



Build a Plate Boundary: Four Teams, Twelve Lessons

DRIVING QUESTION

Why do volcanoes, earthquakes, and mountains happen where they do, and what is moving underneath them?

YOUR CHALLENGE

Build it. Make it work. Teach it. Your team is the class expert on one chapter of Module 4, and your build is how you teach its three lessons.

THE PROJECT

The phenomenon

Two plate boundaries can sit a few hundred kilometres apart and cause very different disasters. One builds mountains and deep earthquakes. The other tears open and fills with lava. It is the same planet with the same heat inside. To explain it you need all of Module 4: how plates move, why rock melts, why faults slip, and how mountains rise. No one team can learn it all in time, so each team becomes the expert on one chapter and teaches it.

THE PROJECT

How it works

- Your group forms on your Scholar Dashboard and picks one focus.
- Each focus is one chapter of Module 4, split into three lessons.
- Each teammate leads one of your three lessons.
- In a group of four, the fourth teammate is the Verifier.
- Your team builds something that works.
- It is not a poster.
- It has to do something you can test.
- Your team keeps one shared group note in Note Studio.
- Everyone types in it at the same time.
- You photograph your build.
- When Dr. Ijezie approves the photos, they appear on the Module 4 page.
- On teach-back day your team teaches its three lessons with the build.
- Everyone learns all twelve lessons.
- Each of you turns in the group note to the Assessment Center, like notes homework.

TEAMS

Four teams, four focuses

Three teams of three and one team of four. Every focus is part of the same driving question: why do volcanoes, earthquakes, and mountains happen where they do?

TEAM	FOCUS QUESTION
Team 1 • Ridge Runners Chapter 13 • Plate Tectonics	What makes the plates move, how do we know they move, and how fast do they go?
Team 2 • Magma Makers Chapter 14 • Volcanism	Why does rock melt in only a few places, and why do some volcanoes explode while others flow?
Team 3 • Fault Line Chapter 15 • Earthquakes	Why do faults stay quiet for years and then shake all at once, and how do we find where an earthquake started?
Team 4 • Root Raisers Chapter 16 • Mountain Building	How do mountains rise, why do rock layers bend and break, and why doesn't erosion just flatten them?

TEAMS

Form your group

Groups form on your Scholar Dashboard. First come, first served: once a group takes a focus, no other group can take it.

1. Talk with your partners first and agree on the focus you want, plus a backup.
2. When Dr. Ijezie opens group forming, a pop-up appears on your Scholar Dashboard.
3. Your dashboard shows the opening time before then.
4. One person signs in to the Scholar Dashboard with their alias and PIN.
5. That person adds each partner by typing at least 3 letters of their alias.
6. Then they pick the group's focus and press Create group.
7. Taken focuses are crossed out.
8. Groups are 3 people.
9. One group in the class can have 4.
10. Everyone in the group now sees the group and focus on their own dashboard.
11. To change a group, talk to Dr. Ijezie.

Team roles

EVERY TEAM

Lead Investigator

- Runs the simulator investigation and the build tests, and records every setting and reading.
- Keeps the team on schedule and checks each day's checkpoint in the group note.
- Leads one of your three lessons.

Hands the raw readings to the Data Analyst by the end of Day 2.

EVERY TEAM

Data Analyst

- Does the team's calculation and checks it with the self-check.
- Builds the data table in the group note, with units on every number and a source for every real-world number.
- Leads one of your three lessons.

Hands a checked table and one finished calculation to the Communicator by the end of Day 3.

EVERY TEAM

Science Communicator

- Leads the build and takes the build photos for approval.
- Plans the teach-back so every lesson gets equal time.
- Leads one of your three lessons.

Uploads at least two approved-quality photos by the test day.

ONLY THE TEAM OF FOUR

Verifier

- Repeats every test and calculation on their own and settles differences.
- Checks every number in the group note against its source.
- Helps each lesson lead and builds the strongest argument against the team's claim before teach-back.

Turns in a one-page verification log with the team's products. In a team of three, the Analyst writes the uncertainty statement and the Lead writes the counter-argument.

What every team makes

- **Working build** (Presented in class · Day 4).

1. The thing your team builds.
 2. It must pass its 'It works when' tests at least twice.
- **Build photos** (Group note · Day 4).
 1. At least two clear photos of the build only (no faces or people), uploaded in your group note.
 2. Approved photos appear on the Module 4 page.
 - **Group note** (Note Studio → Assessment Center · Day 6).
 1. Your shared Note Studio group note: your three lessons, build plan, test data, results, teach-back plan, and each teammate's own contribution and reflection.
 2. Each of you turns in your copy like notes homework.
 - **Teach-back lesson** (Presented in class · Day 6).
 1. A ten-minute lesson: show the build working, then each lesson lead teaches their lesson with it and asks one check question.

Your Note Studio group note

Open Note Studio and choose **ESS Group Project**. Your team types in one shared note at the same time, and nobody can erase a teammate's section.

Build plan and materials

- Sketch description.
- Materials list.
- Who brings what.

What this lesson teaches (one per lesson)

- Two to four key ideas.
- Vocabulary.
- One example.
- The lesson lead writes this; teammates add.

Build log and test data

- Every try:
- Date.
- What you changed.
- Results with units.

What our build shows and what it leaves out

- Claim.
- Evidence from your tests.
- One limit of the build.

Teach-back plan and check questions

- Who teaches what.
- In what order.
- One check question per lesson with the answer.

What I did (each scholar, only you type here)

- Your own work on each day.
- Only you type here.

My reflection (each scholar, only you type here)

- What you learned from another team.
- One thing you would change.

