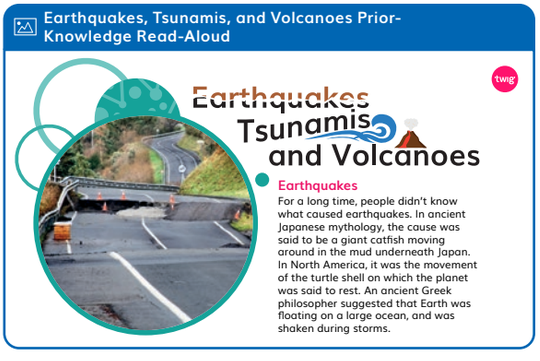
Step 3: Look over any photos and illustrations.

Step 4: Notice any features, e.g., special type, maps, and diagrams.

Step 5: Based on your preview, ask yourself what the text will be about.

In this case, the features are straightforward and comprehension may only be impeded by the text's vocabulary. However, the routine is a useful habit to acquire and should be repeated until established as practice.

Read the **Earthquakes, Tsunamis, and Volcanoes Prior-Knowledge Read-Aloud**. You may ask volunteers to take turns reading paragraphs, rather than reading it yourself.



Introduce the Module Investigative Problem: How can we reduce the damage caused by earthquakes?

Explain that, throughout this module, students will learn about earthquakes, their impact on the natural world and human-made structures, and engineering.

English Learners

ELs, and indeed the entire class, may need some support with the vocabulary in the text. The following words may need to be explained with a synonym, a definition, and an explanation: *originate*, *epicenter*, *tilt*, *split*, *landslides*, *massive*, *trough*, *generated*, *tsunami*, *buoys*, *erupt*, *predicting*, *detect*, *vents*, and *evacuate*.

Read the text aloud without interruption and model using context to decode unfamiliar words, as many are explained or their meaning expanded in the text itself.

English Learners

As you introduce the Module Investigative Problem, ensure that ELs know what an *engineer* is and that *engineering* is what engineers do. Some may not recognize the word as a verb.

Introduce the Module

Play the **Earthquake Engineering Trailer video** to introduce the Engineering Design Challenge. Students will start this later in the module and work on it over a number of lessons.

Students will use the knowledge they gain about earthquakes in the Engineering Design Challenge to plan, create, test, and improve their earthquake-resistant structures. They will use what they learn from their designs to address the Module Investigative Problem.



Reflect

6 min

Formative Assessment

Have students look at the KLEW Chart on page 4 in their Twig Books. Explain that they will fill out this table over the course of the module, demonstrating their knowledge and learning about earthquakes, tsunamis, and volcanoes, and their impact on humans.

Ask students to reflect on how they might know facts about these topics. For example, they might have heard information on television, from their family and friends, or in their science lessons.

Have students fill in the "Know" column (what they know) and the "Wonder" column (what they wonder).

Use the Formative Assessment

Review students' answers to assess their prior knowledge and determine discussion points for the Spark in the next lesson. In particular, note any entries that relate to the concept of waves.

Twig Book, p.4

Reflect

LESSON 1

Fill in the Know and the Wonder columns of the KLEW chart about earthquakes, tsunamis, and volcanoes, and their impact on humans.

Know	Learned	Evidence	Wonder
Earthquakes happen in a specific place and are caused by rocks moving. They make the ground split and cause landslides that can hurt and kill many people. Tsunamis are big waves caused by underwater earthquakes and are very destructive. They can kill thousands of people and cause a lot of damage. There are about 1,500 active volcanoes on Earth and they can be very dangerous. 50 erupt every year.	Earthquakes are made up of waves of energy called seismic waves. The amount of energy in these waves, or magnitude, can be measured by recording their amplitude. The number of deaths caused by earthquakes has decreased over the years. This is because we are building safer and stronger buildings than we used to, as well as developing better emergency procedures and rescue techniques.	The seismometer app showed us how energy is made of waves that can be measured. The "California Shakin'" article showed how the number of deaths has decreased over the last 120 years. In the San Francisco earthquake of 1906, 3,000 people died, compared to 1 person dying in the 2014 South Napa earthquake.	Can we guess when they will happen and how bad they will be? Do they happen in some places more than others? Why? Can we protect people and places from the damage they cause?

Word Wall
- natural disaster
- earthquake
- tsunami

Making Waves

OVERVIEW

Spark	**15 min**	Students review the questions they wrote in their KLEW Charts, and are introduced to the concept of waves by watching a teacher demonstration and a video about raindrops.
Investigate	**15 min**	Students draw a model of waves in water that summarizes their observations from the demonstration and the video, and write an explanation of what they saw.
Report	**8 min**	Students share their models and explanations, identifying which models best represent waves in water and why, and discussing elements of a strong explanation.
Connect	**3 min**	Students are reminded that models can be physical or visual, and that they inspire interrogative questions.
Reflect	**4 min**	Students consider how their understanding of waves has changed, redraw their visual model to include more details, and optionally also rewrite their written explanation.

STANDARDS

NGSS

PE — **4-PS4-1** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move

DCI — **PS4.A** Wave Properties

SEP — **SEP-2** Developing and Using Models

CCC — **CCC-1** Patterns
CCC-5 Energy and Matter

CROSS-CURRICULAR CONNECTIONS

CCSS ELA — **SL.4.1d** Comprehension and Collaboration

WIDA — **Standard 1:** Social and Instructional Language (Listening)
Standard 4: The Language of Science (Listening)

3-D LEARNING OBJECTIVES

Students will:

- View a teacher demonstration and a video about waves, and discuss their observations
- Develop a model of how waves spread out from a center point.

Driving Question 1
How are waves involved in earthquakes?

LESSON 2

RESOURCES

Digital

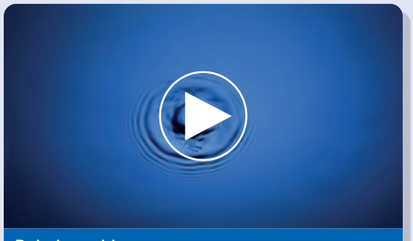
- **Raindrop video**

Teacher

- In kit: Safety goggles
- Clear plastic tub
- Rock
- Water

Student

- In kit: Safety goggles (for students sitting near the demonstrations)
- Optional: Computer or tablet (for students to watch the **Raindrop video** at their own pace)



Raindrop video
Observe a water droplet as it lands in water and creates ripples.

LESSON PREPARATION

- Review students' comments in their KLEW Charts from the previous lesson in order to guide the Spark discussion. List the phenomena that students wondered about and cross-reference to the relevant lessons in the module, especially anything related to waves, including earthquakes and tsunamis.
- Source a clear plastic tub which is large enough for students to observe waves traveling (e.g., surface area of 20 cm × 30 cm).

  Fill the tub with water to 3–5 cm below the top.
- Select and test a small rock big enough to create waves when dropped into the water.

Word Wall

- energy transfer
- waves
- point of impact

Spark

15 min

Fact Board

Earthquake Fact of the Day:

- European settlers experienced their first earthquake in America in 1663.

Discuss the KLEW Charts

Congratulate students on the interesting questions they asked in their KLEW Charts. Point out that they will learn more about earthquakes and how engineering can help make earthquakes less dangerous.

Ask students to first share something about earthquakes from their KLEW Charts and then share something about waves, if possible.

List on the board any phenomena in the KLEW Charts that relate to waves.

Collect and Display—Collect (Language Routine)

Note the everyday language that students use to describe wave phenomena. During the demonstration, capture everyday language students are using that is especially relevant. This may include words like *waves*, *ripples*, *force*, *movement*, *motion*, *impact*, *center*, *source*, *starting point*, and *travel*. This output of language is important, as it will be used as a reference that students can build on and connect to as they develop scientific language.

Safety

You should wear safety goggles during the demonstration. You might also want students closest to the demonstration to wear goggles.

Demonstrate Waves—Drop a Rock in Water

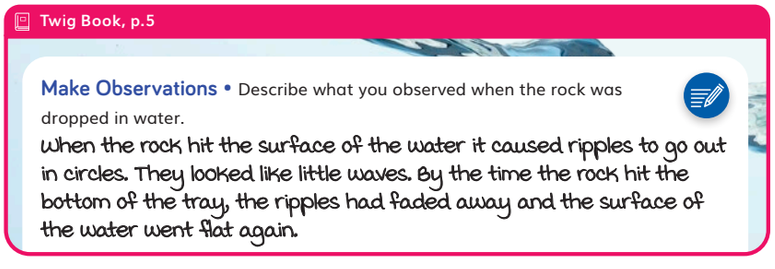
Hold up the rock and explain that you are going to drop it into a tub of water.

- ***What will happen? Why do you think so?***
- The rock will make a splash.
- The rock will sink to the bottom.
- The rock will make waves.
- There won't be any waves on the surface of the water because the rock falls to the bottom.

Remind students to pay close attention to the surface of the water.

Drop the rock into the water.

Ask students to turn to page 5 of their Twig Books and describe what they observed. When they are finished, ask one or more students to describe aloud what happened at the surface of the water.



Special Needs

Conceptual Processing

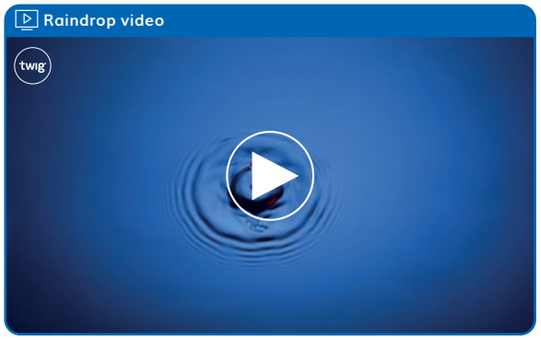
If possible, provide access to at least one computer so that students can watch the video again at their own pace during the activity. They may wish to pause and watch sections of the video again.

Observe the Video

Introduce the video, which shows a raindrop falling on a pool.

Play the **Raindrop video**.

Ask a few students to describe what they observed.



Investigate

15 min

Introduce the Activity

Today, student pairs will share their thoughts and observations from the demonstration and video. They will draw a diagram of what they saw, and write a short explanation along with it. Explain that the diagram is a visual model.

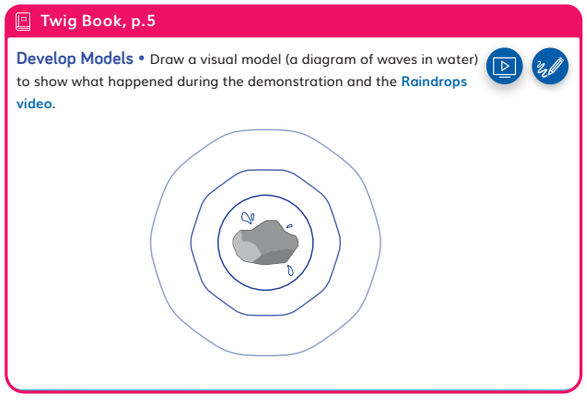
Collect and Display—Collect (Language Routine)

Pay close attention to the language that students are using. Students are going to discuss their observations in pairs—you should listen without interfering and record some of the words and phrases they use. Identify the terms used most often and highlight these during the Report.

Draw a Wave Model

Have student pairs discuss their observations.

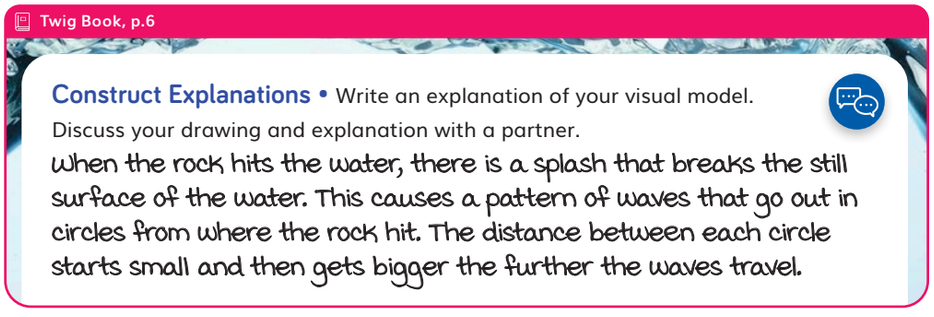
Have students then turn to page 5 in their Twig Books. They should draw a model of waves in water that summarizes these observations, and write an explanation of their model.



Continue to listen to the partner discussions. If students are struggling to make progress on the task, ask some prompt questions.

- ***What happened at the surface of the water?***
- ***Where did the waves start?***
- ***Where did the waves go and how did they move?***
- ***Can you make a drawing of this?***

Encourage students to suggest explanations for why the water moved outwards from the rock when it was dropped in the water.



Challenge

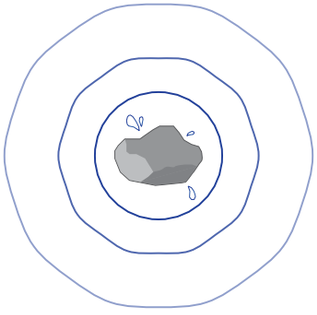
After the video, ask students what they would see if raindrops fell in exactly the same place once every second.

Investigate

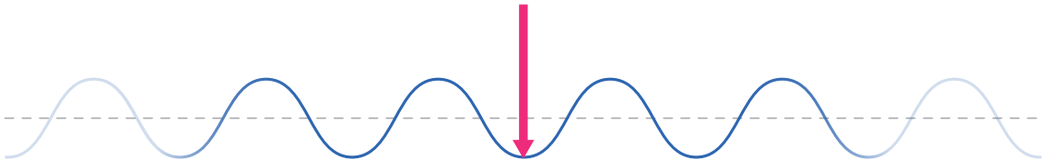
Prepare for the Report

Look for visual models that:

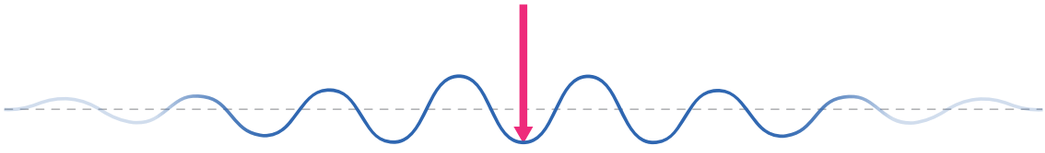
- Show a top view of the waves



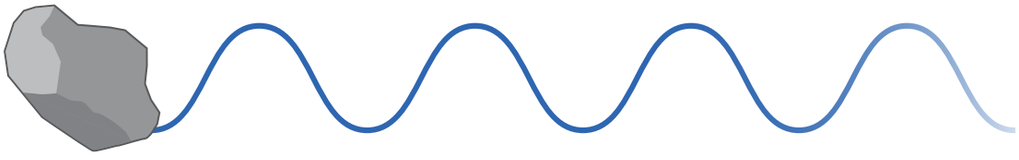
- Show a side view of the waves...
  - ...where the waves are all the same height



  - ...where the waves decrease in height as they get farther from the source



- Show waves spreading out in only one direction from the source



Visual models should include explanations that are labeled with descriptions of size (scale) or shape, or direction of movement. Look for explanations that:

- Describe the waves incorrectly, e.g., "Waves stay the same size as they spread out from the source."
- Describe the waves as spreading out concentrically from the source and getting smaller in height and longer in width as the distance from the source increases
- Mention energy transfer or make a connection to Module 1.

Report

8 min

Share Models and Explanations

Show and discuss a few students' visual models. Have students share which models they think represent waves in water the best, and explain why.

Share a few students' explanations, and prompt students to discuss elements of a strong explanation.

Collect and Display—Display (Language Routine)

Make relevant connections from students' explanations to essential academic vocabulary. Return to the list of terms and phrases captured during the Collect portion of the routine. Students might not use the term *energy transfer*. Introduce *energy transfer* and add it to the academic word wall. Also add *waves* and *point of impact*.

- ***Can you think of any natural events that could create waves in water?***
- Meteorite impacts, earthquakes, underwater landslides, glaciers calving

Have students explain what made them think of these natural events. If students suggest earthquakes, probe for an explanation. Students may have some prior knowledge about earthquakes, their epicenters, and the resulting waves that could add to class discussion.

English Learners

Focus on students' visual models to assist them as they discuss their ideas.

Substantial Support (Emerging Proficiency)

Point to each drawing. Guide students to share information they know and questions they have in their home language. Then offer a few academic words to use as labels for each drawing. Have students repeat the words.

Moderate Support (Expanding Proficiency)

Point to each drawing. Guide students to make I know..., I think..., or I learned... statements about the drawing.

Light Support (Bridging Proficiency)

Point to each drawing. Have students share what they know or think using complete sentences, such as:

- This drawing shows _____. I know that _____. This is important because _____.

Connect

3 min

Connect Today's Learning to SEP-2—Developing and Using Models

Draw students' attention to "Develop and use models" on the Science Tools poster. Ask students where they have developed and made models before:

- Models of energy transfer dealing with cars and collisions in Module 1
- Models of energy transfer beginning with moving air and moving water in Module 2

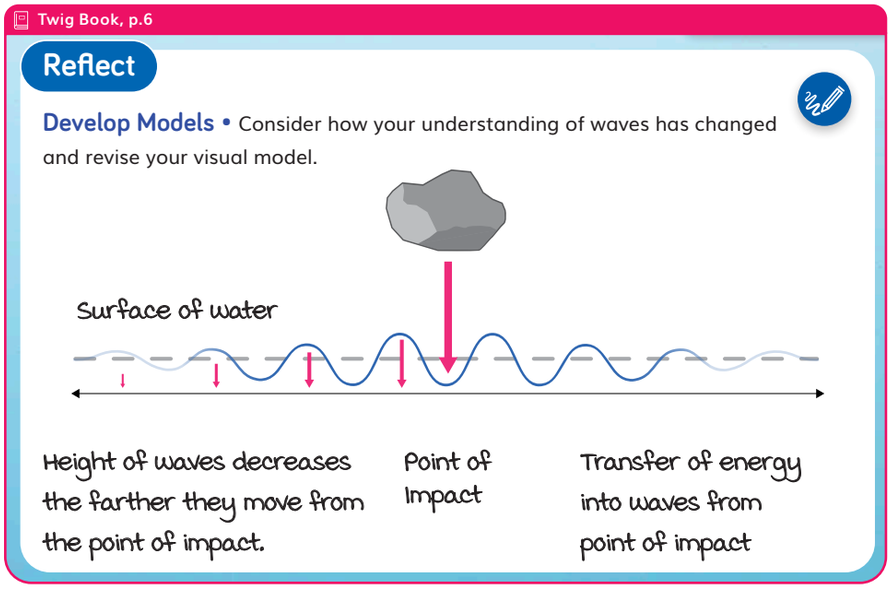
Remind students that models can be physical models, like the buildings they made in the previous lesson, or visual models, like the diagrams they created in this lesson. Models can inspire 'why' or 'how' questions, and can be updated and refined as scientists gain understanding.

Reflect

4 min

Formative Assessment

Have students consider how their understanding of waves has changed. Ask them to turn to page 6 in their Twig Books and redraw their visual model, including more detail. They may also want to update their written explanation, including more information based on their discussion and analysis so far.



Use the Formative Assessment

Review students' models before the next lesson to assess their understanding of how the waves occurred and how they spread out. In the next lesson, make sure you check in with students who are missing any key concepts about waves.

Identify students who still don't demonstrate:

- How energy is transferred to the water to make waves
- A concentric wave pattern
- Waves getting smaller in height and longer in width as they move farther from the source
- How to use appropriate labels on their models.

Look for explanations that don't mention energy, circles, or the decreasing height of the waves as they move farther from the central point where a rock or raindrop hits the water.

Learning the Ropes

OVERVIEW

Spark	**10 min**	Students observe and discuss images of different kinds of waves.
Investigate	**20 min**	Student teams use a rope to make waves, investigating what happens to a wave when a rope is shaken with varying speed and force. They draw pictures of the wave movements and write their observations.
Report	**8 min**	Students share and discuss the results of their investigations, focusing on cause-and-effect relationships.
Connect	**4 min**	Students understand that earthquakes generate waves, and that amplitude and wavelength depend on the intensity of the shaking and how quickly the movement repeats, just like with the ropes.
Reflect	**3 min**	Students label the amplitude and the wavelength on a wave diagram.

STANDARDS

NGSS

PE — **4-PS4-1** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move

DCI — **PS4.A** Wave Properties

SEP — **SEP-2** Developing and Using Models

SEP-3 Planning and Carrying Out Investigations

CCC — **CCC-1** Patterns

CCC-2 Cause and Effect

CNS — Scientific Knowledge Is Based on Empirical Evidence

CROSS-CURRICULAR CONNECTIONS

CCSS ELA — **W.4.3** Text Types and Purposes

WIDA — **Standard 1:** Social and Instructional Language (Listening, Speaking)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Listening, Speaking)

CCSS MATH — **4.MD.A.1** Solve problems involving measurement and conversion of measurement

3-D LEARNING OBJECTIVES

Students will:

- Explore waves and wave patterns through observation, discussion, and note-taking
- Learn the concepts of amplitude and wavelength by observing the height and length of waves
- Briefly explore energy transfers that cause wave patterns to change.

Driving Question 1
How are waves involved in earthquakes?

LESSON 3

RESOURCES

Digital

- **Waves visual**
- **Waves Summary visual**

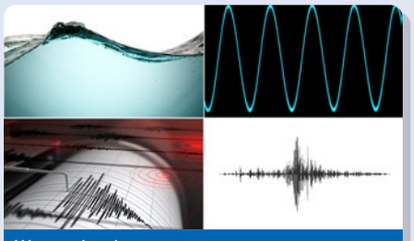
Teacher

- In kit: Masking tape

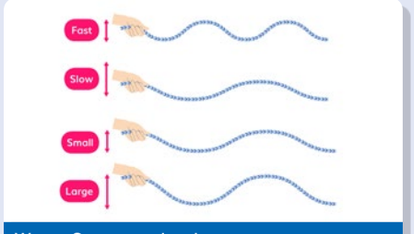
Student

For each group:

- In kit: Jump rope
- In kit: Meter stick (to make approximate measurements)



Waves visual



Waves Summary visual

LESSON PREPARATION

- Practice making a single wave travel along a rope (from a single flick) and making a series of regular waves (by shaking the end at a steady speed).
- There are enough materials in the kit for 10 groups of students. This activity works best with students in groups of 3, or more depending on class size.
- **Optional:** Wrap some masking tape around one or two different places on the rope. This will facilitate the visualization of amplitude by providing visual markers for students to focus on.

Word Wall

- amplitude
- wavelength

Spark

10 min

Fact Board

Earthquake Fact of the Day:

- There are two ways an earthquake can create a tsunami. The first is when shifts in the seabed caused by undersea earthquakes displace large quantities of water; the second is when large quantities of rock break and fall into the water (during an earthquake, or when a meteorite hits a water surface). The largest tsunami wave ever recorded took place on July 9, 1958, when an earthquake in Alaska loosened 30.6 million cubic meters of rock. The rock fell from an altitude of approximately 914 m into the water, creating a wave as high as 524 m above sea level.

Review Visual Models

Have students think about the visual models they created in the previous lesson.

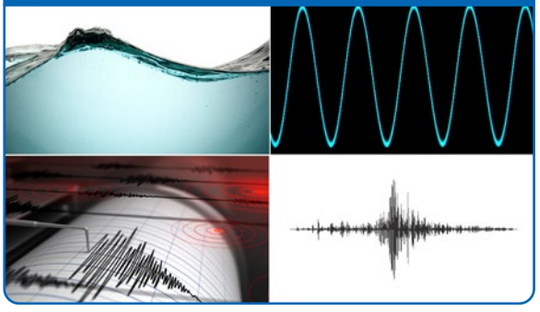
- ***What did your model show?***
- ***How did you revise your visual model and explanation?***
- ***Why did you revise it that way?***

Observe Waves

Display the **Waves visual**, which shows a variety of waves.

Give students a few minutes to record their observations on page 7 of their Twig Books.

Waves visual



Twig Book, p.7

Make Observations • Describe what you observe in the wave images.

The waves all go up and down and form patterns. The height, number, and pattern of the waves is different.

Ask student pairs to discuss what is similar and different about the various waves, and then share their ideas with the rest of the class.

- ***What do the waves have in common?***
- The waves go up and down.
- ***What is different about the waves?***
- Some waves are bigger than others.
- ***How would you describe a wave in your own words?***

Explain that, over the next few days, the class will learn about waves and how they are involved in earthquakes.

Investigate

20 min

Introduce the Activity

Today, students will use a rope to make waves. They will try different motions to create different waves.

Students will work in groups to investigate what happens to a wave when the rope is shaken with varying speed and force.

Collect and Display—Collect (Language Routine)

Listen for and collect the everyday language that students use to describe *amplitude* (e.g., "height of the wave," "going up and down") and *wavelength* (e.g., "number of waves," "distance between the waves"). Don't expect students to use the terms *amplitude* or *wavelength*. You will transition to the formal academic vocabulary during the Display portion of the language routine.

Create Waves

Divide students into groups of 3. Give each group a rope and a meter stick.

Ask groups to follow these instructions:

1. Two students hold either end of the rope.
2. One student shakes the rope while the other tries to keep the rope from moving.
3. The third student observes and takes rough measurements of the waves using the meter stick, and records the team's observations.

Students should shake the rope, varying the speed and force they use, and determine what happens to the wave. Ask them to estimate the height, number, and length of the waves, and record this information in the table on page 8 in their Twig Books, along with any other observations.

Twig Book, p.8

Carry Out Investigations • Use a rope to investigate waves.
Measure the approximate height, length, and number of the waves.

LESSON 3

Observations	Height	Length	Number of Waves
Students should note how the height, length, and number of waves change due to the amount of energy (force and speed) put into moving the rope.			

Explain that it will be hard to measure the moving rope so students' measurements will not be exact; however, their measurements should let them compare waves.

When they have recorded their observations and measurements, ask students to switch roles and make additional waves, varying the speed and force they use.

Safety

Remind students to be careful as they shake the rope. Make sure that each team has a student holding either end of the rope so it does not hit another student.

Special Needs

Social-Emotional Functioning

If the shaking overstimulates some students, cue them to relax and stay focused on the task using a gentle tap on the shoulder or physical proximity.

Investigate

Note: It takes practice to form nice waves that have a regularly repeating pattern, so do not expect students to make perfect waves. They may find it easier if they lay the rope flat on the floor and shake from side to side.

Circulate and listen to groups' discussions. The purpose is for students to become aware of the concepts of amplitude and wavelength of waves.

- ***Do you notice a pattern in the shape of the waves?***
- ***Do you notice a pattern in the size of the waves?***
- ***How would you describe a wave to someone?***
- ***Does the number of waves in the rope change?***
- ***Does the distance between the waves increase/decrease when you shake the rope quickly?***

Do not provide or expect answers or explanations.

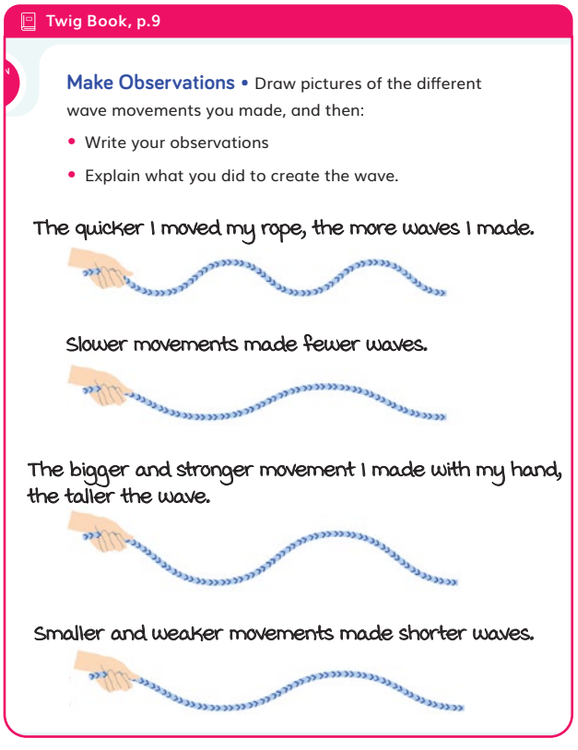
Record Observations

Have students draw pictures of the different wave movements and write their observations on page 9 of their Twig Books. Ask them to write what they did to create different kinds of waves.

Prepare for the Report

Identify student explanations to share with the class.

Look for explanations that mention the cause of the wave, connect wave action to energy transfer, or demonstrate an understanding of how to increase/decrease wavelength and amplitude. Also look for explanations that illustrate the mistaken idea that wavelength and amplitude are connected.



Report

8 min

Discuss Observations

Have the students you selected share the results of their investigations. Encourage them to discuss their observations in terms of cause and effect.

- ***What causes a wave?***
- ***What causes the rope to move?***
- ***What are the effects of shaking the rope?***
- ***Is the effect always the same?***

Students should have discovered two measurable characteristics of waves—amplitude and wavelength. **Note:** Students will not use these terms at this point; they will be introduced during the Display portion of the Collect and Display Language Routine.

Ensure students realize that amplitude and wavelength are not connected. They can increase or decrease one without changing the other.

Assess students' understanding of where the energy that makes waves comes from.

- ***What is the source of the energy that creates the waves?***
- The energy comes from the hand motion.
- ***What do you need to do to put more/less energy into the rope?***
- To put more energy into the rope, you shake the rope more quickly. To put less energy into the rope, you shake the rope more slowly.
- ***What do the waves look like when more energy is transferred to the rope?***
- When more energy is transferred to the rope, the height of the waves increases.
- ***What do the waves look like when energy is transferred to the rope more quickly?***
- When energy is transferred to the rope more quickly, there are more waves.

Students may notice that the height of a wave (amplitude) decreases as it moves along the rope. Explain that the wave transfers energy along the rope and some of the energy transfers away from the wave into the surrounding air, decreasing the energy carried in the wave.

Collect and Display—Display (Language Routine)

Connect the everyday language you collected to the formal academic vocabulary terms *amplitude* (the height of the wave from the wave's undisturbed, or resting, position) and *wavelength* (the distance between successive waves). Make sure students understand that wavelength is connected to the number of waves.

Add *amplitude* and *wavelength* to the academic word wall.

Special Needs

Executive Functioning

Seat students next to a peer who can offer assistance with note-taking, if needed. This is not to copy, but to direct attention and offer tips.

English Learners

Provide support for students' discussions.

Substantial Support (Emerging Proficiency)

Pair students with native English speakers. Provide yes/no and simple response questions for them to answer:

- ***Did you add energy to the rope? How?***
- ***Did you shake it fast or slow?***

Moderate Support (Expanding Proficiency)

Pair students with native English speakers. Guide them to take turns speaking and listening. Provide the following sentence frames:

- A wave is caused by_____.
- When I shake the rope fast, _____.
- When I shake the rope more slowly, _____.

Light Support (Bridging Proficiency)

Prompt students to build on each other's ideas. Use the following sentence starters for support:

- I observed that _____.
- In addition _____.
- Another effect of _____.

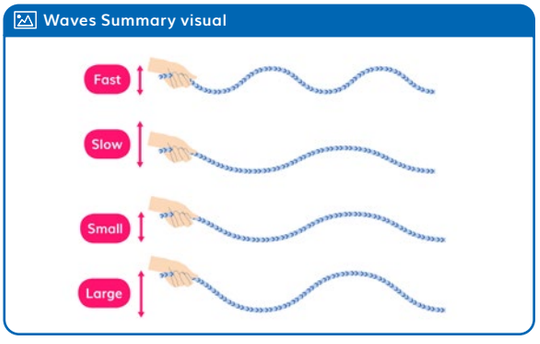
Connect

4 min

Connect Today's Learning to CCC-2—Cause and Effect

Explain that earthquakes also generate waves, either directly in water (causing a tsunami or very large water wave), or through rocks, causing (seismic) waves to travel through the Earth. In earthquakes, the amplitude of the wave depends on the intensity of the shaking, which is just like the amount of energy transferred to the rope. In both earthquakes and ropes, the distance between any two waves depends on how quickly the movement repeats.

Display the **Waves Summary visual** to summarize the activity.



Tie cause-and-effect relationships between waves and the medium (rope, water, the Earth) to other instances students have seen of cause and effect:

- Energy transfer between locations (Module 1, Driving Question 1)
- Crash scene investigators, and energy transfer between objects (Module 1, Driving Question 3)
- Glaciers carving Yosemite Valley and other forces that create landscapes (Module 3, Driving Question 4)

Optional: Make a cause and effect chart, adding the above examples in addition to the wave examples.

Connect Today's Learning to the Nature of Science

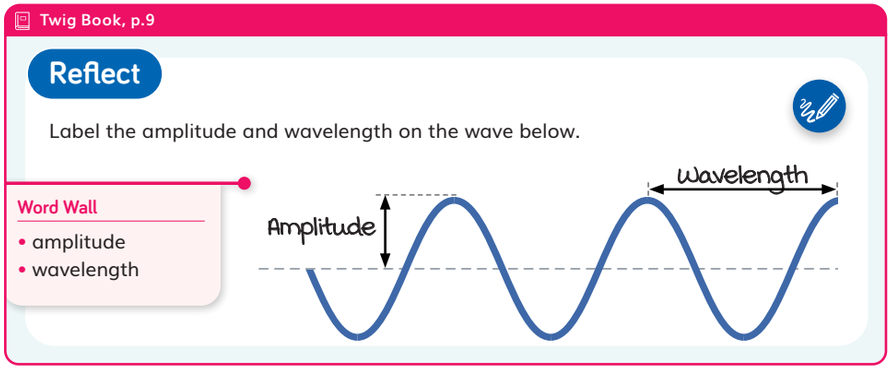
Remind students that scientific findings are based on recognizing patterns. They saw patterns in the waves based on their arm movements. Scientists also use tools to make measurements, as students did today.

Reflect

3 min

Formative Assessment

Have students turn to page 9 in their Twig Books and label the wave diagram with amplitude and wavelength.



Use the Formative Assessment

Review students' answers before the next lesson to ensure that students have a clear understanding of how amplitude and wavelength relate to the shape of a wave. Ensure students understand that amplitude is not simply a matter of a wave's height (or the peak-to-trough distance), but is a wave's height from the undisturbed, or resting, position. Consider finding and displaying a diagram of a wave with its amplitude labeled so that students understand this concept.

Make a note of students whose models are not accurate. Make sure you spend some time listening to their discussions during the Lesson 4 activity with the **Making Waves interactive**.

Rocks and Ducks

OVERVIEW

Spark	**8 min**	Students discuss what they learned about amplitude and wavelength, recall the previous lesson's teacher demonstration, and make predictions about the waves caused by dropping different rocks into water.
Investigate	**20 min**	Student pairs use an interactive to explore cause-and-effect relationships between the size of a rock and the wave created when it is dropped in water, and how it affects a duck floating at various distances.
Report	**8 min**	Students discuss their findings from the activity using academic words.
Connect	**3 min**	Students connect today's activity to the Driving Question, discussing initial ideas about waves and earthquakes.
Reflect	**6 min**	Students make drawings of their predictions of earthquake waves from an earthquake caused by a large fracture and a small fracture.

STANDARDS

NGSS

PE **4-PS4-1** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move

DCI **PS4.A** Wave Properties

SEP **SEP-2** Developing and Using Models

CCC **CCC-1** Patterns
CCC-5 Energy and Matter

CNS Scientific Knowledge Is Based on Empirical Evidence

CROSS-CURRICULAR CONNECTIONS

CCSS ELA **SL.4.1** Comprehension and Collaboration

WIDA **Standard 1:** Social and Instructional Language (Listening, Speaking)
Standard 4: The Language of Science (Listening, Speaking)

3-D LEARNING OBJECTIVES

Students will:

- Explore the amplitude of waves in water
- Consider the energy source for, and energy transferred by, different waves
- Explain the connection between waves and earthquakes.

Driving Question 1
How are waves involved in earthquakes?

LESSON 4

RESOURCES

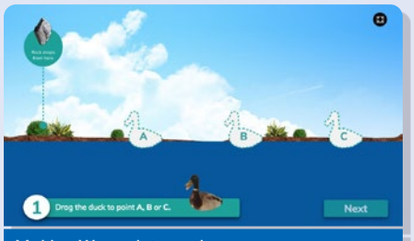
Digital

- **Making Waves interactive**

Student

For each pair:

- Computer or tablet (to use the interactive)



Making Waves interactive
Observe what happens to the ducks when you drop different rocks into the water to create waves

LESSON PREPARATION

- Review your notes from Lesson 2 and the Formative Assessment from Lesson 3.
- Preview the **Making Waves interactive** and familiarize yourself with how to select and test the different variables.

Spark

8 min

Fact Board

Earthquake Fact of the Day:

- Japan has experienced many earthquakes in its history. Out of the 500 ancient wooden pagodas still standing in the country, only two have collapsed in the past 1,400 years. In fact, the shape of a pagoda is known for resisting damage from earthquakes.

Stronger and Clearer Each Time (Language Routine)

Have students do a successive pair-share to describe one thing they learned in the previous lesson about amplitude and wavelength. Encourage students to use a diagram to describe what they learned, or to act out and narrate what happened.

As partners talk, they should press each other for more details and clarify their responses. With each successive pair-share, they should refine their original responses.

Discuss Waves and Make Predictions

If the formative assessments in Lessons 2 or 3 revealed any misunderstandings of waves, amplitude, or wavelength, address those issues in a class discussion. As a starting point, draw examples of different waves which represent incomplete or inaccurate understanding on the board. Ask students to consider and critique the visual models, explaining any additions or changes they suggest.

Remind students of the Lesson 2 demonstration where you dropped a rock into water.

- ***What do you think would have happened if I had dropped a bigger rock in the water?***
- ***What if it had been a smaller rock?***

Have students make predictions and write their ideas on the board.

Investigate

20 min

English Learners

Explain what the different combinations of rock size and duck placement mean. You may want to show one additional example to students to promote comprehension. Clarify the terms *most* and *least*, as needed.

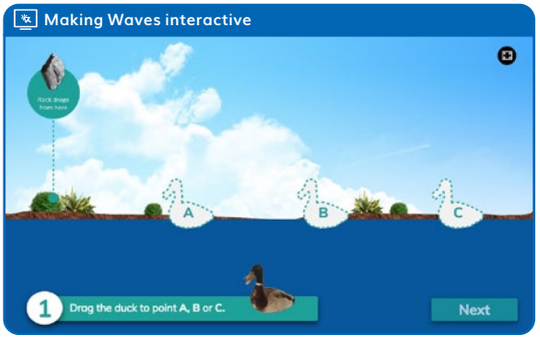
Challenge

Divide students into groups and ask them to think of one or two additional questions about waves that they would like to test and investigate.

Note: It's OK if students make claims that can only be tested outside the interactive.

Introduce the Activity

In this lesson, students will use the **Making Waves interactive** to further explore waves. They will work in pairs to explore the cause-and-effect relationship between the size of a rock and the wave created when the rock is dropped in water. They will observe how the different waves affect a duck that is floating in the water nearby.



Show students how to access and use the interactive. Demonstrate how to select and test variables—the different rock sizes and positions of the duck. Explain that the variables for testing are the different rock sizes (small and large) and the different positions for the duck—A, B, and C. Position A is closest to where the rock hits the water, and position C is farthest from where the rock hits the water.

Explore Waves with the Interactive

Divide students into pairs. Have them use the **Making Waves interactive** to further explore waves and answer the questions on page 10 of their Twig Books.

Ask students to complete the Wave Comparison Chart on page 11 in their Twig Books with the amplitude value that shows on screen for each test. Explain that a higher value means more movement.

Have students then write their observations about the amplitude of the waves in their Twig Books.

Discuss the Interactive

Have pairs discuss their answers to the questions.

Circulate and pay particular attention to students whose visual models in the Lesson 3 formative assessment demonstrated an inaccurate understanding of amplitude. The purpose of the lesson's activity is for students to further explore the concept of amplitude and how it relates to the amount of energy transferred by a wave.

- ***How do the waves made by the big rock compare to those made by the small rock? Why do you think that is?***
- ***Are waves the same height across the water? Why do you think that is?***
- ***Where do you think the waves have the most energy? Why do you think so?***
- ***Where does that energy come from?***
- ***Was your prediction correct about the size of the rock?***

Don't provide answers to these questions at this point.

Prepare for the Report

As you circulate, look at what students have written. Look for:

- Students who do not realize that larger rocks transfer more energy, thus increasing the amplitude of the waves
- Students who correctly noted that the amplitude of a wave decreases the farther it is from the rock's point of impact
- Explanations that can be used in the Connect section.

Twig Book, p.11

LESSON 4

Collect Data • When you have finished using the Making Waves interactive, complete the Wave Comparison chart with the amplitude value that shows on screen for each test.

Remember that a higher value means more movement.



Wave Comparison

	Position A	Position B	Position C
Small Rock	3.00	1.40	1.00
Big Rock	9.00	4.00	3.00

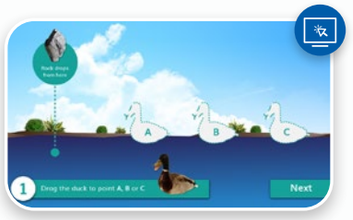
Write your observations about the amplitude of waves.

The heavier the rock, the bigger the amplitude of the waves. The amplitude also decreases the further away the waves are from the point of impact.

Twig Book, p.10

Carry Out Investigations • Use the Making Waves interactive to explore waves. Note the variables for testing:

- Two different rock sizes—small and large
- Three different positions for the duck—A, B, and C



Answer the following questions to guide your exploration.

1. What combination of rock size and duck position causes the duck to move the most?

   The large rock with the duck in position A causes the duck to move the most.

2. What combination of rock size and duck position causes the duck to move the least?

   The small rock with the duck in position C causes the duck to move the least.

3. Are there different combinations of rock size and duck position that have the same outcome?

   Large/Position C and Small/Position A both have the outcome of 3.

Report

8 min

English Learners

Monitor students' progress as they participate in collaborative conversations. Model conversation exchanges to support students' growth.

Substantial Support (Emerging Proficiency)

Students engage in one short answer. The exchange is often highly structured (e.g., using a sentence frame or responding to a direct question).

Moderate Support (Expanding Proficiency)

Students engage in several exchanges. They ask and answer questions, agree and disagree, and build on each other's ideas.

Light Support (Bridging Proficiency)

Students engage in five or more exchanges. They support their ideas with evidence and sufficiently synthesize ideas.

Discuss Findings

Ask pairs to share their findings with the rest of the class. Encourage them to use the words *amplitude* and *energy transfer.*

Students should have noticed that the amplitude of the waves is greater with a large rock. They should also have realized that the amplitude decreases as the distance from the rock's point of impact increases. They might suggest that the amount of energy transferred by the wave decreases as the wave travels away from the source.

Students might be surprised that the amplitude increases with the size of the rock, but that the wavelength doesn't change. If so, explain that the wavelength depends on the depth of the water, not on the size of the rock. For example, ripples in the middle of the pond would have a longer wavelength than those near the edge of the pond, because the pond is deeper in the middle. In the interactive, the ducks are always in the same part of the pond, so the wavelength is the same for both rocks.

Connect

3 min

Connect Today's Learning to the Driving Question

Connect today's activity to the Driving Question.

- ***How does what you've learned about waves in this lesson connect to earthquakes?***
- ***Do you think earthquakes make waves?***

Accept all answers and briefly discuss students' initial ideas about waves and earthquakes. Consider noting students' ideas on the board so you can go back to them after the next few lessons. Don't expect students to make an accurate connection yet.

Connect Today's Learning to CCC-5—Energy and Matter

Remind students that, in Module 1, they learned that emitting sound waves is one way to tell that an object has energy. In Module 2, they built a turbine to capture the energy of the wind. Today, they released energy by dropping a rock. The waves on the pond were the result of that energy release.

Reflect

6 min

Formative Assessment

Remind students that earthquake waves travel through the ground from where the ground initially fractures (the origin of the earthquake).

- ***How do you think the waves from an earthquake caused by a large fracture would look?***
- ***What about the waves of an earthquake caused by a small fracture?***

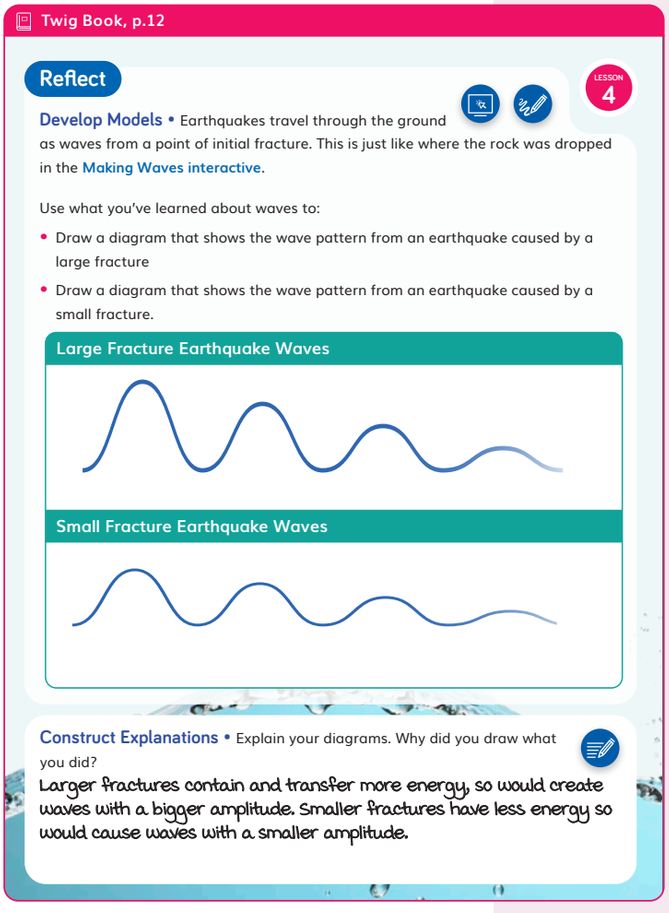
Ask students to turn to page 12 in their Twig Books. They should draw how earthquake waves might look if the earthquake was caused by a large fracture or by a small fracture. Have students write an explanation of each of their diagrams.

Use the Formative Assessment

Review students' answers before the next lesson to see if they could extend their understanding of water waves to earthquake waves.

They should be able to predict that an earthquake caused by a large fracture will release more energy and might generate waves with large amplitude, while an earthquake caused by a small fracture will release less energy and might generate waves with small amplitude.

Make note of students who were not able to predict this, as they may need help in subsequent lessons.


Twig Book, p.12

Reflect

LESSON 4

Develop Models • Earthquakes travel through the ground as waves from a point of initial fracture. This is just like where the rock was dropped in the Making Waves interactive.

Use what you've learned about waves to:

- Draw a diagram that shows the wave pattern from an earthquake caused by a large fracture
- Draw a diagram that shows the wave pattern from an earthquake caused by a small fracture.

Large Fracture Earthquake Waves

Small Fracture Earthquake Waves

Construct Explanations • Explain your diagrams. Why did you draw what you did?

Larger fractures contain and transfer more energy, so would create waves with a bigger amplitude. Smaller fractures have less energy so would cause waves with a smaller amplitude.

How Big Was That Earthquake?




☑ 3-D

OVERVIEW

Spark	**5 min**	Students recap the relationship between the amount of energy transferred by a wave and the amplitude of the wave, and watch a demonstration of a seismometer app.
Investigate	**20 min**	Students read an article about earthquakes and how they can be measured, taking notes as they read.
Report	**10 min**	Students discuss their learning from the text and techniques used by the author.
Connect	**5 min**	Students answer the Driving Question, and add to the "Learned" and "Evidence" columns in their KLEW Charts.
Reflect	**5 min**	Students complete a Pre-Exploration to gauge their understanding of earthquakes.

STANDARDS

NGSS

PE — **4-PS4-1** Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move

DCI — **PS4.A** Wave Properties

ESS3.B Natural Hazards

SEP — **SEP-4** Analyzing and Interpreting Data

SEP-6 Constructing Explanations and Designing Solutions

SEP-8 Obtaining, Evaluating, and Communicating Information

CCC — **CCC-2** Cause and Effect

CCC-3 Scale, Proportion, and Quantity

CROSS-CURRICULAR CONNECTIONS

CCSS ELA — **RI.4.1** Key Ideas and Details

RI.4.4 Craft and Structure

W.4.8 Research to Build and Present Knowledge

SL.4.1 Comprehension and Collaboration

WIDA — **Standard 4:** The Language of Science (Reading)

3-D LEARNING OBJECTIVES

Students will:

- Understand that seismic waves have amplitude that can be measured
- Understand that seismic waves can cause objects to move
- Use information from the text to draw and annotate an earthquake magnitude scale
- Discuss ideas from reading and thinking about the text.

Driving Question 1
How are waves involved in earthquakes?

LESSON 5

RESOURCES

Digital

- **Earthquake Patterns Progress Tracker**

Teacher

- Seismometer 6 app, installed on a smartphone or tablet

LESSON PREPARATION

- Install the Toolbox or Seismometer 6 app onto a smartphone or tablet and test functionality for the Spark section demonstration.

  (For Android devices, the interactive is part of the Toolbox or Toolbox PRO apps by SkyPaw Co. For iOS, the interactive is available as a stand-alone app or as part of the Toolbox PRO app.)

Word Wall

- seismic waves

Spark

5 min

Fact Board

Earthquake Fact of the Day:

- It has long been thought that animals can detect oncoming earthquakes. There was a mass exodus of toads from a pond in L'Aquila, Italy, before the 2009 earthquake struck, and hibernating snakes left their burrows a month before an earthquake struck Haicheng, China, in 1975. One theory is that stressed rocks release charged particles, which then react with groundwater. Animals living near groundwater are very sensitive to any changes in the chemistry of the water and could alter their behavior as a result.

Academic Vocabulary Check (Language Routine)

In previous lessons, you have used the Collect and Display Language Routine to collect the everyday language that students use to describe phenomena and connect this to formal academic vocabulary.

As students encounter concepts from earlier lessons, ensure that they make connections and refer to the formal terms previously posted on the academic word wall, including:

- *energy transfer*
- *earthquake*
- *waves*
- *amplitude*
- *wavelength*

If students are still using everyday language, ask if they can restate their ideas using the formal terms on the academic word wall.

Demonstrate the Seismometer 6 App

Explain that, today, students will learn how earthquakes are detected, measured, and classified.

Remind them that they previously discovered we can measure the amplitude of waves in both water and a rope.

- ***Can you explain the relationship between the amount of energy transferred by a wave and the amplitude of the wave?***
- Adding more energy to a rope causes a wave with a larger amplitude.
- The bigger the amplitude of the wave, the more energy it transfers.

Explain that it is also possible to measure the amplitude of earthquake waves by observing and measuring the amount the ground shakes. The ground can shake up and down, as well as from side to side.

Use the Seismometer 6 app to show how to graph the size of movement.

1. On your smartphone or tablet, open the Seismometer 6 app.
2. Place your device on a book lying flat on a table.
3. Tap the book gently so the device displays a graph of the book's movement that students can see.
4. Tap the book harder to see how the increased movement of the book increases the amplitude of the waves produced.
5. Give the book a small shove to see how even greater movement of the book makes the amplitude of the waves produced even bigger.

Ask students to explain what the app is measuring.

- How much the book moves

Explain that, similarly, scientists use a device called a seismometer to measure how much the ground moves from seismic (earthquake) waves.

Add the term *seismic waves* to the academic word wall.

Investigate

20 min

Introduce the Close Reading

In this lesson, students will read the article "How Big Was That Earthquake?" as a class to learn more about earthquakes and how they are measured. They will then read the article independently and take notes in preparation for discussion. They will use information from the article to develop a magnitude scale in their Twig Books.

Ask students if they know what *magnitude* means. If necessary, explain that it refers to the greatness, size, or importance of something. Ask what students think the word might mean in relation to earthquake waves.

Preview the Text

Have students preview "How Big Was That Earthquake?" using the preview routine.

Step 1: Read the title of the article. It tells its topic.

Step 2: Read the introduction and any headings. These relate to the main ideas of the text. Think about what the main ideas may be.

Step 3: Look over any photos and illustrations. You'll study these later.

Step 4: Notice any features, e.g., special type, maps, or diagrams.

Step 5: Based on your preview, ask yourself what the chapter will be about.

Ask students what type of information they expect to learn based on the preview of "How Big Was That Earthquake?" What challenges might they meet in reading the article? What reading tools do they have to tackle these challenges?

Students should pause to highlight important words and phrases that will help them with class discussion. Have them pay special attention to the term *magnitude* in order to gain more information on how earthquakes are measured. Also note the word *scale* is a word with multiple meanings in English. In this case, it refers to a range of numbers that show the size or strength of the earthquake.

English Learners

Provide additional vocabulary support, as needed.

