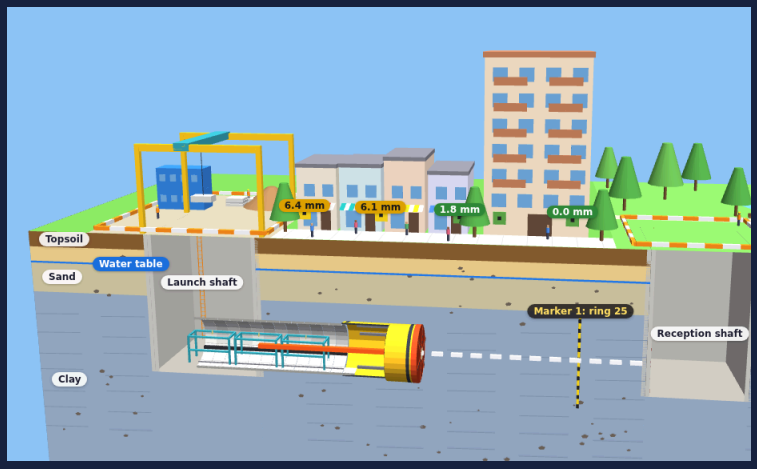
mytekDev

Tunnel Boring Lab: The Street Above, Face Pressure and Settlement

Grades 6-8 · 45 minutes

Engineering · Earth science



Slides, rubric and answer key **Print and go** **No student accounts**

Chromebook friendly

What's included

- A one-page overview: objectives, essential question, vocabulary, standards and assessment
- A 45-minute lesson sequence: warm-up, direct instruction, guided practice, independent practice, closure
- Slides for the board: a PowerPoint file that also opens in Google Slides
- A student worksheet with a QR code and a table for six targets
- A 3-question exit ticket, two to a page, with an answer key
- A rubric: 3 criteria, 4 levels, scored out of 12
- Differentiation for English learners, students with IEPs or 504 plans, and students who need more support or more challenge
- Cross-curricular extensions, and notes for teaching it in grades 4 and 5 and in high school
- Standards: NGSS

Tunnel Boring Lab: The Street Above, Face Pressure and Settlement

Grades 6-8 · 45 minutes · Engineering, Earth science

Level 8 of Tunnel Boring Lab bores 25 rings under a row of shops and an apartment building. Every ring takes a little ground with it, so the street sinks, watched at survey points on the buildings; at 10 mm, the trigger, work stops. The machine holds up the ground ahead, the face, with pressure in a chamber behind its cutterhead. The program in the starter holds that pressure at a target set too low, and the shops sink past their trigger. Students change one number, the target, and find that more pressure means less settlement, until about 2.7 bar, more than the weight of the ground above, where the street is pushed up instead.

At a glance

ESSENTIAL QUESTION

How hard should a tunnel machine press on the ground in front of it?

OBJECTIVES

Students will be able to:

- explain why boring a tunnel makes the ground above it sink
- read settlement from survey points and compare it with a trigger level
- test one number across a range and record the results
- explain why more pressure is not always safer
- choose a target and defend it with the margin on both sides

VOCABULARY

Face, Face pressure, Bar, Settlement, Survey point, Trigger level

STANDARDS

MS-ETS1-2, MS-ETS1-4

TIME AND MATERIALS

45 minutes, grades 6-8.

- One computer or Chromebook per student
- A projector
- The worksheet and exit ticket, one copy each per student
- The rubric, one copy per student if you grade the work

PREP

Make copies of the worksheet and exit ticket. Before class, open mytekdev.com/try/tunnelboringlab?lesson=the-street-above-face-pressure-and-settlement&ref=tpt-tunnelboringlab-3 once on a student computer, which checks that your school's filter allows the app, and follow the short guide yourself: about ten minutes.

ASSESSMENT

- Formative: the questions under What to look for, asked while students work, and the exit ticket (answer key included).
- Summative: the worksheet, scored with the rubric.

TECHNOLOGY AND PRIVACY

Runs in any browser, Chromebooks included, with nothing to install. Students need no account and no email: the link works signed out, and nothing they do is stored on our server unless they choose to save.