Turn in your copy

Photos: at least two of the build only, no faces or people. Dr. Ijezie approves them before they appear on the Module 4 page. On teach-back day:

1. Each of you presses Update my turn-in copy.
2. Turn it in on the Assessment Center.

THE PLAN

Six days, six checkpoints

DAY	WHAT HAPPENS	CHECKPOINT
Day 1 Wed, Feb 10	Form up and plan. Know your three lessons and plan the build. • Form your group on the Scholar Dashboard. • Pick your focus. • Open your group note in Note Studio. • Choose who leads each lesson. • Read the Module 4 slides for your chapter. • In the note, write two key ideas for each of your three lessons. • Sketch the build. • List the materials.	Group note: lesson leads chosen, two key ideas per lesson, build sketch and materials list.
Day 2 Thu, Feb 11	Learn deeply. Become the expert on your lesson. • Each lesson lead fills in their lesson section: key ideas, vocabulary, one example. • Run your team's simulator investigation. • Record every setting and reading. • Gather materials.	Every lesson section filled in; simulator readings recorded with units.
Day 3 Tue, Feb 16	Build. Build the thing and make it run once. • Build it. • Follow your build steps. • Try it once. • Write what happened and what you will fix. • Take progress photos (build only, no faces).	Build log in the group note; first try recorded.
Day 4 Wed, Feb 17	Test and photograph. Prove it works. • Run every 'It works when' test at least twice. • Record results with units. • Upload at least two photos of the finished build in the group note. • Do your team's calculation. • Check it.	Test data complete; two photos uploaded for approval.

DAY	WHAT HAPPENS	CHECKPOINT
Day 5 Thu, Feb 18	Improve and rehearse. Fix what failed, plan the lesson, and practise it. • Fix one thing that did not work. • Test again. • Plan the ten-minute teach-back: two minutes of demo, then each lesson lead teaches with the build. • Write one check question per lesson, with an answer key. • Rehearse with another team. • They give one strength, one question, one fix. • Each of you writes your own contribution and reflection in the group note.	Retest recorded; teach-back plan and three check questions in the group note; every teammate's contribution filled in.
Day 6 Fri, Feb 19	Teach-back day. Teach your lessons and learn all the others. • Each team teaches for ten minutes with its build. • Everyone takes learning notes. • Everyone answers every check question. • Press 'Update my turn-in copy' in the group note. • Turn it in to the Assessment Center. • Last-day partner review in the Assessment Center.	Teach-back given; learning notes; group note turned in; partner review done.

Ridge Runners

FOCUS QUESTION

What makes the plates move, how do we know they move, and how fast do they go?

Every other team needs moving plates. Your team teaches the engine that moves them, the evidence that proves they move, and the three ways plates meet.

Your lessons

1. Plate Tectonics: The Engine — Mantle Heat, Density, and Plate Motion

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Plate Tectonics: The Evidence — Magnetic Stripes and GPS

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Plate Tectonics: Boundary Types and Plate-Motion Math

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 4 Slides — The Dynamic Earth. Read the slides 'The Load-Bearing Frame: Plates and the Engine Below' (lithosphere and asthenosphere), 'Three Forces — Not Equal Partners' (slab pull, ridge push, basal drag), and 'The Tape Recorder: Confirming Plate Motion' (GPS and magnetic stripes). Also read 'Trap 1 — The Liquid Mantle Myth'.

Big ideas you will use

- A plate is the lithosphere: the crust plus the top of the mantle, about 100 km thick on average. Below it, the asthenosphere is solid rock that creeps very slowly.
- Cold, dense rock sinks. Slab pull, where a sinking slab drags the rest of its plate, is the strongest force. Ridge push is second.
- New sea floor records Earth's magnetic field as it cools, so the stripes match on both sides of a ridge. GPS measures plates moving 1 to 15 cm a year.
- Plates pull apart (divergent), push together (convergent), or slide past each other (transform). Distance = rate × time, and 1 cm a year is 10 km in a million years.

Spreading-ridge machine

Build a working sea floor that shows all three boundary types and the magnetic-stripe proof, plus a tub that shows why cold rock sinks and drives the plates.

Materials

- A shoebox lid with two offset slots, each a little longer than your paper strip is wide (your teacher cuts the slots)
- Four strips of adding-machine tape, each about 1 m long
- Two markers of different colours, a ruler, and a timer
- A hardcover book for the continent
- A clear plastic tub of room-temperature water
- A cup of ice water coloured with blue food colouring, and a thermometer

Your model must show

1. Cold, dense water sinks and spreads along the bottom, the way a cold, dense slab sinks and pulls its plate (the engine).
2. Magnetic stripes that match in width and order on both sides of each slot, and wider stripes when you pull faster (the evidence).
3. All three boundary types: strips pull apart at the slots (divergent), slide past each other between the slots (transform), and go down under the book (convergent).

Build steps

1. Put two strips together and feed them up through each slot from below.
2. Fold one strip to each side.
3. Set the book at the left end so the strips slide under it, like old sea floor going down at a trench.
4. Two teammates pull, one at each end, one strip in each hand, at the same slow, steady speed for 60 seconds.
5. The third teammate colours along both slots, switching colour every 10 seconds.
6. Repeat at twice the speed with fresh strips.
7. Draw a straight 'road' across the strips in the gap between the two slots.
8. Pull for 20 seconds and measure how far the road is offset.
9. Engine test: pour the ice-cold blue water slowly down the inside wall at one end of the tub.
10. Watch from the side.
11. Record the temperature of the ice water and the tub water.

It works when

- The ice-cold blue water sinks and spreads along the bottom of the tub as a layer you can see from the side.
- Matching stripes on the two sides of each slot are the same width within 0.5 cm and come in the same order.
- Between the two slots, the road breaks and is offset (measure the offset in cm), while the strips at the book go down under it.

Test it: Run the slow and fast pulls twice each. Record every stripe width in cm on both sides, the road offset in cm, and both water temperatures in °C.