Substantial Support (Emerging Proficiency)

Use pictures, actions, synonyms in English and definitions in students' home language to reinforce key vocabulary.

Moderate Support (Expanding Proficiency)

Provide students with bilingual dictionaries and other translation tools to use as support while reading.

Light Support (Bridging Proficiency)

Prompt students to use English language dictionaries to find the definitions of academic words they don't know while reading.

Investigate

Special Needs

Social-Emotional Functioning

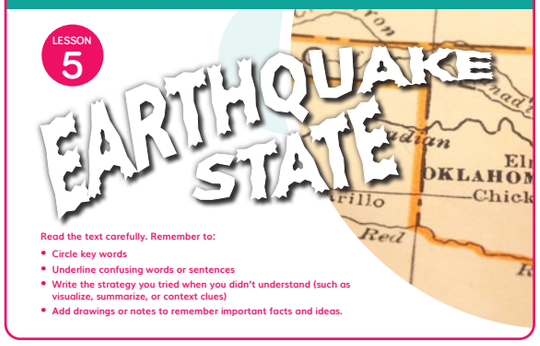
Consider which students work better when paired with a peer for reading. Allow pairs to sit away from others and read aloud.

Close Read

Have students turn to page 13 of their Twig Books. As a class, read through the article "How Big Was That Earthquake?". Ask volunteers to read aloud, one paragraph at a time.

When you have read through the whole article, ask students to complete a second, independent read. As they read, they should take notes and fill in the missing cells in the Magnitude Scale chart on pages 17–18 in their Twig Books. For each example they add to the chart, they should include details from the reading, e.g., the location, year, and magnitude of each earthquake.

Twig Book, pp. 13–14



Twig Book, pp.17–18

LESSON 5 How Big Was That Earthquake?

Reading for Evidence · Hands-On

Collect Data • Use information from "How Big Was That Earthquake?" to fill in the missing sections of this Magnitude Scale chart. Include details for the examples, such as the location, year, and magnitude of the earthquake, where provided in the article.

Magnitude Scale

Class	Magnitude	Effect (Destruction)	Example
Great	10	Results in near total destruction	No example provided
	9	Results in near total destruction	Alaska, 1964, 9.2
	8	Entire towns wiped out and buildings almost completely destroyed	China, 2008, 8.0
Major	7	Ground cracks, roads shake, weak buildings destroyed, others badly damaged	San Francisco, 1906, 7.7
Strong	6	Objects can fall from shelves, walls can crack, walls and floors shake	Italy, 2016, 6.2
Moderate	5	Doors move, glasses and dishes rattle, windows break, cars rock	Oklahoma, 2016, 5.0
Light	4	Buildings lightly shake, as if a truck is driving by	No example provided
Minor	3	Hanging light fixtures or other objects swing	No example provided
Micro	2	Trees sway, doors swing, but you can't tell an earthquake is the cause	No example provided
	1	Only detected by a seismometer	No example provided

17 www.twigscience.com

Driving Question 1 | Lesson 5 18

Consider explaining that there are several scales to measure earthquakes, including:

Richter Scale	A scale from 1 to 10 that measures the amplitude of seismic waves, and is probably the scale you hear about the most.
Moment Magnitude Scale	A scale invented because the Richter scale did not measure large earthquakes well if the seismometers were far away from an earthquake epicenter. The moment magnitude scale also uses a scale from 1 to 10 but uses a different formula. Generally, for most earthquakes, the Richter and moment magnitude scales will be roughly equivalent.
Mercalli Scale	A scale used before the Richter scale was invented. It measures the intensity of earthquake damage and will have different numbers at different locations. It goes from I to XII.

Note: Students are not going to go into detail on the various magnitude scales available—this lesson does not elaborate on which scale was used. The numbers would approximately represent both the Richter and the moment magnitude scales.

Ask students if they know what the word *epicenter* means.

Explain that earthquake waves travel through the ground from where the ground initially fractures (the origin). Explain that the epicenter is not where the earthquake actually started; it's the place at the ground surface directly above the actual origin of the earthquake.

Report

10 min

Discuss the Close Reading

Lead a class discussion on the information presented, and techniques used, in "How Big Was That Earthquake?"

- ***What causes earthquakes?***
- Plates that make up the Earth's crust move and release energy.
- ***What is a seismometer?***
- A device that detects and measures ground movement—it helps tell the size of an earthquake.
- ***What do scientists use to classify the size of an earthquake?***
- A magnitude scale
- ***Why is the magnitude of an earthquake important?***
- It gives us an approximate measure of how powerful an earthquake is (how much energy is released).
- An earthquake's magnitude is related to the effects it may have on people, animals, structures, and the environment.
- ***How does the author give us an idea of the scale of the earthquakes described?***
- The author uses some everyday examples to illustrate the strength of the earthquakes. As the magnitude increases, the effects become progressively more noticeable.

Challenge

Have students discuss the question: What other factors do you think might affect the amount of damage an earthquake causes in an area?

- Population density; distance from the epicenter; quality of building construction; number and intensity of aftershocks; subsequent weather (e.g., heavy rains could cause additional damage); damage to infrastructure (e.g., levees, dams, or suspended highways); geological makeup of the site; depth of the earthquake.

Report

- Doors swing. Light fixtures sway. Cars may even sway back and forth. Objects in a house may fall from shelves. Walls may crack. Whole cities may be destroyed.
- ***How does the author's use of words help us imagine an earthquake?***
- The author uses comparisons (similes and metaphors) and detailed descriptions to get across what it's like to experience an earthquake.
- "At 4.0, an earthquake makes buildings shake lightly, as if a big truck is passing by."
- "Cars may even sway back and forth like rocking chairs."
- "Photos from the aftermath show entire city blocks turned into piles of smoking debris."
- The author also quotes an eyewitness:
- "Lewis Sanders IV was more than 30 miles from the epicenter of the earthquake. He was still shaken. Sanders later wrote on a news website that he woke in the middle of the night to a low rumbling sound and his wife yelling. His walls and floor shook violently. He and his family rushed outside to safety."

Have students share the information about earthquakes from the reading that they added to the Magnitude Scale chart. Have them describe the earthquake and explain where it belongs on the scale.

Connect

5 min

Connect Today's Learning to the Driving Question

Have students turn to page 4 in their Twig Books and look over the KLEW Chart they started in Lesson 1. Remind students of the Driving Question, and elicit an idea about what they have learned about how waves are involved in earthquakes.

Ask the class to share evidence that supports the idea. Have students add to the "Learned" and "Evidence" columns of their KLEW Charts.

Connect to CCC-3—Scale, Proportion, and Quantity

Remind the class of other times they have worked with scale—the scale of time involved in studying the Great Wall of China and the missions in California (Module 3, Driving Question 1), and the size and time scales involved in the formation of the Grand Canyon (Module 3, Driving Question 2).

Reflect

5 min

Pre-Exploration

Have students complete the Earthquake Patterns Pre-Exploration on page 19 in their Twig Books in order to elicit misconceptions about earthquakes.

Have students refer to the list of statements about earthquakes, and check the box next to each statement that they believe to be true.

They should then write whether they think we can see patterns in when and where earthquakes occur, and give details.

Use the Pre-Exploration

Look for students who demonstrate the following misconceptions and record them on the **Earthquake Patterns Progress Tracker**. You will address these misconceptions in future lessons.

Twig Book, p.19

Pre-Exploration

True or False • Read the following statements. Put a check mark by each statement that you think is true.

- Earthquakes are rare events. ☐
- Earthquakes often occur near oceans and mountain ranges. ☑
- All earthquakes are caused by erupting volcanoes. ☐
- Some areas on Earth experience more earthquakes than others. ☑
- Small earthquakes happen every day. ☑
- Earthquakes are most deadly when they cause the ground to open up as people, animals, plants, and buildings can fall into openings and disappear. ☐
- Earthquakes are equally likely to happen anywhere on Earth. ☐

Construct Explanations • Do you think we can see any patterns in when and where earthquakes occur? Give details.

I think there are patterns in where earthquakes occur, because they often occur near oceans and mountains and some areas of the Earth experience more earthquakes than other areas. I don't think there is a pattern in when earthquakes occur, because they happen every day.

Earthquake Patterns Progress Tracker

Earthquake Patterns Pre-Exploration Tracker

Misconception	Look for	Tally	Total	Where addressed	Notes
Earthquakes are rare events.	Students who check statement 1.			Driving Question 2, Lesson 3 Debrief	
All earthquakes are caused by volcanoes erupting.	Students who check statement 3.			Driving Question 2, Lesson 1 Debrief Driving Question 2, Lesson 2 Debrief	
More earthquakes happen in locations where there are more tectonic plates.	Students who check statement 4.			Driving Question 2, Lesson 2 Debrief	
Earthquakes are most deadly when they cause the ground to open up as people, animals, plants, and buildings can fall into openings and disappear.	Students who check statement 7.			Driving Question 2, Lesson 4 Debrief	
Earthquakes are equally likely to happen anywhere on Earth.	Students who check statement 8.			Driving Question 2, Lesson 1 Debrief Driving Question 2, Lesson 2 Debrief Driving Question 2, Lesson 3 Debrief	

Misconception	Look for	Where Addressed
Earthquakes are rare events.	Students who select Statement 1	Driving Question 2, Lesson 3
All earthquakes are caused by erupting volcanoes.	Students who select Statement 3	Driving Question 2, Lessons 1 and 2
Earthquakes are most deadly when they cause the ground to open up as people, animals, plants, and buildings can fall into openings and disappear.	Students who select Statement 6	Driving Question 2, Lesson 4
Earthquakes are equally likely to happen anywhere on Earth.	Students who select Statement 7	Driving Question 2, Lessons 1, 2, and 3

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QUESTION INVESTIGATE ANALYZE EXPLAIN EVALUATE

GRADE **4**
MODULE **4**

EARTHQUAKE ENGINEERING

Module Anchor Phenomenon:
How can we reduce the damage caused by earthquakes?

Driving Question 2
How can patterns help us predict where earthquakes and volcanoes will occur?

Performance Expectation: 4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.

Students collect and interpret data from the Earth Explorer interactive to make sense of core ideas about patterns in the location of tectonic plates, volcanoes, and earthquakes.



Overview: **Full Course**

Driving Question 2 How can patterns help us predict where earthquakes and volcanoes will occur?

	FULL COURSE		
	LESSON	PAGE	SUGGESTED PACING
ENGAGE	1 **Explore the World** Students use an interactive map of the world to explore different physical features of the Earth, with a focus on the locations of mountain ranges, volcanoes, and earthquakes. Students look for patterns in where earthquakes occur.	48	45 min
EXPLORE	2 **An Earthquake Is Born** Students make claims about the causes of earthquakes and explore tectonic plates and earthquakes using an interactive. They revise their claims and discover more about earthquake patterns, then watch a video about the causes of earthquakes.	56	45 min
EXPLAIN	3 **Little Earthquake, Where Are You?** Students watch a video explaining latitude and longitude. They then use a website to source real data about earthquakes that occurred around the world on the previous day, enter this information into the interactive, and analyze the data.	64	45 min
ELABORATE	4 **California Shakin'** Students do a close reading to learn about famous earthquakes in California's history. They then complete a graphic organizer about earthquakes in order to compare and contrast information and identify patterns.	72	45 min + optional 45-min extension
EVALUATE	5 **Earthquakes in Oklahoma** Students read and discuss another informational text about real-life earthquakes, this time with an article about earthquakes in Oklahoma. Students reread to identify important information, before preparing a news report to share what they learned.	80	45 min + optional 45-min extension
EVALUATE	3-D **Benchmark Assessment: Analyzing Maps** Students analyze maps in order to select the best site for a new theme park that has the least risk of being affected by earthquakes.	88	20–30 min

Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · 3-D Assessment

The Full Course is recommended for mastery of the Performance Expectations.
The Fast Track Course delivers the Next Generation Science Standards at an accelerated pace.

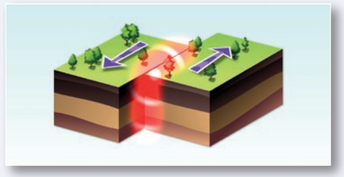
Overview: **Fast Track Course***

Driving Question **2** How can patterns help us predict where earthquakes and volcanoes will occur?

RESOURCES	MATERIALS	
	TEACHER	TWIG SCIENCE LAB KITS
• Family Outreach Letter 2 • Earth Explorer interactive • Earthquake Patterns Progress Tracker	• Computer or tablet for each pair	
• Earth Explorer interactive • Why Earthquakes Happen video • Earthquake Patterns Progress Tracker	• Computer or tablet for every 2–3 students	
• Earth Explorer Graphic Organizer handout • Where on Earth Are You? video • Earth Explorer interactive • Earthquake Patterns Progress Tracker	• Computer or tablet for each pair	
• California Earthquakes Graphic Organizer visual • Earthquake Patterns Progress Tracker • Compare/Contrast visual (optional)	• Colored pencils or highlighters	
• Oklahoma Earthquakes Magnitude Graph visual • Report Guidelines visual		
• Analyzing Maps Benchmark Assessment • Analyzing Maps Teacher Rubrics • Analyzing Maps Student Rubrics		

BENCHMARK ASSESSMENT

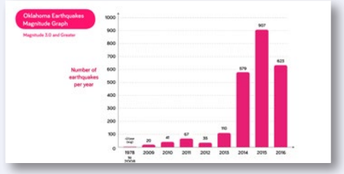
Resource Highlights



Why Earthquakes Happen video



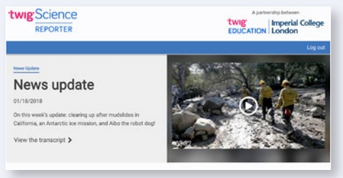
Earth Explorer interactive



Oklahoma Earthquakes Magnitude Graph visual



Professional Learning



Topical science news, features, and careers

twig Science REPORTER

*Fast Track lessons/activities are identified by

FAST TRACK COURSE			
BLOCK	SUGGESTED PACING	LESSONS/ACTIVITIES	NOTES
1	30 min	**Sections from Explore the World** • Demonstrate the Interactive • Introduce the Activity and Connect Today's Learning to CCC-1—Patterns • Identify Patterns with the Interactive • Misconceptions from the Pre-Exploration	
	30 min	**Sections from An Earthquake Is Born** • Introduce the Activity • Explore Tectonic Plates with the Interactive • Discuss Claims and Evidence • Summarize the Video • Revise Claims • Chart SEP-8—Obtaining, Evaluating, and Communicating Information • Formative Assessment • Assess Student Progress	Based on their observations, have students make a claim about what causes earthquakes, and include evidence. Have them write their claim with evidence on page 26 in their Twig Books.
2	40 min	**Sections from Little Earthquake, Where Are You?** • Discuss the Video • Discuss Latitude and Longitude • Introduce the Activity • Demonstrate the Activity • Find and Enter Earthquake Data • Discuss Observations • Misconceptions from the Pre-Exploration	
		California Shakin'	
	40 min	**Sections from Earthquakes in Oklahoma** • Introduce Earthquakes in Oklahoma • Introduce the Close Reading • Close Read • Discuss the Close Reading • Connect to Writing—Informational Texts • Formative Assessment	

Scientist and Engineer Investigation Experience:
Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · 3-D Assessment

Leveled Readers

These high-interest, magazine-style leveled readers give students the opportunity to explore the ideas covered in the module in greater depth and meet real-world scientists and engineers. Available in 4 levels, they can be used in differentiated small-group reading time. On-Level lessons that accompany the readers are provided in the Teacher Edition. Above-Level, Below-Level, and English Learner lessons can be found online at www.twigscience.com.



		Guided Reading	ATOS
OL	On-Level	S	4.9
AL	Above-Level	U	6.2
BL	Below-Level	N	3.2
EL	English Learners	S	4.9

Shake, Rattle, and Roll

Chapter 1: The Curious Scientist

This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend informational texts while reading independently.

Chapter 2: STEM Career: Meet a Seismologist

This chapter focuses on the career of a seismologist. It includes an optional micro-lab in which students learn how energy is stored and released during an earthquake.

Chapter 3: Earthquake-Proofing: What's the Cost?

This chapter focuses on applying the science standards to students' lives, and examines different ways that engineers earthquake-proof buildings.

Already use another ELA program in your class? No problem! Each Twig Science module is aligned to Workshop Models and McGraw-Hill Wonders©. Benchmark Advance™ available online.

ELA CONNECTIONS

Workshop Models

RI.4.1–3 Key Ideas and Details
RI.4.4 Craft and Structure
RI.4.7, 9 Integration of Knowledge and Ideas
SL.4.1–2 Comprehension and Collaboration
SL.4.4–6 Presentation of Knowledge and Ideas
W.4.2, 3 Text Types and Purposes
W.4.4 Production and Distribution of Writing
W.4.7–9 Research to Build and Present Knowledge
W.4.10 Range of Writing

McGraw-Hill Wonders©

Unit 1, Week 3 Thinking It Through
Leveled Reader Landscapes
Student Anthology Earthquakes

Lift foldout for Fast Track information

Differentiated Instruction—Highlights

Driving Question 2 How can patterns help us predict where earthquakes and volcanoes will occur?

English Learners

Lesson 2 Some students may need prompts to help synthesize what they know and to revisit their hypotheses. Offer proficiency-leveled sentence frames to help them put their thinking into writing:

Substantial Support (Emerging Proficiency)
My claim is _____. My evidence is _____.

Moderate Support (Expanding Proficiency)
Based on where I see plates and earthquakes located on the map, my claim is _____. My evidence is _____.

Light Support (Bridging Proficiency)
I see that the plates are located _____ on the map. I notice the earthquakes are located _____ on the map. Thus, I might predict that _____.

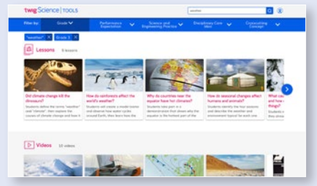
Standard English Learners

Lesson 5 Check in with students whose home dialect differs from Standard English. Encourage them to consider the ways purpose and audience affect register (formal vs. informal language, tone, vocabulary, and so on).

Extension Activities

NGSS-mapped resources to help extend and enrich learning for students of all abilities.

twigScience TOOLS
www.twigsciencetools.com



Challenge

Lesson 1 Have students look at the Historic Earthquakes view. They should search for one large belt where most earthquakes occur and answer the question in their Twig Books.

Special Needs

Visual-Spatial Processing

Lesson 2 For students who struggle with processing information visually, have them work with a peer who can help verbalize what they see during the exploration of the interactive. You may also want to offer a sequence of view selections to complete, so they can conduct a successful analysis.

Conceptual Processing

Lesson 3 It may be helpful for some students to touch and trace the latitude and longitude lines on a world globe. This concrete and tactile opportunity can help reinforce knowledge of latitude and longitude outside the digital realm.

Cultural Connections

Lesson 3 Ask students whether they have family members or friends who live in other states or countries or whether they have traveled to other states or countries. Inquire if any of them know the time zone of that place (e.g., Pacific, Eastern, Central, Mountain, or other). Give an example of needing to account for the time zone difference when calling or visiting another locale.

Time Savers

CCSS English Language Arts

Lesson 4, 5 RI.4.1,3 Key Ideas and Details

Lesson 1, 5 RI.4.7,9 Integration of Knowledge and Ideas

Lesson 2 W.4.2 Text Types and Purposes

Lesson 4 W.4.8–9 Research to Build and Present Knowledge

Lesson 1, 3–5 SL.4.1 Comprehension and Collaboration

Lesson 4 SL.4.4 Presentation of Knowledge and Ideas

WIDA English Language Development

Lesson 1, 3 Standard 1: Social and Instructional Language

Lesson 2 Standard 2: The Language of Language Arts

Lesson 5 Standard 3: The Language of Mathematics

Lesson 1–5 Standard 4: The Language of Science

CCSS Mathematics

Lesson 3, 4 MP.7 Look for and make use of structure

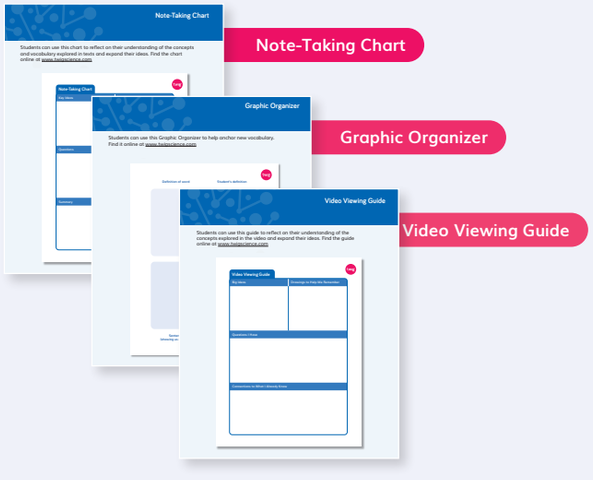
Lesson 5 4.MD.A Measurement and data

Access to Science Literacy and Vocabulary

Word Wall

Driving Question 1	natural disaster, earthquake, tsunami, volcano, energy transfer, waves, point of impact, amplitude, wavelength, seismic waves
Driving Question 2	**ocean, Pacific Ocean, Atlantic Ocean, Ring of Fire, elevation, mountain range, belt, pattern, tectonic plates, fault, fault line, latitude, longitude**
Driving Question 3	dead load, live load, horizontal load, compression (squeezing), tension (stretching), torsion (twisting), bending
Driving Question 4	-
Driving Question 5	civil engineer, structures, forces, mistakes, materials, engineering design process (problem, criteria and constraints, brainstorm, design, build a model, test, refine, share), hazard, safety, revise
Driving Question 6	fair test, data, budget

Additional Differentiated Support



See our full range of vocabulary support tools online.

Explore the World

OVERVIEW

Spark	**8 min**	Students familiarize themselves with an interactive and its options of viewing different layers on a 2-D map of Earth.
Investigate	**20 min**	Students work in pairs using the interactive to look for patterns in the locations of earthquakes, volcanoes, and mountain ranges. They write about one pattern they found interesting.
Report	**10 min**	Students share and discuss the patterns they observed in earthquakes, volcanoes, and mountain ranges around the world.
Connect	**2 min**	The teacher reviews three patterns and data documented during the activity and reiterates what students learned about using maps effectively.
Reflect	**5 min**	Students reflect on how knowing where earthquakes happen helps them answer the Module Investigative Problem.

STANDARDS

NGSS

PE **4-ESS2-2** Analyze and interpret data from maps to describe patterns of Earth's features

DCI **ESS2.B** Plate Tectonics and Large-Scale System Interactions

SEP **SEP-4** Analyzing and Interpreting Data

CCC **CCC-1** Patterns

CNS Scientific Knowledge Is Based on Empirical Evidence

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

CROSS-CURRICULAR CONNECTIONS

EPC **Principle II** People Influence Natural Systems

WIDA **Standard 1:** Social and Instructional Language (Listening, Speaking)

Standard 4: The Language of Science (Listening, Speaking)

CCSS ELA **SL.4.1** Comprehension and Collaboration

RI.4.7 Integration of Knowledge and Ideas

3-D LEARNING OBJECTIVES

Students will:

- Understand that major mountain chains form inside continents or near their edges
- Use maps to locate different land and water features of the Earth
- Describe the patterns of the locations of mountain ranges, earthquakes, and volcanoes
- Using the data in the interactive, conclude that most earthquakes and volcanoes occur in bands or belts that often occur near continent edges
- Make the connection that understanding the patterns might help engineers.

Driving Question 2

How can patterns help us predict where earthquakes and volcanoes will occur?

LESSON 1

RESOURCES

Digital

- **Family Outreach Letter 2**
- **Earth Explorer interactive**
- **Earthquake Patterns Progress Tracker**

Student

For each pair:

- Computer or tablet (to use the interactive)



Earth Explorer interactive

Investigate the relationship between volcanoes, earthquakes and tectonic plates too see if you can spot any patterns.

LESSON PREPARATION

- Print out the **Family Outreach Letter 2** (1 per student) to give to students at the beginning of class. You may also email a copy to parents or guardians.

  This letter suggests ways families can explore earthquake maps with students in order to help them better understand earthquake patterns.

- Preview the **Earth Explorer interactive** and make sure you are familiar with its features, including the five views (Countries, Volcanoes, Historic Earthquakes, Tectonic Plates, and My Earthquakes) and the data required to "Add An Earthquake" (latitude, longitude, magnitude, place, and date reported). You will use the interactive throughout the module as students find earthquake data and add it the explorer.

  Note: You may also conduct the **Earth Explorer interactive** activities as a class.

Word Wall

- ocean
- Pacific Ocean
- Atlantic Ocean
- Ring of Fire
- elevation
- mountain range
- belt
- pattern
- tectonic plates

Spark

8 min

Fact Board

Earthquake Fact of the Day:

- Because of moving plates, geologists predict that Los Angeles will be next to San Francisco in 15 million years, and near Alaska in 85 million years.

Academic Vocabulary Check

- *waves*
- *amplitude*
- *wavelength*
- *seismic waves*
- *magnitude*
- *earthquake*
- *volcano*

Demonstrate the Interactive

Display the **Earth Explorer interactive** on the board with no views turned on (the five views on the screen should be unselected).



- ***What do you see?***
- The Earth
- Continents
- The United States (or any country or region they see)

Point out the five viewing options—Countries, Volcanoes, Tectonic Plates, Historic Earthquakes, and My Earthquakes.

Explain that in this lesson they will use three views—Countries, Volcanoes, and Historic Earthquakes. They will do more work with the Earth Explorer interactive in the next two lessons.

Turn on the Volcanoes view and select a volcano.

- ***What does* elevation *mean?***
- Elevation is how high something is.
- Elevation measures the number of feet above or below sea level
- ***On the map, how can you see land areas with greater elevation?***
- Some areas on the map are lighter than others.
- Some parts of the map have (three-dimensional) texture that shows mountain ranges.

Make sure students realize that the light, textured parts on the continents are mountain ranges (i.e., they show elevation).

Explain that students can turn the different views on or off by selecting them. Clarify that sometimes too much information is overwhelming, and turning a particular view off might help make information clearer.

Investigate

20 min

Introduce the Activity and Connect Today's Learning to CCC-1—Patterns

Today, students will work in pairs to look for patterns relating to where and why earthquakes occur.

Explain that studying maps can help us locate the Earth's land and water features, and these help us notice patterns. Patterns help scientists make models of how the world works. Emphasize that students should not worry if they don't know the answers right away—the idea is to notice patterns that might explain where earthquakes, volcanoes, and mountain ranges are common.

Remind students that they looked for patterns when they studied layers in the Grand Canyon (Module 3, Driving Question 2) and erosion of landscapes (Module 3, Driving Question 4). Explain that scientists might begin an investigation by looking for patterns, before asking questions to try to understand why and how the patterns happen.

Collect and Display—Collect (Language Routine)

As students discuss the **Earth Explorer interactive**, circulate and record some of the everyday terms and phrases you hear them using.

Identify Patterns with the Interactive

Divide students into pairs. Have them explore the **Earth Explorer interactive** and search for patterns.

Note: Some students will select all views and then look for patterns, while other students will select individual views and write about the patterns they see. Both strategies work.

After a few minutes, ask students to describe what they can see when they turn on the Historic Earthquakes view and select an individual earthquake.

- The interactive shows data about the earthquake: magnitude, place, and date reported.

Circulate as students work.

- ***What physical features (e.g., oceans, mountain ranges) does the map show you?***
- ***What do you see when you turn the Volcanoes view on? Do you see any patterns?***
- ***What data supports your observation?***

Remind students that not every piece of data needs to fit a pattern.

- ***Can you find an exception to the pattern you just observed?***
- The volcanoes in Antarctica do not fit the pattern.

English Learners

Pair ELs with a student of higher English proficiency. ELs with lower levels of proficiency can also be placed with students who share the same home language, and they can discuss the patterns in their native language aloud prior to sharing their work in English.

Special Needs

Visual-Spatial Processing

Check in with students to ensure they are clear on ways to use the interactive to add and change views. Offer one-on-one assistance to any student who becomes overwhelmed by the amount of information being displayed. If possible, use a large monitor for viewing to help students who need greater visual support.

Investigate

Twig Book, p.23

Make Observations •
Look at the **Earth Explorer interactive.**



- Open up different views and make observations of patterns in earthquakes, volcanoes, and mountain ranges. Discuss the patterns you find.
- Describe the patterns you see and give examples from the data. Find as many patterns as you can.

Patterns	Examples
Earthquakes mostly happen on coastlines.	The east coast of Canada, North America, and South America.
Volcanoes are more common on, or near, islands.	Japan, Indonesia, Hawaii, and the Philippines have a lot of volcanoes.
Volcanoes cluster in, and around, mountain ranges.	Volcanoes in Alaska: Iliamna, Augustine, Griggs, and Katmai.

Have students record their observations about patterns in earthquakes, volcanoes, and mountain ranges on page 23 of their Twig Books. They should also include examples of where these patterns can be seen in the **Earth Explorer interactive**.

Write About Patterns

Ask students to write individually on page 24 in their Twig Books about one pattern that they found interesting. They should describe the pattern, explain why they found it interesting, include the data that shows the pattern, and add any questions they have about it.

Prepare for the Report

Circulate and look at students' writing. Choose several observations students made about different patterns. Make sure the students whose work you have chosen provide data that supports their patterns.

Look for patterns about mountain ranges, volcanoes, and earthquakes so you have a variety of claims to discuss.

Challenge

Have students look at the Historic Earthquakes view. They should search for one large belt where most earthquakes occur and answer the question in their Twig Books.

Twig Book, p.24

Analyze Data • Write about one pattern that you think is interesting.

1. Describe the pattern.
2. Give data that shows the pattern.
3. Explain why you think it's interesting.
4. Write any questions that you have about the pattern.

Earthquakes mostly happen on coastlines, which is shown by how many have occurred along the east coast of North and South America in particular. This is interesting because mountain ranges and volcanoes also happen in the same place. This pattern makes me question whether mountain ranges, volcanoes, and earthquakes are connected by something underground?

Report

10 min

Collect and Display—Display (Language Routine)

Make connections from informal language to essential academic vocabulary, including: *ocean, Pacific Ocean, Atlantic Ocean, elevation, mountain range, Ring of Fire, belt, pattern,* and *tectonic plates*. Add these terms to the academic word wall.

Discuss Observations

Display the **Earth Explorer interactive** and have students share patterns they observed.

- ***Do you agree with <student>'s pattern? What evidence supports this pattern?***
- ***Not every piece of data has to fit a pattern. Can you find an exception to this pattern?***
- ***If you were an engineer, how might you use this pattern to make buildings safer?***

Below are some patterns students may see and share. As the class reports, record three patterns—one each about mountains, earthquakes, and volcanoes.

- Mountain ranges are often near oceans, but not always.
- Major mountain ranges in North and South America are on the western side of the continents.
- Most earthquakes/volcanoes are near edges of oceans or mountain ranges.
- Most earthquakes are in the same places as volcanoes.
- Earthquakes occur all over the world.
- There is a group of volcanoes in the Mediterranean Sea.
- The Pacific Ocean is surrounded by a ring of volcanoes and earthquakes.

Have any students who completed the Challenge share their observations about the large belt of earthquakes and volcanoes surrounding the Pacific Ocean. Explain that this belt is known as the *Ring of Fire*. Point to the term on the academic word wall.

Misconceptions from the Pre-Exploration

Use the **Earthquake Patterns Progress Tracker** to note if students have the following misconceptions.

Misconception	What to Do
All earthquakes are caused by erupting volcanoes.	Take note of students who can use maps to locate land and water features (e.g., volcanoes and oceans), and who notice similar patterns in the distribution of earthquakes and volcanoes, and think this pattern proves that volcanoes cause earthquakes or vice versa. Explain that patterns and data give us a clue but we still need more information. Let them know they will look at this relationship in the next lesson.
Earthquakes are equally likely to happen anywhere on Earth.	After students discuss patterns, with the Historic earthquakes view off, choose two points on the map (one point in a region with few or no earthquakes). Ask whether an earthquake would be more likely to occur at either of the two points.

Connect

2 min

Connect Today's Learning to PE 4-ESS2-2

Today, students learned about the Earth's physical features, including where earthquakes and volcanoes are most likely to occur. They also learned that maps can be used to locate Earth's features, like bodies of water and mountain ranges. Being able to locate these features with maps will allow students to more easily notice patterns in subsequent lessons.

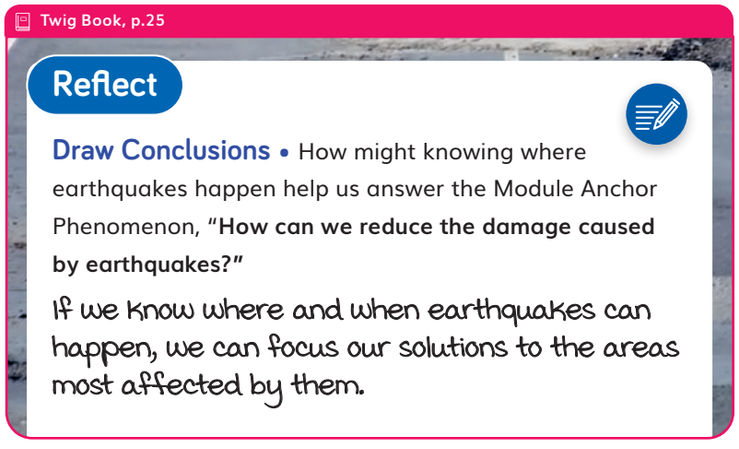
Review the three patterns and data that you documented.

Reflect

5 min

Reflect on Earthquake Patterns

Have students reflect on how knowing where earthquakes happen helps us answer the Module Investigative Problem. They should record their answers on page 25 in their Twig Books.



Use the Reflection

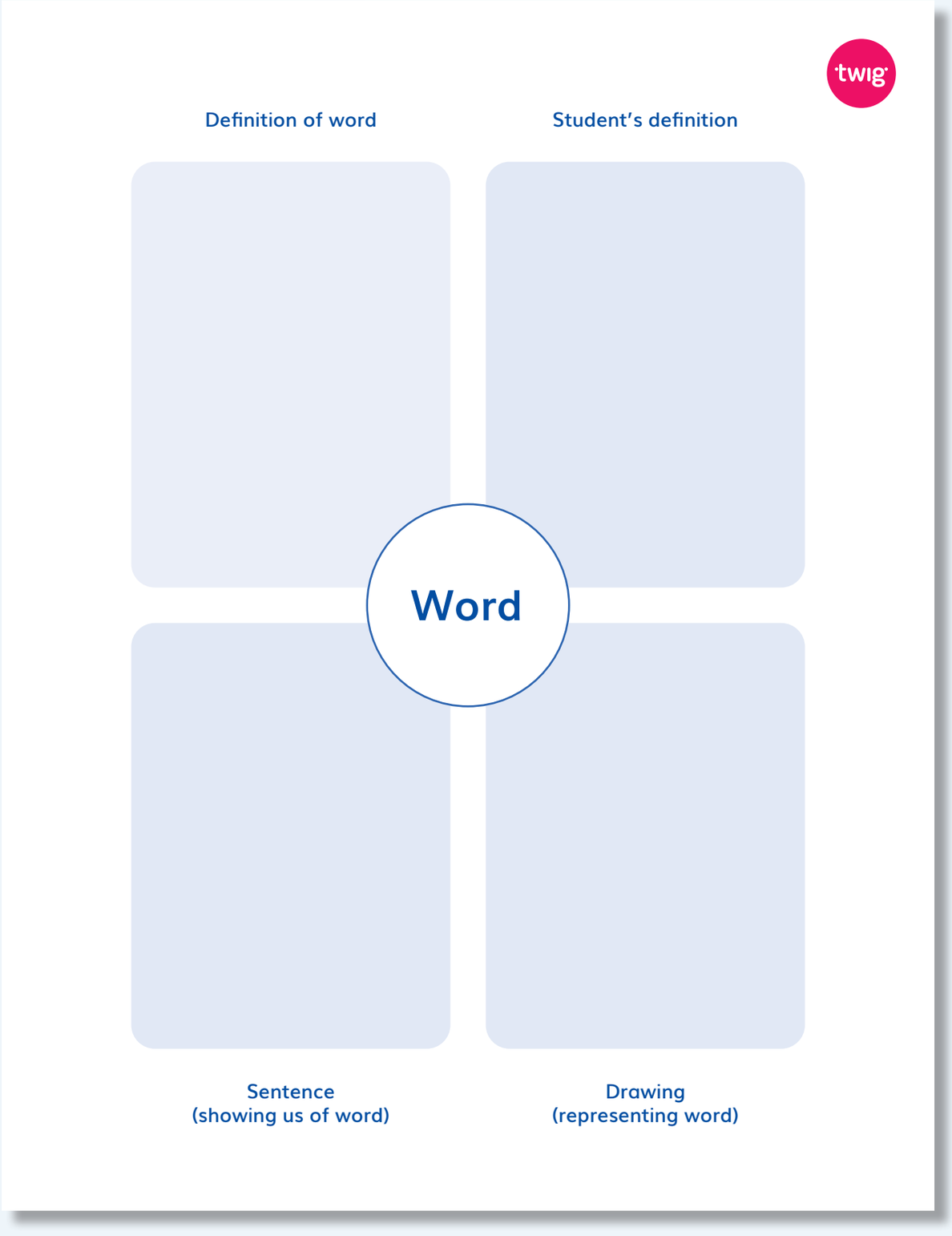
Look for students who understand that places where earthquakes happen often need to have buildings constructed differently than places where earthquakes are rare. Compare, for example, California and Minnesota. Consider pairing students who don't make the connection with ones who do as they are working on the **Earth Explorer interactive** in the next lesson. Alternatively, spend time with students to individually diagnose their thinking and provide guidance.

Assess Student Progress

Use the **Earthquake Patterns Progress Tracker** to note if students can describe that maps can help locate land and water features, and whether students found a pattern involving the locations of mountains, earthquakes, and volcanoes.

Graphic Organizer

Students can use this Graphic Organizer to help anchor new vocabulary.
Find it online at www.twigscience.com



An Earthquake Is Born

OVERVIEW

Spark	**8 min**	Students share what they learned about the connection between seismic waves, earthquakes, and energy, and write a claim about the cause of earthquakes.
Investigate	**15 min**	Students use the interactive to explore tectonic plates, and think how their observations might be used as evidence for their claim about the cause of earthquakes.
Report	**10 min**	Students share their claims and evidence, and watch a video about the cause and consequences of earthquakes. They revise their claims based on their observations, and add evidence from the video and interactive.
Connect	**2 min**	The teacher adds "Evaluate information" to the Science Tools poster.
Reflect	**10 min**	Students complete an organizer with a claim, evidence, and reasoning about the cause of earthquakes.

STANDARDS

NGSS

PE — **4-ESS2-2** Analyze and interpret data from maps to describe patterns of Earth's features

DCI — **ESS2.B** Plate Tectonics and Large-Scale System Interactions

SEP — **SEP-4** Analyzing and Interpreting Data
SEP-7 Engaging in Argument from Evidence
SEP-8 Obtaining, Evaluating, and Communicating Information

CCC — **CCC-1** Patterns
CCC-2 Cause and Effect

CNS — Scientific Knowledge Assumes an Order and Consistency in Natural Systems

CROSS-CURRICULAR CONNECTIONS

CCSS ELA — **W.4.2** Text Types and Purposes

WIDA — **Standard 2:** The Language of Language Arts (Writing)
Standard 4: The Language of Science (Writing)

3-D LEARNING OBJECTIVES

Students will:

- Describe the relationship between the location of tectonic plate boundaries and earthquakes
- Make claims about what causes earthquakes based on what they have learned so far
- Revise claims about what causes earthquakes if necessary and support their claims with evidence and reasoning.

Driving Question 2

How can patterns help us predict where earthquakes and volcanoes will occur?

LESSON 2

RESOURCES

Digital

- **Earth Explorer interactive**
- **Why Earthquakes Happen video**
- **Earthquake Patterns Progress Tracker**

Student

For each pair:

- Computer or tablet (to use the interactive)



Earth Explorer interactive

Investigate the relationship between volcanoes, earthquakes and tectonic plates too see if you can spot any patterns.

LESSON PREPARATION

Word Wall

- fault
- fault line

An Earthquake Is Born

Spark

8 min

Fact Board

Earthquake Fact of the Day:

- There are about 500,000 earthquakes a year, but 400,000 are too small for us to feel. Only around 100 earthquakes cause any damage each year.

Cultural Connection

Many Native Americans of the Pacific Northwest tell stories about two powerful supernatural creatures, the Thunderbird and the Whale. Their epic struggle causes earthquakes and tsunamis.

Academic Vocabulary Check

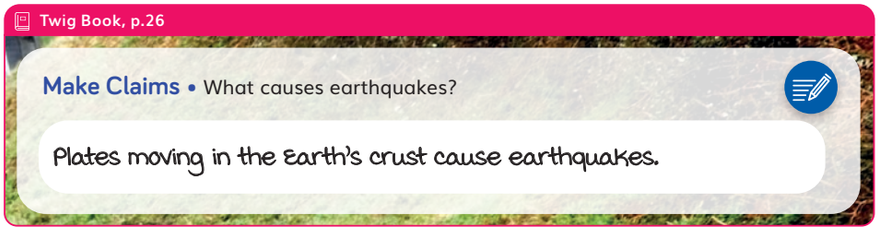
- *amplitude*
- *wavelength*
- *seismic waves*
- *magnitude*
- *earthquake*
- *volcano*
- *tectonic plates*

Review Waves and Energy

Have a few students share what they've learned about the connection between seismic waves, earthquakes, and energy.

- ***How do you measure the amount of energy released in an earthquake?***
- The amount of energy released can be estimated by the magnitude of the earthquake.
- ***What can you remember about earthquakes and waves?***
- The energy released during an earthquake generates seismic waves. The seismic waves cause the ground to move, which is what we feel as an earthquake.

On page 26 of their Twig Books, have students write a claim about the cause of earthquakes. Encourage them to use words from the academic word wall in their claims. Explain that they will have the chance to revise their claims as they learn more about earthquakes throughout the lesson.



Investigate

15 min

Introduce the Activity

Display the **Earth Explorer interactive** with no views selected. Point out and select the Tectonic Plates view.

Ask students if they can explain what a tectonic plate is. Listen to students' ideas, and then explain that the Earth's crust is broken up into a number of interlocking sections called *tectonic plates*.

Students will work in pairs to explore the Tectonic Plates view in the **Earth Explorer interactive**, and look for patterns and evidence that will help them decide if their claim about what causes earthquakes is correct.



Explore Tectonic Plates with the Interactive

Divide students into pairs. Have them explore the **Earth Explorer interactive** with only the Tectonic Plates view selected, and write their observations on page 26 in their Twig Books.

Circulate and make sure students are carefully considering the location of the plates.

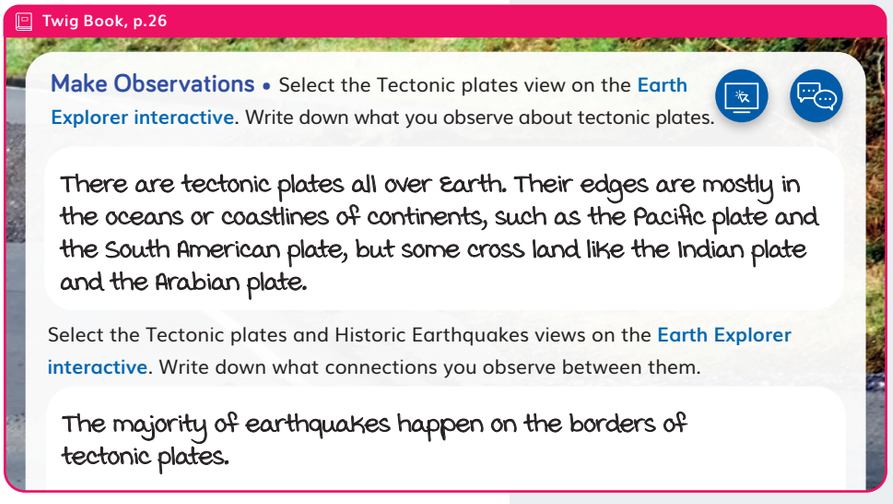
- ***Where are plate boundaries found?***
- Most of the boundaries are underwater or very close to coastal areas, but both the boundary between the Indian Plate and the Eurasian Plate and the boundary between the Arabian Plate and the Eurasian Plate are on landmasses.
- ***Do all plates contain land?***
- Most do, though some plates only have islands on them.

Once pairs have recorded their observations, have them select the Historic Earthquakes view (keeping the Tectonic Plates view displayed), explore the map, and discuss what they observe.

- ***Where have historic earthquakes occurred?***
- ***Where have historic earthquakes occurred in relation to tectonic plates—close to plate boundaries or far from them?***

Ask students to use the information they recorded about tectonic plates to make connections to the Historic Earthquakes view. They should record their observations on page 26 in their Twig Books.

Have students take a few minutes to think how their observations might be used as evidence for the claim they made in the Spark.



Prepare for the Report

Identify students who made the connection that earthquakes tend to occur on or near plate boundaries, and students who offered additional interesting claims. Plan a discussion sequence so that students with less advanced claims can share first, and more advanced students can build on their ideas.

Special Needs

Visual-Spatial Processing

For students who struggle with processing information visually, have them work with a peer who can help verbalize what they see during the exploration of the interactive. You may also want to offer a sequence of view selections to complete, so they can conduct a successful analysis.

Report

10 min

Discuss Claims and Evidence

Have students share their claims with the class. Ask them to identify evidence from the **Earth Explorer interactive** that supports their claim.

Ensure students understand that most earthquakes, especially large ones, occur near plate boundaries.

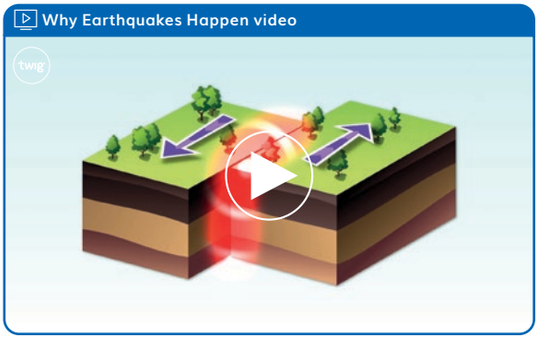
Collect and Display—Display (Language Routine)

Point out that students may have heard the word *fault*. Explain that faults, or fault lines, can be created by the movement of the plates. Add *fault* and *fault line* to the academic word wall.

Summarize the Video

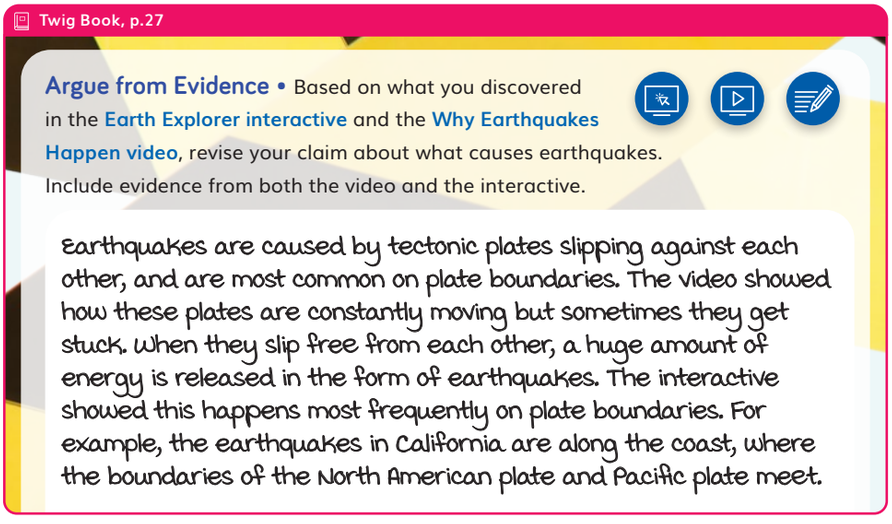
Play the **Why Earthquakes Happen video**, which describes the cause and consequences of earthquakes.

Have several students summarize the video. Make sure that they mention that earthquakes occur due to the movements of tectonic plates. If necessary, replay this segment of the video (0:38 to 1:06).



Revise Claims

Have students revisit their claim about what causes earthquakes, revise it based on their observations, and add evidence from both the video and the **Earth Explorer interactive** to support their claim. They should record their revised claim and evidence on page 27 in their Twig Books.



Misconceptions from the Pre-Exploration

Use the **Earthquake Patterns Progress Tracke**r to note if students have the following misconceptions.

Misconception	What to Do
All earthquakes are caused by erupting volcanoes.	Display the **Earth Explorer interactive** and select the Historic Earthquakes, Volcanoes, and Tectonic Plates views. Point out that plate boundaries are linked to the location of both earthquakes and volcanoes, but that earthquakes are not always caused by volcanoes.
Earthquakes are equally likely to happen anywhere on Earth.	Ask students whether there are more plates in one part of the world than another. In the **Earth Explorer interactive**, point out that plates are distributed evenly across the Earth. Emphasize that earthquakes do not happen randomly; they occur more frequently in locations along plate boundaries.

English Learners

Some students may need prompts to help synthesize what they know and revisit their hypothesis. Offer proficiency-leveled sentence frames to help them represent their thinking in writing.

Substantial Support (Emerging Proficiency):

- My claim is _____. My evidence is _____.

Moderate Support (Expanding Proficiency):

- Based on where I see plates and earthquakes located on the map, my claim is _____. My evidence is _____.

Light Support (Bridging Proficiency):

- I see that the plates are located _____ on the map. I notice the earthquakes are located _____ on the map. Thus, I might predict that _____.

Connect

2 min

Chart SEP-8—Obtaining, Evaluating, and Communicating Information

Remind students that today, they successfully evaluated information, a practice of good scientists. Draw students' attention to the Science Tools poster and add "Evaluate information."

Science Tools

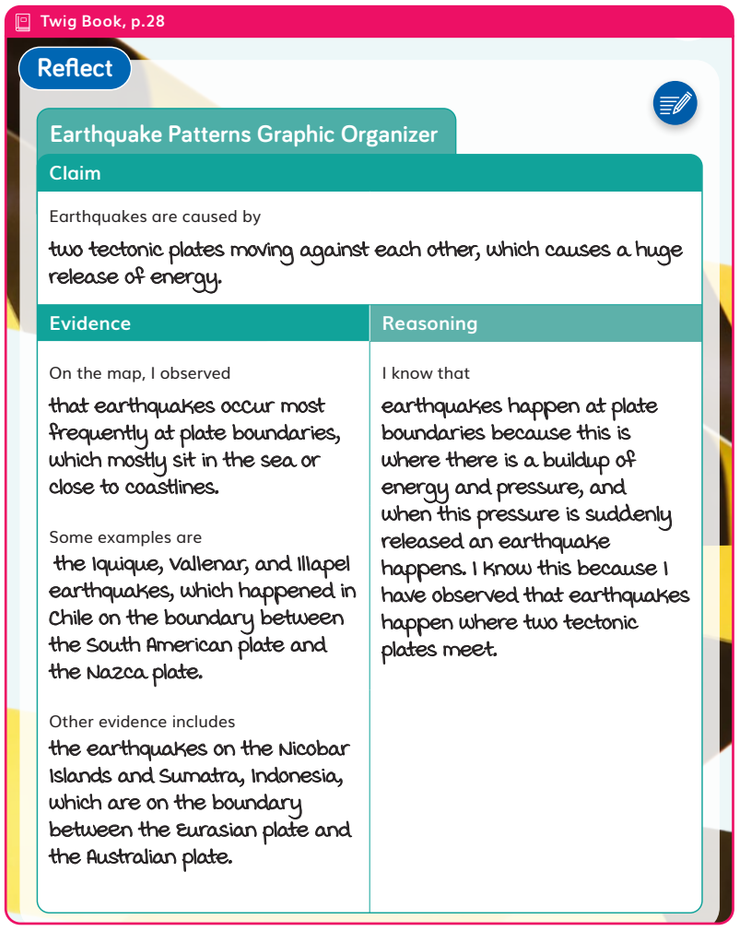
- Plan and carry out investigations
- Construct explanations
- Develop and use models
- Communicate information
- Design solutions
- Obtain information
- Argue from evidence
- Use math and computational thinking
- Ask questions
- **Evaluate information**

Reflect

10 min

Formative Assessment

Have students complete the Earthquake Patterns Graphic Organizer on page 28 in their Twig Books with a claim, evidence, and reasoning about the cause of earthquakes.