Lesson sequence

MINUTES	STAGE	WHAT YOU DO	WHAT STUDENTS DO
0 to 5	**Warm-up** Hook	Show the title, essential question and Today I can slides (about 1 minute). Then the warm-up: what could go wrong above a tunnel? Leave the answers on the board.	Answer the warm-up on the worksheet.
5 to 13	**Direct instruction (I do)** Model it	Project Level 8 and press play, then Speed up twice. The street is drawn cut open along the tunnel's line like a diagram: the buildings and the road on top, then topsoil, sand, clay and granite. The machine is under the street, boring from the launch shaft on the left. The box at the top says what the level wants and what is happening; the guidance screen is the round dial. Point at the survey points on the shops and the apartment building, and the face pressure in the readings. Explain the face and the chamber: the dug soil is held under pressure and pushes back on the ground ahead, and the screw takes it out. Open Blocks and read the program aloud: it runs the screw faster when the pressure is over the target and slower when it is under. Let it run: the shops sink past 10 mm after ring 11 and work stops. **It's working when:** Students do not write the loop today; they change one number in it. Name it as a thermostat for the face: it reads the pressure every 10 seconds and corrects the screw.	Watch, and fill in the vocabulary on the worksheet.
13 to 22	**Guided practice (We do)** One number	Students open the link or scan the QR code. A short guide walks them through the run at 1.6, then changing the target to 1.9. Walk the room until every student has a green result: 25 rings, the worst point down 8.5 mm. **Watch for:** Students who change the 50 or the 100 in the screw block instead. The program still runs, but the result is hard to compare. Point them at the set target block at the top.	Follow the guide. Write both results in the table.
22 to 37	**Independent practice (You do)** Find the window	Students try the target at 2.2, 2.4, 2.6 and 2.8, and record the worst survey point in the result, or what stopped the drive. A drive is many hours of the machine's own time. Speed up, twice, runs it at 6 times faster, 22 minutes of the drive a second, so most runs take under a minute. Play always puts the machine back in the shaft and runs the program as it is now. Walk the room with the What to look for questions. **If they ask:** "At 2.8 the drive stops before a ring is built. What does the result say, and why?" Past the weight **Watch for:** Students who say 2.6 is best because the number is smallest. Ask how far it is from the pressure that pushed the street up.	Fill in the table with six targets, and answer the questions.

MINUTES	STAGE	WHAT YOU DO	WHAT STUDENTS DO
37 to 45	**Closure** Is more always safer? And exit ticket	Show the closure slide. Take answers, then give the trade: more pressure takes less ground, until it lifts the street. A choice with room on both sides is the engineering answer. Back to the warm-up answers. Hand out the exit ticket.	Choose a target and give a reason, then answer the exit ticket.

Before you teach: a ten-minute walkthrough

Open mytekdev.com/try/tunnelboringlab?lesson=the-street-above-face-pressure-and-settlement&ref=tpt-tunnelboringlab-3. A short guide opens over Level 8, The buildings above. The street is drawn cut open along the tunnel's line like a diagram: the buildings and the road on top, then topsoil, sand, clay and granite. The machine is under the street, boring from the launch shaft on the left. The box at the top says what the level wants and what is happening; the guidance screen is the round dial. Here the survey points are the small marks on the fronts of the shops and the apartment building, and their readings are in mm.

1. **The program.** Blocks opens with it written: set target to 1.6; push 50 all round; turn at 3; then 25 times, start a stroke without waiting, and while it is still boring, turn the screw at 50 + 100 x (face pressure - target) and wait 10 seconds; then build a ring. Over the target, the screw runs faster and lets pressure out; under it, slower.
2. **The street.** Every ring takes a little more ground than the tunnel's own size, and the street above sinks into a shallow trough, deepest over the tunnel. The less the face pressure falls short, the less ground each ring takes.
3. **Speed.** A drive is many hours of the machine's own time. Speed up, twice, runs it at 6 times faster, 22 minutes of the drive a second, so most runs take under a minute. Play always puts the machine back in the shaft and runs the program as it is now.
4. **Numbers to expect.** Target 1.6: a point on the shops sinks 10.1 mm after ring 11, and work stops. 1.9: passes, the worst point down 8.5 mm. 2.2: 5.8 mm. 2.4: 4.1 mm. 2.6: 2.3 mm. 2.7 or 2.8: the drive stops before the first ring, the pressure above the ground's weight of 2.5 bar, and the street pushed up.