The Boundary Works — Plate-Margin Simulator: Investigation 1, Two ridges, two speeds

1. On Cross-section + block, set Boundary type to Divergent.
2. Make both plates Oceanic (Left: Oceanic, Right: Oceanic).
3. Set Relative rate to 2 cm/yr and Elapsed time to 20 Myr.
4. Record the Cumulative opening on the readout.
5. Set Relative rate to 12 cm/yr at the same time.
6. Record the wider band.
7. Check that opening = rate $\times$ time on the readout (1 cm/yr = 10 km/Myr).
8. Record the Ridge morphology at each rate: a broad rise at 8 cm/yr or more, an axial rift valley when slower.
9. Switch to Rift to drift.
10. Set Elapsed to 100 Myr.
11. Record the Ocean basin width and the Oldest sea-floor on each margin.

Calculate: Spreading rate from magnetic stripes

1. A magnetic stripe 30 million years old sits 750 km from the ridge axis.
2. Find the half rate and the full rate in km per million years and in cm per year.
3. Then treat the USGS Mid-Atlantic Ridge rate of 2.5 cm/yr as the full rate.
4. How far apart are the two 20-million-year-old stripes on either side of that ridge?

Self-check: Rate $\times$ time must give back the distance.

Real data

- **How fast real ridges spread** · USGS, This Dynamic Earth: Understanding plate motions. USGS reports that the Mid-Atlantic Ridge spreads about 2.5 cm/yr, or 25 km in a million years. The East Pacific Rise near Easter Island spreads fastest, at more than 15 cm/yr. Iceland straddles the Mid-Atlantic Ridge, so part of the ridge is on land.
<https://pubs.usgs.gov/gip/dynamic/understanding.html> · Read on 2026-09-23.
- **Age of the sea floor** · NOAA Science On a Sphere, Age of the Seafloor. NOAA explains that scientists use the magnetic polarity of the sea floor to find its age. The youngest sea floor is at divergent boundaries such as the Mid-Atlantic Ridge, and very little sea floor is older than 150 million years. On the map, read the sea-floor age at two points the same distance from the ridge, one on each side.
<https://sos.noaa.gov/catalog/datasets/age-of-the-seafloor/> · The descriptions were read on 2026-09-23. Read the two map ages yourself and record the date.
- **Earthquakes along the ridge** · USGS Earthquake Catalog. Search around Iceland for magnitude 4 and larger in the past 10 years. Record how many you found and the depth of the deepest one.
<https://earthquake.usgs.gov/earthquakes/search/> · Record your search settings and the date you searched.

Your design decision

1. Your design decision: how to make new sea floor move away from each slot at the same speed on both sides, so the stripes match.

Two build options to compare

- Build option A: one teammate at each end pulls the strips by hand, keeping time to a spoken count.
- Build option B: wind each strip onto a pencil or tube and turn both at the same count.

Your map hotspot

1. Mark where your ridge crosses Iceland, where part of the spreading ridge is on land.

Trap to avoid

The plates do not float on an ocean of molten magma. The mantle is solid rock that flows very slowly. Melt forms only in thin, local pockets, such as under the ridge.

TEACH IT

Show your build working, then teach:

1. Cold, dense rock sinks and pulls its plate behind it (slab pull). The mantle underneath is solid rock that flows very slowly.
2. Magnetic stripes match on both sides of a ridge, and GPS measures plates moving 1 to 15 cm a year.
3. Plates pull apart, push together, or slide past each other, and $\text{distance} = \text{rate} \times \text{time}$ tells how far they move.

Check question: Why do the magnetic stripes on one side of a ridge match the stripes on the other side?

Texas standards

- **ESS.8D** Describe how heat and rock composition affect density within Earth's interior and how density influences the development and motion of Earth's tectonic plates. §112.49(c)(8)(D) *You show how density differences make cold rock sink and move the plates.*
- **ESS.8C** Investigate how new conceptual interpretations of data and innovative geophysical technologies led to the current theory of plate tectonics. §112.49(c)(8)(C) *You use magnetic stripes and GPS, the kinds of evidence that led to plate tectonics.*
- **ESS.8F** Calculate the motion history of tectonic plates using equations relating rate, time, and distance to predict future motions, locations, and resulting geologic features. §112.49(c)(8)(F) *You use rate, time, and distance to work out how fast plates have moved.*
- **ESS.8G** Distinguish the location, type, and relative motion of convergent, divergent, and transform plate boundaries using evidence from the distribution of earthquakes and volcanoes. §112.49(c)(8)(G) *You tell divergent, convergent, and transform boundaries apart by their motion.*
- **7.10A** Describe the evidence that supports that Earth has changed over time, including fossil evidence, plate tectonics, and superposition. §112.27(b)(10)(A) *Grade 6–8 foundation.*

Word bank: lithosphere · asthenosphere · slab pull · sea-floor spreading · magnetic reversal · divergent boundary · transform boundary · half rate

Magma Makers

FOCUS QUESTION

Why does rock melt in only a few places, and why do some volcanoes explode while others flow?

Volcanoes are not everywhere. Your team teaches why rock melts only in certain places, why some magma explodes and some flows, and how volcanoes form chains and put people at risk.

Your lessons

1. Volcanism: Where Rock Melts — Decompression and Flux Melting

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Volcanism: Magma's Personality — Composition, Viscosity, and Gas

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Volcanism: Hot Spots, Volcanic Features, and Hazards

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 4 Slides — The Dynamic Earth. Read the slides 'Fire in the Seams: Why Rock Melts' and 'Two Melting Recipes' (decompression and flux melting, and why silica and gas make explosive volcanoes). Also read 'Trap 2 — Friction Melts the Slab'.

Big ideas you will use

- Most of the mantle stays solid. Rock melts mainly in two ways: when the pressure drops (decompression melting) or when water is added (flux melting).
- Near 100 km deep, water leaves the sinking slab and lowers the melting point of the mantle above it, the way salt lowers the melting point of ice.
- Silica makes magma thick and sticky. Sticky magma traps gas, so it can erupt explosively. Runny, low-silica basalt erupts quietly.
- A hot spot stays almost still while the plate moves over it, so it builds a chain of volcanoes. The volcanoes over the hot spot are active; the older ones farther along the chain are extinct.