Twig Book, p.28

Reflect

Earthquake Patterns Graphic Organizer

Claim

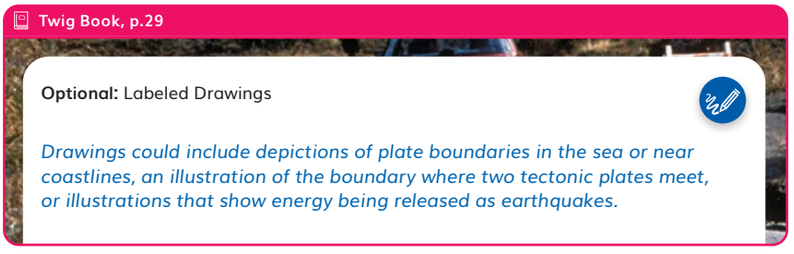
Earthquakes are caused by

two tectonic plates moving against each other, which causes a huge release of energy.

Evidence	Reasoning
On the map, I observed that earthquakes occur most frequently at plate boundaries, which mostly sit in the sea or close to coastlines. Some examples are the Iquique, Vallenar, and Illapel earthquakes, which happened in Chile on the boundary between the South American plate and the Nazca plate. Other evidence includes the earthquakes on the Nicobar Islands and Sumatra, Indonesia, which are on the boundary between the Eurasian plate and the Australian plate.	I know that earthquakes happen at plate boundaries because this is where there is a buildup of energy and pressure, and when this pressure is suddenly released an earthquake happens. I know this because I have observed that earthquakes happen where two tectonic plates meet.

Review what constitutes a strong claim, evidence, and reasoning. For evidence, students should list important data that they have observed using the **Earth Explorer interactive**. For reasoning—explaining their evidence and connecting it to their claim—they should use scientific ideas that they learned from the **Why Earthquakes Happen video**.

Give students the option of supporting their explanations with labeled drawings of the occurrence of earthquakes. They can record their drawings on page 29 in their Twig Books.



Note: At this stage, many students may struggle with differentiating between evidence and reasoning.

Use the Formative Assessment

Review students' responses before the next lesson to determine whether students have a clear understanding of how and where earthquakes occur.

The following statements reflect developing levels of student understanding:

- Student response contains no reference to the locations of earthquakes or to plate boundaries.
- Student response claims that earthquakes occur at only some locations.
- Student response claims that earthquakes occur at plate boundaries.
- Student response claims that earthquakes occur at plate boundaries due to the motions of the plates caused by pressure build up and the release of energy.

Assess Student Progress

Use the **Earthquake Patterns Progress Tracker** to note if students can describe that earthquakes and volcanoes occur in bands along plate boundaries. Based on students' understanding, determine whether to revisit the lesson summary at the beginning of the next lesson.

Little Earthquake, Where Are You?

OVERVIEW

Spark	**7 min**	Students watch and discuss a video explaining latitude and longitude.
Investigate	**25 min**	Using the EMSC website, students enter some of yesterday's earthquakes into the interactive and fill out graphic organizers in their Twig Books.
Report	**8 min**	Students share the patterns they noticed and take notes during a class discussion.
Connect	**2 min**	The teacher adds "Analyze and interpret data" to the Science Tools poster, and students discuss why patterns might be useful for scientists.
Reflect	**3 min**	Students write which parts of the world are the most dangerous for earthquakes based on the patterns they have noticed.

STANDARDS

NGSS

PE — **4-ESS2-2** Analyze and interpret data from maps to describe patterns of Earth's features

DCI — **ESS2.B** Plate Tectonics and Large-Scale System Interactions
ESS3.B Natural Hazards

SEP — **SEP-4** Analyzing and Interpreting Data

CCC — **CCC-1** Patterns

CNS — Scientific Knowledge Assumes an Order and Consistency in Natural Systems

CROSS-CURRICULAR CONNECTIONS

CCSS ELA — **SL.4.1** Comprehension and Collaboration

WIDA — **Standard 1:** Social and Instructional Language (Listening, Speaking)
Standard 4: The Language of Science (Listening, Speaking)

3-D LEARNING OBJECTIVES

Students will:

- Use latitude and longitude data to enter positions of recent earthquakes on a map
- Understand the meaning and importance of magnitude in relation to earthquakes and the damage they cause
- Explore the frequency and geographical distribution of yesterday's earthquakes
- Analyze the data entered and how it compares to the historical earthquakes data.

Driving Question 2

How can patterns help us predict where earthquakes and volcanoes will occur?

LESSON 3

RESOURCES

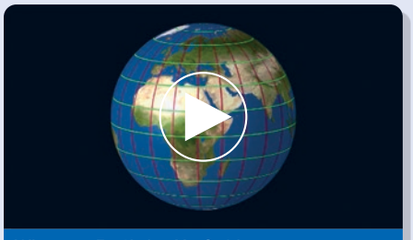
Digital

- **Earth Explorer Graphic Organizer handout**
- **Where on Earth Are You? video**
- **Earth Explorer interactive**
- **Earthquake Patterns Progress Tracker**

Student

For each pair:

- Computer or tablet (to use the interactive)



Where on Earth Are You? video

Believe it or not only two numbers are needed to locate your exact position on Earth – your longitude and latitude!



Earth Explorer interactive

Investigate the relationship between volcanoes, earthquakes and tectonic plates too see if you can spot any patterns.

LESSON PREPARATION

- Print the **Earth Explorer Graphic Organizer handout** (1 per pair).
- Review and become familiar with the information provided on the EMSC website (http://www.emsc-csem.org/Earthquake/) and its search filtering options. **Credit**: EMSC/CSEM, http://www.emsc-csem.org/
  - Determine whether students will work from worldwide data or data from a specific region of the world. If the latter, determine the range of values of latitude and longitude (to the nearest whole number) that covers the chosen area (e.g., to cover the United States, use the ranges [18 < latitude < 72] and [–168 < longitude < –66]). Write the ranges on the board. Make sure that the region you select has enough data for students to make observations.
  - Familiarize yourself with the filtering options on the EMSC search page (http://www.emsc-csem.org/Earthquake/?filter=yes) so that you can demonstrate how to use them. You can filter by date, location (latitude/longitude), and/or magnitude by entering the appropriate values in the corresponding fields. To filter by location, you can either manually enter the coordinates in the input fields or directly select the area of interest on the map.
  - Bookmark the Quick Search preset that allows users to directly retrieve a list of earthquakes with a magnitude greater than or equal to 5 (http://www.emsc-csem.org/Earthquake/world/M5/).

  Note: You can complete this activity as a class. In this case, you will need to search for earthquakes as a group, and determine a system for adding them into the interactive.
- Check the data output before the lesson. If there has been a recent geological event that skews the data (e.g., a volcanic eruption leading to high frequency of earthquakes in one location), consider having students set a date parameter of a few weeks before the event occurred. Alternatively, use the unusual data output as an opportunity to discuss the geological event with the class.
- Determine the time offset between your time zone and UTC (Coordinated Universal Time) using an online time zone converter or by using the times shown on the EMSC website.

Word Wall

- latitude
- longitude

Little Earthquake, Where Are You?

Spark

7 min

Fact Board

Earthquake Fact of the Day:

- The Ring of Fire is a zone in the Pacific Ocean that spans New Zealand, Indonesia, Japan, Alaska, and the west coasts of North, Central, and South America. About nine in 10 of the world's earthquakes occur there. The next most seismic region (about five in 100) is the Alpide belt, which extends from the Mediterranean region through Turkey, Iran, and northern India.

English Learners

Some students might refer to latitude and longitude using their own words or ideas, e.g., lines that go up and down, or across, or back and forth. Revoice student ideas and connect them to the cardinal directions: north, south, east, and west.

Special Needs

Conceptual Processing

It may be helpful for some students to touch and trace the latitude and longitude lines on a world globe. This concrete and tactile opportunity can help reinforce knowledge of latitude and longitude outside the digital realm.

Academic Vocabulary Check

- *pattern*
- *ocean*
- *Pacific Ocean*
- *Atlantic Ocean*
- *elevation*
- *mountain range*
- *fault line*
- *magnitude*
- *earthquake*
- *volcano*
- *Ring of Fire*
- *fault*

Observe the Video

Play the **Where on Earth Are You? video.** If students are confused by the concept of coordinates, you may want to play it a second time.



Discuss Latitude and Longitude

Add the terms *latitude* and *longitude* to the academic word wall, and have students turn and talk with a partner to discuss their meaning.

Once students have finished discussing, ask them to write the definitions they came up with on page 30 of their Twig Books. Have students share what they wrote.

Twig Book, p.30

Obtain Information • Using the Where On Earth Are You? video and what you discussed in class, write definitions of the following terms.

Latitude:

The distance north or south of the equator, expressed in degrees (0–90 degrees north, 0–90 degrees south)

Longitude:

The distance east or west of the prime meridian, which runs from the North to South Pole through Greenwich in the United Kingdom, expressed in degrees (0–180 degrees west, 0–180 degrees east)

Investigate

25 min

Introduce the Activity

Write the previous day's date on the board. Today, students will work in pairs to enter some of the previous day's earthquakes into the **Earth Explorer interactive**. Explain that each pair will note data for up to 10 earthquakes in a graphic organizer and then input this data into the interactive.

Demonstrate the Activity

Display the Earthquake page of the EMSC website. Make sure that the data table and column headings are visible.

Explain that this website shows a list of earthquakes. Ask students to describe what they see.

- The dates/times, latitude, longitude, depth, mag, and region names are given for each entry.
- The table shows how many minutes ago the event happened.
- The latitudes are shown with N or S, and the longitudes with E or W.
- Most of the mag values are between 2 and 5.

Explain that:

- "Mag" is an abbreviation for *magnitude*. Remind students that they looked at magnitude as a measure of the size of an earthquake in the article titled: "How Big Was That Earthquake?"
- UTC (Coordinated Universal Time) is the world's time standard. Provide the time difference between your timezone and UTC.

Scroll through the list to show how many earthquakes occur each day.

Display the **Earth Explorer interactive**. Explain that they can add recent earthquakes to the map by selecting "Add An Earthquake." Choose an earthquake from the EMSC list, and model entering the longitude and latitude (to the nearest two decimal places) with its cardinal direction, as well as the magnitude, place, and date reported. Select "Save."

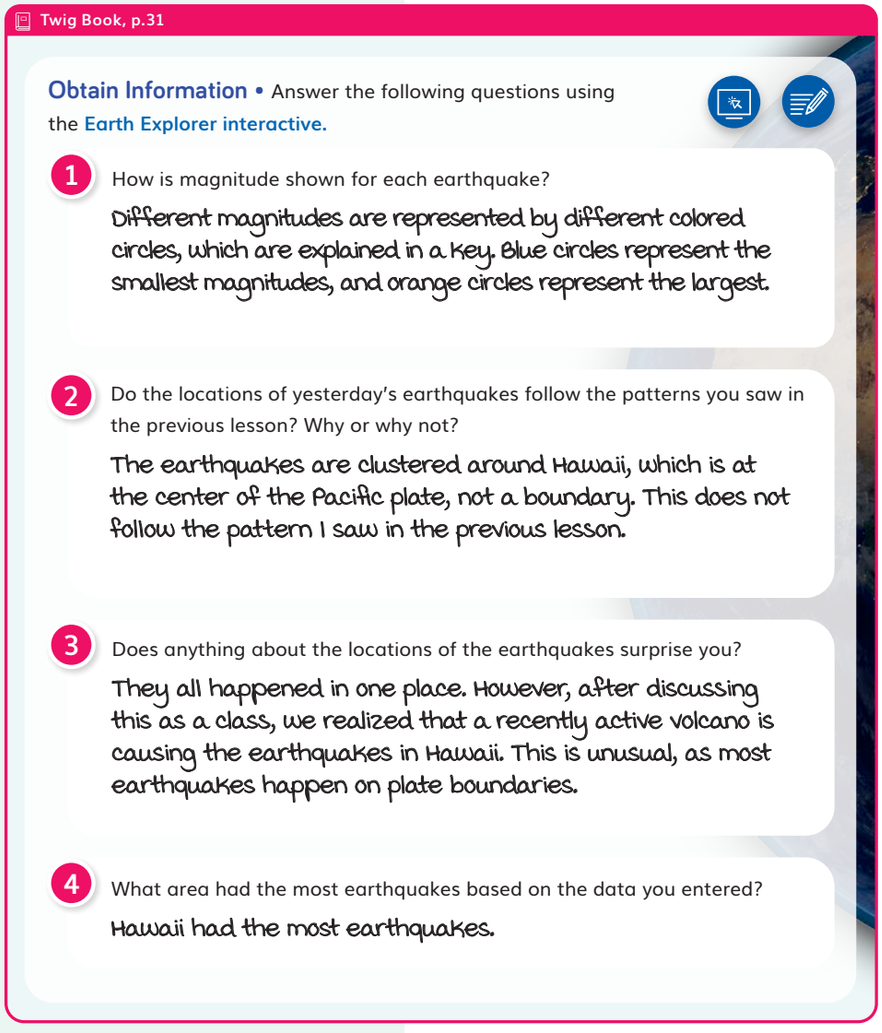


Cultural Connection

Ask students whether they have family members or friends who live in another state or country or whether they have traveled to another state or country. Ask if any of them know the time zone of that place (e.g., Eastern). Give an example of taking time zone differences into account, like making a long-distance call.

Investigate

Find and Enter Earthquake Data


Twig Book, p.31

Obtain Information • Answer the following questions using the Earth Explorer interactive.

1. How is magnitude shown for each earthquake?

   Different magnitudes are represented by different colored circles, which are explained in a key. Blue circles represent the smallest magnitudes, and orange circles represent the largest.

2. Do the locations of yesterday's earthquakes follow the patterns you saw in the previous lesson? Why or why not?

   The earthquakes are clustered around Hawaii, which is at the center of the Pacific plate, not a boundary. This does not follow the pattern I saw in the previous lesson.

3. Does anything about the locations of the earthquakes surprise you?

   They all happened in one place. However, after discussing this as a class, we realized that a recently active volcano is causing the earthquakes in Hawaii. This is unusual, as most earthquakes happen on plate boundaries.

4. What area had the most earthquakes based on the data you entered?

   Hawaii had the most earthquakes.

Guide pairs through the following steps:

1. Bring up the search page of the EMSC website (link in Lesson Preparation).
2. Enter the previous day's date in the "Period" box.
3. If the class will focus on earthquakes in a specific region: Enter the relevant longitude and latitude ranges (written on the board) into the EMSC search page.
4. Select "Get events."

Have students write the relevant earthquake data on their **Earth Explorer Graphic Organizer handouts**. This will help them become familiar with earthquake data more broadly while allowing them to focus on one website at a time, rather than toggling between two.

Note: Each student will have an individual **Earth Explorer interactive** account, so it is OK if multiple students enter the same earthquake data. Student pairs will need to choose one student's account to use for this activity. If conducting the activity as a class, enter the data under your own teacher account.

Have students open the **Earth Explorer interactive** and transfer their data to the interactive using the "Add An Earthquake" feature.

Ask students to answer the questions on page 31 in their Twig Books.

Assess Student Progress

If students weren't able to describe that earthquakes and volcanoes occur in bands along plate boundaries in the formative assessment of the previous lesson, reevaluate their understanding and note this on the **Earthquake Patterns Progress Tracker**.

Prepare for the Report

Note which students have confirmed the patterns from the previous lesson and which students are questioning those patterns.

Report

8 min

Discuss Observations

Lead a class discussion about what students have observed and discovered. Ask students to take notes on page 32 in their Twig Books about important patterns that other students share. Consider connecting the discussion to some of the misconceptions from the Pre-Exploration, given in the table below.

- ***Did you see a pattern in your data?***
- ***Did anyone observe a different pattern?***
- ***Based on what all the teams have just described, can you summarize the data?***
- ***How is the magnitude of each earthquake shown on the map?***
- ***Did you notice any patterns in the magnitude of earthquakes around the world?***
- ***Were there any areas of <the world/a specific region> that had <more/more powerful> earthquakes?***
- ***Were you surprised by the locations of some of the earthquakes?***

Note: When entering data from one day, students may see several earthquakes in one area of the world and nothing in others. They are unlikely to see the spread throughout the Ring of Fire as they did with the Historic Earthquakes view. Point out that this is why scientists look at data over time.

Misconceptions from the Pre-Exploration

Use the **Earthquake Patterns Progress Tracker** to note if students have the following misconceptions.

Misconception	What to Do
Earthquakes are rare events.	Ask students about how many earthquakes happen each day. Ask whether they thought that earthquakes were uncommon before this lesson. Revisit the statement from the Pre-Exploration and point out that the data shows that earthquakes are not rare, and that small earthquakes happen frequently.
Earthquakes are equally likely to happen anywhere on Earth.	Revisit the statement from the Pre-Exploration and point out that earthquakes do not happen randomly but rather occur more frequently in locations along plate boundaries.

Report

English Learners

Give students two minutes to share with a partner what they observed before sharing with the class. Circulate, listen in, and offer feedback such as academic vocabulary support. Use sentence frames for support.

Substantial Support (Emerging Proficiency)

- I saw _____. This pattern _____.

Moderate Support (Expanding Proficiency)

- One pattern I noticed was _____.

Light Support (Bridging Proficiency)

- A pattern I observed _____. This is important because _____.

Introduce the Earth Explorer Investigation

Explain that, over the next few weeks, the class will use the **Earth Explorer interactive** to track earthquakes from all over the world with a magnitude greater than or equal to 5. You will want to use a single account to track earthquake data, so that patterns may be more easily discerned.

Throughout the module, a different student will enter data from up to three earthquakes into the **Earth Explorer interactive** at the same time each day. Display the EMSC preset Quick Search you have bookmarked (see Lesson Preparation). Note when the data will be retrieved and entered, and the roster for which student will enter the data on each day.

Optional: Assign the earthquake research as homework, and ask students to come to class ready to input their earthquake data into the interactive.

Alternatively, students may research the earthquakes in class, using the **Earth Explorer Graphic Organizer handouts** for ease. If you prefer, you may add the earthquake data yourself, displaying the earthquake data and asking students which the class should enter.

Earth Explorer Graphic Organizer handout

Earth Explorer Graphic Organizer

	Latitude (N/S)	Longitude (E/W)	Magnitude	Place	Date reported
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Connect

2 min

Chart SEP 4—Analyzing and Interpreting Data

Explain that scientists make sense of the data they collect by representing it in a table, graph, math equation, or map. Just as students did today, scientists look for patterns in data.

Draw students' attention to the Science Tools poster and add "Analyze and interpret data." Ask students why finding patterns might be useful for scientists. Encourage all answers.

Science Tools

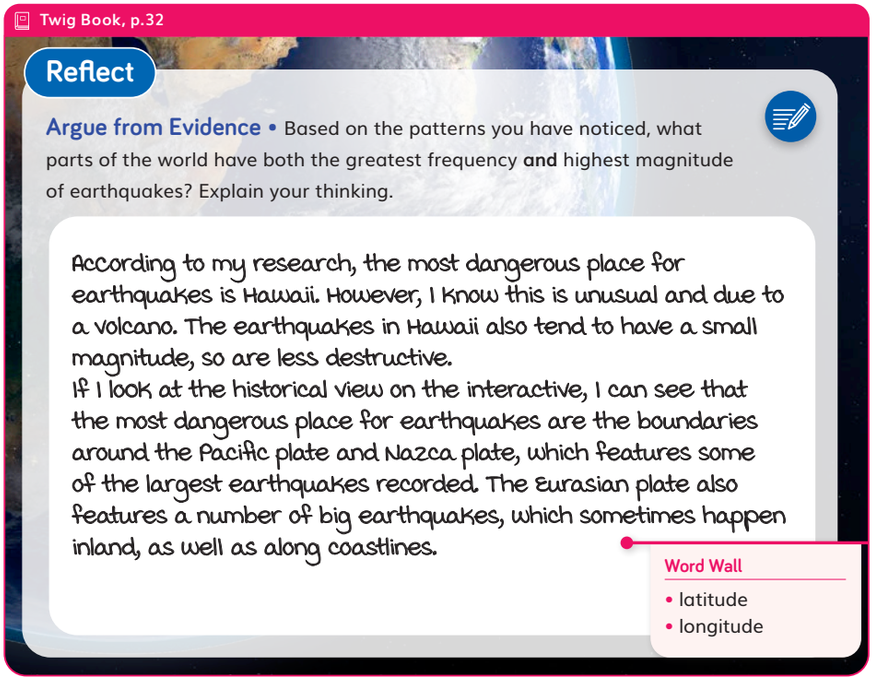
- Plan and carry out investigations
- Construct explanations
- Develop and use models
- Communicate information
- Design solutions
- Obtain information
- Argue from evidence
- Use math and computational thinking
- Ask questions
- Evaluate information
- **Analyze and interpret data**

Reflect

3 min

Formative Assessment

Have students turn to page 32 in their Twig Books and write which parts of the world are the most dangerous for earthquakes based on the patterns they have noticed. They should explain their thinking.



Use the Formative Assessment

Read through students' responses and identify students who need additional support in recognizing earthquake patterns. By now, students should be able to explain that earthquakes occur more frequently in certain areas along plate boundaries. It is not essential that students memorize or name the exact locations, although some students may have reached this level.

For students who do not demonstrate an understanding of earthquake patterns, consider finding time for individual support or extra practice during the next lesson.

California Shakin'

OVERVIEW

Spark	**4 min**	Students discuss regions that are dangerous for earthquakes, identifying California as one of them.
Investigate	**25 min**	Students read a text about some of the most powerful earthquakes in California's history, take notes, and fill in a graphic organizer comparing and contrasting the different earthquakes.
Report	**8 min**	Students discuss the patterns they noticed in earthquakes occurring in California.
Connect	**3 min**	Students use what they learned from the reading to define a problem engineers could solve.
Reflect	**5 min**	Students return to their KLEW Charts from Lesson 1 and add to the "Learned" and "Evidence" columns.

STANDARDS

NGSS

DCI
ESS2.B Plate Tectonics and Large-Scale System Interactions
ESS3.B Natural Hazards

SEP
SEP-1 Asking Questions and Defining Problems
SEP-8 Obtaining, Evaluating, and Communicating Information

CCC
CCC-1 Patterns
CCC-2 Cause and Effect

CETAS
Influence of Science, Engineering, and Technology on Society and the Natural World

CROSS-CURRICULAR CONNECTIONS

EPC
Principle IV There are no Permanent or Impermeable Boundaries that Prevent Matter from Flowing between Systems

CCSS ELA
RI.4.1 Key Ideas and Details
RI.4.4 Craft and Structure
W.4.8 Research to Build and Present Knowledge
SL.4.1 Comprehension and Collaboration

WIDA
Standard 4: The Language of Science (Reading)

3-D LEARNING OBJECTIVES

Students will:

- Do a close reading to identify specific information about earthquakes and the damage they cause
- Compare and contrast information collected from a text
- Discuss ideas presented in a text and explain the ideas they developed from reading and analyzing it
- Find patterns in the data provided in an article about earthquakes in California
- Determine and use key text structures and features.

Driving Question 2

How can patterns help us predict where earthquakes and volcanoes will occur?

LESSON 4

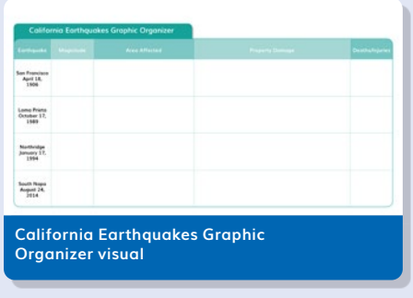
RESOURCES

Digital

- **California Earthquakes Graphic Organizer visual**
- **Earthquake Patterns Progress Tracker**
- Optional: **Compare/Contrast visual** (for the Extension)

Student

- Colored pencils or highlighters



California Earthquakes Graphic Organizer visual

LESSON PREPARATION

If you are unable to add information to the **California Earthquakes Graphic Organizer visual** (e.g., by displaying on a whiteboard), copy the table in the visual onto chart paper.

Spark

4 min

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- The San Andreas Fault is around 1,200 km (750 mi.) long and can produce an earthquake measuring 8.0 on the Richter scale.

Discuss Earthquake Regions

Remind students that they have previously looked at where earthquakes occur and found that some regions of the world are more dangerous than others because of the number of earthquakes that happen there. As a class, discuss and identify where these regions are.

If students don't mention California, identify it as one of the dangerous regions. Let students know that they are going to look at some of California's most dangerous earthquakes in more detail.

Academic Vocabulary Check

- *earthquake*
- *fault*
- *tectonic plates*
- *magnitude*

English Learners

Using the supports below, preview "California Earthquakes" with ELs prior to the class reading. Alternatively, work through part of the article while the other students are annotating the text.

Substantial Support (Emerging Proficiency):
Read the text aloud. Stop to clarify vocabulary words as needed, such as: *magnitude*, *damage*, and *describe*. Provide a synonym or definition as you read (e.g., describe/tell about). Have students find and describe examples of earthquake damage in the photo. You may write sentence frames on the board to support students, such as:

- The earthquake happened on _____. It caused _____.

Continue reading the text. Work through the text, connecting ideas and clarifying vocabulary Model how to use context clues in sentence five on page 35 to define collapsed.

Moderate Support (Expanding Proficiency):
Echo read a few pages of the text. Stop to clarify vocabulary words as needed, such as: *magnitude*, *damage*, *introduced*, *describe*, *severe*, *property*, and *expensive*. Provide a synonym or definition as you read (e.g., describe/tell about). Have students find and describe examples of earthquake damage in the photos. Write sentence frames on the board for students to discuss the text and photos, such as:

- This earthquake _____ because _____.
- The earthquakes caused _____.
- The damage included _____.

Reference a map to help students understand the scope of the geographic area touched by each earthquake. Make connections to the **Earth Explorer interactive**.

Light Support (Bridging Proficiency):
Read the text aloud, alternating between reading a couple of sentences, and having students read. Stop to clarify vocabulary words as needed, such as: *magnitude*, *damage*, *recorded*, *introduced*, *describe*, *severe*, *property*, and *expensive*. Provide a synonym or definition as you read (e.g., describe/tell about). Have students find and describe examples of earthquake damage in the photos. Help them expand on their sentences by combining ideas with the word *and*.

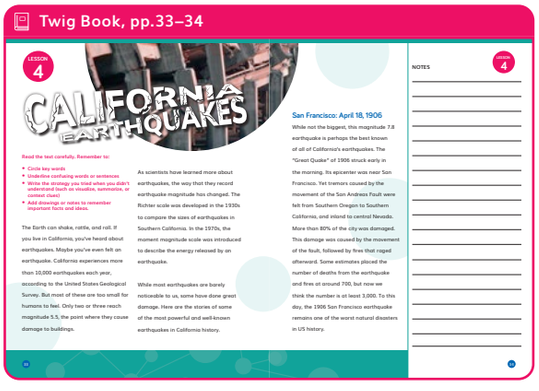
Investigate

25 min

Introduce the Close Reading

Today, students will read an article about some of the most powerful earthquakes in California's history, taking notes as they do so. They will then fill in a graphic organizer, comparing and contrasting the information.

Close Read


Twig Book, pp.33–34

LESSON 4

CALIFORNIA EARTHQUAKES

Read the text carefully. Remember to:

- Circle key words
- Underline confusing words or sentences
- Write the strategy you tried when you didn't understand (look up vocabulary, summarize, or context clues)
- Add drawings or notes to remember important facts and ideas.

The Earth can shake, rattle, and roll. If you live in California, you've heard about earthquakes. Maybe you've even felt an earthquake. California experiences more than 10,000 earthquakes each year, according to the United States Geological Survey. But most of these are too small for humans to feel. Only two or three reach magnitude 5.5, the point where they cause damage to buildings.

As scientists have learned more about earthquakes, the way that they record earthquake magnitude has changed. The Richter scale was developed in the 1930s to compare the sizes of earthquakes in Southern California. In the 1970s, the moment magnitude scale was introduced to describe the energy released by an earthquake.

While most earthquakes are barely noticeable to us, some have done great damage. Here are the stories of some of the most powerful and well-known earthquakes in California history.

San Francisco: April 18, 1906

While not the biggest, this magnitude 7.8 earthquake is perhaps the best known of all of California's earthquakes. The "Great Quake" of 1906 struck early in the morning. Its epicenter was near San Francisco. Yet tremors caused by the movement of the San Andreas Fault were felt from Southern Oregon to Southern California, and inland to central Nevada. More than 80% of the city was damaged. This damage was caused by the movement of the fault, followed by fires that raged afterward. Some estimates placed the number of deaths from the earthquake and fires at around 700, but now we think the number is at least 3,000. To this day, the 1906 San Francisco earthquake remains one of the worst natural disasters in US history.

NOTES

LESSON 4

Have students turn to page 33 of their Twig Books. They should read the text independently and annotate it using different colored highlighters or pencils, following the directions in their Twig Books.

Circulate and take note of areas of confusion (e.g., difficult words, misconceptions). Focus on these when you revisit the text. Conduct over-the-shoulder discussions to help students use and apply reading strategies. For example, model how to stop and summarize after each section to check understanding.

When students finish reading, display the **California Earthquakes Graphic Organizer visual** and have them refer to the copy on page 38 in their Twig Books. Have students work in pairs to reread the portion of the text for each earthquake and record key details on their graphic organizers. Remind students that we often learn new things by looking for patterns in information. Explain that the completed graphic organizer will help them look for patterns.

Investigate

Monitoring English Language Proficiency

Engage students in the following tasks to monitor their English language development. These tasks are best administered individually.

Reading Domain

Use the photo on page 33. Write these sentences:

- Earthquakes cause movements in the Earth's crust.
- During earthquakes, people are often killed when buildings collapse.
- Earthquakes can destroy buildings and cause fires.

Have students read each sentence and choose the one that best matches the photo. Continue with other photos, illustrations, and graphic aids in the text.

Listening Domain

Read aloud the "Loma Prieta" section on page 35.

- ***Why is this earthquake called the "World Series Quake"?***
- ***What effects did the earthquake have?***
- ***Why is this earthquake remembered?***

Have volunteers share information for you to record on the California Earthquakes Graphic Organizer visual.

- ***Do you agree?***
- ***What other details could we add?***
- ***Where in the text did you find these details?***

Twig Book, p.38

Close Read • Complete this chart using information from the article.

California Earthquakes Graphic Organizer

Earthquake	Magnitude	Areas Affected	Property Damage	Deaths
San Francisco April 18, 1906	7.8	Southern Oregon to Southern California	Over 80% of the city, with most damage caused by fires	3,000
Loma Prieta October 17, 1989	6.9	Loma Prieta; San Francisco; Monterey Bay; Watsonville; and Los Gatos	Interstate collapsed; severe destruction to San Francisco Marina District	60
Northridge January 17, 1994	6.7	Northridge in Los Angeles; Las Vegas, Nevada; and Baja California	Major freeways collapsed; buildings, shopping centers, and parking garages damaged	57
North Bay Area August 24, 2014	6.0	San Francisco Bay Area; Nevada border	Older buildings made unsafe; water mains damaged; power lines down	1

Prepare for the Report

Ask students to try and find an important pattern in their table and to give you a subtle signal, e.g., putting a thumb up on their desk when they notice one. Ask students to share their observations.

Report

8 min

Discuss the Close Reading

Discuss "California Earthquakes."

- ***What is similar about these earthquakes? What patterns are there?***
- The earthquakes have similar magnitudes. They all caused at least one fatality.
- ***Which was the most powerful earthquake?***
- The San Francisco earthquake had the highest magnitude and the largest loss of life.
- ***How have the effects of earthquakes changed over time?***
- There is still a lot of property damage, but the number of deaths has decreased even though populations continue to grow.
- ***Why do you think the number of deaths has decreased?***
- There are fewer deaths when the magnitude is lower.
- The populations might be smaller in areas affected by the later earthquakes.
- We have become better at dealing with earthquakes.

Guide students to realize that it is not possible to change the magnitude or location of an upcoming earthquake, but precautions can be taken.

- ***The San Francisco earthquake occurred a lot earlier than the other three earthquakes. If that same earthquake had happened today, do you think the death toll would be as high? Why or why not?***
- The death toll would be a lot lower.
- We have a better understanding of structures and suitable materials, so build stronger houses than we used to. For example, the text says that, in South Napa in 2014, older buildings were badly damaged but newer buildings were not.
- We are more prepared for earthquakes now. We have sprinkler systems inside buildings to combat potential fires. We also have better emergency procedures and rescue techniques.

Misconceptions from the Pre-Exploration

Use the **Earthquake Patterns Progress Tracker** to note if students have the following misconceptions.

Misconception	What to Do
Earthquakes are most deadly when they cause the ground to open up, as people, animals, plants, and buildings can fall into openings and disappear.	In the discussion, ask students what makes an earthquake deadly. If students repeat misconceptions, ask them to look for passages in the text that describe the types of damage done and/or causes of deaths. If necessary, guide students to passages that describe causes of deaths, e.g., fires or collapsed buildings.

Connect

3 min

Connect Today's Learning to the Module Investigative Problem

Remind students of the Module Investigative Problem: How can we reduce the damage caused by earthquakes? Ask students to define a problem that engineers could solve, based on what they learned in the reading.

- Buildings need to be able to stay standing during an earthquake, to reduce both deaths and property damage.

Science Tools

- Plan and carry out investigations
- Construct explanations
- Develop and use models
- Communicate information
- Design solutions
- Obtain information
- Argue from evidence
- Use math and computational thinking
- Ask questions
- Evaluate information
- Analyze and interpret data
- **Define problems**

Chart SEP-1—Asking Questions and Defining Problems

Emphasize that engineers define the problems they need to solve. Draw students' attention to the Science Tools poster and add "Define problems" to it.

Let students know that, in future lessons, they will work toward defining and solving a problem.

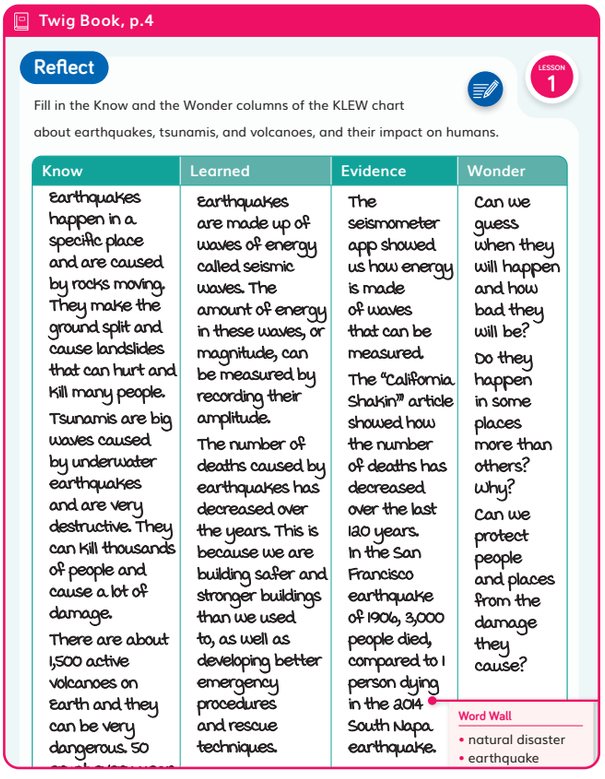
Reflect

5 min

Add to KLEW Charts

Have students go back to their KLEW Chart from Lesson 1 (on page 4 in the Twig Book) and add new information in the "Learned" (claims) and "Evidence" parts of the chart.

Consider revisiting the article in subsequent lessons to focus on key text features and structures that students will encounter in other informational texts.



Twig Book, p.4

Reflect

LESSON 1

Fill in the Know and the Wonder columns of the KLEW chart about earthquakes, tsunamis, and volcanoes, and their impact on humans.

Know	Learned	Evidence	Wonder
Earthquakes happen in a specific place and are caused by rocks moving. They make the ground split and cause landslides that can hurt and kill many people. Tsunamis are big waves caused by underwater earthquakes and are very destructive. They can kill thousands of people and cause a lot of damage. There are about 1,500 active volcanoes on Earth and they can be very dangerous. So	Earthquakes are made up of waves of energy called seismic waves. The amount of energy in these waves, or magnitude, can be measured by recording their amplitude. The number of deaths caused by earthquakes has decreased over the years. This is because we are building safer and stronger buildings than we used to, as well as developing better emergency procedures and rescue techniques.	The seismometer app showed us how energy is made of waves that can be measured. The "California Shakin'" article showed how the number of deaths has decreased over the last 120 years. In the San Francisco earthquake of 1906, 3,000 people died, compared to 1 person dying in the 2014 South Napa earthquake.	Can we guess when they will happen and how bad they will be? Do they happen in some places more than others? Why? Can we protect people and places from the damage they cause?

Word Wall
- natural disaster
- earthquake

Assess Student Progress

Look at students' KLEW charts and use the **Earthquake Patterns Progress Tracker** to note if students were able to use patterns as evidence to support claims.

Extension

Focus on Text Feature—Maps

Have students revisit the map on page 37 of their Twig Books. Review that a map is a flat picture of the Earth. There are five main types of maps—political, physical, landform, transportation, and historical.

Review the steps for reading a political map and apply them to the California earthquake map:

Step 1: Read the title. It tells you what the map is about.

Step 2: Find the map symbols.

Step 3: Look at the map key or legend. It tells you what each map symbol means.

Step 4: Read the map labels and any captions.

Step 5: Find the compass rose. It shows directions on the map.

Have students turn and talk with a partner to explain what they learned from the map. Then, discuss the map as a class.

- ***Why did the author include a map in the article?***
- ***How did the map help you better understand the text?***
- ***When and where could you use a map in your writing?***

To help students understand the use of maps, have them add a map to an upcoming writing assignment. When students have to find or create a text feature, then determine where it should go in a text and why, they are better able to interpret these features in other texts.

Focus on Text Structure—Compare/Contrast

Remind students that writers organize their writing in a way that helps us understand and remember the information. One way is to compare and contrast information.

Point out the signal words writers use when comparing and contrasting information—*both*, *same*, *similar*, *different*, *so*, *therefore*, *but*, *unlike*, *however*, *in contrast to*. Record these on chart paper for student reference.

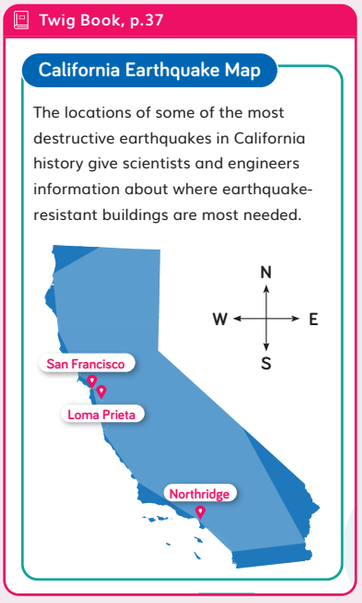
Explain that when a reader see these words in a text, it alerts them to how the text is organized. This is a clue for how they can organize their thinking as they read. They can also use these signal words in their own writing to help their readers better understand their texts.

The writer of "California Earthquakes" describes three different earthquakes and their impact. When we write or talk about the information learned, we can compare and contrast the facts to look for patterns in earthquake magnitude and damage. That helps us connect the ideas.

Ask students to select two earthquakes in the article to compare and contrast. Have them use the text structure frame on the **Compare/Contrast visual** to write their ideas. This frame uses key signal words to model for students. Explain that they can add to this frame as needed.

When completed, have students use the frames to share their findings with the class.

Twig Book, p.37



Earthquakes in Oklahoma

OVERVIEW

Spark	**5 min**	Students examine a graph showing the growing number of earthquakes in Oklahoma in recent years.
Investigate	**15 min**	Students read an informational text about earthquakes in Oklahoma using close reading strategies.
Report	**18 min**	Students write a news report about the change in the number of earthquakes in Oklahoma.
Connect		*There is no Connect in this lesson.*
Reflect	**7 min**	Student pairs take turns to read their news reports to one another.

STANDARDS

NGSS

DCI
- **ESS2.B** Plate Tectonics and Large-Scale System Interactions
- **ESS2.E** Biogeology

SEP
- **SEP-1** Asking Questions and Defining Problems
- **SEP-5** Using Mathematics and Computational Thinking
- **SEP-8** Obtaining, Evaluating, and Communicating Information

CCC
- **CCC-1** Patterns
- **CCC-2** Cause and Effect

CETAS
- Interdependence of Science, Engineering, and Technology
- Influence of Science, Engineering, and Technology on Society and the Natural World

CROSS-CURRICULAR CONNECTIONS

EPC
- **Principle I** People Depend on Natural Systems
- **Principle II** People Influence Natural Systems
- **Principle** III Natural Systems Change in Ways that People Benefit from and can Influence
- **Principle IV** There are no Permanent or Impermeable Boundaries that Prevent Matter from Flowing between Systems
- **Principle V** Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

WIDA
- **Standard 3:** The Language of Mathematics (Speaking, Writing, Reading)
- **Standard 4:** The Language of Science (Reading)

CCSS ELA
- **RI.4.1, RI.4.3** Key Ideas and Details
- **RI.4.7, RI.4.9** Integrations of Knowledge and Ideas
- **W.4.9** Research to Build and Present Knowledge
- **SL.4.1** Comprehension and Collaboration
- **SL.4.4** Presentation of Knowledge and Ideas

CCSS MATH
- **4.MD.B** Represent and interpret data

3-D LEARNING OBJECTIVES

Students will:

- Obtain and discuss information from a text about earthquakes
- Analyze a text and a graph to determine patterns and cause-and-effect relationships
- Present information in a news report in written and oral form.

Driving Question 2

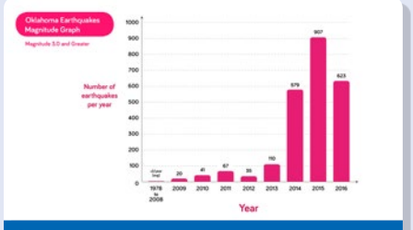
How can patterns help us predict where earthquakes and volcanoes will occur?

LESSON 5

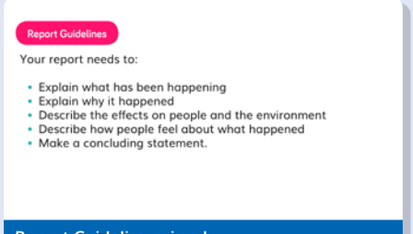
RESOURCES

Digital

- **Oklahoma Earthquakes Magnitude Graph visual**
- **Report Guidelines visual**



Oklahoma Earthquakes Magnitude Graph visual



Report Guidelines visual

LESSON PREPARATION

- There is no Connect in this lesson to allow more time for students to write their reports.
- On a piece of chart paper, write "Questions about the Yearly Rate of Earthquakes in Oklahoma." You will use this chart to collect students' questions about the graph.

Spark

5 min

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

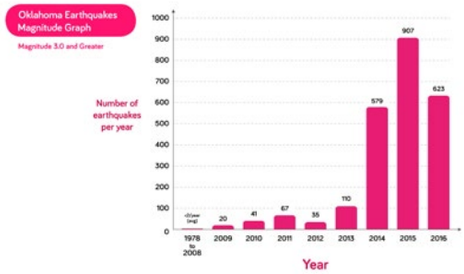
Earthquake Fact of the Day:

- Gaspar de Portolá was the first European to record feeling an earthquake in California. In 1769, his group was camping about 48 km (30 mi.) southeast of Los Angeles when an earthquake struck.

Introduce Earthquakes in Oklahoma

Remind students that in the previous lesson they read about some of the effects of several earthquakes in California. Today, students will look at and explore earthquakes in a seemingly unlikely place—Oklahoma.

Oklahoma Earthquakes Magnitude Graph visual



Display the **Oklahoma Earthquakes Magnitude Graph visual**. On the board, write:

- What do you know from the graph?
- What do you want to know based on the graph?

Ask students to review the graph and answer the questions. Record their answers, observations, and questions on the "Questions about the Yearly Rate of Earthquakes in Oklahoma" chart.

Summarize by defining the problem.

- ***Since 2009, Oklahoma has experienced a dramatic increase in the number of 3+ magnitude earthquakes it experiences each year. This increase in earthquakes has attracted the attention of many people and raises questions that need to be answered.***

English Learners

Preview the article with ELs prior to the class reading using the supports below. Alternatively, work through parts of the article while other students are annotating the text.

Substantial Support (Emerging Proficiency)

Read the text aloud. Stop to clarify vocabulary words as needed, such as: *damaged*, *magnitude*, *deadly*, *decades*, *located*, *tectonic plates*, *skyrocketed*, *dispose*, and *wastewater*. Provide a synonym or definition (e.g., dispose/get rid of).

Look at the graph with students:

Step 1: Read the title to find out what the graph shows.

Step 2: Look at the labels to find out what kinds of information is shown.

Step 3: Read across each line to determine the connection between the date and the number of earthquakes for each year

Step 4: Compare and contrast the information in the graph.

Use sentence frames to support students such as:

In 2009 there were _____ earthquakes, but in 2014 there were _____.

Moderate Support (Expanding Proficiency)

Echo read a few pages of the text. Stop to clarify vocabulary words as needed, such as: *damaged*, *magnitude*, *deadly*, *decades*, *located*, *tectonic plates*, *skyrocketed*, *dispose*, and *wastewater*. Provide a synonym or definition (e.g., dispose/get rid of).

Discuss the graph with students.

Step 1: Read the title to find out what the graph shows.

Step 2: Look at the labels to find out what kinds of information is shown.

Step 3: Read across each line to determine the connection between the date and the number of earthquakes for each year

Step 4: Identify the peak year shown in the graph

Provide sentence frames for students to discuss the text and graph such as:

In 2009 there were _____ earthquakes, but in 2014 there were _____.

The number of earthquakes in 2015 went up to _____ because _____.

Light Support (Bridging Proficiency)

Read aloud the text, alternating reading a sentence or two yourself and then having students read. Stop to clarify vocabulary words as needed, such as: *damaged*, *magnitude*, *deadly*, *decades*, *located*, *tectonic plates*, *skyrocketed*, *dispose*, and *wastewater*. Provide a synonym or definition (e.g., describe/tell about). Help them expand on their sentences by combining ideas with *and*.

Special Needs

Visual-Spatial Processing

Scaffold visually for students when reading about states located near the edges of tectonic plates by displaying the **Earth Explorer interactive** with the Tectonic Plates view selected. This way students can make the cognitive connection.

Earthquakes in Oklahoma

Investigate

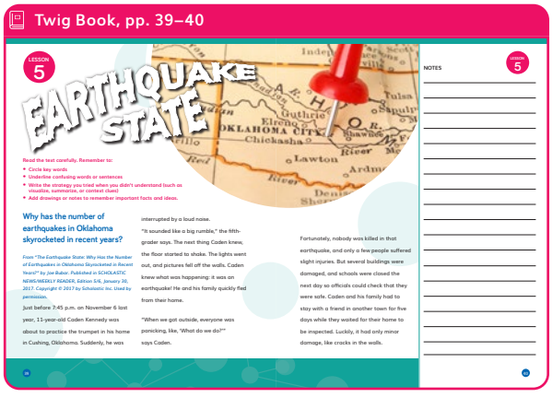
15 min

Introduce the Close Reading

Today, students will read an article about earthquakes in Oklahoma that will answer some of their questions.

Students will be using close reading strategies to understand the text. Together, review the directions on page 39 of the Twig Book.

Students will then write a news report to share what they have learned about Oklahoma earthquakes. They will share their reports with a partner.



Close Read

Have students read and annotate "The Earthquake State: Why Has the Number of Earthquakes in Oklahoma Skyrocketed in Recent Years?" Encourage students to discuss the text and their annotations with a partner. Monitor annotations and student discussions for misconceptions.

Discuss the Close Reading

Use student-generated questions and the prompts below to lead a discussion of the text.

- ***Why does the author include Caden's story? What does his account add to your understanding of the text?***
- ***What evidence in the text shows the author is writing down exactly what people say to him? Why might this help the article?***
- ***What kind of audience do you think the author is writing for?***
- ***How is Oklahoma different from most states that experience a lot of earthquakes? What evidence does the author give?***
- ***What do scientists believe causes the earthquakes in Oklahoma?***
- ***How are humans impacting the environment in Oklahoma?***
- ***Why did the author include a graph of the rate of earthquakes in Oklahoma? How did it help you understand the text?***
- ***Look at the diagram showing the disposal of waste water. Did it help you understand the text? Why might the author have included it?***
- ***When you write science reports, what kind of diagrams and pictures can you include?***

English Learners

As students answer, revoice their ideas to model the language scientists use by restating a statement as a question in order to clarify, apply appropriate language, and involve more students.

For example:

- Cushing had a big earthquake.
- ***What was the magnitude of the earthquake at Cushing? Can anyone give me the exact number?***

Press for details in students' explanations by asking students to challenge an idea, elaborate on an idea, or give an example.

Report

18 min

Connect to Writing—Informational Texts

Explain that students will play the part of reporters for a paper aimed at their peers, and that they are going to write reports on earthquakes in Oklahoma. Before they can write their reports, they need to do research.

Give students time to reread the text with a partner. As they read, students should highlight any information that they think should be included in their report.

Display the **Report Guidelines visual** and read each bullet aloud, or have a student read them aloud. Let students know that there is a copy on page 45 in their Twig Books.

Remind students that a news report is an informational text and they must include facts to back up what they say.

Have students write their reports on page 45 in their Twig Books.

Optional: Give students additional time by having them review their writing during the Reflect and make changes to their report as homework.

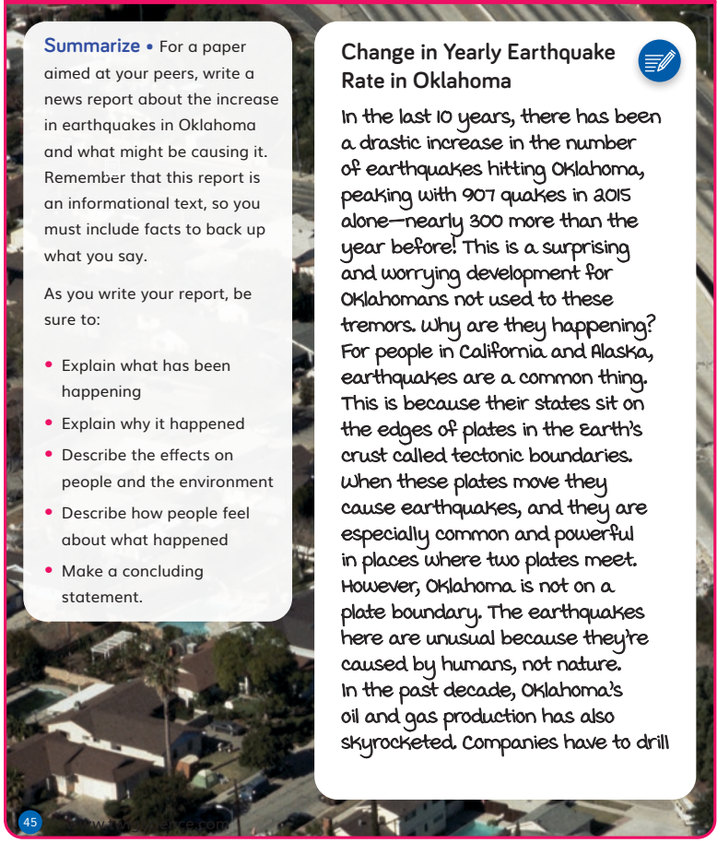
English Learners

Pair students with a more proficient reader and have them read the text aloud. They could adopt the style of a professional news reporter and take turns reading a paragraph or passage.

They should pause at important spots, summarize what has just been read, and mark information they will need for their own news report.

Explain that in their news report, they will need to explain what has happened, why it has happened, any effects it had, and how people feel about what happened.

Twig Book, p.45



Summarize • For a paper aimed at your peers, write a news report about the increase in earthquakes in Oklahoma and what might be causing it. Remember that this report is an informational text, so you must include facts to back up what you say.

As you write your report, be sure to:

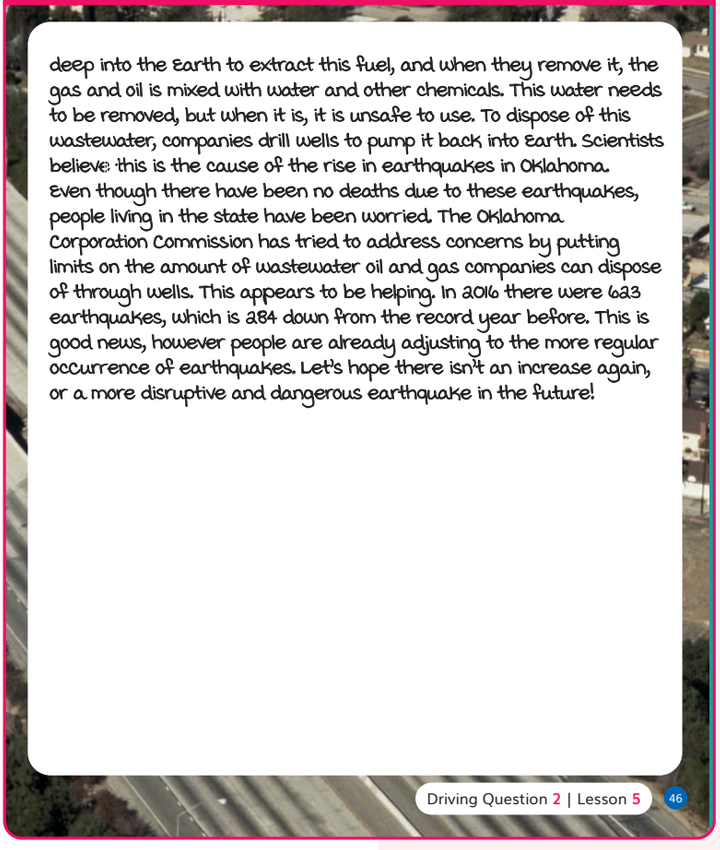
- Explain what has been happening
- Explain why it happened
- Describe the effects on people and the environment
- Describe how people feel about what happened
- Make a concluding statement.