> The level's own target, from the depth and the water table, is about 1.9 bar here (the Level 7 formula). Higher targets take less ground in this model. The model's upper limit is the weight of the ground above, about 2.5 bar at 14 m, plus a little; real projects set it from the ground survey, with a margin.

Background for the teacher

A soft-ground tunnel boring machine holds up the face by keeping the dug soil under pressure in a chamber behind the cutterhead. A screw conveyor takes the soil out at the bottom: turn it faster and the pressure falls, slower and it rises. This kind of machine is called an earth pressure balance machine, because the chamber pressure balances the ground and water pushing in.

However well it is run, a tunnel takes a little more ground than its own size, called volume loss, a fraction of a percent on a well-run drive. The ground above sinks into a trough shaped like a bell curve, deepest over the tunnel.

Engineers predict it before the drive and measure it during it at survey points on buildings, with trigger levels at which work slows or stops. Real projects set two or more trigger levels; the app uses the last one, where work stops.

Too much pressure is also a hazard: past the weight of the ground above, the chamber pushes the ground up, and can blow out at the surface. The safe choice is a window, not a maximum. Nothing in the app caves in on anyone: buildings settle by millimeters, shown as numbers, and never fall.

What to look for

Ask these while students work. A student who has understood the lesson can answer them without help:

- Why does the street sink at all when the tunnel is lined as it goes?
- What does the program do when the pressure is over the target?
- Which building sank first at 1.6, and after which ring?
- Why did 2.8 stop the drive?
- Which target would you choose, and how much room does it leave on each side?

> The last question is the one that matters. A student who names the margin on both sides, sinking and pushing up, has the trade-off. A student who picks 2.6 because it sank least has read the data but not the risk.

Cross-curricular extensions

- Math: plot the worst survey point against the target. Where would you draw the line for 10 mm and for the push-up?
- Earth science: why does sand below the water table run more easily than clay? Try Level 9.
- Careers: look up what a geotechnical engineer or a surveyor does on a tunnel project.
- Civics: a city tunnel passes under homes. Who should be told before it starts, and what should they be told?

Vocabulary

Face	The ground right in front of the cutterhead, where the machine is digging.
Face pressure	How hard the soil in the chamber behind the cutterhead presses back on the face, in bar.
Bar	A unit of pressure. 1 bar is about the pressure of the air around you.
Settlement	How far the ground or a building sinks, in mm.
Survey point	A mark on a building that surveyors measure again and again to see if it moves.
Trigger level	The settlement at which work stops: here 10 mm down, or 5 mm up.

Differentiation

ENGLISH LEARNERS

- Keep the vocabulary slide up, and point at the machine, the guidance screen or the readings as you say each word: the picture carries the meaning.
- Give a sentence frame on a card: When the target is ____, the street ____, because ____.
- Push a hand into a bag of rice to show pressure at the face: too soft and the rice falls in, too hard and it bulges.

STUDENTS WITH IEPS OR 504 PLANS

- Pair students, one at the keyboard and one recording numbers.
- Give the six targets on a card: 1.6, 1.9, 2.2, 2.4, 2.6, 2.8.
- Where the IEP allows a modified assignment, score the first two rubric rows only.

STUDENTS WHO NEED MORE SUPPORT

- Make the first change together on the board.
- Fill in the 1.6 row of the table together from the model run.
- Show where the worst survey point is in the result line.

STUDENTS READY FOR MORE

- Open Level 12: grout the gap behind the rings. How much does the worst point change at the same target?
- Read Help, How it works: what is the formula for the target, and why does it add the water's pressure?
- Open the Python tab and find the loop. What does the 100 do? Try 50 and 200 at target 2.2.

Adapting for other grades

Younger students: In grades 4 and 5, run 1.6 and 1.9 together on the board, then let pairs try 2.8. Score the first two rubric rows, total 8, and 6 meets the objectives.

Older students: In high school, the lesson fits HS-ETS1-3: weigh safety and reliability against the settlement, and write the target as a formula in the depth and the water depth (Level 7). Students can write the control loop themselves from an empty Level 7, and read about the Gaussian settlement trough engineers use to predict it.