BUILD IT

Volcano lab bench

Build three working stations: one that shows how adding something lowers a melting point, one that shows how thick magma traps gas, and one that makes a hot-spot chain of volcanoes.

Materials

- Two cups, crushed ice, table salt, a spoon, and two thermometers
- A baking tray or cutting board propped up at one end as a ramp, with a start and a finish line 20 cm apart
- Water and corn syrup in small cups
- Baking soda, vinegar, two clear cups, and a tray to catch spills
- A box lid with a marker taped tip-up under a hole, its tip just below the top of the lid (the hot spot), sheets of paper, a ruler, and a timer

Your model must show

1. Salt makes ice melt below 0 °C, the way water from a sinking slab lets mantle rock melt at a lower temperature (flux melting).
2. Thick corn syrup flows more slowly than water, and a thick mixture holds its gas bubbles longer, like sticky, silica-rich magma.
3. A still hot spot under a moving plate makes a line of volcanoes that get older in one direction; the youngest ones, over the hot spot, are the active hazard.

Build steps

1. Melting station: fill two cups with crushed ice.
2. Stir 3 spoons of salt into one cup.
3. After 3 minutes, read both thermometers.
4. Viscosity station: put a spoon of water and a spoon of corn syrup on the start line of the ramp at the same time.
5. Time each one to the finish line.
6. Gas station: on the tray, fill one cup with plain vinegar and one with vinegar mixed half-and-half with corn syrup.
7. Add one spoon of baking soda to each.
8. Measure the foam height and time how long the bubbling lasts.
9. Hot-spot station: slide a sheet of paper across the lid in one direction at a steady speed for 60 seconds, pressing it down onto the marker tip every 10 seconds.
10. Flip the paper over.
11. Label the newest dot 'active' and the oldest dot 'oldest'.

It works when

- The salted-ice cup reads at least 3 °C colder than the plain-ice cup.
- Corn syrup takes longer than water to reach the finish line, and the syrup-vinegar cup keeps bubbling longer than the plain vinegar cup (record both times in seconds).
- The hot-spot dots come out in a straight line, and every gap is within 0.5 cm of the average gap (a steady plate).

Test it: Run each station twice. Record temperatures in °C, flow times and bubbling times in seconds, foam heights in cm, and dot spacing in cm.

Safety: Wear goggles for the vinegar and baking soda. Salted ice gets cold enough to hurt skin: hold the cup, not the ice. Stir with the spoon, not the thermometer. Never taste anything. Wipe syrup spills right away.

The Boundary Works — Plate-Margin Simulator: Investigation 2, Where the volcano goes

1. On Cross-section + block, set Boundary type to Convergent with Left: Oceanic and Right: Continental.
2. Read Subduction polarity: the oceanic plate goes down beneath the continent.
3. Set Relative rate to 5 cm/yr and Slab dip to 30°.
4. Set Elapsed time to 2 Myr and read the Arc-trench distance row.
5. Raise the time until an arc appears.
6. Record the time and the Slab tip depth.
7. Confirm the arc sits directly above the slab's ~100 km depth contour, on the overriding plate.
8. Set Elapsed time to 20 Myr.
9. Set Slab dip to 30°, then 45°, then 60°.
10. Record the Arc-trench distance each time.
11. Switch the Left plate to Continental.
12. Watch the volcano vanish.
13. Explain why flux melting needs a subducting, water-bearing slab.

Calculate: Plate speed from a hot-spot track

1. In your hot-spot test, you press the paper onto the hot spot every 10 seconds, and the dots end up 3.0 cm apart.
2. How fast did your 'plate' move, in cm per second?
3. Then a practice problem: an island volcano is 400 km from a hot spot and is 5 million years old.
4. Find the plate speed in km per million years and in cm per year (1 cm/yr = 10 km per million years).

Self-check: Speed × time must give back the distance.

Real data

- **The Cascadia Subduction Zone** · USGS Pacific Coastal and Marine Science Center, Cascadia Subduction Zone Marine Geohazards. USGS describes the Cascadia Subduction Zone as a 1,300 km-long boundary. The Juan de Fuca and Gorda oceanic plates lie to the west and the North America continental plate lies to the east. This sinking ocean plate is the kind of slab that feeds flux melting.
<https://www.usgs.gov/centers/pcmsc/science/cascadia-subduction-zone-marine-geohazards> · Read on 2026-09-23.
- **Mount St. Helens, May 18, 1980** · USGS FAQ, How high was Mount St. Helens before the May 18, 1980 eruption?. USGS reports the summit stood at 2,950 m before the eruption. Afterward, the highest point of the crater rim was 2,550 m. USGS says the volcano lost about 1,300 feet (396 m) of height; subtracting the two heights gives about 400 m. Use it as evidence for the explosive style of arc volcanoes.
<https://www.usgs.gov/faqs/how-high-was-mount-st-helens-may-18-1980-eruption-how-high-was-it-after> · Read on 2026-09-23.

Your design decision

1. Your design decision: how to show that thick, sticky magma traps gas while runny magma lets it escape.

Two build options to compare

- Build option A: add baking soda to plain vinegar and to vinegar thickened with corn syrup, and compare the bubbling.
- Build option B: each teammate blows gently through their own straw into a cup of water and a cup of corn syrup, and compares how the bubbles escape.

Your map hotspot

1. Mark Mount St. Helens on your map and draw the Cascadia trench offshore.
2. Say which plate is sinking.

Trap to avoid

Friction does not melt the sinking slab. The slab is cold. The melting happens above it, after water from the slab lowers the melting point of the mantle.

TEACH IT

Show your build working, then teach:

1. Rock melts when the pressure drops or when water from a sinking slab lowers its melting point.
2. Silica makes magma thick and sticky; sticky magma traps gas, so it can explode.
3. A hot spot stays almost still while the plate moves, so it builds a chain of volcanoes, and the youngest ones, over the hot spot, are the hazard.

Check question: Why is thick, silica-rich magma more likely to explode than runny basalt?