Change in Yearly Earthquake Rate in Oklahoma

In the last 10 years, there has been a drastic increase in the number of earthquakes hitting Oklahoma, peaking with 907 quakes in 2015 alone—nearly 300 more than the year before! This is a surprising and worrying development for Oklahomans not used to these tremors. Why are they happening? For people in California and Alaska, earthquakes are a common thing. This is because their states sit on the edges of plates in the Earth's crust called tectonic boundaries. When these plates move they cause earthquakes, and they are especially common and powerful in places where two plates meet. However, Oklahoma is not on a plate boundary. The earthquakes here are unusual because they're caused by humans, not nature. In the past decade, Oklahoma's oil and gas production has also skyrocketed. Companies have to drill

45

Twig Book, p.46



deep into the Earth to extract this fuel, and when they remove it, the gas and oil is mixed with water and other chemicals. This water needs to be removed, but when it is, it is unsafe to use. To dispose of this wastewater, companies drill wells to pump it back into Earth. Scientists believe this is the cause of the rise in earthquakes in Oklahoma. Even though there have been no deaths due to these earthquakes, people living in the state have been worried. The Oklahoma Corporation Commission has tried to address concerns by putting limits on the amount of wastewater oil and gas companies can dispose of through wells. This appears to be helping. In 2016 there were 623 earthquakes, which is 284 down from the record year before. This is good news, however people are already adjusting to the more regular occurrence of earthquakes. Let's hope there isn't an increase again, or a more disruptive and dangerous earthquake in the future!

Driving Question 2 | Lesson 5 46

Reflect

7 min

Formative Assessment

Have partners take turns reading their reports to each other. The person reading should read the report aloud as if they were delivering a special report on the evening news, and the listener should pay attention to whether the writer has included all of the elements on the **Report Guidelines visual**.

Use the Formative Assessment

Use the written reports to assess students' understanding of the text. Evaluate the reports for inclusion of the required elements and evidence of comprehension of the content.

Standard English Learners

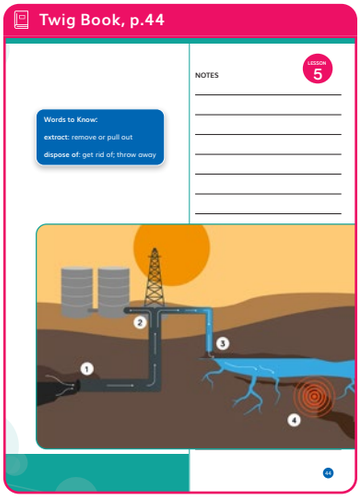
Check in with students whose home dialect differs from Standard English. Encourage them to consider the ways purpose and audience affect register (formal vs. informal language, tone, vocabulary, and so on).

Extension

Focus on Text Feature—Diagrams

Ask students to identify the special text features (e.g., graph, diagram) in, "The Earthquake State: Why Has the Number of Earthquakes in Oklahoma Skyrocketed in Recent Years?", and explain why the author used each one.

Focus students' attention on the diagram on page 44 of their Twig Books.



- ***How do the different parts of this diagram relate to the text?***
- ***What do the arrows in the pipes mean?***
- ***What do you think the concentric circles next to the 4 mean?***
- ***What do the little numbers in circles mean?***
- ***Is there a sequence that the author wants us to understand?***
- ***How does the combination of pictures, signs (arrows), and numbers help us understand this process?***

Ask students why *triggers* might be a suitable word to use when discussing earthquakes. Mention, for example, the trigger of a crossbow: a crossbow has great tension and just needs something to release all the energy stored in its stretched string. One small movement can have a very big, potentially destructive effect. We call this type of usage a *metaphor* because it uses a mental picture of one thing to help describe another.

Monitoring English Language Proficiency

Engage students in the following tasks to monitor their growing English language development. These tasks are best administered individually.

Writing Domain

Have students look at the picture on page 44 and write a brief description of what is happening.

Speaking Domain

As students share their news report on page 45, guide listening students to ask questions after the report has finished. Record the students' use of academic vocabulary and connecting words when answering the questions.

Focus on Text Structure—Compare and Contrast

Discuss the importance of identifying how a text is structured. Explain that figuring out how a text is structured will help them organize their thinking as they read and better comprehend the text.

The author has divided "The Earthquake State: Why Has the Number of Earthquakes in Oklahoma Skyrocketed in Recent Years?" into clear sections. Ask the class to work out where they start and end. What does each section tell us?

Encourage students to look at the headings for clues, and summarize each section after they finish reading it. Then, lead a class discussion of the text.



- ***Why does the author begin the article with an interview of a fifth grader and his personal story?***
- ***Why has the author used short paragraphs at the beginning?***
- ***Spot the author's use of questions to direct our thinking. Does the author ask a question and then answer it?***
- ***Do you think the article has a good conclusion? Is the author leaving us on a positive note?***

Analyzing Maps

This assessment has a Depth of Knowledge level of 3

DoK 3

OVERVIEW

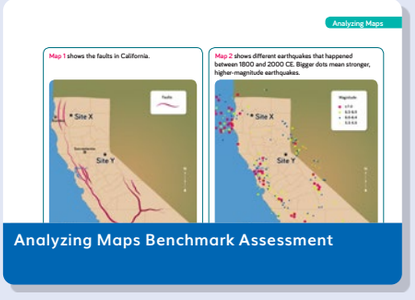
Students are asked to select a suitable location for a new theme park in California, choosing from three possible sites. Maps of California are provided, showing data sets for: where current faults lie; the magnitudes of earthquakes within the last 200 years; and the level of shaking each region experiences during an earthquake. Students interpret these maps and use them to pick a location for the theme park, providing evidence from the map to support their choice.

This assessment is to be completed individually, but you should spend time with the class reviewing the format and the student rubrics. Provide 20–30 minutes for students to complete the assessment.

RESOURCES

Digital

- **Analyzing Maps Benchmark Assessment**
- **Analyzing Maps Teacher Rubrics**
- **Analyzing Maps Student Rubrics**



Analyzing Maps Benchmark Assessment

STANDARDS

Rubric	PE*	SEP	DCI	CCC	DoK
1	4-ESS2-2	**SEP-4** Analyzing and Interpreting Data	**ESS2.B** Plate Tectonics and Large-Scale System Interactions	–	3
2	4-ESS2-2	–	**ESS2.B** Plate Tectonics and Large-Scale System Interactions	**CCC-1** Patterns	3

*Details of the alignment to PE dimensions listed can be accessed online in the **Analyzing Maps Teacher Rubrics.**

BENCHMARK ASSESSMENT

BEFORE THE ASSESSMENT

Prior to starting, take a few minutes to review the assessment and the associated **Analyzing Maps Student Rubrics** with the class. Remind students that they are to complete this assessment individually, so that you are able to gather information about what they know and are able to do in relation to what they have learned so far in the module. Feel free to answer any questions the students may have.

Reminder

Students need to see the maps in color. If you are printing the assessment in gray-scale, the digital colored versions of the maps can be displayed for class reference.

TEACHER RUBRICS

This assessment is evaluated using rubrics that are designed to provide formative information in order to guide further instruction. Each rubric begins by identifying the location of student responses that provide evidence (e.g., Questions 1–2). The rubric levels reflect increasing levels of performance in relation to the knowledge and skills being measured and range from Emerging to Advanced. The bolded rubric language indicates how performances progress across the levels of the rubric.

In the **Analyzing Maps Teacher Rubrics**, each performance level is further explained by accompanying Look Fors, which are located underneath each level. They provide an example of what you might see in student performance at that particular level to help you evaluate student work.

For each Teacher Rubric there is also an Item Level Claim Statement (ILCS). This is a brief statement showing the performance outcome for each rubric, to illustrate how it aligns to the PE.

STUDENT RUBRICS

Before students take the assessment, you are encouraged to share the **Analyzing Maps Student Rubrics** with them. Reviewing rubrics allows students to understand how their work will be evaluated and what they need to produce to achieve each of the four levels. Students should have access to these rubrics while they complete the assessment. When giving students their final rubric scores, you can discuss the evidence from their work that led to each assigned score.

Note: The student version of the rubrics does not contain the Look Fors section, with specific answer examples.

Rubrics

Rubrics for Analyzing Maps

Answer: Students should choose **Site Y** as the best location for the theme park.

Rubric 1: Use Rubric 1 to evaluate student responses for Sections 1–2 of Table 1 and Table 2, or the parts of Question 1 that provide evidence for these sections.

Emerging	Developing	Proficient	Advanced
Student **identifies location that is inaccurate.** **OR** Student **does not select a location.**	Student identifies **accurate** location **using little to no evidence from map** to support the location selected. **OR** Student identifies **accurate location with inaccurate or irrelevant evidence** used to support the location selected.	Student identifies accurate location using **general** evidence to support the location selected.	Student identifies accurate location using **specific and detailed** evidence to support the location selected **and compares identified location to other sites.**
Look Fors: • No response (e.g., "I don't know"). • Incorrect site is identified.	**Look Fors:** • Correct site is identified with superficial or no information from map used (e.g., "Site X because of faults"). • Correct site is identified with inaccurate or irrelevant information from map used (e.g.,"Site X because it is at the bottom of California").	**Look Fors:** • Correct site or sites are identified. • Supporting evidence from map is general and accurate for each site identified (e.g., "Site X because it has the most faults around it").	**Look Fors:** • Correct site or sites are identified. • Supporting evidence from map is accurate, specific, and detailed, and compares the selected site to one or more of the other sites (e.g., "Site X because there are __ faults surrounding this site, compared to Site Y, which has no faults nearby").

PE 4-ESS2-2 SEP SEP-4 DCI ESS2.B DoK 3

ILCS: Student analyzes data from maps to identify the location and types of earth's features on a map.

Rubric 2: Use Rubric 2 to evaluate student responses for Section 3 of Table 1 and Table 2, or the part of Question 1 that provides evidence for these sections.

Emerging	Developing	Proficient	Advanced
Student interprets data from maps and **identifies an inaccurate, incomplete, or irrelevant pattern.** **OR** Student **does not identify any pattern.**	Student interprets data from maps to identify a **general** pattern **supported by minimal/superficial information** from maps.	Student interprets data from maps to identify **an accurate and relevant pattern** supported by **general** information from maps.	Student interprets data from maps to identify an accurate and relevant pattern supported **by a variety of detailed** information from maps.
Look Fors: • No response (e.g., "I don't know"). • Incorrect or irrelevant pattern is identified. • No pattern is identified. • Analysis of map data is inaccurate.	**Look Fors:** • A general and accurate pattern is identified with little to no description and/or information from maps. • A general pattern is identified using vague supporting information from one or both maps (e.g., "Not a lot of earthquakes, lots of lines, lots of faults"). • A partially accurate pattern is identified with supporting information from maps.	**Look Fors:** • An accurate and relevant pattern is identified and described using general information from both related maps (e.g., number of fault lines, near to shaking, strength of ground shaking). • An explanation of a pattern that corresponds to maps.	**Look Fors:** • An accurate and relevant pattern is identified and described using specific and different types of information from both related maps (e.g., scale frequency of faults, magnitude of shaking, distance between sites and faults, or ground shaking). • Explanation of pattern fully corresponds to both maps and cites specific details.

PE 4-ESS2-2 DCI ESS2.B CCC CCC-1 DoK 3

ILCS: Student interprets data maps to identify patterns where earthquakes occur.

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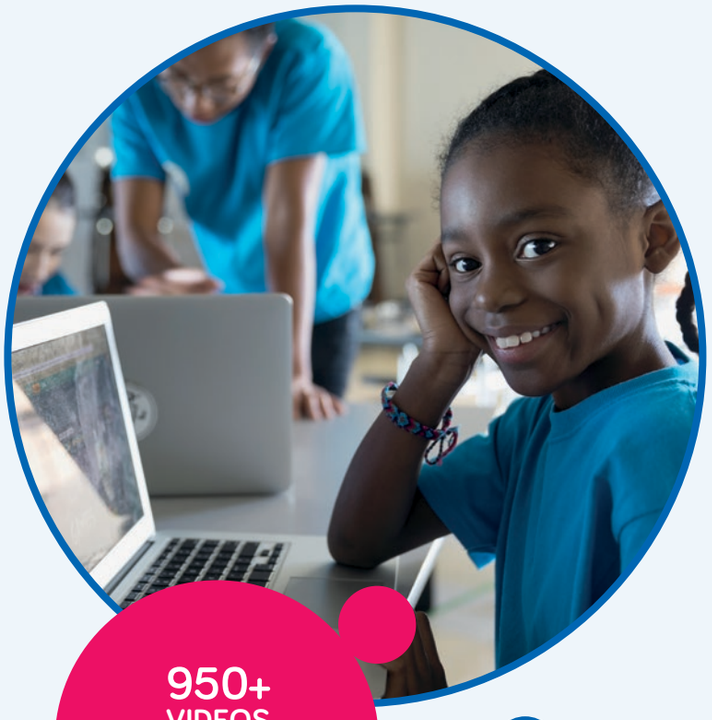
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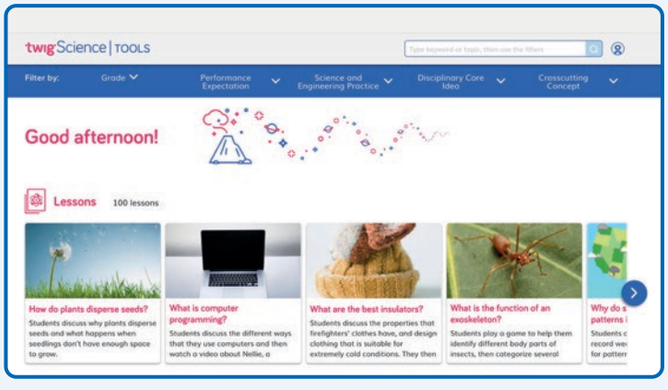


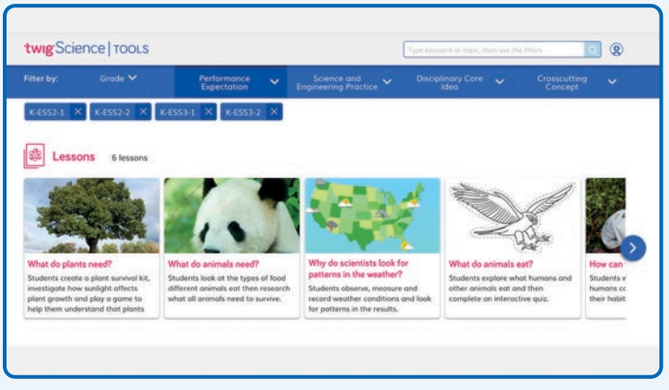
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GRADE **4**
MODULE **4**

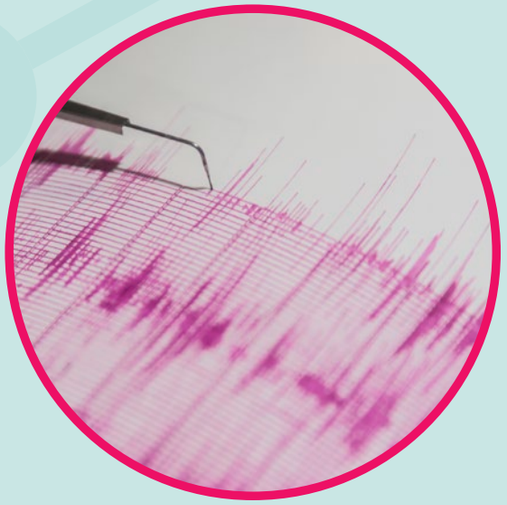
EARTHQUAKE ENGINEERING

Module Anchor Phenomenon:
How can we reduce the damage caused by earthquakes?

Driving Question 3
How can building materials and shapes affect the severity of earthquake damage?

Performance Expectations: 3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost; 3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem; 3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Through a series of investigations, students build understanding of how the shape, structure, and properties of materials affect a building's ability to withstand forces.



Overview: **Full Course**

Driving Question **3** How can building materials and shapes affect the severity of earthquake damage?

		FULL COURSE		
		LESSON	PAGE	SUGGESTED PACING
ENGAGE / EXPLORE	1 ☑3-D	**Overloaded** Students watch a video about forces that engineers must consider in building design, then explore the stability of different shapes and draw conclusions from their observations. They relate these to the paper structures they built in the first lesson.	98	45 min
EXPLORE	2	**Materials and Forces** Students test how compression (squeezing), tension (stretching), torsion (twisting), and bending affect different materials. They watch a video about the properties of wood and make predictions about how wood would respond to different forces.	104	45 min
EXPLAIN / ELABORATE	3	**Straw, Brick, or Wood, Mr. Wolf?** Students engage in another construction activity in which they explore the properties of new materials and how these materials respond to live loads. Students compare results and assess the various materials, then discuss their observations.	110	45 min
EVALUATE	4	**Earthquakes Around the World** Students read two articles and watch a video about historical earthquakes, then make inferences about conditions that influence the effects of an earthquake. They use what they learn to think about how to build safer buildings.	116	45 min

Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · ☑3-D Assessment

The Full Course is recommended for mastery of the Performance Expectations.
The Fast Track Course delivers the Next Generation Science Standards at an accelerated pace.

Overview: **Fast Track Course***

Driving Question **3** How can building materials and shapes affect the severity of earthquake damage?

RESOURCES	MATERIALS		
	TEACHER	TWIG SCIENCE LAB KITS	
• Family Outreach Letter 3 • Building Loads video • Earthquake Safety Progress Tracker	• Trays • Marshmallows • Spaghetti	• Safety goggles	PRE-EXPLORATION
• Wood video	• Graham crackers • Trays • Marshmallows • Spaghetti	• Safety goggles • Pipe cleaners	
• Criteria and Constraints 2 visual	• Trays • Scales • Newspaper • Tape • Spaghetti • Marshmallows	• Safety goggles • Resealable plastic bags • Sand • Meter sticks • Pipe cleaners • String • Straws • Modeling clay	
• Earth Explorer interactive • Earthquakes Around the World video • Earthquake Safety Progress Tracker	• World map or globe • Computer or tablet for each pair		

Resource Highlights



Building Loads video



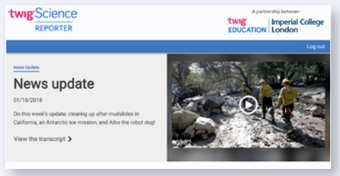
Earth Explorer interactive



Earthquakes Around the World video



Professional Learning



Topical science news, features, and careers

twig Science REPORTER

*Fast Track lessons/activities are identified by

FAST TRACK COURSE			
BLOCK	SUGGESTED PACING	LESSONS/ACTIVITIES	NOTES
1	35 min	**Sections from Overloaded** • **Discuss the Video** • **Introduce the Activity** • **Build Structures** • **Discuss Structures** • **Connect Today's Learning to the Module Investigative Problem** • **Pre-Exploration** • **Use the Pre-Exploration**	Before the lesson, write the following terms on the board: • Compression/Squeezing • Tension/Stretching • Torsion/Twisting • Bending After completing the Discuss Structures section, use the Reflect prompt question on page 51 in the Twig Book to discuss which buildings are safest in an earthquake.
2	25 min	**Sections from Materials and Forces** • **Introduce the Activity** • **Demonstrate Compression (Squeezing)** • **Demonstrate Tension (Stretching)** • **Demonstrate Torsion (Twisting)** • **Demonstrate Bending**	Before the activity, explain that there are four types of force that can act upon a building. Point to the terms on the board, and provide definitions (use the table from page 112). Demonstrate the forces as a teacher demo, pausing to allow students to make predictions about what will happen and why.
	30 min	**Sections from Straw, Brick, or Wood, Mr. Wolf?** • **Introduce the Activity** • **Plan Structures** • **Build Structures** • **Test Structures** • **Write About Structures** • **Discuss Materials**	
	10 min	**Sections from Earthquakes Around the World** • **Discuss the Video** • **Formative Assessment** • **Assess Student Progress**	Explain that students are going to watch a video about two different earthquakes—one in Chile and one in Nepal. Ask them to listen for and take note of how the effects of these earthquakes on people varied and why. Play the **Earthquakes Around the World video**. • ***Why did the earthquakes have such different effects?*** Have students answer the prompt question on page 66 in their Twig Books. Explain that they have seen the effects of two earthquakes, one in Nepal in April, 2015, and in Chile in September, 2015. Remind students of the teacher demonstration of forces, and the structures they have built and tested so far. **Note:** Answers will be different from the sample answers as they will not have read the texts.

Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · 3-D Assessment

Leveled Readers

These high-interest, magazine-style leveled readers give students the opportunity to explore the ideas covered in the module in greater depth and meet real-world scientists and engineers. Available in 4 levels, they can be used in differentiated small-group reading time. On-Level lessons that accompany the readers are provided in the Teacher Edition. Above-Level, Below-Level, and English Learner lessons can be found online at www.twigscience.com.



		Guided Reading	ATOS
OL	On-Level	S	4.9
AL	Above-Level	U	6.2
BL	Below-Level	N	3.2
EL	English Learners	S	4.9

Shake, Rattle, and Roll

Chapter 1: The Curious Scientist

This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend informational texts while reading independently.

Chapter 2: STEM Career: Meet a Seismologist

This chapter focuses on the career of a seismologist. It includes an optional micro-lab in which students learn how energy is stored and released during an earthquake.

Chapter 3: Earthquake-Proofing: What's the Cost?

This chapter focuses on applying the science standards to students' lives, and examines different ways that engineers earthquake-proof buildings.

Already use another ELA program in your class? No problem! Each Twig Science module is aligned to Workshop Models and McGraw-Hill Wonders©. Benchmark Advance™ available online.

ELA CONNECTIONS

Workshop Models

RI.4.1–3 Key Ideas and Details
RI.4.4 Craft and Structure
RI.4.7, 9 Integration of Knowledge and Ideas
SL.4.1–2 Comprehension and Collaboration
SL.4.4–6 Presentation of Knowledge and Ideas
W.4.2, 3 Text Types and Purposes
W.4.4 Production and Distribution of Writing
W.4.7–9 Research to Build and Present Knowledge
W.4.10 Range of Writing

McGraw-Hill Wonders©

Unit 1, Week 3 Thinking It Through
Leveled Reader Landscapes
Student Anthology Earthquakes

Lift foldout for Fast Track information

Differentiated Instruction—Highlights

Driving Question 3 How can building materials and shapes affect the severity of earthquake damage?

English Learners

Lesson 2 For students needing substantial support, model filling in the chart with one example. Use metamodeling as you fill it out and refer to the posted academic vocabulary that you've written on the academic word wall.

Lesson 4 As students verbalize what they notice, encourage them to combine their ideas from the T-chart into more sophisticated sentences to offer additional detail in their compare and contrast statements of the two earthquakes. Offer sentence frames that prompt these added clauses:

Substantial Support (Emerging Proficiency)

In Haiti, the earthquake _____, but in California, the earthquake _____.

Moderate Support (Expanding Proficiency)

The effects of each earthquake differed because in Haiti _____, while in California _____.

Light Support (Bridging Proficiency)

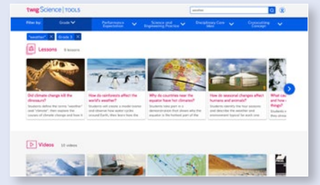
Since California _____, the effects were as compared to Haiti where because _____.

Extension Activities

NGSS-mapped resources to help extend and enrich learning for students of all abilities.

twigScience TOOLS

www.twigsciencetools.com



Challenge

Lesson 1 Have students build structures of three-dimensional shapes, e.g., pyramids, cubes, or prisms, and perform similar tests. Ask students to rank their structures and explain why they put them in the order they did during the Report discussion.

Lesson 3 Have students design and build two structures and write comparisons of the advantages and disadvantages of each.

Special Needs

Fine Motor Skills

Lesson 2 Compressing the materials will require small muscle movements and coordination. Let students know it's OK if some of the materials break. If you sense frustration, students may test materials with a partner and dictate actions to a peer (e.g., "Compress it more!").

Social-Emotional Functioning

Lesson 4 Consider which students work better when paired with peers for reading. Allow pairs to sit away from others and read aloud at their own pace. Allow them additional time to read, if needed.

Time Savers

CCSS English Language Arts

Lesson 4 RI.4.1 Key Ideas and Details

Lesson 4 W.4.9 Research to Build and Present Knowledge

Lesson 1–4 SL.4.1 Comprehension and Collaboration

WIDA English Language Development

Lesson 1, 2, 3 Standard 1: Social and Instructional Language

Lesson 4 Standard 2: The Language of Language Arts

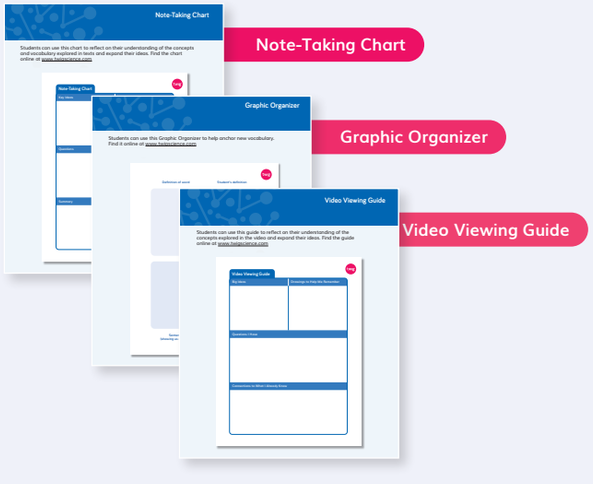
Lesson 1–4 Standard 4: The Language of Science

Access to Science Literacy and Vocabulary

Word Wall

Driving Question 1	natural disaster, earthquake, tsunami, volcano, energy transfer, waves, point of impact, amplitude, wavelength, seismic waves
Driving Question 2	ocean, Pacific Ocean, Atlantic Ocean, Ring of Fire, elevation, mountain range, belt, pattern, tectonic plates, fault, fault line, latitude, longitude
Driving Question 3	**dead load, live load, horizontal load, compression (squeezing), tension (stretching), torsion (twisting), bending**
Driving Question 4	-
Driving Question 5	civil engineer, structures, forces, mistakes, materials, engineering design process (problem, criteria and constraints, brainstorm, design, build a model, test, refine, share), hazard, safety, revise
Driving Question 6	fair test, data, budget

Additional Differentiated Support



See our full range of vocabulary support tools online.

Overloaded

☑ 3-D

OVERVIEW

Spark	**7 min**	Students watch and discuss a video about different kinds of building loads.
Investigate	**20 min**	Student teams build three structures using marshmallows and spaghetti, and perform four tests to see which of the structures are best at coping with different loads.
Report	**10 min**	Student teams share their findings about the stability of their structures and work out which of the shapes would hold up best during an earthquake.
Connect	**3 min**	Students discuss what engineers can do to make buildings less dangerous during earthquakes.
Reflect	**5 min**	Students complete a Pre-Exploration to gauge their understanding of earthquake safety.

STANDARDS

NGSS

PE

3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

DCI

ETS1.A Defining Engineering Problems

ETS1.B Developing Possible Solutions

ETS1.C Optimizing the Design

SEP

SEP-1 Asking Questions and Defining Problems

SEP-2 Developing and Using Models

SEP-3 Planning and Carrying Out Investigations

CROSS-CURRICULAR CONNECTIONS

EPC

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

CCSS ELA

SL.4.1 Comprehension and Collaboration

WIDA

Standard 1: Social and Instructional Language (Listening, Speaking)

Standard 4: The Language of Science (Listening, Speaking)

3-D LEARNING OBJECTIVES

Students will:

- Distinguish and identify dead, live, and horizontal loads
- Investigate the stability of different shapes.

Driving Question 3

How can building materials and shapes affect the severity of earthquake damage?

LESSON 1

RESOURCES

Digital

- **Family Outreach Letter 3**
- **Building Loads video**
- **Earthquake Safety Progress Tracker**

Student

For each group of 3:

- 20 marshmallows
- 20 pieces of spaghetti
- Tray

For each student:

- In kit: Safety goggles



Building Loads video

Learn what engineers need to remember to make sure their buildings are stable, strong, and safe.

LESSON PREPARATION

- Print out the **Family Outreach Letter 3** (1 per student) to give to students at the beginning of class. You may also email a copy to parents or guardians.

  This letter provides possible questions families can ask students about forces that act on buildings, and about how shapes and building materials withstand forces. It also encourages families to do an experiment with students about forces and everyday materials around the home.

- Prepare each team's supply of marshmallows and spaghetti. Consider using colored marshmallows, perhaps assigning a different color to each team, to make the activity more engaging.

- Have extra marshmallows and spaghetti available in case students need replacements.

- Review your notes from the first lesson of the module. If you made drawings or took photos of the paper structures students made, have them ready to show students as a reminder of what they did during that lesson.

Word Wall

- dead load
- live load
- horizontal load

Spark

7 min

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- Scientists estimate that the magnitude 9.1 Indian Ocean earthquake in 2004 released energy equivalent to 23,000 Hiroshima-type atomic bombs.

English Learners

Ensure that ELs know the meaning of the term *stable*. Have students stand with their knees together. Make the sound of blowing wind and have students push on their legs (applying force) to wobble their knees (shaking from side to side). Then have them stand with legs apart, muscles flexed. Make the sound of blowing wind again. Point out that this position is more *stable*—less likely to be moved. They can brace against the wind. Their legs are stable.

Collect and Display—Collect (Language Routine)

Add the terms *dead load*, *live load*, and *horizontal load* to the academic word wall. Ask if any of the words look familiar. Listen for the everyday language that students use to describe what they might know about the terms.

- A load is something you carry.
- Horizontal means sideways.
- Dead and live are opposites.

Discuss the Video

Explain that students will watch a video about building design.

Play the **Building Loads video**.

- ***What forces must a building cope with so it doesn't fall down?***
- ***What are some parts of the building that make up its total weight?***
- ***Why might a building's live load change from day to day?***
- ***Why do you think wind blowing against the side of a building is called a horizontal load?***



Collect and Display—Display (Language Routine)

Ask again about the terms on the academic word wall. Make connections from what they noted in everyday language to the following formal academic terms and their meanings.

- ***Loads are forces applied to buildings.***
- ***The dead load is the weight of the building itself. It applies a downward force to the building.***
- ***The live load is the weight of everything inside the building. This load varies as people come and go. It applies a downward force to the building.***
- ***The horizontal load is the force applied to the sides of a building, such as wind. It applies a sideways force to the building.***

Point to and make connections to *dead load*, *live load*, and *horizontal load* to reinforce these terms.

Investigate

20 min

Introduce the Activity

Today, students will work in groups of 3 to build three structures using marshmallows and spaghetti—a triangle, a square, and a rectangle. They will explore which structures are best at coping with different loads by carrying out four tests.

Build Structures

Ask a volunteer to read the design criteria and constraints from page 49 in the Twig Book. Review the terms with the class if necessary.

Divide students into groups of 3 and distribute the marshmallows and spaghetti.

Allow a couple of minutes for groups to discuss how they will use these resources to build three structures of the following two-dimensional shapes—a triangle, a square, and a rectangle. Clarify that they may break the spaghetti into smaller lengths.

Ask students to select a prediction in their Twig Books about which structure will be the most stable.

Have students conduct the following four tests on each of their structures, describing the results in their graphic organizers:

- **Test 1:** Try to stand the structure up on its own.
- **Test 2:** Apply force to the side of the structure with a finger or by blowing on it.
- **Test 3:** Apply force to the top of the structure by placing a finger on the middle of the top and pressing down gently.
- **Test 4:** Apply more force to the top by pressing down harder.

Once students have finished testing, have them answer the questions on page 50 in their Twig Books.

Prepare for the Report

Circulate and informally assess students' progress. Make note of the structures they build and what they observe. Select one or two teams to lead the discussion.

Twig Book, p.49



Twig Book, p.50

Test	Triangle	Rectangle	Square
1			
2			
3			
4			

LESSON 1

Observations noted in this table, and the answers to the questions 1–3 below, may vary depending on the strength of the designs (e.g. whether reinforcements are used, or what side of the rectangle structure is used as a base). However, students should realize that triangle structures are the strongest, and that rectangles stood on their shorter sides are the weakest.

Make Observations • Answer the following questions.

1. Which structure stands up on its own?
2. Which structure continues to stand when you apply a horizontal load?
3. Which structure continues to stand when you apply a force to the top?

Safety

Students should take care when breaking materials, e.g., spaghetti, and when applying force. Remind them to wear safety goggles and to hold the materials away from their faces and their classmates' faces.

Remind students never to eat any of the materials or put anything in their mouth.

Challenge

Have students build structures of three-dimensional shapes, e.g., pyramids, cubes, or prisms, and perform similar tests. Ask students to rank their structures and explain why they put them in the order they did during the Report discussion.

Report

10 min

English Learners

Monitor students' progress as they participate in collaborative conversations. Model conversation exchanges to support students' growth.

Substantial Support (Emerging Proficiency)

Students engage in one short answer. The exchange is often highly structured.

Moderate Support (Expanding Proficiency)

Students engage in several exchanges. They ask and answer questions, agree and disagree, and build on each other's ideas.

Light Support (Bridging Proficiency)

Students engage in five or more exchanges. They support their ideas with evidence and sufficiently synthesize ideas.

Discuss Structures

Have selected teams present their findings, and ask other students to share experiences that differ. Relate students' observations to the newspaper structures they built in Driving Question 1.

Students may have observed: that the structure based on the triangle is more stable than the other two shapes; that the least stable shape is the rectangle; or that the rectangle's orientation (long side or short side up) affects its stability.

- ***Do you think a triangular building would receive more or less stress from a horizontal load than a square or rectangular building? Why do you think so?***
- The wind might slide better against a triangular building, so it might cause less stress because it doesn't apply force to the sides of the building.
- ***What kind of load might an earthquake add to a building's stress?***
- An earthquake makes a building shake.
- The seismic waves can make the building move from side to side and/or up and down.
- If the earthquake makes the building move from side to side, it's a little bit like what the wind would do—maybe it's applying a horizontal load on the building.

Explain that during earthquakes, as the ground shakes, the lower part of the building moves with the ground because of *inertia*; however, the upper part of the building tries to stay in place. As a result, the building sways from side to side, so earthquakes are a form of *horizontal load*.

If necessary, remind students that *inertia* is the property of matter that doesn't like change—unless an external force acts on it, matter at rest wants to stay at rest, and matter in motion wants to stay in motion. In this case, the ground shaking is the external force acting on the building, which is at rest (*inert*).

Have students revisit their prediction about which structure would be most stable—do their observations support their prediction? Prompt students to draw a star in their graphic organizers next to the structure that the class decided was the most stable after testing.

Connect

3 min

Connect Today's Learning to the Module Investigative Problem

Reiterate and discuss the Module Investigative Problem: How can we reduce the damage caused by earthquakes?

- ***What can engineers do when designing buildings to make them less dangerous during earthquakes?***
- Using stable shapes in the building design might help make it stronger and sustain stronger loads.

Explain that certain shapes provide more stability than others in building design. In particular, triangles are stable shapes that are often used in buildings. Point out that roofs are usually built on a triangular frame.

Reflect

5 min

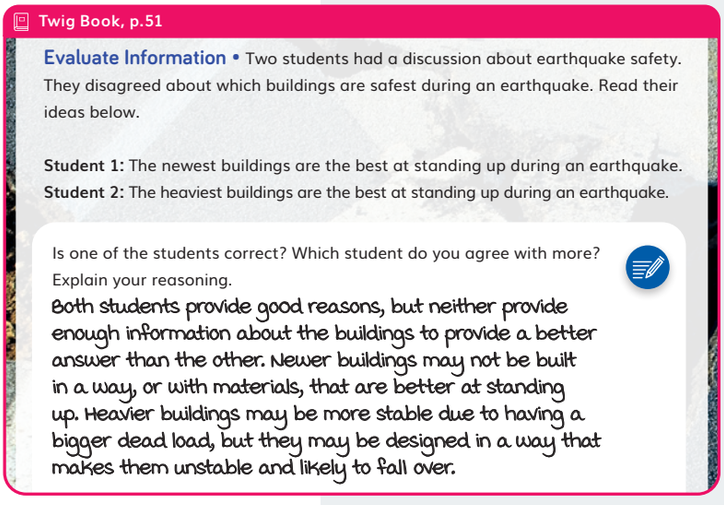
Pre-Exploration

Ask students to complete the Earthquake Safety Pre-Exploration on page 51 in their Twig Books.

Use the Pre-Exploration

Look for students who demonstrated misconceptions in the Earthquake Safety Pre-Exploration and make notes on the **Earthquake Safety Progress Tracker**. Address these misconceptions in subsequent lessons.

Note: There is no correct answer to this prompt. Look for evidence that students are thinking beyond the basic characteristics of weight and age, and include considerations, e.g., building materials in their responses.



Twig Book, p.51

Evaluate Information • Two students had a discussion about earthquake safety. They disagreed about which buildings are safest during an earthquake. Read their ideas below.

Student 1: The newest buildings are the best at standing up during an earthquake.
Student 2: The heaviest buildings are the best at standing up during an earthquake.

Is one of the students correct? Which student do you agree with more? Explain your reasoning.

Both students provide good reasons, but neither provide enough information about the buildings to provide a better answer than the other. Newer buildings may not be built in a way, or with materials, that are better at standing up. Heavier buildings may be more stable due to having a bigger dead load, but they may be designed in a way that makes them unstable and likely to fall over.

Misconception	Look For	Where Addressed
New buildings are always better than old buildings at standing up during an earthquake.	Students who respond that they agree with Student 1 and do not provide reasoning that this depends on building codes or structural considerations such as material or flexibility.	• Driving Question 3, Lesson 4 • Driving Question 5, Lesson 2
Heavy buildings are always better than lightweight buildings at standing up during an earthquake.	Students who respond that they agree with Student 2 and do not provide reasoning that this depends on other structural considerations, such as material and flexibility, or refer to evidence from records/tests.	• Driving Question 3, Lesson 4 • Driving Question 4, Lesson 3 • Driving Question 5, Lesson 2 • Driving Question 6, Lesson 3

Materials and Forces

OVERVIEW

Spark	**10 min**	Students learn that there are four types of force that can act upon a building and mime them with their hands.
Investigate	**25 min**	Students observe a teacher demonstration of the effects of the four forces on graham crackers, and test the effects on marshmallows, spaghetti, and pipe cleaners. They record their results in their Twig Books.
Report		*There is no Report in this lesson.*
Connect	**2 min**	Students are reminded that they tested forces on materials today in order to better understand how to create a model of a building that can survive an earthquake.
Reflect	**8 min**	Students watch a video about forces acting on wood, predict the effects, and record their predictions and explanations.

STANDARDS

NGSS

PE

3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

DCI

ETS1.B Developing Possible Solutions

ETS1.C Optimizing the Design Solution

SEP

SEP-1 Asking Questions and Defining Problems

SEP-2 Developing and Using Models

SEP-3 Planning and Carrying Out Investigations

CCC

CCC-4 Systems and System Models

CROSS-CURRICULAR CONNECTIONS

EPC

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

CCSS ELA

SL.4.1.D Comprehension and Collaboration

WIDA

Standard 1: Social and Instructional Language (Listening)

Standard 4: The Language of Science (Listening)

3-D LEARNING OBJECTIVES

Students will:

- Investigate how materials respond differently when different forces are applied
- Make predictions, record observations, and explain results during investigations.

Driving Question 3

How can building materials and shapes affect the severity of earthquake damage?

LESSON 2

RESOURCES

Digital

- **Wood video**

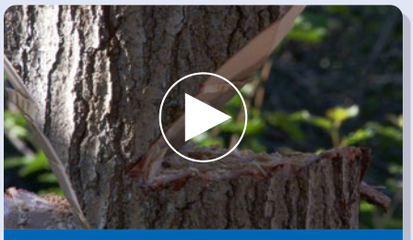
Teacher

- 4 graham crackers

Student

For each student:

- In kit: 4 pipe cleaners
- In kit: Safety goggles
- 4 marshmallows
- 4 pieces of spaghetti
- Tray



Wood video

Observe how people work with wood—from cutting down a tree, to chopping wood, polishing it, and using it to build a home.

LESSON PREPARATION

- There is no Report in this lesson to allow more time for the Investigate
- Conduct the teacher demonstrations beforehand to make sure you know all of the steps. Note that this lesson is structured differently than others.
- Prepare the trays of resources.

  Note: You may ask students to look for additional materials at home to bring in to test in the next lesson's activity.
- On the academic word wall, write:
  - *compression (squeezing)*
  - *tension (stretching)*
  - *torsion (twisting)*
  - *bending*

Word Wall

- compression (squeezing)
- tension (stretching)
- torsion (twisting)
- bending

Spark

10 min

Introduce Forces

Explain that there are four types of force that can act upon a building.

Point to each force on the academic word wall, one at a time, and have the whole class mime with their hands how they imagine this force to work. Pause between forces to offer your own interpretation. Consider the following suggestions:

Compression/Squeezing	Moving your palms towards each other, like playing an accordion
Tension/Stretching	Pulling your fists away from each other, like pulling taffy
Torsion/Twisting	Rotating your fists in opposite directions, like wringing a towel
Bending	Moving your fists downward and toward each other, like bending a bar

Academic Vocabulary Check

- *dead load*
- *live load*
- *horizontal load*

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- Southern California has a whopping 10,000 earthquakes a year. Only a few hundred of these are over a 3.0 magnitude.

Investigate

25 min

Introduce the Activity

Today, students will test the effects of these four forces on a variety of materials. First, you will demonstrate and test the effect that each force has on a graham cracker.

Remind students to focus on you during the demonstrations.

Demonstrate Compression (Squeezing)

Remind students that compression is a squeezing force. When they built their newspaper structures in the first lesson, many of them fell down because the bottom of the building could not hold the dead load. The bottom part of the structure was compressed, or squeezed, by the top part.

Explain that you are going to apply compression to a graham cracker. Students will then test what happens when they compress each of their resources, and record their results on page 52 of their Twig Books.

English Learners

For students needing substantial support, model filling in the chart with one example. Use metamodeling as you fill it out and refer to the posted academic vocabulary that you've written on the academic word wall. Press for details in students' explanations by asking them questions to extend their answers.

Demonstrate	Test
1. Have students write their predictions about what will happen in their Twig Books. Call upon one or two volunteers to share their predictions. 2. Hold the graham cracker by the thin edges and apply compression. 3. Have students describe what happens in their Twig Books.	1. Have students predict in their Twig Books what will happen when they apply compression to each of their resources. 2. Give students 3–4 minutes to test their resources. 3. Have students record their results in their Twig Books.

Call on several students to describe what happened with each material and explain why they think it happened. Make sure students use the word *compression* (*squeezing*) in their explanations.

- The mini marshmallow gets smaller when I compress it but it does not break. When I stop squeezing, it goes back to its original size and shape. I think this happens because the marshmallow is soft.
- The spaghetti breaks when I compress it. I think this happens because it is rigid, but not very thick, so it is fragile.
- The pipe cleaner changes shape when I compress it. I think this happens because it is made of wire and soft material, so it changes shape easily.

Demonstrate Tension (Stretching)

Demonstrate	Test
1. Have students write their predictions about what will happen in their Twig Books. Call upon one or two volunteers to share their predictions. 2. Hold the graham cracker by the thin edges and stretch it. 3. Have students describe what happens in their Twig Books.	1. Have students predict in their Twig Books what will happen when they apply tension to each of their resources. 2. Give students 3–4 minutes to test their resources. 3. Have students record their results in their Twig Books.

Call on several students to describe and explain the results. Make sure they use the word *tension* (*stretching*) in their explanations.

- If I keep stretching the marshmallow, it breaks apart. I think this happens because the marshmallow is soft.
- When I apply tension to the spaghetti, nothing happens. I think this happens because the spaghetti is hard.
- When I apply tension to the pipe cleaner, nothing happens. I think this happens because the pipe cleaner is firm.

Safety

Ask students to take care when breaking materials, e.g., spaghetti, and when applying force. Remind them to wear safety goggles and to hold the materials away from their faces and their classmates' faces.

Remind students never to eat any of the materials or put anything in their mouth.

Special Needs

Fine Motor Skills

Compressing the materials will require small muscle movements and coordination. Let students know it's OK if some of the materials break. If you sense frustration, students may test materials with a partner and dictate actions to a peer (e.g., "Compress it more!").

Note: This peer-scaffold may be applied to the testing of all four forces.

Investigate

Demonstrate Torsion (Twisting)

Demonstrate	Test
1. Have students write their predictions about what will happen in their Twig Books. Call upon one or two volunteers to share their predictions. 2. Twist the graham cracker. It will probably break apart. 3. Have students record what happens in their Twig Books.	1. Have students predict in their Twig books what will happen when they apply torsion to each of their resources. 2. Give students 3–4 minutes to test their materials. 3. Have students record their results in their Twig Books.

Call on several students to describe and explain the results. Make sure they use the word *torsion* (*twisting*) in their explanations.

- The marshmallow holds up at first, probably because it's flexible, but it breaks apart after several twists.
- The spaghetti breaks when I apply torsion because it is brittle.
- The pipe cleaner immediately twists, but it can be put back into place because there is a flexible wire inside.

Demonstrate Bending

Demonstrate	Test
1. Have students write their predictions about what will happen in their Twig Books. Call upon one or two volunteers to share their predictions. 2. Bend the graham cracker. It will probably break apart. 3. Have students describe what happens in their Twig Books.	1. Have students predict in their Twig Books what will happen when they apply bending to each of their resources. 2. Give students 3–4 minutes to test their materials. 3. Have students record their results in their Twig Books.

Twig Book, p.52

	Compression	Tension	Torsion	Bending
Graham Cracker	Prediction: Breaks and crumbles	Prediction: Breaks in half	Prediction: Snaps and falls apart	Prediction: Snaps in half
	Result: Breaks and crumbles	Result: Breaks in half	Result: Snaps and falls apart	Result: Snaps in half
Mini Marshmallow	Prediction: Gets smaller and squashed but doesn't tear	Prediction: Stretches and tears	Prediction: Stretches and tears	Prediction: Bends but doesn't tear
	Result: Squashes, but springs back to original shape	Result: Stretches and tears	Result: Stretches and tears eventually	Result: Bends, doesn't tear, springs back to original shape
Spaghetti	Prediction: Snaps	Prediction: Nothing	Prediction: Snaps	Prediction: Snaps
	Result: Snaps	Result: Nothing	Result: Snaps	Result: Bends, then snaps

Call on several students to describe and explain the results. Make sure they use the word *bending* in their explanations.

- The marshmallow bends but then goes back to its original shape. I think this happens because it is a very flexible material.
- At first, the spaghetti bends. However, if you bend it too much, it breaks. I think this happens because it is brittle.
- I can bend the pipe cleaner without breaking it, and then I can put it back the way it was before. I think this happens because there is a flexible wire inside.

Connect

2 min

Connect Today's Learning to CCC-4—Systems and System Models

Remind students that a system is made up of many parts, which is why we construct a model to see how those parts interact. Today, students tested how different materials respond to different forces, to give them a better idea of how to create a model of a building that will survive an earthquake.

Reflect

8 min

Formative Assessment

Explain that students will watch a video showing a variety of forces acting on another material—wood.

Play the **Wood video**.

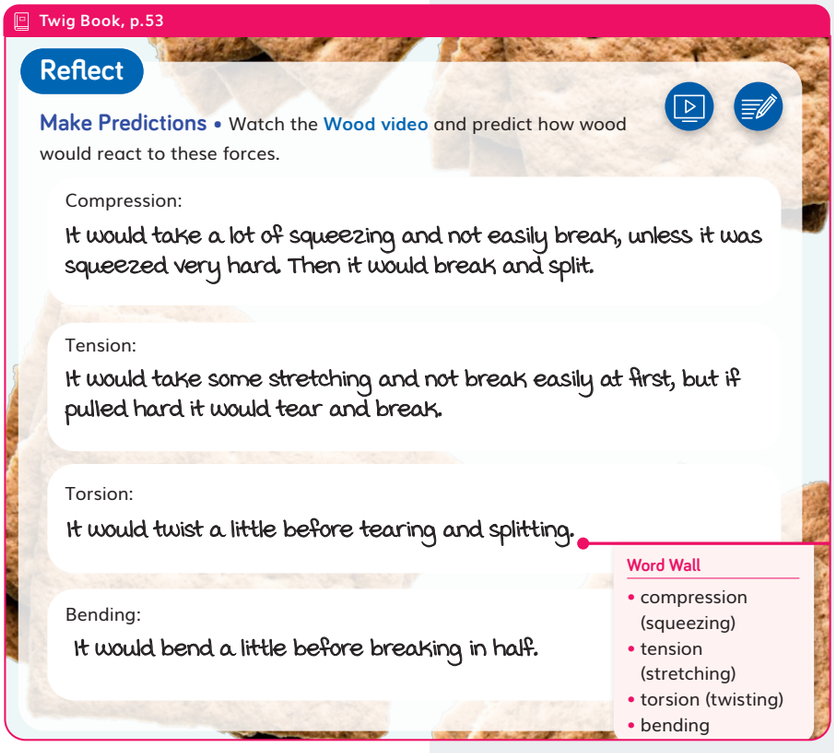
Ask students to predict the effects of compression, tension, torsion, and bending on wood, and to record their predictions and explanations on page 53 in their Twig Books.



Use the Formative Assessment

Read students' responses and look for evidence that students can explain potential strengths and/or failure points of a material when force is applied.

Identify students who need additional support and consider finding time during the building activity of the next lesson to check in with them individually. Alternatively, pair them with students who have demonstrated understanding.



Straw, Brick, or Wood, Mr. Wolf?

OVERVIEW

Spark	**3 min**	Students recall the four forces that can act upon a building—compression, torsion, tension, and bending.
Investigate	**30 min**	Student pairs design, build and test structures, considering what will happen when they place a live load on top of their structures. They do a gallery walk, discussing the advantages and disadvantages of different materials.
Report	**7 min**	Students summarize what they learned about the various materials they worked with today, including their advantages and disadvantages.
Connect	**3 min**	Students understand that, just like engineers, they used different materials for different purposes and tested their structures to find the best solutions to the engineering problem.
Reflect	**2 min**	Students self-assess how effectively they worked today and why, recording their responses in their Twig Books.

STANDARDS

NGSS

PE

3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

DCI

ETS1.A Defining Engineering Problems

ETS1.B Developing Possible Solutions

ETS1.C Optimizing the Design Solution

SEP

SEP-1 Asking Questions and Defining Problems

SEP-3 Planning and Carrying Out Investigations

SEP-6 Constructing Explanations and Designing Solutions

CCC

CCC-6 Structure and Function

CROSS-CURRICULAR CONNECTIONS

EPC

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

CCSS ELA

SL.4.1d Comprehension and Collaboration

WIDA

Standard 1: Social and Instructional Language (Listening, Speaking)

Standard 4: The Language of Science (Listening, Speaking)

3-D LEARNING OBJECTIVES

Students will:

- Test and observe the properties of various materials used to build a structure
- Explain the advantages and disadvantages of different materials.

Driving Question 3

How can building materials and shapes affect the severity of earthquake damage?

LESSON 3

RESOURCES

Digital

- **Criteria and Constraints 2 visual**

Teacher

- Scales

Student

For each student:

- In kit: Safety goggles

For each pair:

- In kit: Resealable plastic bag
- In kit: 25 g sand
- Tray

Two of the following building materials for each pair:

- In kit: 60 g modeling clay
- In kit: 20 pipe cleaners
- In kit: 20 straws
- In kit: 2 yards of string
- 8 marshmallows
- Newspaper
- 20 pieces of spaghetti
- 1 roll of clear tape

For the class:

- In kit: 10 meter sticks

LESSON PREPARATION

- Review your notes from newspaper structures made in the first lesson of the module to recall students' previous constructions.
- There are enough materials in the kit for 15 groups of students.
- For each student pair, fill one plastic bag with 25 g of sand.
- Select and organize each student pair's supplies ahead of class. Make sure that each resource is used by multiple student pairs so students can see different implementations. Suggested quantities are provided in the resources list—you may pair these materials together as you wish. You may also want to provide varying combinations so that students can see how a given material interacts with different materials. Materials to consider pairing together include (but are not limited to):
  - Pipe cleaners and string
  - Newspaper and tape
  - Marshmallows and spaghetti
  - Modeling clay and straws
- Prepare extra materials in case you need to replace any during the lesson.