Student worksheet

Name: _____ Date: _____

Open the app: scan the QR code, or go to mytekdev.com/try/tunnelboringlab?lesson=the-street-above-face-pressure-and-settlement

Essential question: How hard should a tunnel machine press on the ground in front of it?

Warm-up: What could go wrong above a tunnel under a street? _____

1. **Vocabulary.** Face, face pressure, bar, settlement, survey point, trigger level: write each in your own words.

2. **The starter.** Target 1.6: ____ sank ____ mm after ring ____ . The trigger is ____ mm.
3. **My table.** Target / worst survey point (mm) or what stopped it. 1.9: ____. 2.2: ____. 2.4: ____. 2.6: ____. 2.8: ____.

4. **The window.** The street stays inside its triggers from a target of about ____ to about ____ .

1. Which target would you choose for a real street, and why?

2. Why is more pressure not always safer?

Exit ticket

Name: _____

1. Raising the face pressure (but not too far) makes the street: (A) sink more (B) sink less (C) no different

2. A trigger level is: (A) the settlement at which work stops (B) the deepest the tunnel can go (C) the pressure in the chamber

3. A friend sets the target to 3.0 so the street cannot sink at all. Use what you learned today to say what will happen, and what to do instead.

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Exit ticket

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Answer key: exit ticket

QUESTION	ANSWER	WHY
1	B	The face is held closer to the ground's own push, so each ring takes less ground.
2	A	Survey points are watched against it; here 10 mm down or 5 mm up.
3	Open answer	Past the weight of the ground above, about 2.5 bar here, the street is pushed up and the drive stops. Choose a target in the window, such as 2.2, with room on both sides.

Worksheet: what students should find

BLANK	WHAT THE APP SHOWS
The starter	The shops, 10.1 mm, after ring 11. The trigger is 10.
My table	1.9: 8.5. 2.2: 5.8. 2.4: 4.1. 2.6: 2.3. 2.8: stopped before the first ring, the street pushed up.
The window	About 1.9 to about 2.6.
Question 1	Open: a target with room on both sides, about 2.2 to 2.4, with that reason, is the best answer.
Question 2	Past the weight of the ground above, the pressure pushes the street up.

> Every run of Level 8 is the same ground and the same machine, so a target gives the same numbers on any computer. A student whose numbers differ changed another number in the program.

Rubric

Score each row from 1 to 4.

Name: _____

CRITERIA	4 EXCEEDS	3 MEETS	2 APPROACHING	1 BEGINNING
Reading the street	Reads the worst survey point, which building and which ring, and explains why the street sank.	Reads the worst survey point and compares it with the 10 mm trigger.	Says whether it passed without the numbers.	Does not read the result.
Testing a range	Tests six or more targets, records each result, and finds both ends of the window.	Tests four targets and records each result.	Tests one or two.	Does not change the target.
Weighing the trade-off	Chooses a target and defends it with the margin on both sides, sinking and pushing up.	Explains that too much pressure pushes the street up.	Says more pressure is safer.	No explanation.

Total: ____ / 12. A score of 9 or more meets the objectives.

Standards

The lesson is built for evaluating competing solutions against criteria and constraints (MS-ETS1-2) with a model that generates data for each change (MS-ETS1-4). HS-ETS1-3, trade-offs including safety, is in the high school notes.

FRAMEWORK	CODE	GRADES	STANDARD	HOW THE LESSON MEETS IT
NGSS	**MS-ETS1-2**	6-8	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	Students compare six targets against two constraints on the street, the 10 mm trigger down and 5 mm up, and choose one with a reason.
NGSS	**MS-ETS1-4**	6-8	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	The drive is the model; each run generates the settlement data for the next change of the target.

Checked November 2026 against: NGSS: MS-ETS1 Engineering Design.

Optional: save student work in a free class

The whole lesson runs at the link on the worksheet, with no accounts and no sign-up.

To keep students' work, and see it all in one place, make a free class. It takes about ten minutes, once, and covers every lesson in this series: mytekdev.com/tools/class-setup

Students in a class open mytekdev.com/tools/tunnel-boring-lab/lessons/the-street-above-face-pressure-and-settlement/start instead of the worksheet link. Each one gets their own copy of the starter, and the same link reopens it next time.

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