Texas standards

- **ESS.8A** Evaluate heat transfer through Earth's systems by convection and conduction and include its role in plate tectonics and volcanism. §112.49(c)(8)(A) *You explain how heat inside Earth and changes in pressure and water lead to melting and volcanoes.*
- **ESS.8E** Explain how plate tectonics accounts for geologic processes, including sea floor spreading and subduction, and features, including ocean ridges, rift valleys, earthquakes, volcanoes, mountain ranges, hot spots, and hydrothermal vents. §112.49(c)(8)(E) *You explain how subduction and hot spots make volcanoes.*
- **ESS.12A** Evaluate the impact on humans of natural changes in Earth's systems such as earthquakes, tsunamis, and volcanic eruptions. §112.49(c)(12)(A) *You evaluate how explosive eruptions affect people.*
- **7.10B** Describe how plate tectonics causes ocean basin formation, earthquakes, mountain building, and volcanic eruptions, including supervolcanoes and hot spots. §112.27(b)(10)(B) *Grade 6–8 foundation.*

Word bank: magma · decompression melting · flux melting · viscosity · silica · hot spot · volcanic arc

Fault Line

FOCUS QUESTION

Why do faults stay quiet for years and then shake all at once, and how do we find where an earthquake started?

Earthquakes shake the whole class's story. Your team teaches why faults slip, how seismic waves let us find an earthquake, and where earthquakes happen and how risky they are.

Your lessons

1. Earthquakes: Elastic Rebound and Faults

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Earthquakes: Seismic Waves — Finding the Epicentre

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Earthquakes: Where They Happen, Magnitude, and Risk

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 4 Slides — The Dynamic Earth. Read the slides 'When the Frame Slips: Earthquakes' (elastic rebound, focus and epicentre) and 'Reading the Seismic Signal' (P and S waves, the S–P delay, the magnitude scale, and depth as a clue to the boundary). Also read 'Trap 3 — The Linear Magnitude Mistake'.

Big ideas you will use

- A locked fault bends and stores energy for years. When friction loses, the rock snaps back in seconds. This is called elastic rebound.
- The focus is where the break starts underground. The epicentre is the point on the surface right above it.
- P waves are fastest and arrive first. S waves are slower and cannot pass through liquid. The S–P delay tells the distance, and three stations find the epicentre.
- Most earthquakes happen along plate boundaries, and only subduction zones have very deep ones. Each magnitude step means waves 10 times taller and about 32 times more energy.

Earthquake station

Build three working stations: a fault that sticks and then slips, an epicentre locator that classmates can use, and a shake table that tests which building survives.

Materials

- Two wooden blocks, sandpaper, tape, a thick rubber band, and a ruler
- A Slinky
- Graph paper, a drawing compass, and three index cards
- A shallow box lid, a smaller tray, and 6 to 8 marbles for the shake table
- Sugar cubes or small wooden blocks, tape, and a timer

Your model must show

1. The fault stays stuck while the pull builds, then slips all at once, and the 'road' across it ends up offset (elastic rebound).
2. P and S waves on the Slinky, and three S–P delays that locate one epicentre.
3. The same shaking does different damage to different buildings: earthquake risk depends on the shaking and on what people build.

Build steps

1. Fault: tape sandpaper on top of one block and under the other.
2. Set the second block on the first and draw a 'road' down the side across both.
3. Pull the top block slowly with the rubber band.
4. Waves: stretch the Slinky along the floor.
5. Push one end to send a P wave, then shake it sideways to send an S wave.
6. Locator: on graph paper with a scale of 1 cm = 10 km, mark three stations and a secret epicentre, each station within 15 cm of it so the compass reaches.
7. Measure each station's distance in km, divide by 8 to get the S–P delay in seconds, and write each delay on a card.
8. Shake table: set the small tray on the marbles inside the lid.
9. Build two towers of the same height from the same number of cubes, one with tape cross-braces, and stand both on the tray.
10. Slide the tray 2 cm back and forth at a steady count.
11. Count the shakes until each tower falls, and stop at 30.

It works when

- The fault stays stuck while the band stretches, then slips all at once, and the road ends up offset. Record the stretch in cm before each of five slips.
- A classmate uses only your cards, map, and compass to draw three circles that meet within 1 cm of your secret epicentre.
- In both trials, the braced tower survives more shakes than the unbraced tower, or lasts all 30.

Test it: Record the band stretch and the road jump in cm for five slips, twice. Run the locator test with two different classmates. Run each tower twice and count the shakes it survives.

Safety: Wear goggles when you stretch rubber bands. Pull along the table, never toward a face. Carry the compass point down. Keep marbles off the floor so no one slips.

The Boundary Works — Plate-Margin Simulator: Slide, stick, and shake

1. On Cross-section + block, set Boundary type to Transform.
2. Read the Deepest focus row.
3. Set Relative rate to 5 cm/yr and Elapsed time to 10 Myr.
4. Record the Cumulative strike-slip offset.
5. Switch to Shaking hazard.
6. Set Moment magnitude to 6.9 and Focal depth to 15 km.
7. Record four rows: Rupture length, Peak intensity over the rupture, Damaging shaking (MMI VI), and Felt radius (MMI II).
8. Set Moment magnitude to 7.9 and record the same four rows.
9. Note every row marked EXTRAPOLATED and say why the simulator marks it.

Calculate: Magnitude on a log scale, and distance from the S–P delay

1. Compare a magnitude 7.9 earthquake with a magnitude 6.9 and with a magnitude 4.9.
2. For each pair, find how many times taller the seismogram waves are (10 per step) and about how many times more energy is released (about 32 per step).
3. Then a station records the S wave 12 seconds after the P wave.
4. For a nearby earthquake, use about 8 km for every second of delay.
5. How far away is the earthquake?

Self-check: The wave ratio is 10 multiplied by itself once for every magnitude step. The energy ratio is 32 multiplied by itself once for every step. Your distance $\div$ 8 must give back the delay.