Straw, Brick, or Wood, Mr. Wolf?

Spark

3 min

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- Two days after the magnitude 9.6 Chile earthquake in 1960, a nearby volcano started to erupt. However, scientists aren't sure that an earthquake can cause an eruption.

English Learners

Ensure students understand the directions and steps, and the terms *advantage* and *disadvantage*. Explain that an advantage is something positive or good about the material and that a disadvantage is something that causes difficulty or makes it less likely to succeed.

Academic Vocabulary Check

- *dead load*
- *live load*
- *horizontal load*
- *compression*
- *tension*
- *torsion*
- *bending*

Discuss Forces

Ask students to recall the four forces that can act upon a building, tested and discussed in the previous lesson.

If needed, remind students that the four forces are:

- *compression (squeezing)*
- *tension (stretching)*
- *torsion (twisting)*
- *bending*

Investigate

30 min

Introduce the Activity

In this lesson, students will work in pairs to design and build another structure, this time using different materials. They will test their structure by applying a downward compression force, placing a bag of sand on top.

Display the **Criteria and Constraints 2 visual**. Read them aloud, or have a student read them aloud. Explain that these are also on page 54 in the Twig Book.

Students will follow four processes in this activity:

1. Plan structures.
2. Build structures.
3. Test structures.
4. Write about structures.

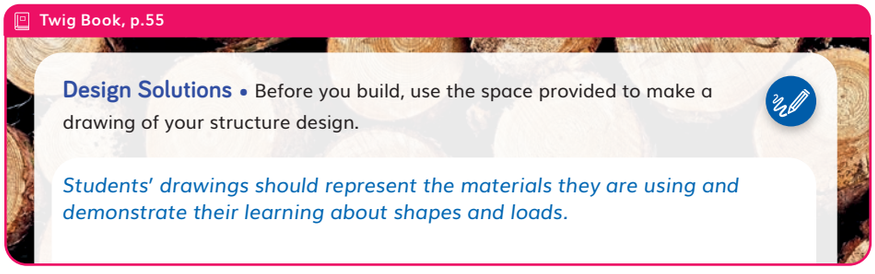
Plan Structures

Organize students into pairs and give each pair a tray containing a bag of sand and the two materials you paired together.

Optional: Pair advanced students together for this activity. If they devise interesting building strategies, the whole class can benefit from observing these ideas during the gallery walk. Students may be able to incorporate these ideas into their building projects later in the module.

Ask pairs to decide on a design for their structure. They should consult the resources in their tray and apply what they have learned about shapes and loads to their design. Remind them that the structure needs to support the weight of one bag of sand.

Have students make a drawing of their planned structure on page 55 in their Twig Books.



Build Structures

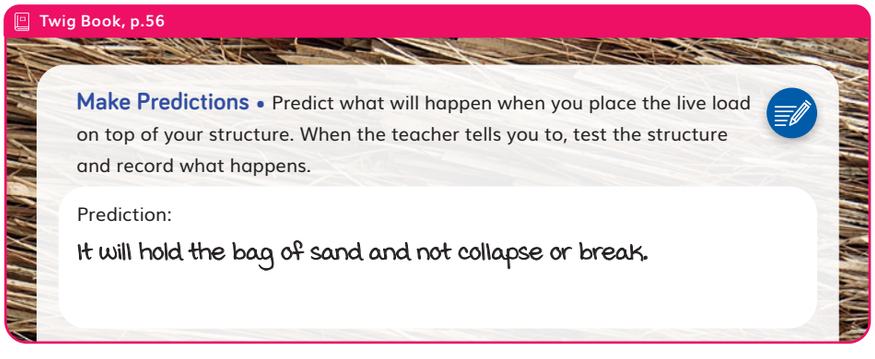
Have students consider their plans and Twig Book drawings and use these to build their structures. Remind them to use a meter stick to check that their structures meet the height criterion.

As students work on their structures, circulate and informally assess their progress. Refrain from troubleshooting and let students identify any problems and possible solutions. Make note of the structures that students build and how they build them.

Test Structures

Ask students what they think will happen when they place the live load of the bag of sand on top of their structure. They should record their prediction on page 56 in their Twig Books.

Have students place the live load of the bag of sand on the structure and record what happens in their Twig Books.



Special Needs

Fine Motor Skills

Building the structure will require small muscle movements and coordination. Let students know it's OK if any of the materials break. If you sense frustration, students may dictate actions to a peer; however, ensure they are engaged in the process with the items they can physically handle with ease.

Safety

Students should take care when breaking materials, e.g., spaghetti, and when applying forces and loads. Remind them to wear safety goggles and to hold the materials away from their faces and their classmates' faces.

Remind students never to eat any of the materials or put anything in their mouth.

Challenge

If time allows, have students design and build two structures and write a comparison of the advantages and disadvantages of each on page 58 in their Twig Books.

Investigate

English Learners

If students struggle understanding key terms such as *advantage* and *disadvantage*, offer cloze sentence frames.

Substantial Support (Emerging Proficiency)

- One advantage of <material> was _____. This is because _____.
- One disadvantage of _____ <material> was _____. This is because _____.

Moderate Support (Expanding Proficiency)

- One advantage of <material> was _____ because _____.
- One disadvantage of <material> was _____ because _____.

Light Support (Bridging Proficiency)

- <Material> has an advantage because _____. I know this because _____.
- <Material> has a disadvantage because _____. I know this because _____.

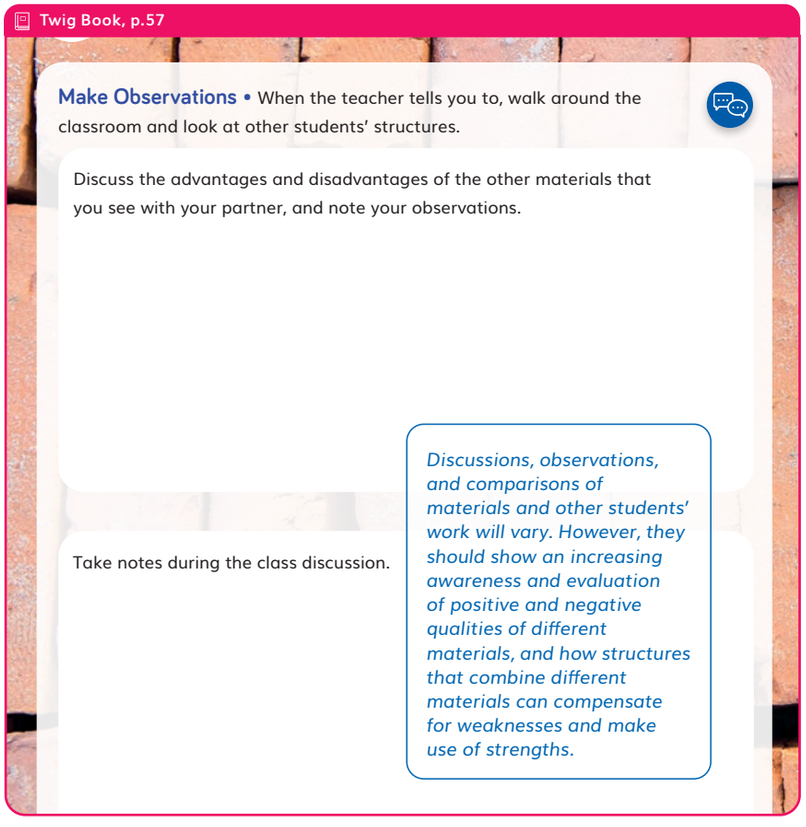
Write About Structures

Ask students to record the two materials that they used on page 56 in their Twig Books.

Have students discuss the advantages and disadvantages of these materials with their partner. They should write one advantage and one disadvantage of each material in their Twig Books.

Do a Gallery Walk

Have students walk around, look at other students' structures, and discuss the advantages and disadvantages of the materials with their partners. They should take notes on these advantages and disadvantages on page 57 in their Twig Books.



Prepare for the Report

As you circulate during the build time and the gallery walk, make note of the structures that students build and how they build them, and of the successes and challenges faced by different students. Look for: stable structures that do not collapse under the live load; stable structures that do collapse under the live load; and structures that are not stable.

Listen without intervening when students discuss the materials to gauge their thinking and anticipate the discussion.

Report

7 min

Discuss Materials

Have a few students (ideally, one for each material) share what they learned about the various materials, including their advantages and disadvantages. Let other students add to or respectfully clarify the information provided.

Summarize students' findings on the board, and have students take notes on page 57 in their Twig Books.

Connect

3 min

Connect Today's Learning to CCC-6—Structure and Function

Summarize today's activity by reviewing the notes you wrote on the board. Focus particularly on the advantages and disadvantages of each type of building material.

Remind students that engineers use different materials for different purposes, and then test their structures in order to find the best solutions to problems.

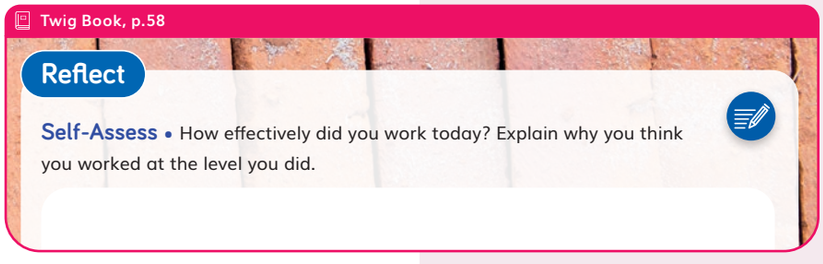
Let students know that their learning from today's lesson will provide important background knowledge to help them solve the building problem posed in the upcoming Engineering Design Challenge, during which they will build and test their structures.

Reflect

2 min

Formative Assessment

Have students self-assess by considering how effectively they worked today and why. They should record their responses on page 58 in their Twig Books.



Use the Formative Assessment

Read students' responses. If students described any difficulties, e.g., lack of effort, motivation, or participation, make notes about how to support these students in future lessons.

Earthquakes Around the World

OVERVIEW

Spark	**7 min**	Students identify what patterns they notice in recent earthquakes compared to historic earthquakes.
Investigate	**15 min**	Students read about two earthquakes, one in California and one in Haiti, highlighting important information.
Report	**15 min**	Students compare the two articles, and compare and contrast the effects of the two earthquakes. They watch a video about two earthquakes, one in Chile and one in Nepal.
Connect	**3 min**	Students understand that their discussion today identified how following building codes can help make buildings safer during earthquakes.
Reflect	**5 min**	Students reflect on how an understanding of materials and shapes helps build safer buildings.

STANDARDS

NGSS

DCI

ESS2.B Plate Tectonics and Large-Scale System Interactions

ESS3.B Natural Hazards

ETS1.B Developing Possible Solutions

SEP

SEP-8 Obtaining, Evaluating, and Communicating Information

CCC

CCC-1 Patterns

CCC-2 Cause and Effect

CROSS-CURRICULAR CONNECTIONS

EPC

Principle II People Influence Natural Systems

CCSS ELA

RI.4.1 Key Ideas and Details

RI.4.9 Integration of Knowledge and Ideas

W.4.9 Research to Build and Present Knowledge

SL.4.1 Comprehension and Collaboration

WIDA

Standard 2: The Language of Language Arts (Speaking, Writing)

Standard 4: The Language of Science (Speaking, Writing)

3-D LEARNING OBJECTIVES

Students will:

- Read to identify specific information about earthquakes
- Interpret evidence indicating that earthquakes are constantly happening throughout the world, and identify patterns in their occurrence
- Compare and contrast conditions that impact earthquake effects
- Explain some of the cause-and-effect relationships regarding the severity of the effects of earthquakes.

Driving Question 3

How can building materials and shapes affect the severity of earthquake damage?

LESSON 4

RESOURCES

Digital

- **Earth Explorer interactive**
- **Earthquakes Around the World video**
- **Earthquake Safety Progress Tracker**

Teacher

- World map or globe

Student

For each pair:

- Computer or tablet (to use the interactive)



Earth Explorer interactive

Investigate the relationship between volcanoes, earthquakes and tectonic plates too see if you can spot any patterns.



Earthquakes Around the World video

Discover how Nepal and Chile have dealt with earthquakes, and learn why one earthquake was far more devastating than the other.

LESSON PREPARATION

- List the three biggest earthquakes on record on the board:There are enough materials in the kit for 15 groups of students.
  - 9.1 (Indian Ocean, Sumatra, 2004; 3.316°N 95.854°E)
  - 9.2 (Prince William Sound, Alaska, 1964; 61.05°N 147.48°W)
  - 9.5 (Valdivia, Chile, 1960; 38.24°S 73.05°W)
- Write the following focus questions on the board:
  - Where and when did the earthquake happen?
  - What was the magnitude of the earthquake?
  - What were the effects of the earthquake?
  - What challenges did the people affected by the earthquake face?
- On chart paper, create a T-chart as shown below to collect information about the texts.

San Francisco Earthquake	Haiti Earthquake

Spark

7 min

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- In 1556, the deadliest earthquake in recorded history occurred in Central China. Many people in the region lived in caves carved out of soft rock—these dwellings collapsed during the earthquake. An estimated 830,000 people were killed.

Special Needs

Visual-Spatial Processing

Add color-coding to key vocabulary in the focus questions: *where*, *when*, *magnitude*, *effects*, and *challenges*. By highlighting key words in color, students can clearly focus on what information to look for in their article.

Social-Emotional Functioning

Consider which students work better when paired with a peer for reading. Allow pairs to sit away from others and read aloud at their own pace. Allow them additional time to read, if needed.

Review Earthquake Patterns



Display the **Earth Explorer interactive** and show the data that students have recorded so far.

Turn on the Historic Earthquakes view.

- ***What do you notice about the patterns of recent earthquakes as compared to historic earthquakes?***

Point to the historic earthquakes you wrote on the board and explain that these are the three highest-magnitude earthquakes of all time.

Turn off the Historic Earthquakes view. Ask 1–3 volunteers to enter these earthquakes into the **Earth Explorer interactive**.

Investigate

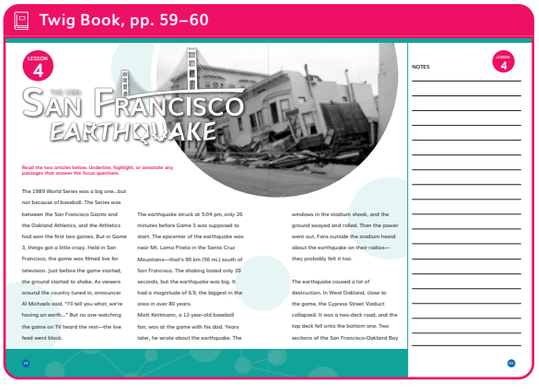
15 min

Introduce the Close Reading

As a class, students will read two articles about earthquakes, one in California and one in Haiti. They will discuss what they've read and compare and contrast the effects of each earthquake, drawing conclusions about how to use the information they learned to make living through an earthquake safer.

Introduce the four focus questions, written on the board. Explain that students should underline, highlight, or annotate any passages in their articles that answer one of these questions.

Close Read



Before you begin the reading, ask students to point out the location of California on a world map or globe. Show them where it is if they can't find it.

Now ask them to find Haiti on the map or globe. Show them where it is if they can't find it.

Have students turn to page 59 in their Twig Books. Read the two articles as a class, having volunteers take turns to read paragraphs.

Remind students to underline, highlight, or annotate any passages in their article that answer any of the focus questions on the board.

Note: As students read, stop to clarify the following words by providing a synonym—*epicenter*, *magnitude*, *destroyed*, *damaged*, *building codes*, *identify*, *seismometer*, *demolished*, and *makeshift* (for instance, *makeshift* means *rough-and-ready*, *temporary*). When you get to the fifth sentence of paragraph four of "The 1989 San Francisco Earthquake," emphasize the difference between *destroyed* and *damaged*. It is crucial to the argument.

Prepare for the Report

Circulate as students read. Look for students who have underlined or highlighted different pieces of information related to the focus questions. Ask these students to share.

Report

15 min

Discuss and Compare the Texts

Discuss the openings, and then endings, of the articles. Encourage students to try one of these techniques in their future writing.

- ***How does the author set the scene to engage the reader?***
- Both articles focus on the experience of one young person—Matt Kettmann in San Francisco was at the World Series baseball game, while Sebastien Delatour in Haiti was at home with his family.
- ***In "The 1989 San Francisco Earthquake," why does the author return to the baseball game to end the article?***
- It is a common pattern in a newspaper article to come back to where the piece started—it makes for a satisfying ending.
- ***In "Devastation in Haiti," look at the way the author has ended the article. Does it make you keep thinking?***
- It ends on a fresh idea to encourage the reader to continue thinking about the issues.

Give students a couple of minutes to underline or highlight all the facts they can find in "The 1989 San Francisco Earthquake" paragraphs 2 and 4, and the "Devastation in Haiti" paragraphs 1, 3, and 4. When they've finished, discuss the articles as a whole.

English Learners

Substantial Support (Emerging Proficiency)

Pull together a small group and guide them through the first paragraph or two of their article. Model using the focus questions and verbalize what they can underline or highlight, and why. Then have them verbalize what to look for next and how they will make note of it.

Moderate Support (Expanding Proficiency)

Pair ELs with a more proficient reader and have them read aloud. They should highlight unknown words and use context clues to assist them. Offer clarification of terms as needed, especially around words related to the focus questions (e.g., *ruined*).

Light Support (Bridging Proficiency)

Pair ELs with a more proficient reader and have them take turns reading the paragraphs aloud. They should work to sound smoother and to read more quickly, while still pausing to attend to the focus questions.

Report

English Learners

As students verbalize what they notice, encourage them to combine their ideas from the T-chart into more sophisticated sentences to offer additional detail in their compare and contrast statements of the two earthquakes. Offer sentence frames that prompt these added clauses:

Substantial Support (Emerging Proficiency)

- In Haiti, the earthquake _____, but in California, the earthquake _____.

Moderate Support (Expanding Proficiency)

- The effects of each earthquake differed because in Haiti _____, while in California _____.

Light Support (Bridging Proficiency)

- Since California _____, the effects were _____ compared to Haiti where _____ because _____.

Challenge

Have students answer the questions on page 65 of their Twig Books.



- ***The author of the San Francisco article includes a lot of information. What is the effect of all this detail? Why would a writer include it?***
- It shows the article is very well researched; it makes it feel real; it puts the reader right in the scene; it feels scientific, not vague.
- ***Has the author of the Haiti article been equally exact? How many matching facts can you find?***
- Date, time, place, location of epicenter, magnitude of earthquake, number of people killed, houses destroyed, cost of damage, number of people left homeless
- ***Why has the author been less exact in "Devastation in Haiti"?***
- The earthquake happened outside of the United States and the information isn't readily available; the catastrophe was so big the exact numbers don't mean as much; the author is focusing on other things, like the suffering of the survivors.
- ***How does the author explain why the earthquake in Haiti had such a terrible effect on residents?***
- There were no building codes, resulting in poorly-constructed houses that were liable to fall down; the damage was so bad relief couldn't reach survivors.
- ***In "The 1989 San Francisco Earthquake," what does the author mean by "wake-up call" (paragraph five)? Who is being woken up? What might be the result?***
- The civil engineers and city planners were "woken up" by the earthquake. The shock of the earthquake made them realize all the things they still needed to do to make the city safer.

Ask students to answer the four focus questions on the board. Record their answers on the T-chart and then discuss.



- ***Compare the two earthquakes by asking: How would you compare the magnitude of the earthquakes?***
- They had almost the same magnitude.
- ***How would you compare the effects of the earthquakes on people?***
- The death rates were very different.
- ***What lessons can you learn from looking at these two earthquakes?***
- Safe building codes are one of the only ways we can help lessen the damage earthquakes do to people and communities.

Observe the Video

Explain that students are going to watch a video about two different earthquakes—one in Chile and one in Nepal. Ask them to listen for how the effects of these earthquakes on people varied and why.

Play the **Earthquakes Around the World video**. Ask students to consider how the video compares to the articles they read.



Misconceptions from the Pre-Exploration

Use the **Earthquake Safety Progress Tracker** to note if students have the following misconceptions:

Misconceptions	What to Do
New buildings are always better than old buildings at standing up during an earthquake.	When students discuss how differences in building codes may have led to differences in the extent of deaths and damage caused, ask whether a building's age determines its safety during an earthquake.
Heavy buildings are always better than lightweight buildings at standing up during an earthquake.	Explain that the construction of the building and adherence to building codes, not the weight of the building or the time that it was built, determine the building's stability during an earthquake.

Connect

3 min

Connect Today's Learning to the Module Investigative Problem

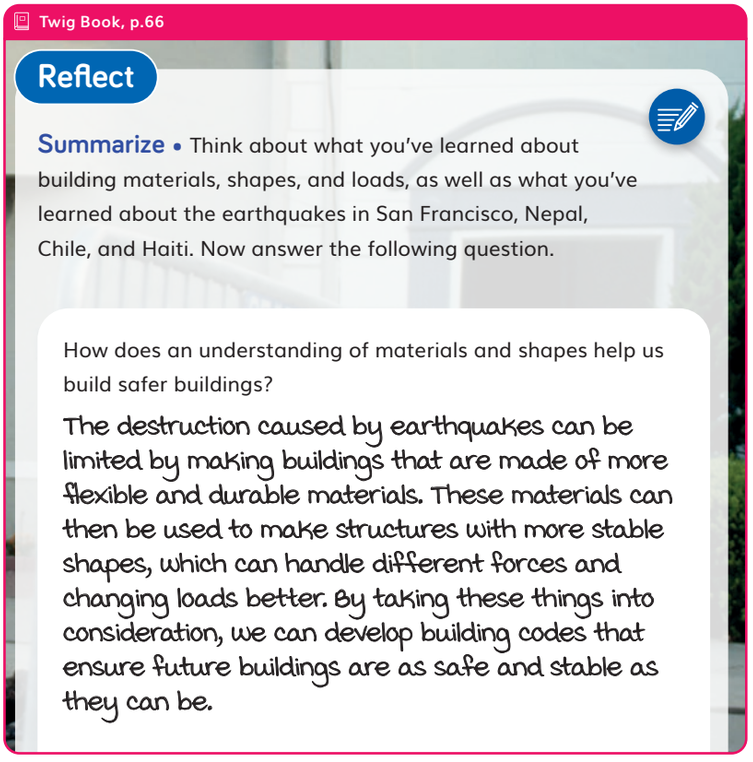
Remind students of the Module Investigative Problem: How can we reduce the damage caused by earthquakes? Briefly summarize the important points from the readings and T-chart. Point out that students' discussion has identified how following building codes can help make buildings safer during earthquakes.

Reflect

5 min

Formative Assessment

Have students turn to page 66 in their Twig Books and reflect on how an understanding of materials and shapes helps us build safer buildings.



Assess Student Progress

Read students' responses and use the **Earthquake Safety Progress Tracker** to note students who understand that building codes, materials, shapes, and loads affect building safety.

Identify students who do not mention building codes, materials, shapes, or loads. Consider checking in with these students during upcoming building activities.

GRADE **4**
MODULE **4**

EARTHQUAKE ENGINEERING

Module Anchor Phenomenon:
How can we reduce the damage caused by earthquakes?

Driving Question 4

How can our understanding of earthquakes and materials help us build safer buildings?

Performance Expectations: 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans; 3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost; 3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem; 3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Students design, build, and test their first earthquake-resistant structures.



Overview: **Full Course**

Driving Question **4** How can our understanding of earthquakes and materials help us build safer buildings?

		FULL COURSE			
		LESSON		PAGE	SUGGESTED PACING
ENGAGE	EXPLORE	1	**Back to the Drawing Board** Students begin an Engineering Design Challenge. They examine and discuss the rubric for the challenge, as well as its criteria for success and constraints, before designing their structures and ordering their materials.	128	45 min
EXPLAIN	ELABORATE	2	**Let's Build It!** Students review their designs from the previous lesson and build their structures. They conduct preliminary tests, discuss the difficulties they encounter, and predict how their structures will perform in further tests.	134	45 min
EVALUATE		3 ☑3-D	**Rumble and Shake! It's an Earthquake!** Students test the stability of their structures using a shake table and self-evaluate using the rubric. They discuss the results of the tests, and, as homework, each student shows their parents or guardians a video of their test.	140	45 min

Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · ☑3-D Assessment

The Full Course is recommended for mastery of the Performance Expectations.
The Fast Track Course delivers the Next Generation Science Standards at an accelerated pace.

Overview: **Fast Track Course***

Driving Question 4 How can our understanding of earthquakes and materials help us build safer buildings?

RESOURCES	MATERIALS	
	TEACHER	TWIG SCIENCE LAB KITS
• Family Outreach Letter 4 • Materials Order Form handout • Earthquake-Resistant Design Rubric visual • Criteria and Constraints 3 visual • Earthquake Safety Progress Tracker	• Building materials: Glue, marshmallows, newspaper, paper, pencils, spaghetti, tape	• Building materials: Aluminum foil, cardboard, craft sticks, foam sheets, modeling clay, paper clips, pipe cleaners, straws, string, toothpicks
• Materials Order Form handout • Criteria and Constraints 3 visual	• Building materials used in Lesson 1 • Scissors • Camera (phone, tablet, etc.) • Metric rulers	• Safety goggles • Building materials used in Lesson 1
• Family Outreach 1 handout • Earthquake-Resistant Design Rubric visual • Earthquake-Resistant Design Rubric • Earthquake Safety Progress Tracker	• Tray • Camera (phone, tablet, etc.) • Small prize for winning team	• Safety goggles • Sand • Masking tape • Resealable plastic bags • Stopwatch

PERFORMANCE TASK

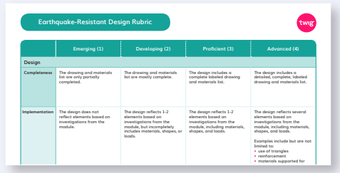
Resource Highlights



Criteria for Success and Constraints 3 visual



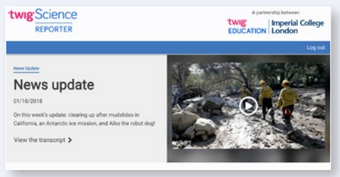
Earth Explorer interactive



Earthquake-Resistant Design Rubric



Professional Learning



Topical science news, features, and careers

twig Science REPORTER

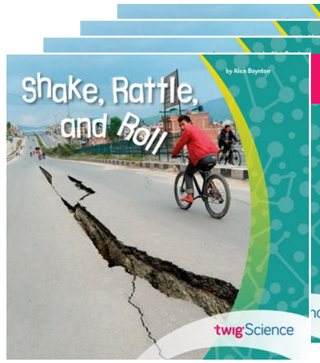
*Fast Track lessons/activities are identified by

FAST TRACK COURSE			
BLOCK	SUGGESTED PACING	LESSONS/ACTIVITIES	NOTES
1 3-D	25 min	**Sections from Back to the Drawing Board** • **Introduce the Rubric** • **Introduce the Activity** • **Discuss and Design Structures**	Modify the text slightly when introducing the activity. Explain that students will work as part of a team on the Engineering Design Challenge. They will design, build, and test a new earthquake-resistant structure.
	25 min	**Sections from Let's Build It!** • **Build Structures** • **Discuss Structures**	To save time, prepare the materials store ahead of the activity, assigning each material a cost, and displaying it on the table. Assign a Materials Manager in each team who will take a **Materials Order Form handout** to the store and fill out the correct prices per unit. The Materials Managers should also fill out the order form and collect the materials required before they start to build. When displaying the **Criteria for Success and Constraints 3 visual**, make it clear that the teams will have one day/class session to design and build their structure. After teams have completed their designs, have each take a turn at presenting to the class. Limit this to 10 minutes. Introduce the Building Process Checklist on page 72 in the Twig Book. Explain that students should check each box as they complete the task.
	30 min	**Sections from Rumble and Shake! It's an Earthquake!** • **Test Structures** • **Self-Assess** • **Assess Student Work** • **Discuss Test Results** • **Misconceptions from the Pre-Exploration**	

Scientist and Engineer Investigation Experience:
Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · 3-D Assessment

Leveled Readers

These high-interest, magazine-style leveled readers give students the opportunity to explore the ideas covered in the module in greater depth and meet real-world scientists and engineers. Available in 4 levels, they can be used in differentiated small-group reading time. On-Level lessons that accompany the readers are provided in the Teacher Edition. Above-Level, Below-Level, and English Learner lessons can be found online at www.twigscience.com.



		Guided Reading	ATOS
OL	On-Level	S	4.9
AL	Above-Level	U	6.2
BL	Below-Level	N	3.2
EL	English Learners	S	4.9

Shake, Rattle, and Roll

Chapter 1: The Curious Scientist

This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend informational texts while reading independently.

Chapter 2: STEM Career: Meet a Seismologist

This chapter focuses on the career of a seismologist. It includes an optional micro-lab in which students learn how energy is stored and released during an earthquake.

Chapter 3: Earthquake-Proofing: What's the Cost?

This chapter focuses on applying the science standards to students' lives, and examines different ways that engineers earthquake-proof buildings.

Already use another ELA program in your class? No problem! Each Twig Science module is aligned to Workshop Models and McGraw-Hill Wonders©. Benchmark Advance™ available online.

ELA CONNECTIONS

Workshop Models

RI.4.1–3 Key Ideas and Details
RI.4.4 Craft and Structure
RI.4.7, 9 Integration of Knowledge and Ideas
SL.4.1–2 Comprehension and Collaboration
SL.4.4–6 Presentation of Knowledge and Ideas
W.4.2, 3 Text Types and Purposes
W.4.4 Production and Distribution of Writing
W.4.7–9 Research to Build and Present Knowledge
W.4.10 Range of Writing

McGraw-Hill Wonders©

Unit 1, Week 3 Thinking It Through
Leveled Reader Landscapes
Student Anthology Earthquakes

Lift foldout for Fast Track information

Differentiated Instruction—Highlights

Driving Question 4 How can our understanding of earthquakes and materials help us build safer buildings?

English Learners

Lesson 1 As students reflect, invite ELs to describe or restate aloud the strategies they noticed other groups using with materials, shapes, loads, and design. Direct students to language posted on the academic word wall to show how their ideas and language have evolved, and to support their writing.

Lesson 3 Check in with ELs individually to see if they have questions or need clarification on the rubric and how to begin the self-assessment. They may work with a partner to complete it and/or you can add prompts or model a segment.

Standard English Learners

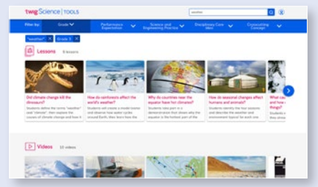
Lesson 3 As you go through the demonstration, explain each step, and then record your results in the Test Chart as a model. Use Standard English to explain and narrate the test for an audience—this will be a recorded test (captured on video) for others to view, so the language should be formal and explanatory.

Extension Activities

NGSS-mapped resources to help extend and enrich learning for students of all abilities.

twig Science TOOLS

www.twigsciencetools.com



Special Needs

Physical Disability

Lesson 2 Make sure the classroom has clear pathways so students have room to move their structures to other positions.

Executive Functioning

Lesson 2 Compliment positive behavior and careful work to promote focus and consistency.

Lesson 3 Allow students with attention issues to stand and view the various tests from different vantage points in the room (e.g., stand in back, over to the side, near the front). Moving to different spots (while maintaining a safe distance) can spur engagement.

Social-Emotional Functioning

Lesson 1 Ensure you have offered sufficient (or even additional time) for students to think through their plan and design. Check in with any student who seems unclear as you go over the order form, and offer one-on-one assistance, repeating the information or offering additional clarification as needed.

Time Savers

CCSS English Language Arts

Lesson 1–3 SL.4.1 Comprehension and Collaboration

CCSS Mathematics

Lesson 1, 2 4.NBT.B.4–6 Use place value understanding and properties of operations to perform multi-digit arithmetic

Lesson 1–3 4.MD.A Measurement and data

Lesson 3 MP6 Attend to precision

Lesson 1, 2 MP7 Look for and make use of structure; MP8 Look for and express regularity in repeated reasoning

WIDA English Language Development

Lesson 1–3 Standard 1: Social and Instructional Language

Lesson 1–3 Standard 3: The Language of Mathematics)

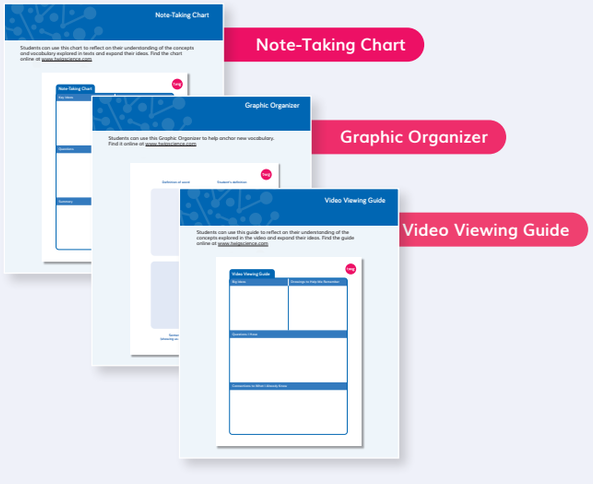
Lesson 1–3 Standard 4: The Language of Science

Access to Science Literacy and Vocabulary

Word Wall

Driving Question 1	natural disaster, earthquake, tsunami, volcano, energy transfer, waves, point of impact, amplitude, wavelength, seismic waves
Driving Question 2	ocean, Pacific Ocean, Atlantic Ocean, Ring of Fire, elevation, mountain range, belt, pattern, tectonic plates, fault, fault line, latitude, longitude
Driving Question 3	dead load, live load, horizontal load, compression (squeezing), tension (stretching), torsion (twisting), bending
Driving Question 4	-
Driving Question 5	civil engineer, structures, forces, mistakes, materials, engineering design process (problem, criteria and constraints, brainstorm, design, build a model, test, refine, share), hazard, safety, revise
Driving Question 6	fair test, data, budget

Additional Differentiated Support



See our full range of vocabulary support tools online.

Back to the Drawing Board

OVERVIEW

Spark	**8 min**	Students review the design rubric for the module's Performance Task, the Engineering Design Challenge.
Investigate	**25 min**	Students write three things they learned that they want to include in their design, and three things they do not. Student teams discuss and design their earthquake-resistant building.
Report	**6 min**	Students hold a class brainstorming session about their designs, sharing concerns or questions they may have about their design and proposing solutions.
Connect	**3 min**	Students share ideas about why they think focusing on waves and forces may be important to solving an engineering problem.
Reflect	**3 min**	Students write or draw one design feature that reflects something they learned in class.

STANDARDS

NGSS

PE

4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

DCI

ETS1.A Defining Engineering Problems

ETS1.B Developing Possible Solutions

SEP

SEP-1 Asking Questions and Defining Problems

SEP-2 Developing and Using Models

SEP-3 Planning and Carrying Out Investigations

SEP-6 Constructing Explanations and Designing Solutions

CROSS-CURRICULAR CONNECTIONS

EPC

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

WIDA

Standard 1: Social and Instructional Language (Listening, Speaking)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Listening, Speaking)

CCSS ELA

SL.4.1 Comprehension and Collaboration

CCSS MATH

4.NBT.B.4–6 Use place value understanding and properties of operations to perform multi-digit arithmetic

4.MD.A.1–3 Solve problems involving measurement and conversion of measurements

3-D LEARNING OBJECTIVES

Students will:

- Review prior knowledge and discuss learning from past experiments to inform new designs
- Begin the first stage of the module's Performance Task, the Engineering Design Challenge, by working with peers to design an earthquake-resistant structure that meets specified criteria and constraints.

Driving Question 4

How can our understanding of earthquakes and materials help us build safer buildings?

LESSON 1

RESOURCES

Digital

- **Family Outreach Letter 4**
- **Materials Order Form handout**
- **Earthquake-Resistant Design Rubric visual**
- **Criteria and Constraints 3 visual**
- **Earthquake Safety Progress Tracker**

Teacher

A selection of building materials:

- In kit: Aluminum foil, cardboard, craft sticks, foam sheets, modeling clay, paper clips, pipe cleaners, straws, string, toothpicks
- Glue, marshmallows, newspaper, paper, pencils, spaghetti, clear tape

LESSON PREPARATION

- Print out the **Family Outreach Letter 4** (1 per student) to give to students at the beginning of class. You may also email a copy to parents or guardians.

  This letter provides families with an overview of the Engineering Design Challenge and suggests questions families can ask students as they explain the videos of the shake-table test of their structures.

- Customize the **Materials Order Form handout** as needed to include the materials you have available. If you add any materials, make sure you include the prices of the items as well as spaces for students to enter quantities and tally the values. Print out a handout for each team of students. Each team will have a budget of $60, though you can modify this amount. Emphasize the importance of selecting materials carefully, so they don't end up with a surplus of any material, and so that materials remain accessible to all students.
  Take note of what each team spends for reference in future lessons to help students keep to the set budget.

- Set up the selection of building materials into a "store" so that teams may, after completing their order form, make their purchases and collect their materials.

  Note: Students will need to use these same building materials in Driving Question 6. Ensure you collect and store all unused materials at the end of the Lesson 2 building activity.

Spark

8 min

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- As early as 350 BCE, the ancient Greek philosopher Aristotle recognized that soft ground shakes more than hard rock in an earthquake.

Academic Vocabulary Check

- *live load*
- *compression*
- *bending*

Introduce the Rubric

Explain that, for the next three lessons, students will work as part of a team on the Engineering Design Challenge. They will design, build, and test a new earthquake-resistant structure.

Display the **Earthquake-Resistant Design Rubric visual**. Explain that a rubric is a guide listing specific criteria for grading or scoring academic papers, projects, or tests. This rubric will be used to evaluate their designs.

Note: Do not display the final section, "Poster." This will be used in Driving Question 6.

Point out that this rubric has three main categories:

1. Design
2. Build
3. Test

Review the different aspects of the rubric with the class, drawing attention to the different proficiency levels.

Investigate

25 min

Special Needs

Social-Emotional Functioning

Ensure you have offered sufficient (or even additional time) for students to think through their plan and design.

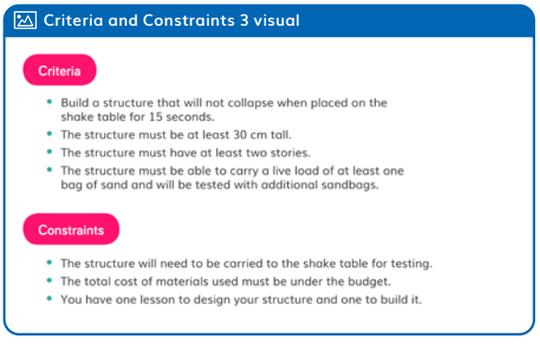
Check in with any student who seems unclear as you go over the order form, and offer one-on-one assistance, repeating the information or offering additional clarification as needed.

English Learners

As students reflect, invite ELs to describe aloud the criteria and constraints. Direct students to language posted on the academic word wall to show how their ideas and language have evolved and to support their writing.

Introduce the Activity

Display the **Criteria and Constraints 3 visual** and read it aloud.

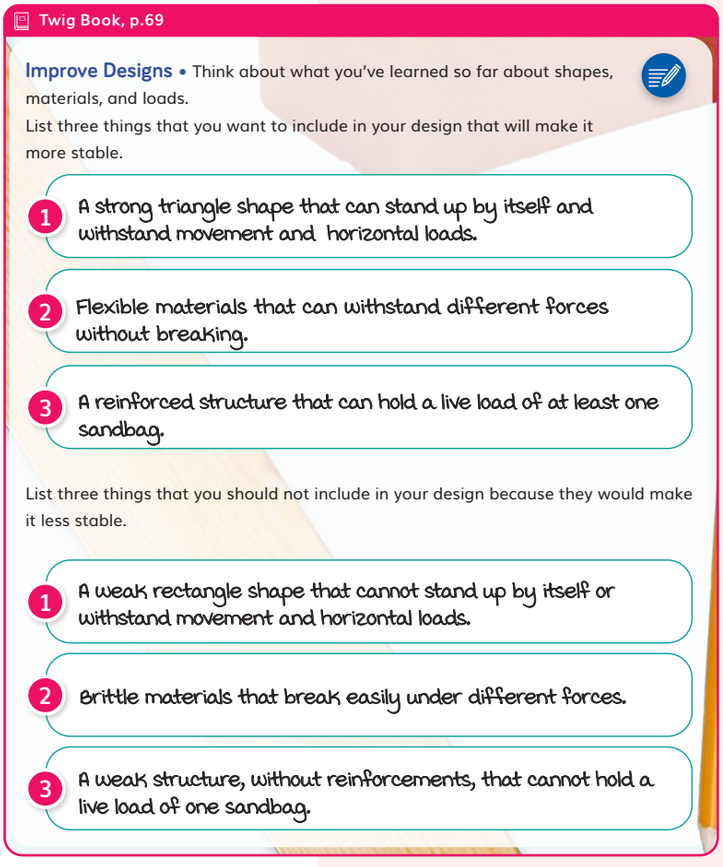


Have students reflect on what they have learned about engineering, considering shapes, loads, and materials, as well as structures they've previously built. Point out that they tested and saw many designs—some worked, and some didn't. Students should look back at all their previous experiences, notes, and the knowledge they gained to guide their current designs.

Have students turn to page 69 in their Twig Books and write three things they want to include in their design to help with stability, and three things they do not.

Organize students into teams of 4. Give each team a copy of the **Materials Order Form handout**. Explain that each team will have a budget of $60 (or the amount you chose) to purchase their materials. There will be a prize for the team that builds the cheapest structure that meets the criteria.

Clarify that the goal of the lesson's activity is to design the structure and purchase the materials. In the next lesson, students will build the structure.


Twig Book, p.69

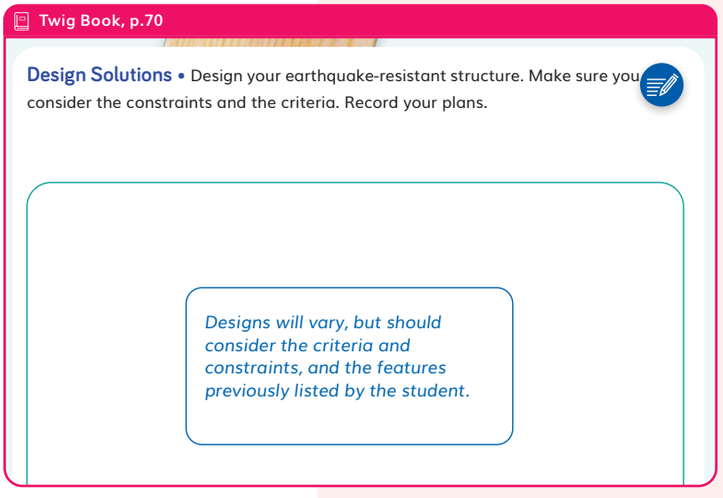
Improve Designs • Think about what you've learned so far about shapes, materials, and loads.

List three things that you want to include in your design that will make it more stable.

1. A strong triangle shape that can stand up by itself and withstand movement and horizontal loads.
2. Flexible materials that can withstand different forces without breaking.
3. A reinforced structure that can hold a live load of at least one sandbag.

List three things that you should not include in your design because they would make it less stable.

1. A weak rectangle shape that cannot stand up by itself or withstand movement and horizontal loads.
2. Brittle materials that break easily under different forces.
3. A weak structure, without reinforcements, that cannot hold a live load of one sandbag.


Twig Book, p.70

Design Solutions • Design your earthquake-resistant structure. Make sure you consider the constraints and the criteria. Record your plans.

Designs will vary, but should consider the criteria and constraints, and the features previously listed by the student.

Design Structures

Have teams discuss and design their earthquake-resistant building. They should record their designs on page 70 in the Twig Book.

Remind students that they need to fill out their order forms within the budget. They may visit the store to assess materials, if they need help deciding which to purchase.

Circulate and assess students' ideas.

- ***How will you know that your building is a success?***
- ***How will you make sure that your structure will be able to stand the stress of shaking?***
- ***Can you think of more than one way to design the building? Which one will you choose?***
- ***How will you make sure it is strong enough to carry the live load?***
- ***What potential problems can you see in your design that might make it collapse? How might you prevent these from happening?***
- ***Which materials will you choose and why? What are their properties?***
- ***How will you put your materials together to make the structure strong enough to withstand the sand bag placed on the top?***
- ***Did you make sure that your building will have the right dimensions?***

Collect the order forms at the end of the activity. You will use the forms to prepare the materials from the store for each group before the next lesson. Check the math on the forms and keep a record of each team's remaining funds—you may need to refer to it in the next lesson.

Prepare for the Report

Identify teams with questions or concerns that may benefit from class discussion. Encourage these teams to share.

Report

6 min

Discuss Designs

Hold a class brainstorming session about students' designs. Students can share concerns or questions they may have about their own design and have the whole class propose solutions.

Remind students to focus on making sure that their design achieves the specified criteria for success but keeps within the given constraints. Explain that, in the next lesson, they will receive the materials they ordered and build their structures.

Connect

3 min

Connect Today's Learning to SEP-6—Constructing Explanations and Designing Solutions

In this lesson, students applied scientific ideas about waves and forces to solve the problem of designing an earthquake-resistant building. Ask them to share why they think focusing on these things may be important to solving an engineering problem.

Point out that students' hard work and well-researched designs will help them reduce the impacts of earthquakes on humans.

English Learners

Brainstorms often pull in dominant speakers. If ELs are challenged to verbalize their ideas, offer sentence frames at their proficiency levels as prompts, encouraging them to build on what others have said during the brainstorm.

Substantial Support (Emerging Proficiency)

- One question I have about my design is _____. Should I _____ or _____?

Moderate Support (Expanding Proficiency)

- <Student>'s idea made me think about _____. Now, I am wondering if _____.

Light Support (Bridging Proficiency)

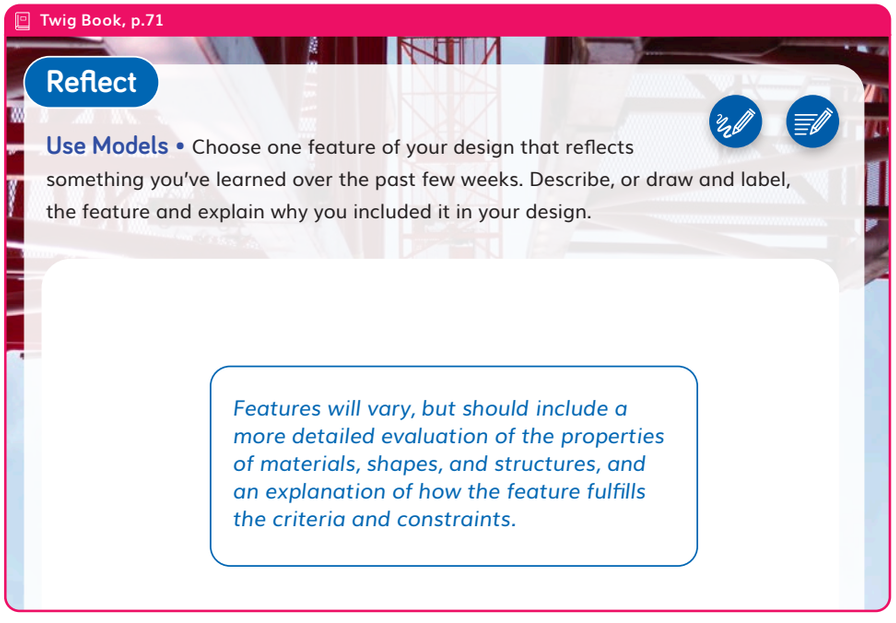
- In addition to what <student> said, I think my design _____. What would be a good recommendation for that?

Reflect

3 min

Formative Assessment

Have students turn to page 71 in their Twig Books and write about or draw and label one feature of their designs that reflects something they've learned over the past few weeks.



Use the Formative Assessment

Read students' responses. Look for evidence that students are considering: criteria and constraints; their learning about materials, shapes, and loads; and how these considerations help reduce the impacts of earthquakes on people.

Determine teams that may benefit from individual support during the next lesson.

English Learners

As students reflect, invite ELs to describe or restate aloud the strategies they noticed other groups using with materials, shapes, loads, and design. Direct students to language posted on the academic word wall to show how their ideas and language have evolved, and to support their writing.

Let's Build It!

OVERVIEW

Spark	**5 min**	Students review the criteria and constraints for their designs.
Investigate	**25 min**	Student teams build their structures, complete a Building Process Checklist, and measure and record the height and number of stories of their structures in their Twig Books.
Report	**6 min**	Two student groups share their buildings and experiences with the rest of the class. Students identify any problems they encountered and predict what will happen when they test their structures.
Connect	**5 min**	Students begin to answer the Driving Question.
Reflect	**4 min**	Students describe one way that their teams worked well together in today's lesson.

STANDARDS

NGSS

PE

4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

DCI

ETS1.A Defining Engineering Problems

ETS1.B Developing Possible Solutions

ETS1.C Optimizing the Design Solution

SEP

SEP-1 Asking Questions and Defining Problems

SEP-3 Planning and Carrying Out Investigations

SEP-6 Constructing Explanations and Designing Solutions

CROSS-CURRICULAR CONNECTIONS

EPC

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

WIDA

Standard 1: Social and Instructional Language (Listening, Speaking)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Listening, Speaking)

CCSS ELA

SL.4.1 Comprehension and Collaboration

CCSS MATH

4.NBT.B.4–6 Use place value understanding and properties of operations to perform multi-digit arithmetic

4.MD.A.1–3 Solve problems involving measurement and conversion of measurements

3-D LEARNING OBJECTIVES

Students will:

- Continue to work toward the Performance Task by building an earthquake-resistant structure which meets specified criteria and constraints
- Identify problems and discuss solutions.

Driving Question 4

How can our understanding of earthquakes and materials help us build safer buildings?

LESSON 2

RESOURCES

Digital

- **Materials Order Form handout**
- **Criteria and Constraints 3 visual**

Teacher

- Camera (phone, tablet, etc.)

Building materials used in Lesson 1:

- In kit: Aluminum foil, cardboard, craft sticks, foam sheets, modeling clay, paper clips, pipe cleaners, straws, string, toothpicks
- Glue, marshmallows, newspaper, paper, pencils, spaghetti, clear tape

Student

For each student:

- In kit: Safety goggles

For each team:

- Metric ruler
- Scissors

LESSON PREPARATION

- Review the completed order forms students completed in the previous lesson and prepare the requested materials for each team.
- Keep a running record of the amount of money each team spends on materials. The team that spends the least to build a structure that withstands the tests will earn a small prize in the next lesson.
- Stock the store with extra materials in case students need them during the activity.
- Print out new **Materials Order Form handouts** in case students need more supplies from the store.

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- Australia sits on one of the fastest-moving plates. In fact, it moves so fast that scientists have had to adjust Australia's latitude and longitude four times over the past 60 years (1966, 1984, 1994, and 2016). The adjustment made in 1994 was an incredible 656 feet.

English Learners

Check in with ELs individually to see if they have questions or need clarification on the Criteria and Constraints. Ensure they are participating equitably in the process. Encourage ELs to use the Building Process Checklist as a basis to clarify what the activity requires if they are unsure.

Spark

5 min

Review the Criteria and Constraints

Remind students they have been working in teams to create an earthquake-resistant structure. Display and review the **Criteria and Constraints 3 visual**. These can also be found on page 72 in the Twig Book.

Investigate

25 min

Introduce the Activity

Today, students will build their structures according to the design they created in the previous lesson.

Introduce the Building Process Checklist on page 72 in the Twig Book. Explain that students should check each box as they complete the task.

Let students know that their supplies are ready in the store. Hand back each team's completed **Materials Order Form handout**. Have each team send a representative to the store to collect their materials.

Clarify that the store is still open. If students discover during the activity that they need more supplies, or wish to purchase supplies they hadn't thought of initially, they can fill in a new **Materials Order Form handout** and go to the class store to purchase more.

Materials Order Form handout

Materials Order Form

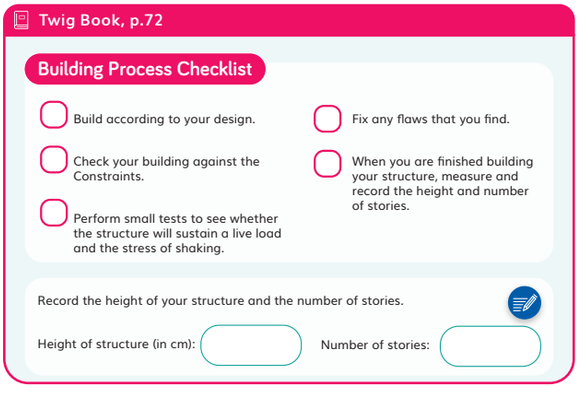
Material	Price	Quantity	Cost ($)
Paper	$0.50/sheet	sheet(s)	
Newspaper	$0.25/sheet	sheet(s)	
Cardboard	$1/piece	piece(s)	
Aluminum foil	$1/foot	foot/feet	
Foam	$4/sheet	sheet(s)	
Craft stick	$1/pack of 5	pack(s) of 5	
Pipe cleaner	$0.50 each	unit(s)	
Spaghetti (thin)	$2/pack of 10	pack(s) of 10	
Toothpick	$1/pack of 10	pack(s) of 10	
Pencil	$2 each	unit(s)	
Straw	$0.25 each	unit(s)	
Mini marshmallow	$2/pack of 10	pack(s) of 10	
String	$2/yard	yard(s)	
Glue	$5/bottle	bottle(s)	
Paper clip	$2/pack of 10	pack(s) of 10	
Modeling clay	$4/piece	piece(s)	
Tape	$0.25/piece	piece(s)	
Loan amount: $_____		Total	
		Final Cost	

Build Structures

Have teams build their structures, marking off the Building Process Checklist as they work.

Circulate and help teams assess their structure for stability as they build. Help students identify:

- Whether their design will withstand the shake table test, and why or why not
- Weak points in their structure, and ways to reinforce these
- Where to place the sand bag (live load), and why.



If students visit the store to purchase more materials, check the math on their order form and dispense the requested items if it is correct. If it is not, ask students to revise their calculations. Update your record of the team's available funds.

Remind students to conduct preliminary horizontal and live load tests. They might use a few pencils to simulate a live load; they might gently shake or blow on their structure to simulate a horizontal load.

When they finish building their structures, have students measure the height and record this and the number of stories on page 72 in their Twig Books.

Ask groups that finish early to provide support to groups who are experiencing difficulty. They should try to identify problems and suggest possible fixes for them.

Collect all unused materials. They will be needed again in Driving Question 6.

Prepare for the Report

Identify two groups to lead the discussion—one that had an easier time building their structure and another that had a more difficult time.

Safety

Students should take care when breaking materials, e.g., spaghetti, and when applying forces and loads. Remind them to wear safety goggles and to hold the materials away from their faces and their classmates' faces.

Remind students never to eat any of the materials or put anything in their mouth.

Special Needs

Executive Functioning

Compliment positive behavior and careful work to promote focus and consistency.

Physical Disability

Make sure the classroom has clear pathways so students have room to move their structures to another spot.

English Learners

Provide linguistic frames to assist students in presenting their ideas and internalizing linking words.

Substantial Support (Emerging Proficiency)

- I predict that _____ .

Moderate Support (Expanding Proficiency)

- I predict _____ because _____.

Light Support (Bridging Proficiency)

- Based on _____, I predict _____ because _____.

Report

6 min

Discuss Structures

Invite the two groups you selected to share their buildings and experiences with the rest of the class. Ask them to share any problems they encountered and predict what will happen when they test their structures in the next lesson.

Lead a class discussion on these experiences and predictions. Let students share their own experiences.

Connect

5 min

Connect Today's Learning to the Driving Question

Review and discuss the Driving Question.

- ***Why do earthquakes occur and how does the energy released cause damage to buildings?***
- ***How did your team use your understanding of earthquakes to design your structure?***

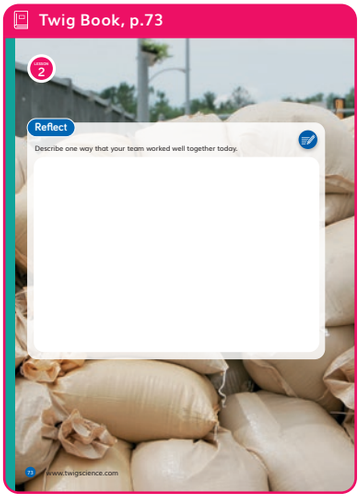
Give students a camera to pass around to take photos of their structures. Print these out for use in the next lesson.

Reflect

4 min

Formative Assessment

Have students turn to page 73 in their Twig Books and describe one way that their team worked well together today.



Use the Formative Assessment

Read students' responses and determine what group strategies students found useful. Make notes for future lessons.

Safety Handouts

Safety handouts are available online at www.twigscience.com

Science Safety Rules

Work like a Scientist

- Work like a real scientist works in the lab: carefully! Don't throw anything and make sure you handle everything with care.
- Scientists don't make things up as they go. You should always know exactly what you're going to do before you do it. Follow all of your teacher's instructions. They will keep you safe and help you know what you're doing. If you planned your own experiment, go over the plan with your teacher before you start.



- Scientists keep their labs and themselves as clean as possible. This can be challenging. That's why they don't eat, drink, chew gum, touch their faces, or rub their eyes while they work. They also wash their hands before they start and after they finish.



- Scientists keep everything neat and organized! Leave your backpacks and jackets where your teacher tells you. Bring just your notebook and pencil to the workstation.
- Investigate only what the teacher has told you to investigate. Don't work in the classroom when the teacher is gone, and don't even think about taking anything out of the classroom unless the teacher says so.

Grade K-3

Grade 4-6

Rumble and Shake! It's an Earthquake!

☑3-D



OVERVIEW

Spark	**10 min**	Students review the criteria and constraints and the design rubric so that they understand the aims of the activity.
Investigate	**25 min**	Student teams test their building models using an earthquake simulator and record observations in their Twig Books.
Report	**6 min**	Students discuss how their structures were affected by the earthquake test.
Connect	**2 min**	Students understand that testing and revising a design based on previous results is an important part of engineering.
Reflect	**2 min**	Students receive Family Outreach handouts and access to a video to watch at home.

STANDARDS

NGSS

PE

4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

DCI

ESS3.B Natural Hazards

ETS1.B Developing Possible Solutions

ETS1.C Optimizing the Design Solution

SEP

SEP-3 Planning and Carrying Out Investigations

SEP-6 Constructing Explanations and Designing Solutions

CROSS-CURRICULAR CONNECTIONS

CCSS ELA

SL.4.1c Comprehension and Collaboration

WIDA

Standard 1: Social and Instructional Language (Listening, Speaking)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Listening, Speaking)

CCSS MATH

4.MD.A.1–3 Solve problems involving measurement and conversion of measurements

3-D LEARNING OBJECTIVES

Students will:

- Complete the first stage of the Performance Task by testing structures for stability during a simulated earthquake
- Explain and discuss the results with peers
- Self-evaluate multiple aspects of a project.

Driving Question 4

How can our understanding of earthquakes and materials help us build safer buildings?

LESSON 3

RESOURCES

Digital

- **Family Outreach 1 handout**
- **Earthquake-Resistant Design Rubric visual**
- **Earthquake-Resistant Design Rubric**
- **Earthquake Safety Progress Tracker**

Teacher

- In kit: Masking tape
- In kit: Resealable plastic bags
- In kit: Sand
- In kit: Stopwatch
- Camera (phone, tablet, etc.)
- Scales
- Small prize for winning team
- Tray

Student

For each student:

- In kit: Safety goggles

LESSON PREPARATION

- Make your own structure for the teacher demonstration using the same materials provided to students. Make sure that your structure is strong enough to resist the first test so that you can test it with at least one sand bag. Take a photo of your structure and print it out.
- Create a Test Chart by copying the table below onto chart paper.

Team	Picture of Structure	Money Spent	Did the Structure Collapse on Test 1?	Number of Sandbags

- Print out the photos that you took of students' structures from the previous lesson.
- Build your earthquake simulator and testing station:
  - Select a table or desk to be used as a station.
  - Fill a tray with sand (3–6 cm deep) and set the tray at the station.
  - On the edge of the table, affix two pieces of masking tape approximately 30 cm apart. The pieces of tape will serve as signposts to indicate how much you should move the tray on the table.
  - Simulate an earthquake by moving the tray back and forth between the two pieces of tape for 15 seconds.
  - Prepare five live loads (sand bags). Fill each plastic bag with 25 g of sand.
  - Set up the earthquake simulator/shake table.
  - Set up a camera to record videos of the tests.

  Note: You will use both the earthquake simulator and the sand bags again, so make sure to keep the materials.
- Prepare a small prize for the team that spent the least on a structure that survived the tests.
- Determine the appropriate method for sending videos home, e.g., by email or through your school's learning management system. Print out the **Family Outreach 1 handout** (1 per student) to give to students at the end of class.

Rumble and Shake! It's an Earthquake!

Spark

10 min

Review the Rubric

Have students review the Criteria and Constraints on page 69 of their Twig Books.

Display the **Earthquake-Resistant Design Rubric visual.** Read it as a class so that all students are clear on what the aim of the activity is. Explain that students will use the rubric to self-assess after they test their structures.

Investigate

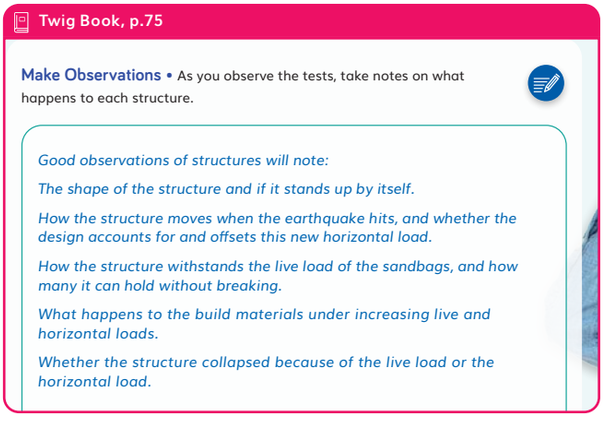
25 min

Introduce the Activity

Today, students will test the structure they built in the previous lesson and record their results.

Test Structures

Display the Test Chart and go over its categories with students. Attach the photos you printed of each team's structure and your demonstration structure. Ask each team to fill in the first three columns of the chart.



Demonstrate how to use the earthquake simulator (by rapidly moving the tray between the two pieces of tape for 15 seconds).

Show your structure to students and run through the testing steps on page 74 in the Twig Book.

Have teams come up one at a time and test their structures while other teams note observations on page 75 in their Twig Books.

Since each team will run their own tests, different students will be activating the simulator, which may lead to discrepancies in results. Consider establishing a Fair Test Controller as you did in Module 1. Ask students to try as much as possible to work the simulator the same way, but do not strictly enforce this. Take notes about any differences and use these a discussion point during the Report.

Self-Assess

Ask students to self-evaluate their tests using the **Earthquake-Resistant Design Rubric visual.**

Assess Student Work

Use the **Earthquake-Resistant Design Rubric** to assess student work. Determine if students have a reasonable understanding of their strengths and weaknesses. Use this information to advise students on areas in which they need improvement.

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- After the 1960 Chile earthquake, seismometers recorded seismic waves all over the Earth. The waves lasted for days. This phenomenon is known as the free oscillation of the Earth.

Standard English Learners

As you go through the demonstration, explain each step, and then record your results in the Test Chart as a model. Use Standard English to explain and narrate the test for an audience—this will be a recorded test (captured on video) for others to view, so the language should be formal and explanatory.

Prepare for the Report

As students observe, they should note in their Twig Books what happens to each structure. For instance, they might note when it collapsed, and whether this happened when adding a new sand bag, or when shaking it on the simulator. Anticipate the discussion with this information.

Report

6 min

Discuss Test Results

Point to the completed Test Chart. Lead a discussion about how the structures were affected by the earthquake tests.

- ***What were the weak points of the structures that collapsed first?***
- ***What could you have done to prevent these points from collapsing?***
- ***What made <team>'s structure so stable? Why do you think so?***
- ***Look at the costs. Did the teams whose structures were the most stable spend more than teams whose structures collapsed?***
- ***<Team>'s structure collapsed when they added their <nth> sand bag, before they shook the structure with the simulator. What does that tell you about their structure?***

Congratulate the team that built the most stable structure while spending the least of their budget. Hand them the small prize you prepared.

Misconceptions from the Pre-Exploration

Use the **Earthquake Safety Progress Tracker** to note if students have the following misconception.

Misconceptions	What to Do
Heavy buildings are always better than lightweight buildings at standing up during an earthquake.	When students discuss which structures were most stable during the earthquake tests and provide reasoning, revisit the statement from the **Earthquake Safety Progress Tracker**. Ask students whether their results demonstrated other more significant characteristics than weight. If a scale is accessible, weigh the different structures and list the results on the board. If the heaviest structures were not the most stable, point out that you have noticed the statement from the **Earthquake Safety Progress Tracker** is not true. If the heaviest structures do turn out to be the most stable, ask students for other reasons why the building might have been stable (for example, the group used a heavy material that was also flexible, or they added a lot of reinforcements).

Safety

Students should take care when breaking materials, e.g., spaghetti, and when applying forces and loads, and using the shake table. Remind them to wear safety goggles and to hold the materials away from their faces and their classmates' faces.

Remind students never to eat any of the materials or put anything in their mouth.

Special Needs

Executive Functioning

Allow students with attention issues to stand and view the various tests from different vantage points in the room (e.g., stand in back, over to the side, near the front). Moving to different spots (while maintaining a safe distance) can spur engagement.

English Learners

Check in with ELs individually to see if they have questions or need clarification on the rubric and how to begin the self-assessment. They may work with a partner to complete it and/or you can add prompts or model a segment.

Connect

2 min

Connect Today's Learning to the Module Investigative Problem

Remind students of the Module Investigative Problem: How can we reduce the damage caused by earthquakes?

Ask students to explain how the Engineering Design Challenge relates to the Module Investigative Problem.

Explain that an important aspect of engineering is learning from testing and revising a design based on previous results. Explain that students will have the chance to revise, build, and test their designs one final time in later lessons.

Materials Order Form handout

Materials Order Form

Material	Price	Quantity	Cost ($)
Paper	$0.50/sheet	sheet(s)	
Newspaper	$0.25/sheet	sheet(s)	
Cardboard	$1/piece	piece(s)	
Aluminum foil	$1/foot	foot/feet	
Foam	$4/sheet	sheet(s)	
Craft stick	$1/pack of 5	pack(s) of 5	
Pipe cleaner	$0.50 each	unit(s)	
Spaghetti (thin)	$2/pack of 10	pack(s) of 10	
Toothpick	$1/pack of 10	pack(s) of 10	
Pencil	$2 each	unit(s)	
Straw	$0.25 each	unit(s)	
Mini marshmallow	$2/pack of 10	pack(s) of 10	
String	$2/yard	yard(s)	
Glue	$5/bottle	bottle(s)	
Paper clip	$2/pack of 10	pack(s) of 10	
Modeling clay	$4/piece	piece(s)	
Tape	$0.25/piece	piece(s)	
Loan amount: $_____		Total	
		Final Cost	

Ask students to keep their designs, measurements, data, photos, video, and **Materials Order Form handouts** so they can analyze their data before starting on another build in Driving Question 6.

Reflect

2 min

Assign Homework

Inform students how to access their videos. Ask them to show their videos to their families and explain what they have been doing in the last week.

Give each student a copy of the **Family Outreach 1 handout**, which gives students guidance when playing their videos.

Point out the directions to follow before playing the video, while watching the video, and after the video ends. Ask students to have a family member sign their forms.

Family Outreach 1 handout

Family Outreach 1: Video Recording of Earthquake Test

Name: _____

- **Before the video:** Tell your family about the Module. (Example: "In science, we have been learning about earthquakes. Three important things I learned include _____. My team created a structure that had to _____.")
- Tell your family the purpose of the building activity and what they should watch for in the video. (Example: "In the video, you will see that _____ [explain your choice of design and construction, including shape and materials]. We made our buildings this way because _____.")
- **During the video:** Narrate what is happening and why it is happening. (Example: "In this part, you will see that the earthquake test was successful/unsuccessful because _____.")
- **After the video:** Describe how you would revise your building. (Example: "If I did this again, I would change _____.") Share what your biggest challenge was and what you enjoyed learning the most.

Ask your family for questions or comments (for example, what did they learn?) and write them here:

Have your parent or guardian sign this sheet and bring it in to your teacher for the next lesson.

Parent/Guardian Signature: _____

Date: _____

GRADE **4**
MODULE **4**

EARTHQUAKE ENGINEERING

Module Anchor Phenomenon:
How can we reduce the damage caused by earthquakes?

Driving Question 5
What can we learn from engineers that will help us revise our designs?

Performance Expectation: 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Students discuss and make sense of observations and information obtained from their investigations with physical models, as well as informational texts and videos that explore real engineering solutions from around the world.



Overview: **Full Course**

Driving Question 5 What can we learn from engineers that will help us revise our designs?

	FULL COURSE			
	LESSON		PAGE	SUGGESTED PACING
ENGAGE	1	**Better Safe than Sorry** Students watch and discuss a video showing what happens in a room during an earthquake. They identify potential hazards in the classroom and discuss ways to lessen the danger. As homework, they identify potential hazards in their own homes.	150	45 min
EXPLORE	2 	**Civil Engineering** Students listen to a reading about civil engineering and how it creates solutions to building problems, including those caused by earthquakes. They use information from the text to define civil engineering and explain its effects on their lives.	156	45 min
EXPLAIN	3  ☑ 3-D	**Think Outside the Box** Students read to determine how knowledge of materials and forces can help solve the problem of earthquake damage. They review one possible solution and assess its advantages and disadvantages, then argue for or against using it in their own homes.	162	45 min
ELABORATE	4	**A Bright Idea** Students watch a video about a famous example of trial-and-error in engineering, before writing about what failure means to engineers. They then review their previous work on the Engineering Design Challenge, discussing ways to improve their designs.	168	45 min
EVALUATE	☑ 3-D	**Earthquake Solutions** Students identify the best solution for protecting a building from earthquakes based on constraints, explaining their decisions.	174	20–30 min

Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · ☑ 3-D Assessment

The Full Course is recommended for mastery of the Performance Expectations.
The Fast Track Course delivers the Next Generation Science Standards at an accelerated pace.

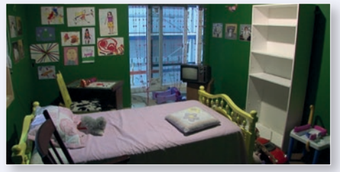
Overview: **Fast Track Course***

Driving Question 5 What can we learn from engineers that will help us revise our designs?

RESOURCES	MATERIALS	
	TEACHER	TWIG SCIENCE LAB KITS
• Family Outreach Letter 5 • Shaking Room video • Earthquake Safety Progress Tracker	• Camera (phone, tablet, etc.), optional	
• Earthquake Safety Progress Tracker • LAX Engineer video	**Recommended Trade Book:** • *Civil Engineering and the Science of Structures* by Andrew Solway	
• Earthquake Safety Progress Tracker	• Colored pencils or highlighters	
• Earth Explorer interactive • Edison video • Earthquake Safety Progress Tracker	• Documentation from the Engineering Design Challenge in Driving Question 4 (e.g., test video, self-evaluation, project design drawings, photos, notes)	
• Earthquake Solutions Benchmark Assessment • Earthquake Solutions Teacher Rubrics • Earthquake Solutions Student Rubrics		

BENCHMARK ASSESSMENT

Resource Highlights



Shaking Room video



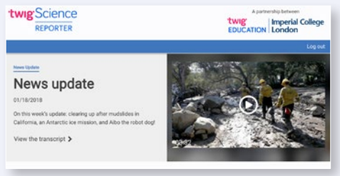
Earth Explorer interactive



Edison video



Professional Learning



Topical science news, features, and careers

twig Science REPORTER

*Fast Track lessons/activities are identified by

FAST TRACK COURSE			
BLOCK	SUGGESTED PACING	LESSONS/ACTIVITES	NOTES
1	20 min	**Sections from Better Safe than Sorry** • **Observe the Video** • **Discuss Observations** • **Identify Earthquake Hazards at Home**	After watching the **Shaking Room video**, ask students to identify Earthquake hazards in the classroom.
	10 min	**Sections from Civil Engineering** • **Review Earthquake Hazards** • **Introduce Civil Engineers** • **Assess Student Progress**	Play the **LAX Engineers video** from the Connect in Lesson 2. It shows the creative solutions used by a team of civil engineers to earthquake-proof a building at the Los Angeles International airport. Explain that students will look at the problem of constructing earthquake-safe buildings through the eyes of one engineer.
	20 min	**Sections from Think Outside the Box** • **Introduce the Close Reading** • **Close Read** • **Complete the T-Chart**	
	15 min	**Sections from A Bright Idea** • **Introduce the Activity** • **Analyze Previous Structures**	Emphasize that identifying difficulties and revising designs are important parts of the engineering design process. A failure that occurs when something is completed and in use can be a disaster. However, the failure of a design when something is in progress is an opportunity for learning and improvement.

Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · 3-D Assessment

Leveled Readers

These high-interest, magazine-style leveled readers give students the opportunity to explore the ideas covered in the module in greater depth and meet real-world scientists and engineers. Available in 4 levels, they can be used in differentiated small-group reading time. On-Level lessons that accompany the readers are provided in the Teacher Edition. Above-Level, Below-Level, and English Learner lessons can be found online at www.twigscience.com.



		Guided Reading	ATOS
OL	On-Level	S	4.9
AL	Above-Level	U	6.2
BL	Below-Level	N	3.2
EL	English Learners	S	4.9

Shake, Rattle, and Roll

Chapter 1: The Curious Scientist

This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend informational texts while reading independently.

Chapter 2: STEM Career: Meet a Seismologist

This chapter focuses on the career of a seismologist. It includes an optional micro-lab in which students learn how energy is stored and released during an earthquake.

Chapter 3: Earthquake-Proofing: What's the Cost?

This chapter focuses on applying the science standards to students' lives, and examines different ways that engineers earthquake-proof buildings.

Already use another ELA program in your class? No problem! Each Twig Science module is aligned to Workshop Models and McGraw-Hill Wonders©. Benchmark Advance™ available online.

ELA CONNECTIONS

Workshop Models

RI.4.1–3 Key Ideas and Details
RI.4.4 Craft and Structure
RI.4.7, 9 Integration of Knowledge and Ideas
SL.4.1–2 Comprehension and Collaboration
SL.4.4–6 Presentation of Knowledge and Ideas
W.4.2, 3 Text Types and Purposes
W.4.4 Production and Distribution of Writing
W.4.7–9 Research to Build and Present Knowledge
W.4.10 Range of Writing

McGraw-Hill Wonders©

Unit 1, Week 3 Thinking It Through
Leveled Reader Landscapes
Student Anthology Earthquakes

Lift foldout for Fast Track information

Differentiated Instruction—Highlights

Driving Question 5 What can we learn from engineers that will help us revise our designs?

English Learners

Lesson 1 Ensure that ELs know the meaning of the term *hazard* (a source of danger). For students with lower proficiency, consider having them name some of the main objects shown in the classroom photos or sketches aloud. They will need this language when they identify areas posing a hazard.

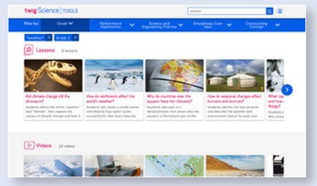
Lesson 2 Provide extra time to preview the graphic organizer. Ask students what they know about each key word and prompt them for more details so that they have an idea of what to look for in the reading.

Lesson 3 Ensure ELs know what a "subheading" refers to in informational text. If they do not, quickly show them a subheading in the current reading.

Extension Activities

NGSS-mapped resources to help extend and enrich learning for students of all abilities.

twig Science TOOLS
www.twigsciencetools.com



Challenge

Lesson 1 Have students fill in the table in their Twig Books. Under the Hazard column, they should list each hazard they circled on their classroom photos. They should fill in the other two columns based on their partner discussions.

Lesson 3 Students use their imagination to create and draw an earthquake-proof home.

Special Needs

Physical Disability

Lesson 1 Offer students a lightweight flashlight to point out and illuminate hazardous areas that they might not be able to physically reach.

Strengths-Based Approach

Lesson 4 Invite a student to share a time they struggled with or failed at a task and what strategy they used to address it. Many students with identified special needs are very resilient and their insights can help their peers.

Cultural Connections

Lesson 2 For students who speak or understand Spanish, point out that the term *civil* is a cognate. It is spelled exactly the same way (civil) and pronounced in a nearly identical fashion. Highlighting cognates allows students to capitalize on the funds of knowledge they possess and can bring to the classroom.

Lesson 4 Mention the work of Guillermo Gonzáles Camarena, a Mexican engineer who invented the first color television using scrap parts from a flea market when he was only 17 years old. Many of his inventions failed at first, but without these failures and revisions we would not have many of the devices we enjoy today.

Time Savers

CCSS English Language Arts

Lesson 2, 3 RI.4.1–3 Key Ideas and Details
Lesson 3 RI.4.7 Integration of Knowledge and Ideas
Lesson 4 W.4.4 Production and Distribution of Writing
Lesson 2, 3 W.4.7,9 Research to Build and Present Knowledge
Lesson 1–4 SL.4.1–2 Comprehension and Collaboration

WIDA English Language Development

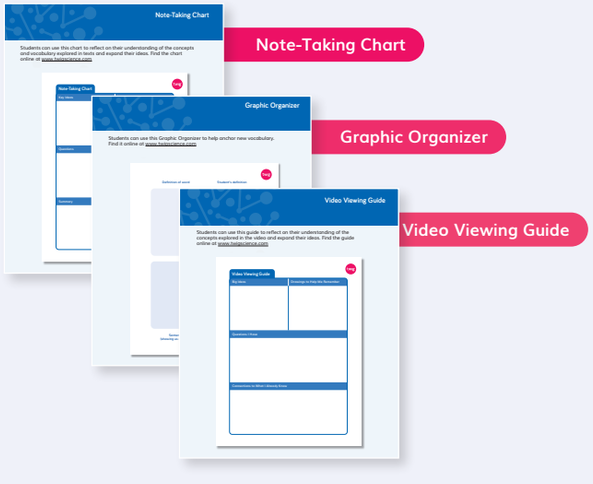
Lesson 1
Standard 1: Social and Instructional Language
Lesson 4
Standard 2: The Language of Language Arts
Lesson 1–4
Standard 4: The Language of Science

Access to Science Literacy and Vocabulary

Word Wall

Driving Question 1	natural disaster, earthquake, tsunami, volcano, energy transfer, waves, point of impact, amplitude, wavelength, seismic waves
Driving Question 2	ocean, Pacific Ocean, Atlantic Ocean, Ring of Fire, elevation, mountain range, belt, pattern, tectonic plates, fault, fault line, latitude, longitude
Driving Question 3	dead load, live load, horizontal load, compression (squeezing), tension (stretching), torsion (twisting), bending
Driving Question 4	-
Driving Question 5	**civil engineer, structures, forces, mistakes, materials, engineering design process (problem, criteria and constraints, brainstorm, design, build a model, test, refine, share), hazard, safety, revise**
Driving Question 6	fair test, data, budget

Additional Differentiated Support



See our full range of vocabulary support tools online.

Better Safe than Sorry

OVERVIEW

Spark	**10 min**	Students watch a video of the inside of a bedroom shaking during an earthquake.
Investigate	**15 min**	Student pairs walk around the classroom and identify earthquake hazards, marking them on photos or sketches of the room.
Report	**10 min**	Students share their observations about what happened in the video, and discuss how to make the safety hazards in the classroom safer.
Connect	**5 min**	Students hear a summary of the earthquake hazards they found and the solutions they offered.
Reflect	**5 min**	Students identify hazards they might encounter at home and offer suggestions to make them safer.

STANDARDS

NGSS

PE **4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

DCI **ESS3.B** Natural Hazards

CCC **CCC-2** Cause and Effect

CROSS-CURRICULAR CONNECTIONS

EPC **Principle** III Natural Systems Change in Ways that People Benefit from and can Influence

CCSS ELA **SL.4.1–2** Comprehension and Collaboration

WIDA **Standard 1:** Social and Instructional Language (Listening, Speaking)

Standard 4: The Language of Science (Listening, Speaking)

3-D LEARNING OBJECTIVES

Students will:

- Identify and discuss the potentially dangerous effects of earthquakes inside buildings
- Suggest possible solutions to mitigate the hazards identified.

Driving Question 5

What can we learn from engineers that will help us revise our designs?

LESSON 1

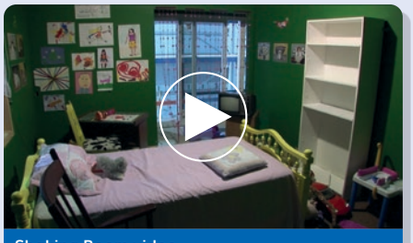
RESOURCES

Digital

- **Family Outreach Letter 5**
- **Shaking Room video**
- **Earthquake Safety Progress Tracker**

Teacher

- Optional: Camera (phone, tablet, etc.)



Shaking Room video
Observe a child's bedroom shaking during an earthquake.

LESSON PREPARATION

- Print out the **Family Outreach Letter 5** (1 per student) to give to students at the beginning of class. You may also email a copy to parents or guardians.

  This letter guides families to help students identify potential earthquake hazards at home and encourages families to develop an earthquake-preparedness plan with students.

- Stand in the middle of the classroom and take four photos, one of each side of the classroom. Include the whole wall (where most of the earthquake hazards might be), part of the ceiling, and as much of the inside of the classroom as possible.

  Optional: Instruct students to sketch of each side of the classroom and collect these to distribute during the activity.

- Print out a set of the four photos for each student pair.

Better Safe than Sorry

Spark

10 min

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

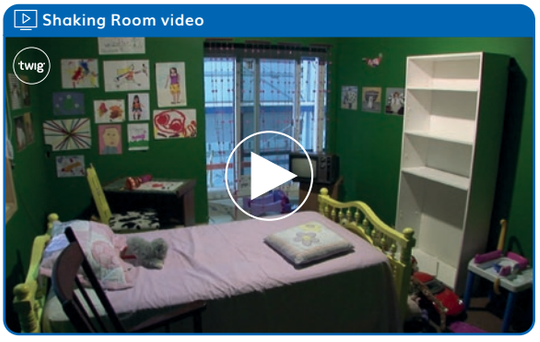
Earthquake Fact of the Day:

- The 2004 Indian Ocean earthquake was deadly, triggering a series of massive tsunamis that killed at least 225,000 people in 12 different countries.

Challenge

Ask students to fill in the table on page 79 of their Twig Books. Under the Hazard column, they should list each hazard they circled on their classroom photos. They should fill in the other two columns based on their discussion with their partner.

Observe the Video



Remind students that in the last lesson they used an earthquake simulator to test structures that they built. They looked at external damage and whether or not the building collapsed.

Explain that today students will investigate what happens inside buildings during an earthquake.

Play the **Shaking Room video.**

Stronger and Clearer Each Time (Language Routine)

Have students turn and talk with two partners, one after the other, about what they noticed in the video. Encourage students to build on each other's ideas.

If needed, write some sample questions students can ask each other:

- What objects fell? What objects did not fall?
- What happened to the furniture?
- What could people have done to make the environment safer?

After a few minutes, play the **Shaking Room video** a second time.

Have students meet with a third partner in order to strengthen and refine their observations.

Investigate

15 min

Introduce the Activity

Today, students will work in pairs to identify things in the classroom which might be potential hazards during an earthquake.

Ask students to look around the classroom from their seats and think about what in the room might be a potential hazard.

Identify Earthquake Hazards in the Classroom

Distribute the four photos or sketches of the classroom to each pair.

Ask pairs to walk around the classroom, identifying potential hazards in an earthquake. Have them circle these hazards on their photos. Prompt them to choose at least two of their circled hazards and discuss with their partner what could be done to make them safer.

Prepare for the Report

Select pairs that identified a variety of potential hazards or identified hazards other teams missed, and call on these students.

Report

10 min

Discuss Observations

Ask students to share their observations about the **Shaking Room video**.

Students may have noticed that the tall shelf did not fall, and wonder why this was the case. Ask them why they think it did not fall down. If possible, play the video again and pause it at the beginning before the room starts shaking. Point out the bracket in the top-right corner of the shelf, and explain that the shelf is secured to the wall—it is unlikely to fall. A tall piece of furniture is more likely to sway and fall during an earthquake, and therefore poses more of a safety risk.

Have students identify the hazards they found in the classroom. For each hazard, have them explain why the item is dangerous and what could be done to make it safer.

Have students reflect on other objects that might be a safety hazard that they did not see in the video or in the classroom.

- ***Are there any items in your bedroom that might be dangerous?***
- ***How could you make the items less dangerous?***

If students have filled out the chart on page 79 of their Twig Books, have them share it.

Connect

5 min

Summarize Hazards and Solutions

Summarize the lesson's activity by listing some of the potential hazards that students identified as well as the solutions they offered to make them safer.

If possible, implement some of students' suggestions during the week.

English Learners

Ensure that ELs know the meaning of the term *hazard* (a source of danger). For students with lower proficiency, consider having them name some of the main objects shown in the classroom photos or sketches aloud. They will need this language when they identify areas posing a hazard.

Special Needs

Physical Disability

Offer students a lightweight flashlight to point out and illuminate hazardous areas that they might not be able to physically reach.

Cultural Connection

If there is time during the lesson, briefly share that other children around the world are also addressing earthquake safety. Let students know about Nirjan, a Nepalese boy, whose family had to rebuild their home after a major earthquake in 2015. Nirjan is no longer afraid of earthquakes because he understands how and why they happen, and knows of ways to lessen their impact.

Reflect

5 min

English Learners

Since ELs will not be able to work with peers for the Reflect, offer optional cloze sentence frames at their proficiency level as an added language support.

Substantial Support (Emerging Proficiency)

- In my home, I see _____. One way to make this space safer is by _____.

Moderate Support (Expanding Proficiency)

- In my home, I notice a few dangers like _____. These could be made safer by _____.

Light Support (Bridging Proficiency)

- In my home, some of the safety hazards I see include _____. Safety could be improved by _____.

Identify Earthquake Hazards at Home

Have students suggest hazards they might encounter at home. Review how students could make these safer.

Ask students to find potential hazards in their home tonight and think of ways to make these safer. Explain that students should write their findings on page 80 in their Twig Books and be prepared to discuss these during the next lesson.



Assess Student Progress

Use the **Earthquake Safety Progress Tracker** to note if students understand that, while we cannot prevent earthquakes, we can do things to reduce their impacts.

Students can use this guide to reflect on their understanding of the concepts explored in the video and expand their ideas. Find the guide online at www.twigscience.com

Video Viewing Guide

Big Ideas	Drawings to Help Me Remember

Questions I Have

Connections to What I Already Know

Civil Engineering

OVERVIEW

Spark	**8 min**	Students recall some of the earthquake hazards they found at home, as well as their solutions. They also consider what a civil engineer does.
Investigate	**20 min**	Students listen to a read-aloud about the job of civil engineers and make notes in their graphic organizers.
Report	**8 min**	Students discuss what they have learned about civil engineering, what challenges engineers face, and how their job changed over time.
Connect	**6 min**	Students watch a video about the creative solution a team of civil engineers used to earthquake-proof a famous building in Los Angeles.
Reflect	**3 min**	Students reflect on how their lives have been affected by civil engineering.

STANDARDS

NGSS

PE — **4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

DCI — **ESS3.B** Natural Hazards

ETS1.B Developing Possible Solutions

SEP — **SEP-8** Obtaining, Evaluating, and Communicating Information

CETAS — Interdependence of Science, Engineering, and Technology

Influence of Science, Engineering, and Technology on Society and the Natural World

CNS — Scientific Knowledge Is Based on Empirical Evidence

Science Is a Human Endeavor

CROSS-CURRICULAR CONNECTIONS

EPC — **Principle IV** There are no Permanent or Impermeable Boundaries that Prevent Matter from Flowing between Systems

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

CCSS ELA — **RI.4.1** Key Ideas and Details

W.4.7 Research to Build and Present Knowledge

SL.4.2 Comprehension and Collaboration

WIDA — **Standard 4:** The Language of Science (Reading)

3-D LEARNING OBJECTIVES

Students will:

- Define the work of a civil engineer and determine how civil engineers affect their lives.

Driving Question 5

What can we learn from engineers that will help us revise our designs?

LESSON 2

RESOURCES

Digital

- **Earthquake Safety Progress Tracker**
- **LAX Engineer video**

Additional Resources

- Use our recommended trade book, *Civil Engineering and the Science of Structures* by Andrew Solway, or replace with your own



LAX Engineer video

Discover how engineers can adapt a building's structure to make it safer in an earthquake.

LESSON PREPARATION

Word Wall

- civil engineer
- structures
- forces
- mistakes
- materials
- engineering design process
- problem
- criteria and constraints
- brainstorm
- design
- build a model
- test
- refine
- share

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- If you have a swimming pool, you might notice that the water sloshes around after an earthquake. This is called a seiche, and it's caused by the seismic waves of the earthquake.

Cultural Connection

For students who speak or understand Spanish, point out that the term *civil* is a cognate. It is spelled exactly the same way and pronounced in a nearly identical fashion. Highlighting cognates allows students to capitalize on the funds of knowledge they possess and can bring to the classroom.

Spark

8 min

Review Earthquake Hazards

Have a few students share the potential earthquake hazards they found in their home, as well as the solutions they thought of. Encourage other students to suggest solutions to the hazards their classmates shared.

Introduce Civil Engineers

Add *civil engineer* to the academic word wall. Explain that *civil* means "relating to the general public, their activities, and their needs."

Have student pairs discuss the following questions:

- What is a civil engineer?
- What do you think a civil engineer does?

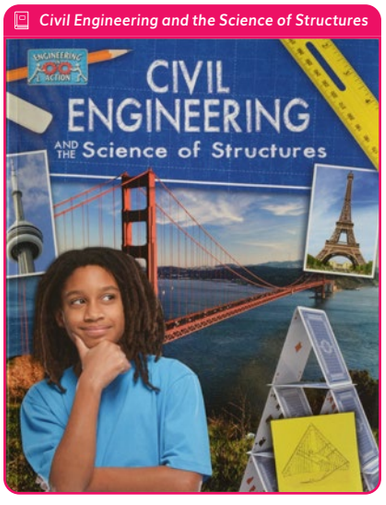
Ask volunteers to share their answers with the class.

Investigate

20 min

Introduce the Close Reading

Remind students that one of their science tools is finding information that will help them answer questions. Today, students will listen and take notes as you read from *Civil Engineering and the Science of Structures*. This text explores the field of civil engineering, focusing on how engineers build and design structures through the engineering design process.



Review Earthquake-Resistant Structures

Ask students to share what they already know about building earthquake-resistant structures. This will provide students with background to draw on during your read-aloud.

Give students 2 minutes to turn and talk with a partner and share what they know about the topic.

Vocabulary Routine

Ensure students understand important new chapter vocabulary using the vocabulary routine. Explain that writers often emphasize these terms by boldfacing them.

Step 1: Read aloud some of the boldfaced content words from pages 4–9 (**surveyor, pioneer, geologists, collaborate**) and pages 18–29 (**computer model, scale model, mass damper, composites**).

Step 2: Guide students to decode each of these words using, for example, context clues and visual aids.

Step 3: Read the word first, then have students repeat it three times to help them remember it.

Step 4: Have students turn to the Visual Glossary on page 31 and familiarize themselves with it.

Step 5: Review additional words using simple definitions and context sentences. Point out related words to expand students' vocabulary.

evaluate

Define: to find out how good something is, to check its value

Example: The shopper evaluated six hairdryers and chose the best.

investigate

Define: to look into something inquire into carefully

Example: The detective investigated the crime scene.

identify

Define: to find out what something is and pinpoint it

Example: The doctor identified the problem with the patient.

brainstorm

Define: to try to solve a problem by talking with other people, each person contributing ideas freely

Example: The employees brainstormed a name for the new chocolate bar.

prototype

Define: an original or first model of something

Example: The test pilot flew the aircraft prototype, and it flew quite well.

Read Aloud

Ask students to take notes in the graphic organizer on page 81 in their Twig Books while you read. They should:

- Write key words and phrases for the four terms listed in their organizers (*civil engineer, materials, engineering design process, prototype*)
- Note their questions and confusions about the text by jotting down the page and paragraph number of the confusing sentence or section.

Begin reading, making sure to take appropriate pauses so students can process. Allow for discussion to occur in these breaks as well.

Reread pages 4–5, 8–14, 18, 20–21, 24–25, and 28–29 so that students can take additional notes. Consider reading additional pages if time allows.

Give students a few minutes to look over their notes, add any additional information, and consider any questions they might have about the text.

Add the following terms to the academic word wall: *structures, forces, materials, mistakes, engineering design process (problem, criteria and constraints, brainstorm, design, build a model, test, refine,* and *share).*

English Learners

Provide extra time to preview the graphic organizer. Ask students what they know about each key word. For example, they should be able to think of instances when they used a design process that had steps (including both criteria and constraints). Prompt them for more details, so they have an idea of what to listen for in the reading based on the key words.

Substantial Support (Emerging Proficiency)

After the read-aloud, go back and work with a small group of students to guide them more closely through another read-aloud of some of the text. Offer clarification of terms and assistance with the graphic organizer if they were not able to maintain the pace of the class.

Moderate and Light Support (Expanding and Bridging Proficiency)

Partner ELs with a proficient listener. Offer additional wait time when pausing.

Investigate

Prepare for the Report

Circulate and identify areas of confusion to focus on. Identify students who have diverse evidence, and invite them to share. Below is an example completed organizer.

Twig Book, p.81

Close Read • As you listen to the reading you should:

- Write down key ideas for each key word listed
- Note any questions you have about what you hear.

Key Word	Key Idea
civil engineer	Shapes our environment; makes structures like skyscrapers, bridges, dams, tunnels, railways, drains, sea walls
materials	Older materials include iron, stone, and steel; new materials include plastics, composites, smart glass, self-healing concrete
engineering design process	Eight-step process; problem, criteria and constraints, brainstorm, choose a design, build a model, test, refine, share
prototype	A model engineers build to test their designs; they can build them by hand or design them on a computer

Report

8 min

Discuss Civil Engineers

Discuss what students have learned about civil engineers.

- ***What is a civil engineer? What do they do?***
- ***How are science and engineering related?***
- ***What are some of the challenges civil engineers face?***
- ***How has civil engineering changed over time?***
- ***How does civil engineering relate to earthquakes?***

Misconceptions from the Pre-Exploration

Use the **Earthquake Safety Progress Tracker** to note if students have the following misconceptions.

Misconceptions	What to Do
New buildings are always better than old buildings at standing up during an earthquake.	If students think that new buildings are more stable, explain that this might be true—not because they are new, but because our building codes are better.
Heavy buildings are always better than lightweight buildings at standing up during an earthquake.	If they repeat the misconception that heavy buildings are the most stable, ask for other observations about previous structure designs. Highlight characteristics like shape, flexibility, reinforcement, or symmetry.

Connect

6 min

Connect Today's Learning to Engineering, Technology, and Applications of Science

Summarize how civil engineers build and design structures that have an effect on our natural systems. Their solutions to a problem require creativity and imagination, and those solutions can have both strengths and weaknesses. Some examples from the text include Sir Sandford Fleming, whose work led to the creation of time zones (page 5), and the weakness of the Vajont Dam, where a landslide behind the dam caused a devastating overflow (page 25).

Introduce the video, which shows the creative solutions used by a team of civil engineers to earthquake-proof a building at the Los Angeles International airport.

Play the **LAX Engineer video**.

Explain that students will look at the problem of constructing earthquake-safe buildings through the eyes of an engineer in the next lesson.



Reflect

3 min

Formative Assessment

Ask students to reflect on how their lives have been affected by civil engineering, and to record their thoughts in their Twig Books. They should support their arguments with details from the text.



Assess Student Progress

Read students' responses. Use the **Earthquake Safety Progress Tracker** to note if students understand that engineers design and build structures to meet societal demands as well as solve problems.

Special Needs

Expressive and Receptive Language

Ask students to note additional keywords, rather than pinpoint key ideas, as they listen to the read-aloud. This can help them process the language in the text.

Think Outside the Box

OVERVIEW

Spark	**5 min**	Students write an answer to why engineers need to know about different materials and the forces they need to withstand in an earthquake.
Investigate	**18 min**	Students read a text about how an engineer in Japan devised a solution to reduce the risk of people getting hurt or killed by collapsing buildings.
Report	**15 min**	Students discuss the illustrations to understand Shoichi Sakamoto's invention, and analyze the text.
Connect	**2 min**	Students understand that engineering solutions often require creativity and imagination, and that solutions can have both strengths and weaknesses.
Reflect	**5 min**	Students explain in writing whether or not they would use the airbag system in their own homes.

STANDARDS

NGSS

PE
4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

DCI
ESS3.B Natural Hazards
ETS1.B Developing Possible Solutions

SEP
SEP-6 Constructing Explanations and Designing Solutions
SEP-8 Obtaining, Evaluating, and Communicating Information

CETAS
Interdependence of Science, Engineering and Technology
Influence of Science, Engineering, and Technology on Society and the Natural World

CNS
Scientific Knowledge Is Based on Empirical Evidence
Science Is a Human Endeavor

CROSS-CURRICULAR CONNECTIONS

CCSS ELA
RI.4.1, RI.4.3 Key Ideas and Details
RI.4.7 Integration of Knowledge and Ideas
W.4.9 Research to Build and Present Knowledge
SL.4.1 Comprehension and Collaboration

WIDA
Standard 4: The Language of Science (Reading)

3-D LEARNING OBJECTIVES

Students will:

- Evaluate an engineering solution to building for earthquake safety.

Driving Question 5

What can we learn from engineers that will help us revise our designs?

LESSON 3

RESOURCES

Digital

- **Earthquake Safety Progress Tracker**

Student

- Colored pencils or highlighters

LESSON PREPARATION

On chart paper, create a T-chart as shown below.

Evidence of a Solution	Evidence of Problems

Word Wall

- hazard
- safety
- revise

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- The swimming pool at the University of Arizona lost water due to sloshing (or a *seiche*) caused by the 1985 Michoacan, Mexico earthquake 2,000 km (1,240 mi.) away.

Challenge

Invite students to take inspiration from Shoichi Sakamoto's creative and unusual design by creating their own earthquake-proof home. Ask them to make a drawing of their creations on page 89 in their Twig Books using pencil, colored pencil, ink, or marker. Students should label the parts of the drawing to help the viewer understand how it's engineered. Remind them that, since they can create anything, they should be creative.

Spark

5 min

Review Earthquake-Resistant Materials

Ask students to reflect on their learning from the last lesson about how engineers decide on the right materials when they build a structure, and then answer the question on page 89 in their Twig Books.

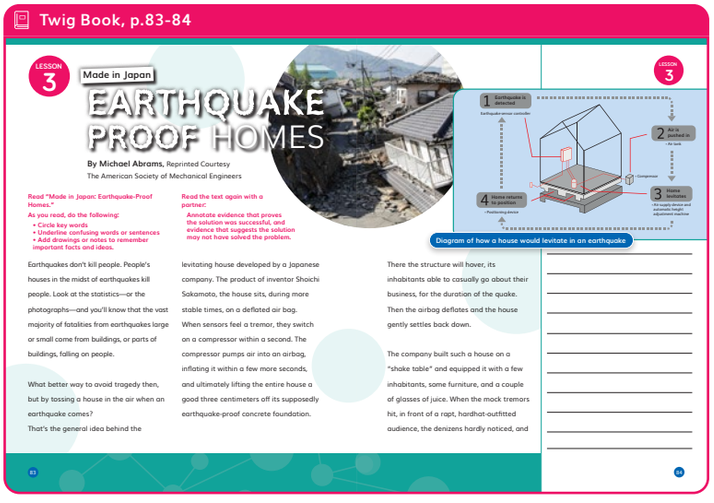
Have a few students share their answers.

Investigate

18 min

Introduce the Close Reading

Remind students that engineers work to solve problems. One example of a problem is that people are hurt or killed by collapsing buildings during earthquakes. Ask students to think about how knowledge of materials and forces—as well as imagination—can be used to solve this problem.


Twig Book, p.83-84

LESSON 3

Made in Japan

EARTHQUAKE PROOF HOMES

By Michael Abrams, Reprinted Courtesy The American Society of Mechanical Engineers

Read "Made in Japan: Earthquake-Proof Homes."
As you read, do the following:
- Circle key words
- Underline confusing words or sentences
- Add drawings or notes to remember important facts and ideas.

Read the text again with a partner.
Annotate evidence that proves the solution was successful, and evidence that suggests the solution may not have solved the problem.

Diagram of how a house would levitate in an earthquake

Earthquakes don't kill people. People's houses in the midst of earthquakes kill people. Look at the statistics—or the photographs—and you'll know that the vast majority of fatalities from earthquakes large or small come from buildings, or parts of buildings, falling on people.

What better way to avoid tragedy then, but by tossing a house in the air when an earthquake comes?
That's the general idea behind the levitating house developed by a Japanese company. The product of inventor Shoichi Sakamoto, the house sits, during more stable times, on a deflated air bag. When sensors feel a tremor, they switch on a compressor within a second. The compressor pumps air into an airbag, inflating it within a few more seconds, and ultimately lifting the entire house a good three centimeters off its supposedly earthquake-proof concrete foundation.

There the structure will hover, its inhabitants able to casually go about their business, for the duration of the quake. Then the airbag deflates and the house gently settles back down.

The company built such a house on a "shake table" and equipped it with a few inhabitants, some furniture, and a couple of glasses of juice. When the mock tremors hit, in front of a rapt, hardhat-outfitted audience, the denizens hardly noticed, and

Introduce "Made in Japan: Earthquake-Proof Homes" on page 83 of the Twig Book. Students will read the text to find out what problem the engineer was trying to solve, and how he solved it.

Close Read

Have the class review the directions on page 83 in the Twig Book.

Ask students to read the text independently and annotate it using different colored highlighters or pencils.

Have students reread the text with a partner. They should annotate evidence that proves the solution was successful and evidence that shows that the solution may not have solved the problem.

Circulate and take note of areas of common confusion. Focus on these when you revisit the text (e.g., difficult words or misconceptions).

Complete the T-Chart

Show students the T-chart you created before the lesson. As a class, complete the chart with evidence that the solution was successful and evidence that there are problems with the solution.

Give students a few minutes to review their annotations.

Prepare for the Report

As students review their notes, identify those who have recognized important evidence.

Evidence of a Solution	Evidence of Problems
• When the mock tremors hit, the people inside hardly noticed. • Not a drop of liquid was spilled. • It would take care of a smaller earthquake. • It would dampen some of the motions.	• The shake test dealt only with side-to-side motion. • Most earthquakes are not limited to a two-dimensional plane. • 3 cm of levitation will only protect a house from earthquakes that don't rise higher than 3 cm. • If there is a tall wave, the house may slip off its foundation. • The first tremors that would start the system may very well be the biggest, most destructive tremors. • This system is only good for that rare, lateral-shaking earthquake that never moves the earth higher than 3 cm. • It costs three million Yen per house (more than $37,000).

Report

15 min

Discuss the Close Reading

Have a class discussion about the text, its text features, and the three illustrations.

- ***How do the numbers in the first diagram help explain the idea?***
- ***Do you find the diagram easier to understand than the written explanation?***
- ***How do the dotted lines and arrows help your understanding? What happens after Stage 4?***
- ***Why did the artist make the house see-through in the first and second diagrams?***
- ***Do the people in the second diagram look alarmed or calm? Why do you think this is?***
- ***What do the blue arrows show?***
- The blue arrows show the direction of shaking—horizontal not vertical.
- ***What does the chart on the side mean?***
- The chart indicates the earthquake, shown by the trace line in the center.
- ***What do the "Normal" and "Levitating" labels in the third diagram mean?***
- ***What part of the house is illustrated? How can you tell?***
- These are two illustrations of the same part of the house. It could be a bottom corner, because of the concrete base and the gutter.
- ***What does the red circle show?***
- The red circle shows the gap when the house is lifted off the ground because of the airbag device.
- ***What does the title tell you?***
- The title tells us that this invention comes from Japan.
- ***What do the subheadings, "Minimizing Damage" and "Improving Design," tell you?***
- "Minimizing Damage" tells us that the article doesn't promise a perfect answer to earthquakes. This idea cuts the damage down—it minimizes it. "Improving Design" tells us that engineers are always looking for ways to improve on an idea, and the paragraph suggests ways that the air-bag solution falls short and needs to be improved.

English Learners

Support students to access and comprehend the text.

Substantial Support (Emerging Proficiency)

Gather a small group of students together and guide them through the close reading. Begin with a preview of the first illustration.