Real data

- **Magnitude and intensity** · USGS, Earthquake Magnitude, Energy Release, and Shaking Intensity. USGS says each whole-number increase in magnitude means a tenfold increase in amplitude on a seismogram and 32 times more energy. An earthquake has one magnitude, but its shaking intensity changes from place to place.
<https://www.usgs.gov/programs/earthquake-hazards/earthquake-magnitude-energy-release-and-shaking-intensity> · Read on 2026-09-23.
- **The great 1906 earthquake** · USGS, The Great 1906 San Francisco Earthquake. USGS reports that the 1906 earthquake broke the northernmost 477 km (296 miles) of the San Andreas Fault. It was felt from southern Oregon to south of Los Angeles and inland as far as central Nevada. A 2008 study listed by USGS gives the best estimate of its moment magnitude as 7.9.
<https://earthquake.usgs.gov/earthquakes/events/1906calif/18april/> · Read on 2026-09-23. The magnitude comes from the USGS study listed in Sources.
- **The 1989 Loma Prieta earthquake** · USGS earthquake event page, M 6.9 Loma Prieta, California, October 1989. The USGS catalogue lists this magnitude 6.9 earthquake at a depth of 17.2 km.
<https://earthquake.usgs.gov/earthquakes/eventpage/nc216859/executive> · Read on 2026-09-23.

- **An earthquake inside the sinking slab** · USGS earthquake event page, M 6.8, 7 km SSE of Longbranch, Washington, February 28, 2001. The USGS catalogue lists this magnitude 6.8 earthquake at a depth of 51.8 km. Then use the USGS Earthquake Catalog to find the deepest earthquake under western Washington and Oregon in the last 50 years.

<https://earthquake.usgs.gov/earthquakes/eventpage/ww10530748/executive> · Magnitude and depth read from the USGS catalogue on 2026-09-23. Record your own search and its date.

- **A giant deep earthquake near Tonga and Fiji** · USGS earthquake event page, M 8.2 2018 Fiji Earthquake. USGS says this magnitude 8.2 earthquake came from faulting inside the sinking Pacific slab, about 560 km below the South Pacific and several hundred km west of the Tonga Trench. The USGS catalogue lists its depth as 600 km. USGS calls earthquakes deeper than 300 km deep-focus.

<https://earthquake.usgs.gov/earthquakes/eventpage/us1000gcii/executive> · Read on 2026-09-23. The two depths come from two parts of the same USGS page. Explain why they can differ.

- **Who felt it** · USGS Did You Feel It?. Open the Did You Feel It? map for a recent California earthquake. Record its magnitude and how far away people reported feeling it.

<https://earthquake.usgs.gov/data/dyfi/> · Record the earthquake you chose and the date you read the page.

Your design decision

1. Your design decision: how to make your fault stick, store energy, and then slip all at once, like a locked fault.
2. A smooth fault just slides and never makes an earthquake.

Two build options to compare

- Build option A: two blocks with sandpaper faces, one pulled along by a rubber band so you can see the stretch build up.
- Build option B: two blocks with sandpaper faces, one pulled by a spring scale so you can read the pull at the moment it slips.

Your map hotspot

1. Mark the part of the San Andreas that broke in 1906 and the Loma Prieta epicentre, and say which way each plate moves.

Trap to avoid

A magnitude 6 earthquake is not twice as strong as a magnitude 3. Each step makes the seismogram waves 10 times taller and releases about 32 times more energy.

TEACH IT

Show your build working, then teach:

1. A locked fault bends and stores energy, then snaps back all at once: elastic rebound.
2. P waves arrive first and S waves later; the longer the delay, the farther away the earthquake, and three stations find the epicentre.
3. Most earthquakes happen along plate boundaries. Each magnitude step means waves 10 times taller and about 32 times more energy, and risk depends on what we build.

Check question: Why does a locked fault make a sudden earthquake instead of sliding smoothly all the time?

Texas standards

- **ESS.8G** Distinguish the location, type, and relative motion of convergent, divergent, and transform plate boundaries using evidence from the distribution of earthquakes and volcanoes. §112.49(c)(8)(G) *You use where and how deep earthquakes happen to tell plate boundaries apart.*
- **ESS.12A** Evaluate the impact on humans of natural changes in Earth's systems such as earthquakes, tsunamis, and volcanic eruptions. §112.49(c)(12)(A) *You evaluate how earthquake shaking affects people and buildings.*
- **ESS.1D** Use appropriate tools such as a drawing compass, magnetic compass, bar magnets, topographical and geological maps, satellite imagery and other remote sensing data, Geographic Information Systems (GIS), Global Positioning System (GPS), hand lenses, and fossil and rock sample kits. §112.49(c)(1)(D) *You use a drawing compass and a scaled map to locate an epicentre.*
- **ESS.2C** Use mathematical calculations to assess quantitative relationships in data. §112.49(c)(2)(C) *You use magnitude ratios to work with a log scale.*
- **8.8A** Compare the characteristics of amplitude, frequency, and wavelength in transverse waves, including the electromagnetic spectrum. §112.28(b)(8)(A) *Grade 6–8 foundation.*
- **6.10B** Model and describe the layers of Earth, including the inner core, outer core, mantle, and crust. §112.26(b)(10)(B) *Grade 6–8 foundation.*

Word bank: fault · elastic rebound · focus · epicentre · P wave · S wave · magnitude · intensity

Root Raisers

FOCUS QUESTION

How do mountains rise, why do rock layers bend and break, and why doesn't erosion just flatten them?

The other teams make the forces. Your team shows what they build: where mountains rise, how squeezing folds and breaks rock, and how uplift and erosion work together over time.

Your lessons

1. Mountain Building: Settings — Convergence, Collision, and Isostasy

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

2. Mountain Building: Stress, Folds, and Faults

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

3. Mountain Building: Uplift Meets Erosion — Motion History and Climate

Publisher lesson: your textbook pages. Dr. Ijezie shares the pages in class.