- ***What do you see?***
- ***What do you notice about the house?***

Explain that houses can be an earthquake hazard. Chunk portions of the text and read these aloud with them, pausing to let them circle unknown words. Come up with student-friendly definitions together, and draw out their understanding of the engineering problem being solved. Then have them resume at the stage where students reread with a partner.

Moderate Support (Expanding Proficiency) and Light Support (Bridging Proficiency)

For the reading, pair ELs with a partner who has a higher level of English proficiency and is a more fluent reader.

English Learners

Ensure ELs know what a "subheading" refers to in informational text. If they do not, quickly show them a subheading in the current reading.

Report

15 min

Monitoring English Language Proficiency

Engage students in the following tasks to monitor their growing English language development. These tasks are best administered individually.

Writing Domain

Have students look at the diagrams on pages 84 and 85, choose one, and write a brief description of what is happening.

Reading Domain

Use the photo on pages 83-84. Write these sentences:

- Earthquakes kill people.
- People die during earthquakes when houses collapse on them.
- People can be hurt or killed by pieces of building falling on them.

Have students read each sentence, then choose the sentence that the photo could provide evidence for. Continue with other photos, illustrations, and graphic aids in the text.

Speaking Domain

As students share their answers to the Listening Domain questions, record their use of academic vocabulary and connecting words.

Listening Domain

Read aloud the "Improving Design" section on pages 87.

- ***What is a problem with the new earthquake-proofing design? Why do scientists think it's still important to try this design?***

Review the following vocabulary terms with your class, providing a simple definition and a synonym or antonym when possible: *levitating*, *stable*, *deflated*, *tremor*, *compressor*, *levitate*, *hardhat-outfitted*, *retrofitted*, *structures*, *minimizing*, *solution*. Then, discuss the text as a whole.

- ***The author begins the article with some strong statements—do you agree with these? Do these statements catch your attention?***
- ***The second paragraph opens with a question—are we meant to answer? Can you spot any evidence that the author is exaggerating for effect?***
- The diagram on the opposite page doesn't involve throwing a house in the air, and a house is heavy and can't be easily thrown. This is an exaggeration. It's a way to get our attention.
- ***Look at the definition of the invention in the third paragraph. Can you follow it? Do you understand the idea?***
- ***Why has the author used the word* supposedly *to describe the earthquake-proof foundation?***
- The word *supposedly* adds an element of doubt. Maybe the foundation isn't as earthquake-proof as it is claimed to be.
- ***Why has the author used the word* gently*?***
- The author uses *gently* to emphasize the intended effect of the new invention—to bring calm to an otherwise terrifying event like an earthquake.
- ***In the fourth paragraph, we are told about the experimental house. Why did they put people drinking fruit juice in the house before they shook it?***
- The fruit juice was added because, if the experiment was a success, the people would not be harmed and the fruit juice wouldn't spill. It would be evidence that the shaking was dampened down by the airbag.
- ***Why were the observers wearing hard hats?***
- The observers were wearing hard hats in case it didn't work.
- ***What happened when the house shook? Did the invention work?***
- The invention worked—no one was harmed and the fruit juice didn't spill.
- ***Why does the author quote Deke Smith?***
- The author quotes Smith because they are an expert. The author isn't saying they agree with them, but is giving a counterargument to balance the positivity from the Japanese company.

Have students use their annotations and the T-chart while you discuss the following questions:

- ***What evidence did you find to show Shoichi Sakamoto created an earthquake-proof home?***
- ***Why does Deke Smith think this is not the whole solution to solving the problem of earthquake damage to houses?***
- ***What problems remain to be solved to create earthquake-proof homes?***

As you discuss, add the terms *hazard*, *safety*, and *revise* to the academic word wall.

Connect

2 min

Connect Today's Learning to SEP-6—Constructing Explanations and Designing Solutions

Summarize students' ideas and evidence from the discussion. Emphasize the importance of evaluating solutions for how well they meet the criteria for success. Explain that engineering solutions can require creativity and imagination, and that solutions can have both strengths and weaknesses.

Explain that students will need their notes, designs, and previous work from the Engineering Design Challenge in the next lesson.

Reflect

5 min

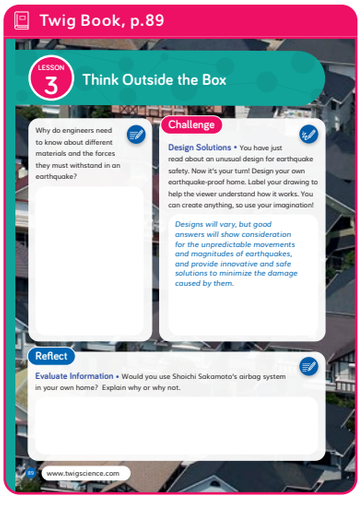
Formative Assessment

Have students write on page 89 in their Twig Books whether or not they would use Shoichi Sakamoto's airbag system in their own homes, and why.

Assess Student Progress

Read students' responses. Students should support their arguments with details from the text.

Use the **Earthquake Safety Progress Tracker** to note if students understand that solutions to an engineering problem have constraints (limits), such as materials and time.



Special Needs

Executive Functioning

Ensure students who have any issues with organization have a way to sort, keep, store, and easily access all previous work so they can begin the next lesson in a structured manner, ready to go.

A Bright Idea

OVERVIEW

Spark	**15 min**	Students return to the Earth Explorer interactive to check if any patterns emerged, discuss the concept of failure, and watch a video about Thomas Edison's journey to creating a lightbulb.
Investigate	**15 min**	Students write about what failure might mean to a scientist or engineer. They review the structures they built in this Driving Question, and think about ways to change or improve them.
Report	**10 min**	Students share what they wrote about failure from a scientist or engineer's perspective and describe how they are going to change and improve their designs.
Connect	**2 min**	Students understand that a failure of a design while it's still in progress is an opportunity for learning and development.
Reflect	**3 min**	Students create a newspaper headline about the changes to their building design projects.

STANDARDS

NGSS

PE — **4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

DCI — **ETS1.B** Developing Possible Solutions

ETS1.C Optimizing the Design Solution

SEP — **SEP-6** Constructing Explanations and Designing Solutions

CROSS-CURRICULAR CONNECTIONS

CCSS ELA — **W.4.4** Production and Distribution of Writing

SL.4.1 Comprehension and Collaboration

WIDA — **Standard 2:** The Language of Language Arts (Writing)

Standard 4: The Language of Science (Writing)

3-D LEARNING OBJECTIVES

Students will:

- Relate the creation of the light bulb by Thomas Edison to engineering practices
- Discuss the importance of trial and error in research and engineering
- Explain why failure does not mean the end of a research project, but is in fact an essential component of research which can lead to improvement
- Assess previous earthquake-resistant building designs and propose improvements.

Driving Question 5
What can we learn from engineers that will help us revise our designs?

LESSON 4

RESOURCES

Digital

- **Earth Explorer interactive**
- **Edison video**
- **Earthquake Safety Progress Tracker**

Student

- Documentation from the Engineering Design Challenge (e.g., test video, self-evaluation, project design drawings, photos, notes)



Earth Explorer interactive

Investigate the relationship between volcanoes, earthquakes and tectonic plates too see if you can spot any patterns.



Edison video

Learn about Thomas Edison's difficult yet successful journey creating a safe and efficient lightbulb.

LESSON PREPARATION

- Review your notes from previous Engineering Design Challenges to refresh your memory on students' structures, the problems they encountered, the solutions they suggested, and whether or not they worked.
- On the board, list the magnitudes, coordinates, and dates of the six largest earthquakes in the United States from the past 350 years:
  - Mag 9; Lat 45; Long –125 (January 26, 1700)
  - Mag 8.6; Lat 53.49; Long –162.83 (April 1, 1946)
  - Mag 8.6; Lat 51.5; Long –175.63 (March 9, 1957)
  - Mag 8.3; Lat 58.37; Long –136.67 (July 9, 1958)
  - Mag 9.2; Lat 61.05; Long –147.48 (March 27, 1964)
  - Mag 8.7; Lat 51.29; Long 178.55 (February 4, 1965)

  Note: The magnitude and coordinates for the first of these are estimates due to the lack of accurate historical records.

Spark

15 min

Investigations in Progress

Open the EMSC Quick Search preset you bookmarked and display the **Earth Explorer Interactive.** Print off one copy of the **Earth Explorer Graphic Organizer handout** and give this to the student assigned to enter earthquake data for today.

Have the student find up to three recent earthquakes with a magnitude greater than or equal to 5, noting these on the handout. They should then add these to the class's **Earth Explorer interactive** account.

Fact Board

Earthquake Fact of the Day:

- Alaska is the most seismic state in the United States. Since 1900, Alaska has averaged one magnitude 8+ earthquake every 13 years; one magnitude 7–8 earthquake each year; six magnitude 6–7 earthquakes each year; 45 magnitude 5–6 earthquakes each year; 320 magnitude 4–5 earthquakes each year; and an average of 1,000 total earthquakes each month.

Academic Vocabulary Check

- *hazard*
- *safety*
- *civil engineer*
- *structures*
- *engineering design process*
- *criteria*
- *constraints*
- *materials*
- *forces*
- *mistakes*
- *refine*
- *revise*



Review Earthquake Patterns

Display the **Earth Explorer interactive** and show the data students have recorded.

Have students point out any changes since the review they did in Driving Question 3, Lesson 4.

- ***Have new patterns emerged?***
- ***Are the earthquakes we've entered confirming your previous observations?***
- ***Can you identify regions of the world that have a lot of larger earthquakes, and regions that do not?***

Point to the earthquake data you've written on the board and explain that these are the six largest earthquakes to occur in the United States in the past 350 years. Have volunteers add these earthquakes to the **Earth Explorer interactive**.

Note: The 9.2-magnitude earthquake from March 1964 was entered in Driving Question 3, Lesson 4, so it does not need to be entered again.

Discuss Failure

Discuss the concept of failure with students.

Write the main ideas that emerge on the board as they share their thoughts, but do not elaborate.



- Failure means that I wasn't able to make something work.
- I feel sad when I fail.
- I think that others think I'm not good at doing things.
- It doesn't matter to me what others think.

Explain that students will watch a video about a scientist who failed many times before he succeeded.

Play the **Edison video**.

Investigate

15 min

Introduce the Activity

Today, students will work with their teams from the Engineering Design Challenge to review their structures and think of ways to change and improve them.

Analyze Previous Structures

Have teams look at their previous work for the Engineering Design Challenge—test videos, self-evaluations, project design drawings, photos, and notes.

Ask them to think about the building designs of groups that were more successful than theirs and determine whether some aspects of those designs might improve their own.

Twig Book, p.90

Improve Designs • List aspects of your last design that you need to improve upon and explain the changes you will make in your next design.

Aspects to Improve	Changes in Next Design

Observations and changes will vary, but it is important for students to recognize that failures and weaknesses of their last design are opportunities to improve and make better designs next time.

Have teams work together to fill in the table on page 90 in their Twig Books. In the left column, they should list aspects of their design they need to improve; in the right column, they should explain what they are going to change in their next design.

As teams complete their tables, circulate and guide students to reflect upon their own experiences of failure in the Engineering Design Challenge.

- ***Were you disappointed by the results?***
- ***Did you feel that you failed?***
- ***Do you remember how you felt?***
- ***What did you learn from the experience?***
- ***Were you able to think of an explanation of why the experiment didn't work? What did you do to fix it?***
- ***Did it work then?***
- ***What did you do next?***

Twig Book, p.91

Communicate Information • Write a paragraph about what failure means for a scientist or an engineer.

Failure is an important and essential part of being a scientist or engineer. It can be disappointing, but a failed experiment or design allows scientists and engineers to find how their predictions or solutions were wrong. This knowledge shows them how they change and fix their work to be better, even if failure happens again. Failure isn't about not being good or smart enough, but an opportunity to learn and develop. It is an important and helpful part of achieving success.

Write About Failure

Ask students to write about what failure might mean for a scientist or an engineer. They should record their short paragraphs on page 91 of their Twig Books.

Special Needs

Strengths-Based Approach

Invite a student to briefly share a time they struggled with or failed at a task and what strategy they used to address it. Many students with identified special needs are very resilient and their insights can help their peers.

Cultural Connection

Mention the work of Guillermo González Camarena, a Mexican engineer who invented the first color television using scrap parts from a flea market when he was only 17 years old. His work became the foundation for the pixels we see on modern computer screens, smartphones, and more. Many of his inventions failed at first.

Point out that without these failures and revisions, we would not have many of the devices we enjoy today.

English Learners

For students needing additional guidance, model how you would explain your thinking to a partner. Provide students with sentence frames to prompt oral explanations:

Substantial Support (Emerging Proficiency)

- I think we should change _____ because _____.

Moderate Support (Expanding Proficiency)

- I would do it this way in the next design: _____. My reason is that _____.

Light Support (Bridging Proficiency)

- When we tried _____, I learned that_____. Therefore, _____.

Report

10 min

Discuss Failure

Ask a few volunteers to share the paragraphs they wrote on failure from the viewpoint of a scientist or an engineer. Have the class discuss their ideas and contrast them with the initial impressions they shared during the Spark, displayed on the board.

Point out that failure is often perceived negatively: people often feel sad when they put effort into something that doesn't work; they sometimes feel they should quit rather than risk failing again; and they often think others will judge them if they fail.

Explain that failure shouldn't stop scientists and engineers. Experiments usually fail several times before they are successful. The secret to success is to learn from failure. Scientists and engineers look at the results, compare them to their predictions, and determine what worked and what didn't. They then try to find solutions to fix things that don't work until they reach their goal. For scientists and engineers, there is no failure—only an opportunity for learning and better understanding.

Ask a few students to describe what they need to improve in their designs and how they are going to change that aspect.

Connect

2 min

Connect Today's Learning to Engineering Design

Emphasize that identifying difficulties and revising designs are important parts of the engineering design process.

A failure that occurs when something is completed and in use can result in tragedy:

- The failure of heat shields on the Space Shuttle Columbia resulted in the shuttle's disintegration, causing the deaths of all crew members.
- The failure of seawalls to protect the Daiichi nuclear power plant in Japan resulted in a partial meltdown with one confirmed fatality.
- The failure of several safety systems on the Deepwater Horizon oil rig resulted in one of the largest marine oil spills in history.

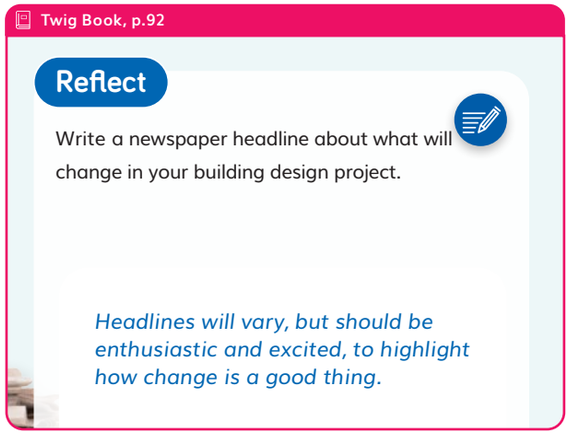
However, the failure of a design when something is in progress is an opportunity for learning and improvement.

Reflect

3 min

Formative Assessment

Ask students to create a short newspaper headline on page 92 in their Twig Books about what will change in their building design project.



Assess Student Progress

Read students' newspaper headlines as well as the tables they completed with their teams. Use the **Earthquake Safety Progress Tracker** to note if, in their headlines, students acknowledge that designs should be tested to identify failure points and that, most of the time, multiple tries are necessary to succeed.

Determine which groups may need support in thinking of additional ways to improve their structures.

Earthquake Solutions

This assessment has a Depth of Knowledge level of 2

DoK 2

OVERVIEW

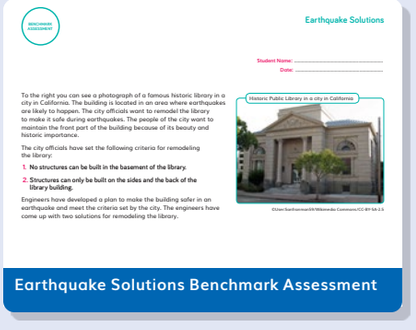
Students are asked to identify the best solution for protecting a famous historic library building in California, based on constraints. Students are provided with two potential solutions and will consider the effects an earthquake will have on the building using each. They will identify the best solution for protecting the building and will explain their decision.

This assessment is to be completed individually, but you should spend time with the class reviewing the format and the student rubrics. Provide 20–30 minutes for students to complete the assessment.

RESOURCES

Digital

- **Earthquake Solutions Benchmark Assessment**
- **Earthquake Solutions Teacher Rubrics**
- **Earthquake Solutions Student Rubrics**



Earthquake Solutions Benchmark Assessment

STANDARDS

Rubric	PE*	SEP	DCI	CCC	DoK
1	4-ESS3-2	**SEP-6** Constructing Explanations and Designing Solutions	**ESS3.B** Natural Hazards	–	1
2	4-ESS3-2	–	**ESS3.B** Natural Hazards	**CCC-2** Cause and Effect	2

*Details of the alignment to PE dimensions listed can be accessed online in the **Earthquake Solutions Teacher Rubrics.**

BENCHMARK ASSESSMENT

BEFORE THE ASSESSMENT

Prior to starting, take a few minutes to review the assessment and the associated **Earthquake Solutions Student Rubrics** with the class. Remind students to complete this assessment individually so that you can gather information about what they know and are able to do in relation to what they have learned so far in the module. Give students an opportunity to ask you any questions they may have.

TEACHER RUBRICS

This assessment is evaluated using rubrics that are designed to provide formative information in order to guide further instruction. Each rubric begins by identifying the location of student responses that provide evidence (e.g., Questions 1–2). The rubric levels reflect increasing levels of performance in relation to the knowledge and skills being measured, and range from Emerging to Advanced. The bolded rubric language indicates how performances progress across the levels of the rubric.

In the **Earthquake Solutions Teacher Rubrics**, each performance level is further explained by accompanying "Look Fors", which are located underneath each level. They provide an example of what you might see in student performance at that particular level to help you evaluate student work.

For each Teacher Rubric there is also an Item Level Claim Statement (ILCS). This is a brief statement showing the performance outcome for each rubric, to illustrate how it aligns to the PE.

STUDENT RUBRICS

Before students take the assessment, share the **Earthquake Solutions Student Rubrics** with them. Reviewing rubrics allows students to understand how their work will be evaluated and what they need to produce to achieve each of the four levels. Students should have access to these rubrics while they complete the assessment. When giving students their final rubric scores, you can discuss the evidence from their work that led to each assigned score.

Note: The student version of the rubrics does not contain the Look Fors section, with specific answer examples.

Rubrics

Rubric 1: Use Rubric 1 to evaluate student responses for Questions 1 and 2.

Emerging	Developing	Proficient	Advanced
Student **identifies incorrect solution**. **OR** Student **does not identify a solution.**	Student identifies **correct solution with an explanation that superficially addresses constraints or knowledge about earthquakes.** **OR** Student identifies correct solution with explanation that **includes inaccurate or irrelevant information about constraints or earthquakes.**	Student identifies correct solution with an explanation **that accurately** addresses constraints or knowledge about earthquakes.	Student identifies correct solution with an explanation that **clearly and accurately** addresses constraints **and** knowledge about earthquakes **in relation to the other solution**
Look Fors: • No response (e.g., "Not sure"). • Incorrect solution is identified.	**Look Fors:** • Correct solution is identified with vague explanation (e.g., "Solution 2, because it will protect the building the best on its sides"). • Correct solution is identified with explanation that includes inaccurate or irrelevant information about constraints or earthquakes (e.g., "Solution 2, because it fits the city budget best and is made of the strongest materials (steel), which will protect the building best").	**Look Fors:** • Correct solution is identified with an explanation that accurately addresses both constraints OR includes accurate knowledge about the impact of earthquakes (e.g., "Solution 2 is my choice because it is put outside the building, and can be on the sides of the building, not on the front." OR "Solution 2 is best, because the steel-made cross braces will help keep the walls of the library from shaking during an earthquake and protect it from falling down").	**Look Fors:** • Correct solution is identified with an explanation that directly and accurately addresses both constraints and includes accurate knowledge about the impact of earthquakes and how they relate to each other (e.g., "Solution 2 is my choice because the cross braces can be placed on all sides of the building except the front to protect it from earthquakes. This solution meets the criteria because it is placed outside of the building and not on the front of the building. The cross bars will absorb the shaking of the earthquake, due to being made of steel, and due to their shape and position on the building. Because the cross bars will be on three sides on the building, it will absorb the shock of the shaking and prevent the building from being damaged and falling down").

PE 4-ESS3-2 SEP SEP-6 DCI ESS3.B DoK 1

ILCS: Students will identify and evaluate multiple solutions for reducing impacts of natural hazards on humans, in terms of meeting design criteria and constraints.

Rubric 2: Use Rubric 2 to evaluate student responses for Questions 3, 4, and 5.

Emerging	Developing	Proficient	Advanced
Student explanation of the effect of earthquakes on the unprotected and/or protected library is **inaccurate, incomplete, or irrelevant.** OR Student **does not identify any differences in effect of earthquakes on the library.**	Student explanation of the effect of an earthquake on the unprotected and protected library is **supported by superficial knowledge of earthquake safety.**	Student explanation of the effect of an earthquake on the unprotected and protected library is supported by **general and accurate knowledge of earthquake safety.**	Student explanation of the effect of an earthquake on the unprotected and protected library is supported by accurate, **relevant**, and **detailed** knowledge of earthquake safety.
Look Fors: • Incorrect cause-effect sequence is identified. • No cause-effect sequence is identified.	**Look Fors:** • A general cause-effect sequence is identified with vague references to relationships between the building structure, the protection, and the shaking from the earthquake (e.g., "The solution makes the library stronger so earthquakes won't hurt it").	**Look Fors:** • An accurate and relevant cause-effect sequence is identified with references to relationships between the building structure, the protection, and the shaking from the earthquake (e.g., "The solution helps protect the building by making the structure move less; with no protection the movement may cause the library to fall down").	**Look Fors:** • An accurate and relevant cause-effect sequence is identified and explained using detailed descriptions about the building structure, the protection, and the shaking from the earthquake (e.g., "The solution helps protect the building by increasing the amount of force needed to move the parts of the building. There may still be damage, but there will be less damage with protection").

PE 4-ESS3-2 DCI ESS3.B CCC CCC-2 DoK 2

ILCS: Students will use knowledge of earthquake safety to explain how a solution reduces the impact of an earthquake.

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QUESTION INVESTIGATE ANALYZE EXPLAIN EVALUATE

GRADE **4**
MODULE **4**

EARTHQUAKE ENGINEERING

Module Anchor Phenomenon:
How can we reduce the damage caused by earthquakes?

Driving Question 6
How can we redesign our buildings to make them safer during earthquakes?

Performance Expectations: 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans; 3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost; 3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem; 3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

In the final presentation of their engineering designs, students explain how decisions about building characteristics, such as materials' flexibility, shape, and symmetry, address the Module Anchor Phenomenon.



Overview: **Full Course**

Driving Question 6 How can we redesign our buildings to make them safer during earthquakes?

		FULL COURSE			
		LESSON		PAGE	SUGGESTED PACING
ENGAGE / EXPLORE		1	**Final Little Changes** Students review their designs based on what they have learned, before purchasing the materials for their structures.	184	45 min
EXPLAIN / ELABORATE		2	**Built to Last** In teams, students build their structures according to their revised designs. Students discuss the difficulties they encountered and predict how their structures will hold up to the tests in the next lesson	188	45 min
EVALUATE		3 ☑3-D	**Rumble! Tumble! Crumble!** Students test the stability of the structures they've designed and built. Students self-evaluate using the Earthquake-Resistant Design Rubric, then discuss the results of the tests.	192	45 min
ELABORATE		4	**Preparing Our Presentation** In teams, students prepare posters and informative presentations for the gallery walk in the next lesson.	198	45 min
EVALUATE		5 ☑3-D	**Presenting Our Work** Students present their posters in a gallery walk and self-assess their presentations. As a class, they discuss their ideas about the Module Investigative Problem.	202	45 min

Scientist and Engineer Investigation Experience:

Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · ☑3-D Assessment

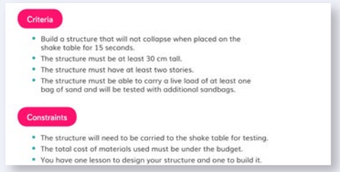
The Full Course is recommended for mastery of the Performance Expectations.
The Fast Track Course delivers the Next Generation Science Standards at an accelerated pace.

Overview: **Fast Track Course***

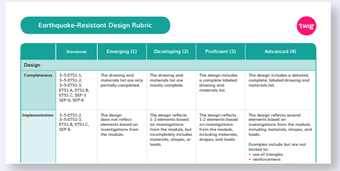
Driving Question 6 How can we redesign our buildings to make them safer during earthquakes?

RESOURCES	MATERIALS		
	TEACHER	TWIG SCIENCE LAB KITS	
• Family Outreach Letter 6 • Materials Order Form handout • Criteria and Constraints 3 visual • Earthquake-Resistant Design Rubric visual • Earthquake Safety Progress Tracker	• Building materials: Glue, marshmallows, newspaper, paper, pencils, spaghetti, tape	• Safety goggles • Building materials: Aluminum foil, cardboard, craft sticks, foam sheets, modeling clay, paper clips, pipe cleaners, straws, string, toothpicks	
• Materials Order Form handout • Criteria for Constraints 3 visual • Earthquake Safety Progress Tracker	• Building materials used in Lesson 1 • Metric rulers	• Safety goggles • Building materials used in Lesson 1	
• Family Outreach 2 handout • Earthquake-Resistant Design Rubric visual • Earthquake-Resistant Design Rubric • Earthquake Safety Progress Tracker	• Seismometer 6 app, installed on a smartphone or tablet • Tray • Camera (phone, tablet, etc.) • Scales • Small prize for winning team	• Safety goggles • Masking tape • Stopwatch • Resealable plastic bags • Sand	PERFORMANCE TASK
• Poster Guidelines visual • Earthquake-Resistant Design Rubric visual • Earthquake Safety Progress Tracker	• Glue • Markers • Photos of structures built by student teams • Poster paper • Poster boards		
• Earthquake-Resistant Design Rubric visual • Earthquake-Resistant Design Rubric			PERFORMANCE TASK

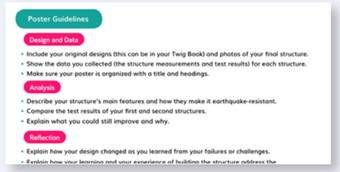
Resource Highlights



Criteria and Constraints 3 visual



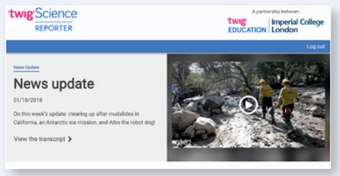
Earthquake-Resistant Design Rubric



Poster Guidelines visual



Professional Learning



Topical science news, features, and careers

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*Fast Track lessons/activities are identified by ⏱

FAST TRACK COURSE			
BLOCK	SUGGESTED PACING	LESSONS/ACTIVITIES	NOTES
1	40 min	**Sections from Final Little Changes** • Introduce the Activity • Review Structure Designs • Discuss Ideas and Concerns • Connect Today's Learning to DCI ETS1.B—Developing Possible Solutions • Formative Assessment	To save time, prepare the materials store ahead of the activity, assigning each material a cost, and displaying it on the table. Assign a Materials Manager in each team who will take an **Materials Order Form handout** to the store and fill out the correct prices per unit. The Materials Managers should also fill out the order form and collect the materials required before they start to build.
	35 min	**Sections from Built to Last** • Review Design Changes • Build Structures • Connect Today's Learning to the Driving Question	
2 3-D	35 min	**Sections from Rumble! Tumble! Crumble!** • Introduce the Activity • Test Structures • Self-Assess • Assess Student Work • Discuss Test Results • Formative Assessment	
		Preparing Our Presentation	
		Presenting Our Work	

Scientist and Engineer Investigation Experience:
Digital Investigation · Hands-On Investigation · Video Investigation · Reading for Evidence · 3-D Assessment

Leveled Readers

Differentiated Instruction—Highlights

Driving Question **6** How can we redesign our buildings to make them safer during earthquakes?

These high-interest, magazine-style leveled readers give students the opportunity to explore the ideas covered in the module in greater depth and meet real-world scientists and engineers. Available in 4 levels, they can be used in differentiated small-group reading time. On-Level lessons that accompany the readers are provided in the Teacher Edition. Above-Level, Below-Level, and English Learner lessons can be found online at www.twigscience.com.



		Guided Reading	ATOS
OL	On-Level	S	4.9
AL	Above-Level	U	6.2
BL	Below-Level	N	3.2
EL	English Learners	S	4.9

Shake, Rattle, and Roll

Chapter 1: The Curious Scientist

This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend informational texts while reading independently.

Chapter 2: STEM Career: Meet a Seismologist

This chapter focuses on the career of a seismologist. It includes an optional micro-lab in which students learn how energy is stored and released during an earthquake.

Chapter 3: Earthquake-Proofing: What's the Cost?

This chapter focuses on applying the science standards to students' lives, and examines different ways that engineers earthquake-proof buildings.

Already use another ELA program in your class? No problem! Each Twig Science module is aligned to Workshop Models and McGraw-Hill Wonders©. Benchmark Advance™ available online.

ELA CONNECTIONS

Workshop Models

RI.4.1–3 Key Ideas and Details
RI.4.4 Craft and Structure
RI.4.7, 9 Integration of Knowledge and Ideas
SL.4.1–2 Comprehension and Collaboration
SL.4.4–6 Presentation of Knowledge and Ideas
W.4.2, 3 Text Types and Purposes
W.4.4 Production and Distribution of Writing
W.4.7–9 Research to Build and Present Knowledge
W.4.10 Range of Writing

McGraw-Hill Wonders©

Unit 1, Week 3 Thinking It Through
Leveled Reader Landscapes
Student Anthology Earthquakes

English Learners

Lesson 1 Offer extra time for ELs to refamiliarize themselves with the rubric. Clarify any terms as needed. Help students bridge from their own language and concepts to the formal criteria outlined in the rubric.

Lesson 2 Offer students additional wait time to allow them to form and verbalize a question. Wait time is an important part of pacing when teaching ELs. In some cases, students may be internally translating and need a moment to catch up with the rest of the class. If you feel that some students may need added assistance, seek them out individually and ask them if they need any clarifications.

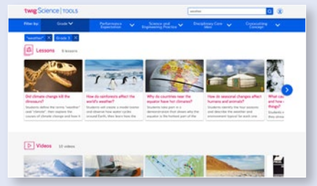
Lesson 3 In order to advance the way ELs are discussing their opinions about the testing, recast student responses to include modal expressions and phrasing.

Extension Activities

NGSS-mapped resources to help extend and enrich learning for students of all abilities.

twigScience TOOLS

www.twigsciencetools.com



Challenge

Lesson 5 Ask students to write notes in their Twig Books about which structures they think were the most successful, the most creative, and the most improved.

Special Needs

Executive Functioning

Lesson 3 If a student struggles to focus as they wait for their turn (or once their turn has passed), offer them an important job to keep them engaged. For example, they could let the test team know when to begin by calling out "Start your test!" You might also wish to designate various spaces where they could stand to watch the tests from different vantage points.

Lesson 4 Provide additional guidance to students who struggle to put a poster together or have difficulties organizing the information. For example, help them use titles and headers, and help them choose and position photos, diagrams, and drawings to enhance their writing. Remind students to put themselves in the shoes of a person that doesn't know anything about the topic, and look at their poster with the eyes of that person to see if the content is clear and understandable.

Lift foldout for Fast Track information

Time Savers

CCSS English Language Arts

Lesson 1–3, 5 SL.4.1 Comprehension and Collaboration

Lesson 3 W.4.4 Production and Distribution of Writing

Lesson 3, 4 W.4.10 Range of Writing

Lesson 4 W.4.7 Research to Build and Present Knowledge

Lesson 4, 5 SL.4.4–6 Presentation of Knowledge and Ideas

WIDA English Language Development

Lesson 1, 2, 3, 5 Standard 1: Social and Instructional Language

Lesson 4 Standard 2: The Language of Language Arts

Lesson 1–5 Standard 3: The Language of Mathematics

Lesson 1–5 Standard 4: The Language of Science

CCSS Mathematics

Lesson 1–5 4.MD.A Measurement and Data

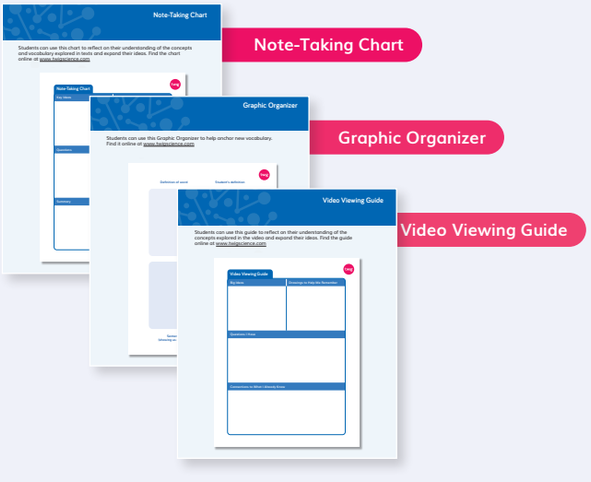
Lesson 1–5 MP6 Attend to precision

Access to Science Literacy and Vocabulary

Word Wall

Driving Question 1	natural disaster, earthquake, tsunami, volcano, energy transfer, waves, point of impact, amplitude, wavelength, seismic waves
Driving Question 2	ocean, Pacific Ocean, Atlantic Ocean, Ring of Fire, elevation, mountain range, belt, pattern, tectonic plates, fault, fault line, latitude, longitude
Driving Question 3	dead load, live load, horizontal load, compression (squeezing), tension (stretching), torsion (twisting), bending
Driving Question 4	-
Driving Question 5	civil engineer, structures, forces, mistakes, materials, engineering design process (problem, criteria and constraints, brainstorm, design, build a model, test, refine, share), hazard, safety, revise
Driving Question 6	**fair test, data, budget**

Additional Differentiated Support



See our full range of vocabulary support tools online.

Final Little Changes

OVERVIEW

Spark	**5 min**	Students review the criteria and constraints and the design rubric for their engineering design.
Investigate	**20 min**	Student teams continue to work on their designs, altering them according to their findings and reflections from the previous lessons.
Report	**8 min**	Students share questions, concerns, and ideas about their structures in a class discussion, brainstorming answers and solutions.
Connect	**5 min**	Students are reminded that communicating with peers and revising ideas are both important parts of engineering design.
Reflect	**7 min**	Students complete sentence frames about their redesigns in their Twig Books.

STANDARDS

NGSS

PE

4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

DCI

ETS1.A Defining Engineering Problems

ETS1.B Developing Possible Solutions

SEP

SEP-1 Asking Questions and Defining Problems

SEP-3 Planning and Carrying Out Investigations

CROSS-CURRICULAR CONNECTIONS

EPC

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

CCSS ELA

SL.4.1D Comprehension and Collaboration

WIDA

Standard 1: Social and Instructional Language (Listening, Speaking)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Listening, Speaking)

CCSS MATH

4.MD.A.3 Solve problems involving measurement and conversion of measurements

3-D LEARNING OBJECTIVES

Students will:

- Begin the second stage of the Performance Task, revising designs based on the results of previous tests and designing a stable structure to meet given criteria and constraints
- Discuss design ideas with peers.

Driving Question 6

How can we redesign our buildings to make them safer during earthquakes?

LESSON 1

RESOURCES

Digital

- **Family Outreach Letter 6**
- **Materials Order Form handout** (introduced in Driving Question 4, Lesson 1)
- **Criteria and Constraints 3 visual**
- **Earthquake-Resistant Design Rubric visual**
- **Earthquake Safety Progress Tracker**

Student

For each student:

- In kit: Safety goggles (if students start building their structures)

Building materials used in Driving Question 4, Lesson 1:

- In kit: Aluminum foil, cardboard, craft sticks, foam sheets, modeling clay, paper clips, pipe cleaners, straws, string, toothpicks
- Glue, marshmallows, newspaper, paper, pencils, spaghetti, clear tape

LESSON PREPARATION

- Print out the **Family Outreach Letter 6** (1 per student) to give to students at the beginning of class. You may also email a copy to parents or guardians.

  This letter provides families with an overview of the second Engineering Design Challenge and suggests questions families can ask students as they discuss the videos of their revised buildings.
- Review your notes from previous build lessons to recall students' previous structures.
- Reassemble the store from Driving Question 4, Lesson 1 so that students may look at materials before ordering them.
- Print out new **Materials Order Form handouts** (1 per team).
- Review the budget from Driving Question 4, Lesson 1. If you think $60 (or the amount you initially changed it to) was too high or too low, change it to a value you think is more appropriate.

Final Little Changes

Spark

5 min

Review the Rubric

Display and review the **Criteria and Constraints 3 visual**.

Display and review the **Earthquake-Resistant Design Rubric visual**. Remind them that they used this rubric to self-assess at the end of Driving Question 4, Lesson 3. Point out that this rubric has a new category, "Poster," that they will focus on later.

Investigate

20 min

Introduce the Activity

In their teams from the previous build, students will alter their designs according to their findings, discussions, and reflections from the past few lessons. In subsequent lessons, they will build and test their designs. As before, there will be a prize for the team whose structure survives the most tests and costs the least.

They will purchase materials from the store as before, and, if they have time, they can start building their revised structure today.

Give a **Materials Order Form handout** to each team.

Review Structure Designs

Have students review the table they filled out on page 91 of their Twig Books in Driving Question 5, Lesson 4 and discuss the changes and improvements they'd like to make to their designs.

Ask them to draw their new design on page 95 in their Twig Books.

Circulate and assess their ideas.

- ***What changes did you decide to make? Why?***
- ***Does your design still have weaknesses? How could you fix them?***
- ***How did you choose your materials? What are their properties?***

Twig Book, p.95

Improve Designs • Look over the table you filled out on page 90. Think about everything you've learned, discovered, and discussed about engineering for earthquake safety. With your team, revise your last design for a structure that meets all the Criteria and Constraints. Draw your new design and label changes made.

Drawings will vary, but good redesigns will consider insights from the table and apply knowledge about the ongoing process of designing solutions, which should better meet the criteria and constraints.

Explain that if teams want to start building their structures, they should go to the store and hand over their order forms. Check the math on the lists and dispense the requested items if it is correct. If it is not, ask students to revise their calculations.

Collect the order forms at the end of the activity and double-check all student calculations.

Prepare for the Report

Identify teams with concerns that might benefit from class discussion.

Fact Board

Earthquake Fact of the Day:

- In 1958, an earthquake occurred in Alaska's remote, sparsely-populated Lituya Bay. The resulting tsunami was 100 feet high, the highest tsunami wave ever recorded.

English Learners

Offer extra time for ELs to refamiliarize themselves with the rubric. Clarify any terms as needed. Help students bridge from their own language and concepts to the formal criteria outlined in the rubric.

Safety

Students should take care when breaking materials, e.g., spaghetti, and when applying forces and loads. Remind them to wear safety goggles and to hold the materials away from their faces and their classmates' faces.

Remind students never to eat any of the materials or put anything in their mouth.

Special Needs

Executive Functioning

Scaffold for students who need assistance by checking in with them 1-on-1 about their table from Driving Question 5, Lesson 4. Have them verbalize how it will assist their redesign and answer any questions they may have.

Report

8 min

Discuss Design Challenge

Invite students to share questions, concerns, and ideas about their structures for class discussion. Have the class brainstorm together to propose solutions and answers.

Connect

5 min

Connect Today's Learning to DCI ETS1.B—Developing Possible Solutions

Summarize the ideas shared during the Report. Remind students that communicating with peers and revising ideas are both important parts of engineering design. Explain that scientists and engineers communicate with their teammates (colleagues), but also communicate with researchers all over the world. Emphasize that sharing ideas and receiving feedback from others during the engineering design process helps improve designs.

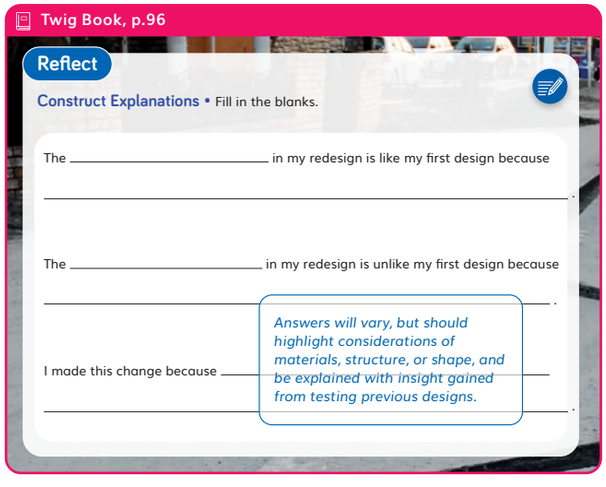
Explain that, in the next lesson, students will receive the materials they ordered and begin to build their revised structures (if they have not already started).

Reflect

7 min

Formative Assessment

Have students complete the sentence frames on page 96 in their Twig Books.



Use the Formative Assessment

Read students' responses and determine how well students are incorporating ideas and vocabulary related to materials, shapes, and loads. Look for evidence that students are using results from prior class research and tests to identify failure points and address them.

If needed, take some time during the next lesson to remind students to refer to their notes from previous lessons and incorporate these ideas and vocabulary into their work.

English Learners

Provide support as students complete the sentence frames in their Twig Books.

Substantial Support (Emerging Proficiency)

Read aloud the sentence frames and have students repeat. List key words on the board related to the activity and review them. Work with students to verbalize their answer to each part of the frame, offering vocabulary support before writing.

Moderate Support (Expanding Proficiency)

Have students work with a partner to complete each frame orally first to clarify their ideas before writing.

Light Support (Bridging Proficiency)

Have students share their completed sentence frames with a partner to get feedback on their ideas. Prompt them to revise, as needed.

Built to Last

OVERVIEW

Spark	**5 min**	Students consider the changes they've made to their structures, and one team shares some of their revisions with the class.
Investigate	**25 min**	Student teams build their improved structures, and record the height and number of stories of their new designs.
Report	**5 min**	Two student groups share their structures and describe any problems they encountered. They also predict what will happen when their structure is tested.
Connect	**5 min**	Students discuss their answers to the Driving Question.
Reflect	**5 min**	Students name their structure and explain why the name fits their structure well.

STANDARDS

NGSS

PE

4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

DCI

ETS1.A Defining Engineering Problems

ETS1.B Developing Possible Solutions

ESS3.B Natural Hazards

ETS1.C: Optimizing the Design Solution

SEP

SEP-1 Asking Questions and Defining Problems

SEP-3 Planning and Carrying Out Investigations

SEP-6 Constructing Explanations and Designing Solutions

CROSS-CURRICULAR CONNECTIONS

EPC

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

CCSS ELA

SL.4.1.B Comprehension and Collaboration

CCSS MATH

4.MD.A.3 Solve problems involving measurement and conversion of measurements

WIDA

Standard 1: Social and Instructional Language (Listening, Speaking)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Listening, Speaking)

3-D LEARNING OBJECTIVES

Students will:

- Continue to work toward the second stage of the Performance Task by building a structure based on which solutions better meet the criteria for success
- Identify problems and work with peers to find solutions during a build task.

Driving Question 6

How can we redesign our buildings to make them safer during earthquakes?

LESSON 2

RESOURCES

Digital

- **Materials Order Form handout**
- **Criteria and Constraints 3 visual**
- **Earthquake Safety Progress Tracker**

Student

For each student:

- In kit: Safety goggles

For each team:

- Metric ruler

Building materials used in Lesson 1:

- In kit: Aluminum foil, cardboard, craft sticks, foam sheets, modeling clay, paper clips, pipe cleaners, straws, string, toothpicks
- Glue, marshmallows, newspaper, paper, pencils, spaghetti, clear tape

LESSON PREPARATION

- Review your notes from previous build lessons to recall students' previous structures.
- Review the completed order forms that students filled in during the previous lesson and prepare the requested materials for each team.
- Keep a running record of the amount of money used by each team to buy their supplies. You will need to update this record if students purchase more items during the activity. The team that spends the least amount on building a structure that withstands the tests will earn a small prize in the next lesson.
- Print out new **Materials Order Form handouts** (1 per team) in case students need to buy more supplies from the store.
- Restock the store.

Built to Last

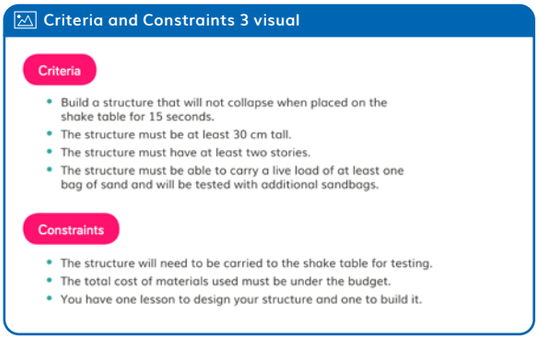
Spark

5 min

Review Design Changes

Review the **Criteria and Constraints 3 visual.**

Ask students to look at their work from the previous lesson in their Twig Books, and to consider all the changes and revisions they decided to make to their structures. Invite a team to explain one or two of their changes to the rest of the class.



Fact Board

Earthquake Fact of the Day:

- Data collected by the 1960s and 1970s Apollo space missions revealed that the Moon also has earthquakes, or rather moonquakes. The most powerful moonquakes occur only 20 to 30 km (10 to 20 mi.) below the surface, can last up to ten minutes, and reach 5.5 on the Richter scale.

Safety

Students should take care when breaking materials, e.g., spaghetti, and when applying forces and loads. Remind them to wear safety goggles and to hold the materials away from their faces and their classmates' faces.

Remind students never to eat any of the materials or put anything in their mouth.

English Learners

Offer students additional wait time to allow them to form and verbalize a question. Wait time is an important part of pacing when teaching ELs. In some cases, students may be internally translating and need a moment to catch up with the rest of the class. If you feel that some students may need added assistance, seek them out individually and ask them if they need any clarifications.

Special Needs

Executive Functioning

It may help some students to organize the remaining material in a way that relates to their redesign.

Investigate

25 min

Introduce the Activity

Today, teams will finish building their structures. Students can purchase more materials during the lesson by filling out a new order form and visiting the store.

Ask if students have any questions regarding the activity or their designs.

Build Structures

Have teams spend a few minutes reviewing their designs and then begin building. Ensure students work collaboratively. Point out that this is part of the rubric for this project.

Help students review and assess their structures.

- ***What changes did you make to your design? Why?***
- ***Are you satisfied with your new design?***
- ***What will happen when the structure shakes on the earthquake simulator?***
- ***What will happen when you put the live load on it?***
- ***Do you think you have fixed all the weak points of your structure?***
- ***What could you do to further reinforce it?***
- ***Do you need to buy more supplies to reinforce it?***

Have students record the number of stories, and the height in cm, on page 97 in their Twig Books.

If any teams finish early, ask them to provide support to any teams that are struggling.

Prepare for the Report

Identify two groups to lead the discussion—one that had an easy time building their structure, and one that had a more difficult time.

Check in with each group to make sure their construction is complete.

Report

5 min

Discuss Problems and Predictions

Invite the two groups you selected to share their structures with the rest of the class. Ask them to describe any problems that they encountered and to predict what will happen when they test their structures.

Encourage the rest of the class to join in with the discussion. Ask other students to describe their own experiences and predictions.

Connect

5 min

Connect Today's Learning to the Driving Question

Summarize the activity and highlight particularly well-reasoned revisions to students' engineering designs.

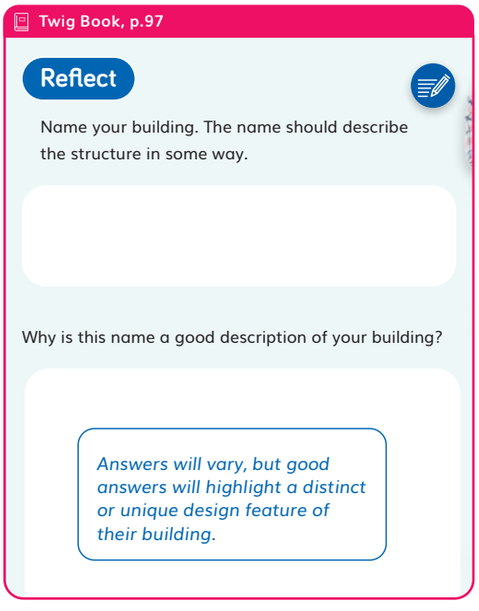
Reiterate and discuss the Driving Question. Encourage students to share, discuss, expand upon, and refine ideas as a class. Remind students that in the next lesson they will test their revised structures.

Reflect

5 min

Formative Assessment

Have students turn to page 97 in their Twig Books and invent a name that describes their structures. They should explain why the name is a good description.



Use the Formative Assessment

Read students' answers. Look for students who have incorporated ideas about the types of materials and other design elements they used or the purpose of the structure.

Identify teams that may need further assistance describing their structures' elements and purpose. Consider assisting these teams when they create their posters in Lesson 4. If many students appear to need further assistance, consider reviewing and emphasizing the design concepts in the next lesson.

English Learners

Provide linguistic frames to assist students in presenting their ideas and internalizing linking words.

Substantial Support (Emerging Proficiency)

- I predict that _____.

Moderate Support (Expanding Proficiency)

- I predict _____ because _____ .

Light Support (Bridging Proficiency)

- Based on _____, I predict _____ because _____ .

Rumble! Tumble! Crumble!

3-D

OVERVIEW

Spark	**5 min**	Students discuss why they will use a seismograph as they test their structures.
Investigate	**27 min**	Student teams conduct a final test of their structures, taking notes in their Twig Books to record what happens.
Report	**5 min**	Student teams compare the results of their test with the previous test they conducted. They discuss what they would do differently if they had time to build a third structure.
Connect	**3 min**	Students look at the "Poster" category of the design rubric and learn they will be assessed based on a poster presentation.
Reflect	**5 min**	Students choose two designs they thought were successful, then document and compare them.

STANDARDS

NGSS

PE

4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

3–5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost

3–5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem

3–5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

DCI

ETS1.B Developing Possible Solutions

ETS1.C Optimizing the Design Solution

SEP

SEP-1 Asking Questions and Defining Problems

SEP-3 Planning and Carrying Out Investigations

SEP-6 Constructing Explanations and Designing Solutions

CROSS-CURRICULAR CONNECTIONS

EPC

Principle V Decisions Affecting Resources and Natural Systems are Complex and Involve Many Factors

CCSS ELA

W.4.4 Production and Distribution of Writing

W.4.10 Range of Writing

SL.4.1.C Comprehension and Collaboration

CCSS MATH

4.MD.A.3 Solve problems involving measurement and conversion of measurements

WIDA

Standard 1: Social and Instructional Language (Listening, Speaking)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Listening, Speaking)

3-D LEARNING OBJECTIVES

Students will:

- Complete the second stage of the Performance Task by testing the stability of their structures on an earthquake simulator
- Self-assess to determine how well project criteria have been met.

Driving Question 6

How can we redesign our buildings to make them safer during earthquakes?

LESSON 3

RESOURCES

Digital

- **Family Outreach 2 handout**
- **Earthquake-Resistant Design Rubric visual**
- **Earthquake-Resistant Design Rubric**
- **Earthquake Safety Progress Tracker**

Teacher

- In kit: Safety goggles
- In kit: Masking tape
- In kit: Stopwatch
- In kit: Resealable plastic bags
- In kit: Sand
- Camera (phone, tablet, etc.)
- Scales
- Seismometer 6 app, installed on a smartphone or tablet
- Small prize for winning team
- Tray

Student

For each student:

- In kit: Safety goggles

LESSON PREPARATION

- Build your earthquake simulator and testing station:
  - Choose a table or desk to be used as a station.
  - Fill a tray with sand (3–6 cm deep) and set the tray on the station.
  - On the edge of the table, affix two pieces of masking tape approximately 30 cm apart.
  - Simulate an earthquake by moving the tray back and forth between the two pieces of tape for 15 seconds.
  - Prepare five live loads (sand bags). Fill each plastic bag with 25 g of sand.
  - Set up a camera to record the tests.
  - Set up the Seismometer 6 app (see Driving Question 1, Lesson 5) on a book next to the earthquake simulator.
- If you want students to include the seismometer graphs in their posters or take them home, ensure that you can email the graphs of the Seismometer 6 app from the phone on which it is installed.
- Take photos of all structures.
- Assess each structure to get a sense of how it was built and with what materials, its strengths and weaknesses, and how it might respond to the tests. This preliminary assessment will help you anticipate and guide the Report discussion.
- Prepare a small prize for the team that spent the least on a structure that did not collapse.
- Print a copy of the **Family Outreach 2 handout** for each student.

Word Wall

- fair test
- data
- budget

Spark

5 min

Fact Board

Earthquake Fact of the Day:

- The Chinese astronomer Zhang Heng (CE 78–139) invented one of the first known earthquake detectors nearly 2,000 years ago. Made of eight bronze dragons encircling a cylinder and eight bronze frogs below, it could detect the direction of an earthquake.

English Learners

In order to advance the way ELs are discussing their opinions about the testing, recast student responses to include modal expressions and phrasing.

- In my opinion, the seismograph will probably _____.

Discuss Seismographs

Show students the Seismometer 6 app and explain that you will be using a seismograph during this lesson's tests.

- ***Why would we use a seismograph in this test?***
- ***What information will it give us and why is it important?***

Remind students that, to be able to compare structures, it's important to try to have the same testing conditions for each one. Using a seismograph will show us if the simulated earthquakes are approximately the same and if the structures are being tested under the same conditions.

Explain that, in today's formal tests, you will activate the earthquake simulator. Clarify that having the same person doing the test will reduce the likelihood of simulating different earthquakes for students' structures.

Collect and Display—Collect (Language Routine)

Make note of the everyday language students use to describe testing conditions. This output of language is important, as it will be used as a reference that students can build on and connect to as they develop scientific language.

Investigate

27 min

Introduce the Activity

Today, teams will perform the final tests on their structures.

Review the testing steps on page 98 in the Twig Book.

Twig Book, p.98

Test Solutions • Test the structure you designed and built by following these steps.

1. Put on your safety goggles.
2. Make sure the video is ready to record and have your stopwatch ready.
3. Test that your structure can survive an earthquake by shaking it with the earthquake simulator for 15 seconds.
4. If your structure does not collapse, place a sand bag on the structure and shake for 15 seconds. Record your result. Repeat by adding additional bags, one at a time, until the structure collapses.
5. Wait for the teacher to stop the video.

Live Load	Time
0	
1	
2	
3	
4	
5	

Test Structures

Have teams come up one at a time and test their structures in front of the class, with you operating the earthquake simulator. Remind students to record how long the structure stands for each live load test on page 98 in their Twig Books.

Students not currently testing should take notes in their Twig Books about what happens during the tests. If you are going to email the seismograph's graphs, do so now.

Self-Assess

When a team finishes testing, ask them to use the **Earthquake-Resistant Design Rubric visual** to self-assess their project. Students should ignore the "Poster" category of the rubric for now—they will refer to it in the next lesson.

Assess Student Work

Assess students' work with the **Earthquake-Resistant Design Rubric**.

Prepare for the Report

Determine which team built the most stable structure for the least money.

Safety

Students should take care when testing their structures on the shake table. Remind them to wear safety goggles.

Remind students never to eat any of the materials or put anything in their mouths.

Special Needs

Executive Functioning

If a student struggles to focus as they wait for their turn (or once their turn has passed), offer them an important job to keep them engaged. For example, they could let the test team know when to begin by calling out "Start your test!" You can also designate various spaces where they could stand to watch the tests from different vantage points.

Report

5 min

Discuss Test Results

Congratulate the team that built a structure that survived the most tests and that spent the least amount of their budget. Hand them the prize you prepared.

Ask students to compare their results from this test to the results of the test they did using their first designs.

Have students discuss what they would do differently if they had time to build a third structure.

Collect and Display—Display (Language Routine)

Make relevant connections from what students said in their explanations to essential academic vocabulary about testing conditions. Add the terms *fair test*, *data*, and *budget* to the academic word wall.

Misconceptions from the Pre-Exploration

Use the **Earthquake Safety Progress Tracker** to note if students have the following misconception.

Misconception	What to Do
Heavy buildings are always better than lightweight buildings at standing up during an earthquake.	Ask students to summarize what characteristics they think are most important in determining the stability of a structure during an earthquake. If they repeat the misconception that the heaviest buildings are the most stable, ask for other observations about the winning design(s). Highlight characteristics like shape, flexibility, reinforcement, or symmetry.

Connect

3 min

Discuss the Rubric

Display the **Earthquake-Resistant Design Rubric visual** and draw students' attention to the "Poster" category. Explain that, in the next lesson, they will prepare a poster presentation of all the work they did in the past few weeks. They will be assessed according to the "Poster" section of the rubric.

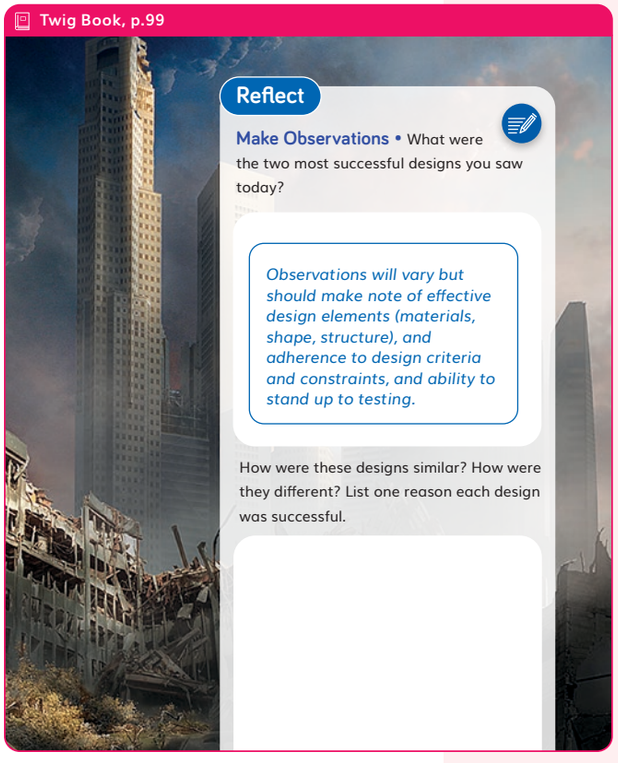
They will have a chance to review the rubric and ask questions at the start of the next lesson.

Reflect

5 min

Formative Assessment

Have students turn to page 99 in their Twig Books and note two designs that they thought were successful. Ask them to compare designs and provide a reason why they think each one was successful.



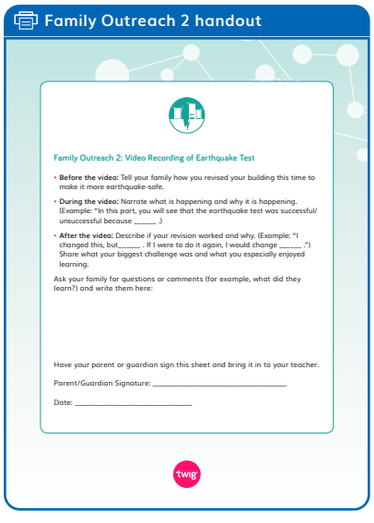
Use the Formative Assessment

Read students' responses. They should refer to designs that remained standing during the shake table test and make comparisons between the designs. Their reasoning should include ideas related to the success of the structure during the test or to the design elements. Identify students who do not incorporate these ideas into their reasoning. Consider working with these students individually during the poster-making session in the next lesson.

Assign Homework

Ask students to share the videos of their second build with their families. Give a **Family Outreach 2 handout** to each student, which provides guidance to students as they present their videos.

Ask students to have a family member sign the form.



Preparing Our Presentation

OVERVIEW

Spark	**10 min**	Students study a visual explaining poster guidelines and review the design rubric, focusing on the "Poster" category.
Investigate	**25 min**	Student teams prepare posters that show everything they have done in the module to build their models and address the Module Investigative Problem.
Report		*There is no Report in this lesson.*
Connect	**5 min**	Students learn that by creating and presenting their posters, they share information in a clear and understandable way, just like scientists.
Reflect	**5 min**	Students' posters are assessed using the guidelines previously discussed.

STANDARDS

NGSS

PE — **4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

DCI — **ESS3.B** Natural Hazards

SEP — **SEP-8** Obtaining, Evaluating, and Communicating Information

CNS — Influence of Science, Engineering, and Technology on Society and the Natural World

CROSS-CURRICULAR CONNECTIONS

CCSS ELA — **W.4.7** Research to Build and Present Knowledge

W.4.10 Range of Writing

SL.4.5 Presentation of Knowledge and Ideas

WIDA — **Standard 2:** The Language of Language Arts (Writing, Listening)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Writing, Listening)

CCSS MATH — **4.MD.A.3** Solving problems involving measurement and the conversion of measurements

3-D LEARNING OBJECTIVES

Students will:

- Begin to work toward the third and final stage of the Performance Task by creating posters and presentations of their work over the past few weeks.

Driving Question 6

How can we redesign our buildings to make them safer during earthquakes?

LESSON 4

RESOURCES

Digital

- **Earthquake-Resistant Design Rubric**
- **Poster Guidelines visual**
- **Earthquake-Resistant Design Rubric visual**
- **Earthquake Safety Progress Tracker**

Student

For each team:

- Glue
- Markers
- Photo of the team's structure
- Poster paper
- Poster board

LESSON PREPARATION

- There is no Report in this lesson to allow more time for teams to work on their posters.
- Print out photos of the structures built if students do not already have them and distribute these to teams.
- Review the "Poster" category of the **Earthquake-Resistant Design Rubric**. Modify it if necessary to suit your needs.

Preparing Our Presentation

Spark

10 min

Fact Board

Earthquake Fact of the Day:

- The destruction caused by earthquakes can be extremely costly when they occur in densely-populated areas. For example, the 2011 Tohoku-Oki earthquake and tsunami in Japan is estimated to have cost $300 billion in damage.

Twig Book, p.100



Preparing Our Presentation

LESSON 4

Poster Guidelines

Design and Data

- Include your original designs (this can be in your Twig Book) and photos of your final structure.
- Show the data you collected (the structure measurements and test results) for each structure.
- Make sure your poster is organized with a title and headings.

Analysis

- Describe your structure's main features and how they make it earthquake-resistant.
- Compare the test results of your first and second structures.
- Explain what you could still improve and why.

Reflection

- Explain how your design changed as you learned from your failures or challenges.
- Can you answer the Module Anchor Phenomenon: How can we reduce the damage caused by earthquakes?

Challenge

Add a section on your poster about where you might build a full-scale version of your structure, and why. Include a description of the site, a drawing or map, and a written explanation.

Driving Question 6 | Lesson 4

English Learners

Offer ELs additional time to preview the rubric with a partner who can paraphrase and reiterate what must be on the poster, and what they need to do during the presentation. Repetition is key for ELs with lower levels of English proficiency. If time can be allotted outside of the lesson, ELs may wish to briefly rehearse their presentation in advance of the in-class session.

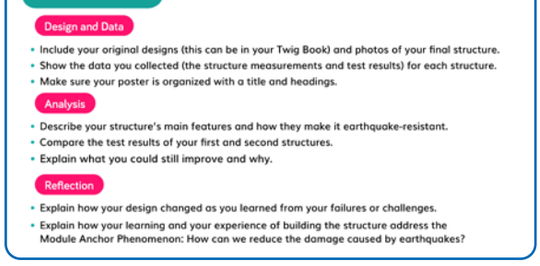
Academic Vocabulary Check

- *engineering design process*
- *materials*
- *budget*
- *structures*
- *criteria*
- *constraints*
- *refine*
- *revise*
- *live load*
- *dead load*
- *compression*
- *fair test*
- *data*

Introduce the Poster Guidelines

In the next lesson, each team will present the work they have done to engineer their structures over the past few weeks. Explain that they will create a poster and present it to their classmates.

Poster Guidelines visual



Poster Guidelines

Design and Data

- Include your original designs (this can be in your Twig Book) and photos of your final structure.
- Show the data you collected (the structure measurements and test results) for each structure.
- Make sure your poster is organized with a title and headings.

Analysis

- Describe your structure's main features and how they make it earthquake-resistant.
- Compare the test results of your first and second structures.
- Explain what you could still improve and why.

Reflection

- Explain how your design changed as you learned from your failures or challenges.
- Explain how your learning and your experience of building the structure address the Module Anchor Phenomenon: How can we reduce the damage caused by earthquakes?

Display the **Poster Guidelines visual** and read the bullet points aloud, or ask a student to do so. Point out these guidelines are also on page 100 in the Twig Book. Pause after each category to answer any questions.

Review the Rubric

Display the **Earthquake-Resistant Design Rubric visual** and display the "Poster" category. Read through the category as a class. Have student pairs discuss the various components and proficiency levels of the category.

Remind students that you will be using the rubric to assess their work.

Investigate

25 min

Introduce the Activity

Today, teams will make posters that show everything they have done throughout the module to both build their structures and address the Module Investigative Problem: How can we reduce the damage caused by earthquakes?

Their posters will be displayed in a gallery walk in the next lesson, and each team will answer their classmates' questions about their posters.

Create Posters

Have teams work together to create their poster. They should consult their notes, KLEW Charts, and any other materials they collected which contain relevant information. They may display their original designs from their Twig Books without tearing the pages out. However, they should rewrite the data they collected in a finished format for their posters. Explain that scientists and engineers need to present data clearly.

Circulate and identify highlights from each poster to share during the Connect.

Have students think about what they will say during their presentation. They should ask themselves:

- How will we start our presentation?
- What will we say?
- How will our presentation end?

Remind students that they should prepare to respond to any questions that might be asked during the gallery walk.

Connect

5 min

Connect Today's Learning to SEP-8—Obtaining, Evaluating, and Communicating Information

Remind students that scientists and engineers need to communicate their ideas and evidence to others. They may share information in writing or in spoken presentations, and use graphs, diagrams, models, and data tables to make their information clear and understandable to their audience.

Explain that, by creating and presenting their posters, students are practicing these important skills.

Identify highlights you observed as students were creating their posters.

Reflect

5 min

Formative Assessment

Look over teams' posters.

Use the Formative Assessment

Check that teams' posters address all of the guidelines.

Identify teams whose posters do not provide sufficient evidence. Think of questions to ask these teams during the gallery walk presentations in the next lesson. These questions should aim to address any missing or insufficient elements.

Special Needs

Executive Functioning

Provide additional guidance to students who struggle to put a poster together or have difficulties organizing the information. For example, help them use titles and headers, and help them choose and position photos, diagrams, and drawings to enhance their writing. Remind students to put themselves in the shoes of a person that doesn't know anything about the topic, and look at their poster with the eyes of that person to see if the content is clear and understandable.

English Learners

Review the Poster Guidelines with students before they work on their presentations.

Substantial Support (Emerging Proficiency)

Read aloud each guideline. Highlight key words such as *original*, *design*, *collected*, and *structure*. Rephrase each guideline to assist in understanding. Have students restate each point in their own words.

Moderate Support (Expanding Proficiency)

Review the guidelines, highlighting key words such as *original*, *design*, *collected*, and *structure*. Have students restate each point in their own words to check understanding.

Light Support (Bridging Proficiency)

Have students read the guidelines to a partner and restate them in their own words. Circulate, listen in, and check understanding.

Presenting Our Work

☑ 3-D

OVERVIEW

Spark	**5 min**	Students learn they will be using the "Poster" rubric category to self-assess their posters and presentations.
Investigate	**20 min**	Students present their posters with their teams and do a gallery walk to view other presentations and posters.
Report	**5 min**	The teacher and students share what they consider to be the highlights of the presentations.
Connect	**7 min**	Students summarize their ideas about the Module Investigative Problem. They share, discuss, and refine ideas as a class.
Reflect	**8 min**	Students self-assess their presentations and posters, noting the description in each row of the rubric that best describes their work.

STANDARDS

NGSS

PE — **4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans

DCI — **ESS3.B** Natural Hazards

SEP — **SEP-8** Obtaining, Evaluating, and Communicating Information

CETAS — Influence of Science, Engineering, and Technology on Society and the Natural World

CROSS-CURRICULAR CONNECTIONS

CCSS ELA — **SL.4.1** Comprehension and Collaboration

SL.4.4, SL.4.6 Presentation of Knowledge and Ideas

WIDA — **Standard 1:** Social and Instructional Language (Speaking)

Standard 3: The Language of Mathematics (Writing, Reading)

Standard 4: The Language of Science (Speaking)

CCSS MATH — **4.MD.A.3** Solve problems involving measurement and the conversion of measurements

3-D LEARNING OBJECTIVES

Students will:

- Complete the final stage of the Performance Task as they communicate information about the engineering process in visual and oral presentations
- Answer peers' questions about their work.

Driving Question 6

How can we redesign our buildings to make them safer during earthquakes?

LESSON 5

RESOURCES

Digital

- **Earthquake-Resistant Design Rubric visual**
- **Earthquake-Resistant Design Rubric**

LESSON PREPARATION

- Review your notes from the previous lesson's Formative Assessment to inform your line of questioning during students' presentations.
- If possible, ask teachers and/or students from other classes to participate in the gallery walk in order to ask students questions.

Presenting Our Work

Spark

5 min

Fact Board

Earthquake Fact of the Day:

- Some of the earliest scientific seismometers were called spring-pendulum seismometers—they could weigh up to 15 tons! A medium-sized one still located in Mexico City reaches a height of three stories.

English Learners

Offer one sample question students might ask of a team, and let them think of the other on their own. They should look at the language of the rubric for ideas.

Substantial Support (Emerging Proficiency)

- Did every person on your team help with the new build?

Moderate Support (Expanding Proficiency)

- How did your team decide on the features of your structure?

Light Support (Bridging Proficiency)

- What types of design changes impacted your final test?

Challenge

Ask students to write notes on page 101 in their Twig Books about which structures they think were the most successful, the most creative, and the most improved.

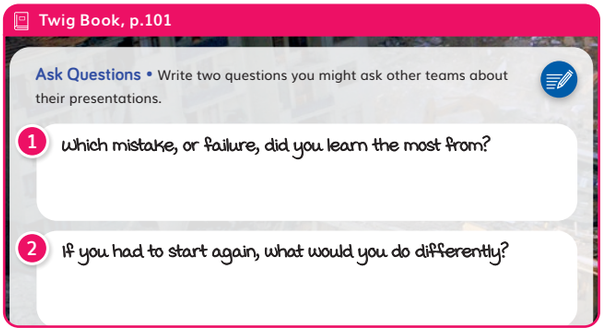
Prepare for the Presentation

Display the **Earthquake-Resistant Design Rubric visual**. Point out the "Poster" category to remind students of its content, and explain that they are going to be using this part of the rubric to self-assess their posters and presentations.

Provide students with guidelines for how to respectfully observe presentations and ask questions.

Have students turn to page 101 of their Twig Books and write two questions that they might ask other teams.

To help students relax, have the class do a confidence pose. Have students choose a pose that they associate with feeling confident and successful. Ask them to hold that pose for 30 seconds.



Investigate

20 min

Introduce the Activity

Students will now present their posters with their teams. Remind them that when they are not presenting, they will do a gallery walk to view other students' presentations.

Gallery Walk and Presentations

Have teams begin their gallery walk and presentations.

If possible, bring in teachers and/or students from other classes to watch presentations and ask questions. Otherwise, have two students from each team present and explain the poster while the other team members listen to other teams' presentations and ask questions. Have students switch roles after 10 minutes.

Prepare for the Report

Circulate as students present and note highlights, such as:

- Students asking good questions
- Students explaining their poster clearly
- Students with great visuals
- Students working well with their team members to present their poster.

Report

5 min

Discuss Presentation Highlights

Discuss highlights from both the gallery walk and the presentations.

Have students share what they consider the highlights of the presentations. Share some of your own highlights as well.

Connect

7 min

Connect Today's Learning to Engineering Design and the Module Investigative Problem

Congratulate students on the work that they did to design, test, revise, and present their earthquake-resistant buildings. Explain that students have demonstrated understanding of the engineering design process and explored the Module Investigative Problem: How can we reduce the damage caused by earthquakes?

Ask students to summarize their ideas about the Module Investigative Problem. Encourage them to share, discuss, expand upon, and refine ideas as a class.

Reflect

8 min

Self-Assess

Ask students to self-assess their posters and presentations using the "Poster" category of the rubric.

Explain that they should look at each category and try to choose the level of proficiency that most closely fits their experiences. Have them note on a separate piece of paper the descriptions that best describe their work.

Assess Student Work

Assess students' work using the **Earthquake-Resistant Design Rubric**. Remember that some student work (e.g., their original designs) may be in their Twig Books.

Review students' self-assessments and compare them to your own to determine if students have a reasonable understanding of their strengths and weaknesses. Use this information to advise students on areas to improve.

GRADE **4**
MODULE **4**

Shake, Rattle, and Roll

Chapter 1: The Curious Scientist
This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend informational texts while reading independently.

Chapter 2: STEM Career: Meet a Seismologist
This chapter focuses on the career of a seismologist. It includes an optional micro-lab in which students learn how energy is stored and released during an earthquake.

Chapter 3: Earthquake-Proofing: What's the Cost?
This chapter focuses on applying the science standards to students' lives, and examines different ways that engineers earthquake-proof buildings.

Find Above-Level, Below-Level, and English Learner lessons online at www.twigscience.com.



Leveled Reader Lessons OL

The Curious Scientist

First Read

Overview

This chapter focuses on the practices scientists use to learn about earthquakes. It teaches students strategies that skilled readers use to navigate and comprehend information while reading independently.

Objectives

Students will:

- Navigate and read informational texts
- Apply comprehension and vocabulary strategies
- Interpret text features (headings, maps, graphs)
- Read and write across texts.

CCSS ELA Standards

- RI.4.1
- RI.4.2
- RI.4.3
- RI.4.4
- RI.4.6
- RI.4.7
- RI.4.9
- RI.4.10
- L.4.4

Preview the Text

Have students preview Chapter 1 using the preview routine.

Step 1: Read the title of the chapter. It tells the topic of the chapter.

Step 2: Read the introduction and headings. They relate to the main idea of each section of the chapter. Think about what the main ideas may be.

Step 3: Look over the photos and illustrations. You'll study them later.

Step 4: Notice any features, such as special type, maps, or diagrams.

Step 5: Based on your preview, ask yourself what the chapter will be about.

Prompt students to share their answers to Step 5, along with any other comments or questions they have about the text.

- ***What challenges might you face in reading the chapter?***
- ***What reading tools do you have to tackle them?***

Prepare

Ask students to share what they already know about earthquakes, and how scientists have learned about them. What have they read, seen, or heard in videos and other readings? This will provide students background they can draw on as they read.

Give students 2 minutes to do a turn and talk with a partner and share what they know about the topic.

Vocabulary Routine

Ensure students understand important new chapter vocabulary using the vocabulary routine.

- ***Why might an author boldface a term?***
- ***What does this add to the text?***

Step 1: Have students find and read the boldfaced content terms in Chapter 1 (**data**, **crust**, **tectonic plate**, **fault line**, **seismic waves**, **seismograph**, **magnitude**).

Step 2: Ask students to turn to the Visual Glossary on page 31. Tell students it may help them understand a given term.

Step 3: Repeat the terms as a class to confirm pronunciations.

Step 4: Point out the meanings of multiple-meaning words such as *crust* and *fault* that may cause students confusion.

Step 5: Review the additional academic words using the following simple definitions and context sentences. Point out related words and word parts to expand students' vocabulary.

originate

Define: to begin

Example: Where did the game of baseball *originate*?

Ask: Why would it be important to know where a rumor originated?

Related Words: origin, original

observation

Define: the act of looking closely at something and noticing details

Example: *Observations* of plants have taught us how they grow best.

Ask: What interesting observations have you made at school?

Related Words: observe, observer, observing, observatory

Word Part: *-tion*

massive

Define: very large

Example: The *massive* building had over fifty floors.

Ask: What is the most massive thing you've seen?

Related Words: gigantic, huge

Word Part: suffix *-ive* (adjective form of a verb)

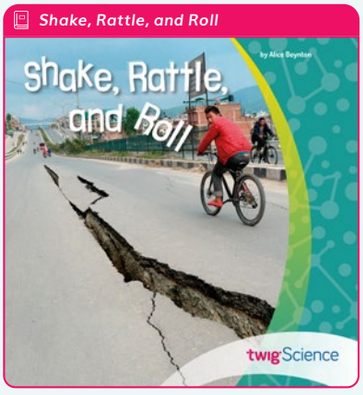
ancient

Define: very old; of a time in the long past

Example: The scientists dug up an *ancient* city in Egypt.

Ask: What can you learn from ancient books, artifacts, and tools?

Related Word: modern (antonym)



The Curious Scientist

Level Up

For students who struggle with the On Level book, guide them through a reading of the Below Level book first. Then have them listen to a recording of the On Level book and follow along with the text. This scaffolding should prepare students for reading the On Level book in small groups.

Pacing

It is recommended that you read one chapter each Driving Question of the module. If the module extends past three Driving Questions, revisit the chapters.

As an alternative, read topic-related books from your reading program or classroom leveled library in later weeks.

Engage students in reading across texts activities to help them analyze and synthesize the information. For example, have students complete a Venn diagram to compare and contrast two of the books, followed by writing a summary of their findings.

Special Needs

Provide digital tools (e.g. tablets) for students to record notes. Allow alternate ways of expressing ideas, such as through drawings.

Read

Ask students how they might approach reading Chapter 1. Model text navigation, if needed. Since students have already previewed the text, they should start by rereading the title and introduction.

Tell students to begin their reading of the main text. If they struggle with a boldfaced term, prompt them to use context clues and/or structural analysis to pronounce and determine its meaning.

Note: If necessary, they may turn to the Visual Glossary on page 31.

The author may suggest the reader look at a photograph, chart, or other visual. In this case, they should stop and do so. If not, they should read the section or page and then look at its visuals.

- ***Does the visual illustrate something in the text?***
- ***Does it add new information? How does that information relate to the text?***

Remind students they can go back and study the photos and illustrations more closely when they finish reading. Tell students that if the page has a sidebar, they should read it last.

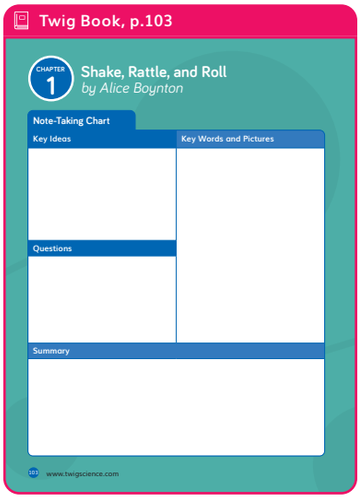
Connect to Writing—Note-Taking

Have students turn to the Note-Taking Chart on page 103 of their Twig Books.

As students read Chapter 1, ask them to:

1. Write down key words and phrases to help them remember the big ideas; they can also draw pictures
2. Note their questions and confusions about the text by jotting down the page and paragraph number of the confusing sentence or section
3. Write a two- or three-sentence chapter summary.

While students are reading and taking notes, circulate and take note of any common confusion. During the after-reading discussion, you can go back to the text and model your thinking to clarify.



Build Content Knowledge

During the discussion of the text, focus on the following Next Generation Science Standards.

PERFORMANCE EXPECTATIONS	**4-ESS2-2** Analyze and interpret data from maps to describe patterns of Earth's features.	*Focus on reading and interpreting the maps on pages 10, 12, and 13. Teach students a map-reading routine; discuss how these maps complement the text.*
DISCIPLINARY CORE IDEAS	**ESS3.B** Natural Hazards	*Stress the three kinds of natural hazards mentioned in the text and how they are related: earthquakes, tsunamis, and volcanoes. Have students record details on the causes and effects of earthquakes.*
SCIENCE AND ENGINEERING PRACTICES	**SEP-1** Asking Questions and Defining Problems	*Highlight the steps Aristotle took to arrive at his conclusions about earthquakes (collected facts, recorded data, asked questions, made observations, arrived at conclusions based on evidence); relate these to today's science and engineering practices.*
CROSSCUTTING CONCEPTS	**CCC-1** Patterns	*Emphasize the patterns that can be determined by looking at the Ring of Fire maps on pages 12–13.*

Ask Text-Dependent Questions

Ask the following text-dependent questions to deepen students' comprehension. Prompt students to cite evidence in the text (specific words, sentences, and illustrations) to support their answers.

pages 3–5	*Why did the author include the information on Aristotle? How does it compare to the information on earthquake myths? What does the author think about Aristotle's conclusions? How do you know?*
pages 6–7	*Why did the author include the illustration of the stone being dropped in the water? How does that help the reader?*
pages 8–9	*Why is an earthquake's magnitude important? How do you know?*
pages 10–11	*How does the comic strip on page 11 add to what you know about tsunamis? Why might the author have included it?*
pages 12–13	*What patters do you notice on the map?*
pages 14–15	*What emergency procedures are used in places where earthquakes are common? How are these procedures similar to the ones you use for natural disasters where you live?*

The Curious Scientist

Second Read

Revisit the Text

Ask students to identify the special text features in Chapter 1 and explain why the author used them.

- ***Why did the author include the illustration and caption on page 10?***
- ***What information did these add?***

Focus on Text Feature—Map

Direct students to the Tectonic Plate map on page 12. Review that a map is a flat picture of part of the Earth. There are five main types of maps: political, physical, landform, transportation, and historical.

Review the following steps for reading a map and apply them to this one.

Step 1: Read the title. This tells you what the map shows.

Step 2: Find the map symbols.

Step 3: Look at the map key or legend. This tells you what the map symbols mean.

Step 4: Read the map labels and any captions.

Step 5: Find the compass rose (if present). This shows directions on the map.

Give students 2 minutes to turn and talk with a partner and share what they learned from the map.

- ***Why did the author include maps in this chapter?***
- ***How did the maps help you understand the chapter better?***
- ***When and where could you use a map in your writing?***

Prompt students to share their answers.

Focus on Text Feature—Graph

Direct students to the graph on page 9. Review that a graph is a picture that shows information about amounts or numbers. It tells a lot with very few words and lets you quickly compare and contrast information.

There are many types of graphs, such as bar graphs, circle graphs, line graphs, and pictographs.

Review the following steps for reading a graph and apply them to the moment magnitude scale graph.

Step 1: Read the title. This tells you what the graph shows.

Step 2: Read the labels. Ask what they tell about the kinds of information in the graph.

Step 3: Read across each line of the graph and determine the connection between the earthquake magnitude, number of earthquakes per year, and total energy release.

Step 4: Compare and contrast the information in the graph.

Give students 2 minutes to turn and talk with a partner and share what they learned from the graph.

- ***Why did the author include the graph?***
- ***How did the graph help you understand the chapter better?***
- ***When and where could you use a graph in your own writing?***

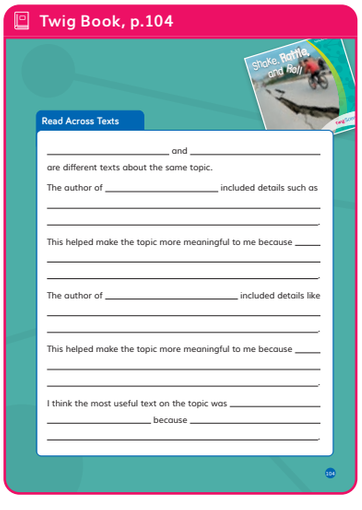
Prompt students to share their answers.

To help students understand the use of maps or graphs, have them add one to an upcoming writing assignment. When students have to find or create a text feature and then determine where it should go in their own writing and why, they can more easily interpret it in other texts.

Connect to Writing—Read Across Texts

Have students compare Chapter 1 to one of the other texts they've read in class. Ask them to complete the Read Across Texts writing frame on page 104 of their Twig Books. Students who wish to expand their ideas can use the frame as a springboard, rather than following it directly.

Prompt students to share their comparisons.



STEM Career: Meet a Seismologist

First Read

Overview

This chapter focuses on the career of a seismologist and includes an optional micro-lab in which students learn how energy is stored and released during an earthquake.

Objectives

Students will:

- Navigate and read informational texts
- Apply comprehension and vocabulary strategies
- Interpret text features (headings, maps, graphs)
- Read and write across texts.

CCSS ELA Standards

- RI.4.1
- RI.4.2
- RI.4.3
- RI.4.4
- RI.4.6
- RI.4.7
- RI.4.9
- RI.4.10
- L.4.4

Word Study Support

Write key vocabulary words syllable by syllable, such as vol-can-ol-o-gist. Guide students to use what they know about syllable types to read each word. For example, a closed syllable (e.g. vol, can, ol, gist) ends in a consonant and usually has a short vowel sound. An open syllable (e.g. o) ends in a vowel and usually has a long vowel sound.

Preview the Text

Have students preview Chapter 2 using the preview routine introduced in Chapter 1.

Prompt students to share their answers to Step 5, along with any other comments or questions they have about the text. Tell them that this chapter includes an interview.

- ***How might the interview format affect your reading of the chapter?***

Prepare

Ask students to share what they already know, or want to know, about seismologists—scientists who study earthquakes. What have they read, seen, or heard in videos and other readings? Remind students that this will provide background they can draw on as they read.

Give students 2 minutes to turn and talk with a partner and share what they know about seismologists.

Vocabulary Routine

Ensure students understand important new chapter vocabulary (**seismologists**, **volcanologists**) using the vocabulary routine introduced in Chapter 1.

Point out that the *-ist* at the end of *seismologist* and *volcanologist* means "a person who specializes in a (specific) art or science or skill." Ask students to brainstorm other related words with -ist (such as *artist*, *scientist*, and *violinist*).

Review the additional academic words to expand students' vocabulary.

evacuate

Define: to leave a place, such as a dangerous one, for safety or as a precaution

Example: We had to *evacuate* our neighborhood for fear of mudslides.

Ask: Why would you have to evacuate your home?

Related Words: evacuates, evacuated, evacuating, evacuation

remote

Define: far off, removed

Example: The scientists studied plants on a *remote* island.

Ask: What might be different about traveling to a remote place?

Related Words: close (antonym), near (antonym)

erupt

Define: to burst forth

Example: When the volcano *erupts*, it sends rock, lava, and gases into the air.

Ask: What happens when a person erupts with anger?

Related Words: erupting, eruption

Read

Ask students how they might approach reading Chapter 2. As you did in the previous chapter, help students navigate the text. Since students have already previewed the text, they should start by rereading the title and introduction.

Tell students to begin their reading of the main text. Remind students that the chapter is set up as an interview, so they should read the questions and then the answers. If students struggle with a boldfaced term, prompt them to use decoding and context clues to determine its meaning.

Note: If necessary, they may turn to the Visual Glossary on page 31.

If the author suggests the reader look at a photograph or other visual, they should stop and do so. If not, students should read the section or page first before looking at its visuals.

- ***What do the visuals add to the text?***

Have students whisper read the chapter. Listen in and offer feedback, if needed. If students struggle, model strategies to help them understand the text (such as visualize, clarify, and make inferences).

Discuss with students how they navigated the text. Have students turn to a partner and retell the most fascinating or surprising thing they read in the chapter.

STEM Career: Meet a Seismologist

Build Content Knowledge

During the discussion of the text, focus on the following Next Generation Science Standards.

PERFORMANCE EXPECTATIONS	**3–5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	***If conducting the micro-lab, guide students as they experiment and debrief with partners.***
SCIENCE AND ENGINEERING PRACTICES	**SEP-2** Developing and Using Models **SEP-6** Constructing Explanations and Designing Solutions	***Help students relate the materials used in the experiment to parts of the Earth (e.g. blocks represent tectonic plates).*** ***Prompt students to summarize their understanding of how earthquakes occur. Have them share any questions they still have.***
CROSSCUTTING CONCEPTS	**CCC-6** Structure and Function	***Review the parts of the Earth's crust shown on page 8 and how tectonic plates function.***

Ask Text-Dependent Questions

Ask the following text-dependent questions to deepen students' comprehension. Prompt students to cite evidence in the text (specific words, sentences, and illustrations) to support their answers.

page 16	***What does a seismologist do? Can you cite details in the text?***
page 17	***What dangers does a seismologist face? What might a seismologist do to prepare for these dangers?***
page 18	***How does a seismologist prepare for the dangers on the job?***
page 18	***What else would you like to know about earthquakes? Where can you find out more?***
page 19	***What does the author want you to know about a seismologist's tools?***

Optional Micro-Lab—Earthquake Blocks

To deepen students' understanding of the key science concepts presented in the book and highlighted above, you may have them conduct the optional micro-lab, Earthquake Blocks on pages 20–21. You may want to start this investigation on a later day and let students continue their exploration during independent work time.

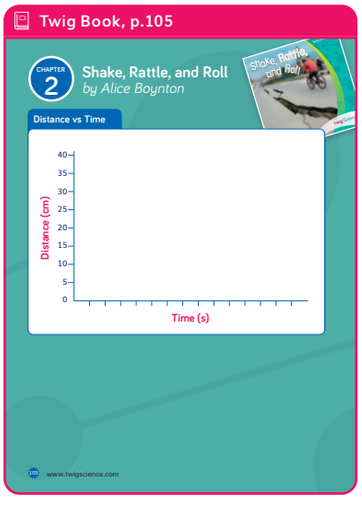
Step 1: Make sure each student has all the necessary materials—2 x 4 piece of wood, eye bolt, 10 thin rubber bands, sandpaper, tape measure, timer, and glue.

Step 2: Assist students as they prepare the materials.

Step 3: Guide students through a reading of the directions before they begin, and have them restate each step of the directions to a partner.

Step 4: Give students time to experiment with the materials.

Step 5: Prompt students to draw or graph their findings in the Distance vs. Time graph on page 105 of their Twig Books. Provide time for students to share and compare their findings.



STEM Career: Meet a Seismologist

Second Read

Revisit the Text

Ask students to identify the format of Chapter 2 and explain how it affected the way they navigated the text.

- ***Did you read this chapter differently from Chapter 1?***
- ***If so, what did you do?***

Focus on Fluency—Partner Read

Model reading the introduction using standard phrasing, intonation, and speed. Prompt students to pay attention to these as you read. For example, pause deliberately at a comma. Reread the introduction one sentence at a time, and have students echo-read.

Ask student pairs to reread the interview. One student should act as interviewer and the other should act as interviewee. Once students finish, ask them to switch roles. Circulate, listen in, and offer feedback. Take note of students who need additional support, as well as specific aspects of the reading they struggle with (such as decoding or phrasing).

Focus on Vocabulary—Context Clues

Explain to students the many tools they can use to figure out the meaning of a word while reading. One tool is context clues, or the words and sentences around the unknown word. Authors provide different kinds of clues in their writing.

- **Word Part Clues:** Prefixes, suffixes, e.g.
- **Definition/Restatement:** Definition of the word is given right after it, often in parentheses or followed by is or means
- **Synonym:** Word with a similar meaning is given, often using the word or, that is, or which is
- **Antonym:** Word is contrasted with something that means the opposite
- **Examples:** Lists of related things are given and the word is often followed by such as, include, these, or for example
- **General Clues**

Model for students how to use definition/restatement and synonym clues to determine word meanings. Write the following sentences from Chapter 2: "For example, earthquake swarms are an important sign. That's when lots of little earthquakes occur near a volcano."

- ***Look at the words I underlined:* earthquake swarms. *What does this term mean? The first sentence (and the sentence before it) explains that earthquake swarms are an important sign a volcano might erupt. The second sentence says they are "lots of little earthquakes that occur near a volcano." The author has given a definition of the term in the following sentence to help the reader understand the new vocabulary.***

Continue modeling using the word segments on page 6. Point out the key word *or*. Direct students' attention to the following pages and words. Guide them to identify the clues the author provided to help the reader determine the word's meaning.

- *fault line*: definition (page 6)
- *seismic waves*: definition (page 7)
- *crust*, *mantle outer core*, *inner core*: definition (page 8)
- *magnitude*: definition (page 8)
- *tsunami*: definition (page 10)

When students read Chapter 3, guide them to identify and use context clues to determine the meanings of the following words.

- *tremor*: definition (page 24)
- *engineers*: definition (page 25)

Prompt students to use some of these context clues in their own writing to support readers' understanding.

Connect to Writing—Informative Texts

Tell students that they will write an article about a seismologist for a school newspaper, and review the format of the article. Remind students to introduce the article topic in an engaging way to draw in their readers. Prompt students to use details and quotes from the interview in the article. This genre reformulation strategy helps deepen students' understanding of the chapter's content.

Point out the importance of grouping related information into paragraphs, such as the tools seismologists use in one paragraph and the dangers they face in another.

Explain to students that variety in sentence length makes a text more interesting. If all the sentences were very long, the text would be boring. Model how to combine the sentences using *and*:

- **Original Sentences:** Rebecca Bell studies rocks. She studies seismic waves. She does experiments on the waves.
- **Sentence Combining:** Rebecca Bell studies rocks and seismic waves. She also does experiments on the waves to learn more about earthquakes.

Have student pairs brainstorm visuals they could add to their article (e.g. photos and captions).

- ***What do the visuals add to readers' understanding of your topic?***

Optional: Extend this activity by encouraging students to use digital tools to type and design their articles, add visuals, and print them for display on a classroom wall.

Standard English Learners

Many SELs have difficulties with subject-verb agreement when the verbs *do/does*, *have/has*, and *was/were*, e.g. are used. Additional grammar instruction and practice may be needed—write an example problem sentence, then provide contrastive analysis. Write the Standard English form above that sentence and discuss the key differences as a class.

Earthquake Proofing: What's the Cost?

First Read

Overview

This chapter examines various approaches that engineers use to earthquake-proof buildings, and focuses on applying the science standards to students' lives.

Objectives

Students will:

- Navigate and read informational texts
- Apply metacognitive comprehension strategies (summarize)
- Use text structures (compare/contrast)
- Write a compare/contrast summary
- Synthesize information related to the Module Investigative Problem.

CCSS ELA Standards

- RI.4.1
- RI.4.2
- RI.4.4
- RI.4.5
- RI.4.7
- RI.4.8
- RI.4.10
- L.4.4

English Learners

Provide sentence frames to support students' responses.

- I read that _____.
- To stay safe during an earthquake, _____.
- Earthquake safety is important because _____.

Preview the Text

Have students preview Chapter 3 using the preview routine introduced in Chapter 1.

Ask students to share their answers to Step 5.

- ***What challenges might you face in reading?***
- ***What reading tools do you have to tackle these challenges?***

Prepare

Prompt students to share what they already know about earthquake safety. What have they read, seen, or heard in videos and other readings? Remind students that this will provide background they can draw on as they read.

Give students 2 minutes to do a turn and talk with a partner and share what they know about the topic.

Vocabulary Routine

Ensure students understand important new chapter vocabulary (**nowcasting**, **tremors**, **engineers**) using the vocabulary routine introduced in Chapter 1.

Review the additional academic words to expand students' vocabulary.

prevent

Define: to stop from happening

Example: I closed the window to *prevent* the rain from coming in.

Ask: How can you prevent mosquito bites?

Related Words: prevention, preventable, unpreventable

hazard

Define: a danger or risk that can be difficult to avoid

Example: Climbing a ladder without help can be a *hazard*.

Ask: What hazards could someone face at the beach?

Related Words: hazardous (antonym: safety)

reduce

Define: to lessen; to bring down to a smaller amount

Example: You can *reduce* the risk of sunburn if you use sunscreen.

Ask: How do you reduce your amount of homework?

Related Words: reduction, reduced, reducing (antonym: increase)

collapse

Define: to fall down or cave in

Example: I was so tired that I *collapsed* onto the couch.

Ask: What could cause a building to collapse?

Related Words: collapsed, collapsing, collapsible

Read

Ask students how they might approach reading Chapter 3. Model text navigation, if needed. Since students have already previewed the text, they should start by rereading the title and introduction.

Tell students to being their reading of the main text. If they struggle with a boldfaced term, prompt them to use context clues and/or structural analysis to pronounce and determine its meaning.

Note: If necessary, they may turn to the Visual Glossary on page 31.

If the author suggests the reader look at a photograph, chart, or other visual, they should stop and do so. If not, students should read the section or page first before looking at its visuals.

- ***How do the visuals contribute to your understanding of the text?***

Remind students that if the page has a sidebar, they should read it last.

Have students whisper read the chapter. Listen in and offer feedback. When students struggle, remind them of the metacognitive strategies they can use to help them understand the text (such as summarize, visualize, predict, ask questions, make inferences, clarify, and other fix-up strategies).

Metacognitive Strategy—Summarize

Explain to students that skilled readers use strategies to check their comprehension as they read. One strategy is stopping and summarizing what the author has written. When you summarize, you restate in your own words the most important ideas in the text. If you can't easily summarize, it means you need to go back and reread, or use another strategy. If you can summarize, then you can continue reading.

Read page 23 to model summarizing.

- ***Let me summarize, or share the main ideas in the text so far, to see if I understand. Scientists have learned where earthquakes are likely to occur. However, they haven't learned when an earthquake will happen. How did I do? Do you think I understand what I've read?***

As they read the chapter, prompt students to periodically stop and summarize their reading. Point out good stopping points, if needed. Remind students that this is just one of the strategies they can use to check their comprehension while they read.

When they finish reading, have students discuss how they navigated the text.

- ***Did summarizing help you check your understanding as you read?***

Earthquake Proofing: What's the Cost?

Build Content Knowledge

During the discussion of the text, focus on the following Next Generation Science Standards.

PERFORMANCE EXPECTATIONS	**4-ESS3-2** Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.	***Emphasize the solutions presented by various scientists for earthquake-proofing buildings. Have students compare and contrast the solutions in terms of cost and practicality.***
DISCIPLINARY CORE IDEAS	**ETS1.A** Defining Engineering Problems **ETS1.B** Developing Possible Solutions **ETS1.C** Optimizing the Design Solution	***Highlight the problems engineers are trying to solve and the variety of solutions they're testing.***
SCIENCE AND ENGINEERING PRACTICES	**SEP-2:** Developing and Using Models **SEP-6:** Constructing Explanations and Designing Solutions	***Point out how engineers create models, such as shaking tables, to test their building plans.***
CROSSCUTTING CONCEPTS	**CCC-6** Structure and Function	***Focus on the structural changes made to buildings to make them earthquake-proof.***

Ask Text-Dependent Questions

Ask the following text-dependent questions to deepen students' comprehension. Prompt students to cite evidence in the text (specific words, sentences, and illustrations) to support their answers.

pages 22–23	***What does the author want you to know about earthquake prediction? Why did the author include the photo and caption about the Diablo Canyon Power Plant?***
page 24	***What have scientists done to help us predict earthquakes? How are these things making a difference? Cite examples.***
page 25	***What do engineers do to select the best place to build something? Why is this important?***
pages 26–27	***What does the author think about earthquake-proofing a city? How do you know? What is your opinion? Why?***
page 28	***What creative things are scientists doing to make buildings safer from earthquakes? Which of these ideas might work best? Why?***

Second Read

Revisit the Text

Ask students to identify the special text features in Chapter 3 and explain why the author used these.

- ***How do the photos and captions add to your understanding?***
- ***How can you use the headings to summarize what you read?***

Focus on Text Structure—Compare/Contrast

Direct students' attention to the text's structure and discuss the importance of identifying this when reading. Explain that determining how a text is structured will help students organize their thinking as they read and better comprehend the text.

Read the definition of the Compare/Contrast text structure:

- ***This type of text points out the likenesses and differences between two or more subjects.***

Have student pairs reread page 28, "Testing Continues."

- ***How does the author compare the two houses, or show how they are alike?***
- ***How does the author contrast them, or show how they are different?***
- ***Does the author use text only, or text and photos?***

Discuss signal words, explaining that writers often use them to indicate a text's structure. Reinforce the use of signal words with the following steps:

Step 1: Display a list of compare/contrast signal words and phrases (such as *like*, *as*, *similar to*, *different than*, *in contrast*, *likewise*) and encourage students to look for them in future texts they read.

Step 2: Read page 28, prompting students to listen for signal words that indicate comparisons and contrasts.

Step 3: Record these signal words on a chart as students identify them (including *likewise* and *different*).

Step 4: Ask students to brainstorm other signal words, and add them to your chart.

During small group lessons, you can highlight these words and ask students how they helped them organize their thinking as they read. You may also emphasize how noticing these words can help students more easily remember details about how two or more things are similar or different.

Earthquake Proofing: What's the Cost?

Connect to Writing—Compare/Contrast

Have students summarize page 28 using the Compare/Contrast writing frame on page 106 of their Twig Books. Students who wish to expand their ideas can use the frame as a springboard, rather than following it directly. Prompt students to share their summaries.

Writing Support

Have students record their completed frame in their journals. Ask them to underline the compare and contrast signal words (e.g. *similar*, *different*). Prompt students to refer to the completed writing frame when writing compare and contrast informational text pieces.

Synthesize Information

To show their growing body of knowledge, have students write a response to the Module Investigative Problem: How can we reduce the damage caused by earthquakes? To build students' writing stamina, provide an uninterrupted block of writing time for students. Increase the amount of time over the course of the year.

Review students' writing and provide revision notes so that students can revise during independent work time. For example, you may ask students to rewrite their introductory sentences to better grab the reader's attention, or add greater detail to a particular fact they've included.

English Learners

Writing frames provide great speaking frames. Suggest that ELs or students needing additional support use the writing frame when presenting their ideas.

Monitoring English Language Proficiency

During your leveled reader instruction, engage students in the following tasks to monitor their growing English language development. These tasks are best administered individually.

Writing Domain

Have students look at the map on page 10 and write a brief description of what is happening.

Reading Domain

Use the illustration on page 13. Write these sentences on the board:

- All the Earth's earthquakes can be found on the Ring of Fire.
- Earthquakes and volcanoes are common along the Ring of Fire.
- Volcanoes cause earthquakes and tsunamis.

Have students read each sentence, then choose the one that best matches the illustration. Continue with other photos, illustrations, and graphic aids.

Listening Domain

Read aloud the paragraph about West Africa on page 4.

- ***Who lives on the giant's head?***
- ***What else can be found there?***
- ***What causes an earthquake?***

Speaking Domain

If students share their Earthquake Blocks experiment graph, record their use of academic vocabulary and connecting words to explain their comparisons.

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EARTHQUAKE ENGINEERING

GRADE **4**
MODULE **4**

Performance Expectation Progressions

NGSS Topic Arrangements: Earth's Systems; Engineering Design

Earthquake Engineering introduces one NGSS Performance Expectation (PE) in Physical Sciences (4-PS4-1) and explores two in Earth Sciences (4-ESS2-2 and 4-ESS3-2). These PEs address waves, natural hazards, and the mapping of Earth's features and forces.

Three additional PEs engage students in engineering design: 3–5-ETS1-1, 3–5-ETS1-2, and 3–5-ETS1-3. While aspects of engineering design are addressed in other Grade 4 modules, Earthquake Engineering emphasizes designing structures to solve problems that arise from natural hazards.

► PROGRESSION ►

PRIOR KNOWLEDGE				CURRENT GRADE	FUTURE KNOWLEDGE
KINDERGARTEN	GRADE 1	GRADE 2	GRADE 3	GRADE 4	GRADE 6
Module 2 K-PS2-2 K–2-ETS1-1 **Marble Run Engineer** Students define a force as a push or a pull. They discover that using a stronger push or pull causes an object to speed up or slow down more quickly, and that when objects touch or collide they can push each other, causing changes in direction and/or speed. **Module 3** K-ESS3-2 K–2-ETS1-2 **Be Prepared** Students are introduced to the idea that natural processes can affect humans. They read about natural hazards posed by different forms of severe weather. They ask questions to understand and prepare for a severe weather scenario. They design umbrellas, exploring the connection between choice of materials and specific weather conditions.	**Module 2** 1-PS4-1 **Animal Reporters** Students develop an introductory understanding of sound waves. They investigate everyday objects to produce sounds. They discover that sounds cause objects to move and that all sounds are caused by vibrations.	**Module 1** 2-ESS2-2 **My Journey West** Students learn to interpret geological features on maps. They create maps and explore ways that maps can be used to convey different types of information. **Module 2** 2-PS1-2 K–2-ETS1-3 **Master of Materials** Students build and test the strength of model towers made of different materials. **Module 3** K–2-ETS1-1 **Save the Island** Students explore the effects of erosion and sea-level rise on Tangier Island. They define design criteria to address these problems. Students learn about engineering solutions and evaluate each against their design criteria.	**Module 4** 3-ESS3-1 3–5-ETS1-1 3–5-ETS1-2 **Weather Warning HQ** Students investigate natural hazards from severe weather. They explore the relationship between storms and lightning, and between lightning and hazards such as wildfires. They compare the relative effectiveness of different approaches to reducing hazards and to educating people about them.	**Module 5** 4-PS4-1 **Super Survivors** Students investigate waves in water and sound waves. They model wave motion, exploring patterns of wave amplitude and wavelength. They discover how waves in water transfer energy. They compare the effect of waves on objects in the open ocean versus objects near shore.	**Module 2** MS-ESS2-5 MS-ESS2-6 **Destination Everywhere!** Students explore the causes of weather and regional climates. They look for patterns on an interactive map and identify possible relationships between weather, climate, and geology.

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