Also read: Module 4 Slides — The Dynamic Earth. Read the slides 'Raising the Roof: Mountain Building' (isostasy and the crustal root) and 'Two Mountain-Building Settings' (the Andes model and the Himalaya model, and erosion as a construction partner).

Big ideas you will use

- Mountains rise where an ocean plate sinks under a continent (like the Andes) or where two continents collide (like the Himalayas).
- Thick, light crust floats high on the mantle, and most of its thickness is a root below, like an iceberg. This balance is called isostasy.
- Stress is a push or pull on rock. Squeezing folds rock layers and pushes one slab over another along a thrust fault.
- Rain, rivers, and ice wear the top of a range down, and the root floats the range part of the way back up. India still pushes into Asia a few centimetres every year.

BUILD IT

Mountain workshop

Build two working stations: a float tank that shows why tall mountains have deep roots and bounce back when eroded, and a squeeze box that folds and breaks rock layers.

Materials

- A clear tub of water and four or five matching flat wooden blocks (wider than they are tall, so a stack of three does not tip)
- A ruler taped upright inside the tub, and a marker
- A clear plastic storage box (shoebox size)
- Dry sand, and flour or cocoa powder for thin coloured layers
- A flat board or stiff card that fits across the box, as the pusher
- Tape and paper towels

Your model must show

1. A thicker stack floats higher and also sinks deeper, like a mountain range and its root (isostasy).
2. Squeezing folds the sand layers and breaks them along thrust faults.
3. Taking the top block off (erosion) lets the stack float back up, so the top drops by less than the block you removed (rebound).

Build steps

1. Float test: float one block, then stacks of two and three taped together.
2. Measure the height above the water and the depth below it for each.
3. Erosion test: with the three-block stack floating, read the height of its top above the water.
4. Take the top block off and read the new top height.
5. Squeeze box: pour 1 cm layers of dry sand into the box, with a thin layer of flour between each.
6. Level each layer gently.
7. Push the board in slowly from one end, 1 cm at a time, to 5 cm.
8. Draw what you see through the side after each centimetre.

It works when

- Each added block makes the stack stand higher above the water and reach deeper below it (record both in mm).
- After 5 cm of push, the layers show at least one fold or thrust fault, and the pile is taller near the board.
- When you take the top block off, the top of the stack drops by less than one block's thickness.

Test it: Run each test twice. Record heights and depths in mm, push distance and pile height in cm, and a drawing of each result.

Safety: Keep water away from laptops. Mop spills right away so no one slips. Pour sand and flour slowly and low so no dust flies.

The Boundary Works — Plate-Margin Simulator: When two continents meet

1. On Cross-section + block, set Boundary type to Convergent with Left: Continental and Right: Continental.
2. Check that the volcano vanishes.
3. Set Elapsed time to 0, 10, 20, and 35 Myr.
4. Record the Crustal thickness and the Airy peak elevation each time.
5. At 20 Myr, record the Deepest focus.
6. Switch Left to Oceanic and record the Deepest focus again at the same time.
7. Explain it: flux melting needs a subducting, water-bearing slab, and collision has none.

Calculate: The root under a mountain range, and plate-motion history

1. In the simulator, peak height $h = \text{crust thickening} \times (\text{mantle density} - \text{crust density}) \div \text{mantle density}$.
2. Use a crust density of 2.87 and a mantle density of 3.3.
3. Find h and the root depth (thickening – h) when the crust thickens by 10 km, 20 km, and 35 km.
4. Then use the USGS rate of 45 mm/yr for India moving toward Eurasia.
5. How far does India move in 1 million years, in km?

Self-check: Peak height + root depth must equal the thickening. For the rate, 1 cm/yr = 10 km per million years.

Real data

- **How the Himalayas formed** · USGS, This Dynamic Earth: The Himalayas. USGS reports that about 80 million years ago, India was roughly 6,400 km south of Asia, moving north at about 9 m a century. India hit Asia about 40 to 50 million years ago, and its advance slowed by about half. Both continents have about the same rock density, so neither could sink under the other. The Himalayas still rise more than 1 cm a year.
<https://pubs.usgs.gov/gip/dynamic/himalaya.html> · Read on 2026-09-23.
- **The 2015 Nepal earthquake** · USGS earthquake event page, M 7.8 Nepal, April 25, 2015. The USGS catalogue lists this magnitude 7.8 earthquake at a depth of 8.2 km. USGS says it came from thrust faulting between the India and Eurasia plates, where India converges with Eurasia at 45 mm/yr, and about 18 mm/yr of that drives the uplift of the Himalayas.
<https://earthquake.usgs.gov/earthquakes/eventpage/us20002926/executive> · Read on 2026-09-23.
- **How deep Himalayan earthquakes go** · USGS Earthquake Catalog. Search a box around Nepal for magnitude 4.5 and larger in the past 20 years. Record the depth of the deepest earthquake and compare it with a subduction zone.
<https://earthquake.usgs.gov/earthquakes/search/> · Record your search box and the date you searched.

Your design decision

1. Your design decision: how to show both the folding at the surface and the deep root below.
2. Most classroom materials show one or the other, not both.

Two build options to compare

- Build option A: wooden blocks floating in a tub of water, stacked higher to show that a taller range has a deeper root.
- Build option B: layers of sand and flour pushed from one end to show folding and thickening.

Your map hotspot

1. Mark the 2015 Nepal earthquake and the highest part of the range, and say which plate is pushing.

Trap to avoid

Mountains are not stacked on top of the crust. They are the part of a thickened crust that shows, and most of the thickness is a root below. The water in a float model stands in for solid mantle that flows very slowly.

TEACH IT

Show your build working, then teach:

1. Mountains rise where plates converge or collide; thick, light crust floats high and has a deep root (isostasy).
2. Squeezing stress folds rock layers and breaks them along thrust faults.
3. Erosion wears the top down and the root floats the range part of the way back up, and rate $\times$ time tells how far India has pushed into Asia.

Check question: When erosion removes rock from the top of a mountain range, why does the land not drop by the full amount removed?

Texas standards

- **ESS.8E** Explain how plate tectonics accounts for geologic processes, including sea floor spreading and subduction, and features, including ocean ridges, rift valleys, earthquakes, volcanoes, mountain ranges, hot spots, and hydrothermal vents. §112.49(c)(8)(E) *You explain how plate convergence and collision build mountain ranges.*
- **ESS.8D** Describe how heat and rock composition affect density within Earth's interior and how density influences the development and motion of Earth's tectonic plates. §112.49(c)(8)(D) *You describe how the density of crust and mantle sets how high a range stands.*
- **ESS.8F** Calculate the motion history of tectonic plates using equations relating rate, time, and distance to predict future motions, locations, and resulting geologic features. §112.49(c)(8)(F) *You use rate, time, and distance to work out how far India has moved.*
- **6.6D** Compare the density of substances relative to various fluids. §112.26(b)(6)(D) *Grade 6–8 foundation.*
- **7.10B** Describe how plate tectonics causes ocean basin formation, earthquakes, mountain building, and volcanic eruptions, including supervolcanoes and hot spots. §112.27(b)(10)(B) *Grade 6–8 foundation.*

Word bank: collision · isostasy · crustal root · stress · fold · thrust fault · uplift · erosion

Day 6: teach, learn, decide

Teach-back day. Every team teaches its three lessons, so everyone leaves knowing all twelve.

ABOUT 40 MINUTES

Teach-back lessons

Each team teaches for ten minutes: two minutes showing the build working, then each lesson lead teaches their lesson with the build and asks one check question. Every visitor writes an answer.

ABOUT 7 MINUTES

Council

Mixed groups answer the driving question using evidence from all four teams.

ABOUT 8 MINUTES

On your own

Exit ticket, then turn in your group note and do the partner review.

Your learning notes, for every team's lesson

- Team and lessons
- What the build showed
- Key idea from each lesson
- My answers to their check questions
- A question I still have

SCORING

The rubric

One rubric for every ESS team project. Your team is scored together on the first four rows; the last row is scored for you alone. Read it before you start and check your work against it before teach-back day.

STRAND	4 • EXEMPLARY	3 • PROFICIENT	2 • DEVELOPING	1 • BEGINNING
Lesson science Content accuracy across all your lessons • 25% • team	Every lesson is correct and complete, uses the right vocabulary, and connects to the other lessons and the driving question.	Every lesson is correct, with key ideas and vocabulary.	One lesson has errors or gaps, or the ideas are listed without explanation.	Lessons are missing or mostly wrong.
The build works Function, testing, and photos • 25% • team	The build passes every 'It works when' test at least twice, the results have units, one fix improved it, and clear approved photos show it.	The build passes its tests, with recorded results and photos.	The build works only partly, or the tests are not recorded.	The build does not work or was not tested.
Teaching the class Teach-back and check questions • 20% • team	Each lesson lead teaches clearly with the build; most classmates answer the check questions correctly; timing is right.	Every lesson is taught with the build, and check questions are asked.	Some lessons are rushed or taught without the build.	The lesson is missing or unclear.
Group note Note Studio group note and evidence • 20% • team	Every section is complete, data has units and sources, the claim matches the evidence, and it names one limit of the build.	Every section is complete, with data and a claim.	Some sections are thin or missing.	The note is mostly empty.
My contribution Individual work, partner and teacher ratings • 10% • each scholar	You led your lesson well, did your role on time, and made a teammate's work better. Your contribution section, partner ratings, and teacher rating agree.	You led your lesson and did your role on time.	Your part was late or only partly done.	Little evidence of your part.

The first four rows are scored for the team. My contribution, your learning notes, and your exit ticket are scored for you alone.

ON YOUR OWN

Exit ticket

1. Pick a lesson another team taught. Explain its main idea in two or three sentences.
2. Name one test from another team's build and what it proved.
3. A boundary has earthquakes 500 km deep and a line of explosive volcanoes. What kind of boundary is it? Use two teams' lessons to explain.
4. Name the part of your team's work you did yourself, and one thing you would rebuild.

Sentence starters

- *Our team claims that ____ because ____.*
- *We observed _____. From that we infer _____.*
- *The evidence that supports this is _____, which shows _____.*
- *In the simulator, when we changed _____, the _____ went up / went down by _____.*
- *The data came from _____, and we read it on _____.*
- *One limit of our build is _____.*
- *Our build and the real Earth do not match at _____. The physical cause is _____.*
- *I agree with _____ because _____. I would add _____.*
- *I have a different idea. The evidence _____ suggests _____.*
- *Can you explain how _____ connects to _____?*

Supports you can use

- Every packet has a word bank. Look up any word in the Ascent Lexicon.
- You may draft in the language you think in best and then write the final version in English.
- Use the sentence starters above in your claim, your lesson, and the council.
- The teach-back lesson can be split between teammates, and it can use the slide's pictures and numbers as notes.
- Ask your teacher for a printed packet, a larger-print copy, or extra time on any checkpoint.

STANDARDS

Standards for the whole project

These are selected connections to the Texas standards for Earth Systems Science (19 TAC §112.49), not a claim that this project fully covers each one. No engineering-design (HS-ETS) standard is claimed.

- **ESS.3B** Communicate explanations and solutions individually and collaboratively in a variety of settings and formats. §112.49(c)(3)(B) *Every team teaches its lessons to the class and explains its build.*
- **ESS.3C** Engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence. §112.49(c)(3)(C) *The council argues from evidence across all four teams.*
- **ESS.2A** Identify advantages and limitations of models such as their size, scale, properties, and materials. §112.49(c)(2)(A) *Every team names what its build leaves out and why, because of size, scale, and materials.*

SOURCES

Where the numbers come from

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Build a Plate Boundary: Four Teams, Twelve Lessons · drijezie.com/courses/earth-systems-science/projects/plate-boundary/