Family edition

Tunnel Boring Lab: Stay on the Line, Steering by Thrust

Ages 11-14 · about 45 minutes, in one sitting

In Tunnel Boring Lab your child programs a tunnel boring machine under a city street, and steers it the way real ones are steered: by pushing harder on one side.

What you need

- A computer or Chromebook with a current browser.
- The link: mytekdev.com/try/tunnelboringlab?lesson=stay-on-the-line-steering-by-thrust&ref=fam-tunnelboringlab-1. No account, no email and nothing to install.

Before you start: try it once yourself

Open mytekdev.com/try/tunnelboringlab?lesson=stay-on-the-line-steering-by-thrust&ref=fam-tunnelboringlab-1. A short guide opens over Level 2, Stay on the line. 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.

1. **The push.** The starter pushes 50 on every side (top, bottom, left, right), out of 100, turns the cutterhead at 3 turns a minute, and bores a stroke and builds a ring 20 times. A stroke is 1.6 m, one ring's width.
2. **The guidance screen.** The filled dot is the machine's head and the small ring its tail; the middle is the line; the orange circle is the 50 mm limit. Past 100 mm the dot waits at the edge, and the box gives the distance. A laser in the tunnel behind the machine measures it. The machine never sees the line.
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.** Left at 50, the right at: 50, ring 20 ends 341 mm right (342 off, with 15 mm low); 60, 228 right; 70, 114 right; 80, on the line sideways and 15 mm low, and it passes; 90, 114 left; 100, 228 left. 80 on the left with 50 on the right: 683 right. 30 on the left with 80 on the right: 228 left.

> Every push in this level ends 15 mm low: the machine is heavy and dips a little each ring. It is inside the limit, so the lesson is the side to side, but a child who asks has seen something real. Pushing harder on the bottom lifts it.

The ideas, in plain words

A tunnel boring machine moves by pushing off the tunnel it has just built. Hydraulic cylinders round the inside of its shield press against the last ring of the concrete lining, and push the machine forward one ring's width, a stroke.

Then the machine stands still while a new ring is built inside its tail, and pushes off that one.

Nothing at the front turns. To go round a curve, the crew pushes harder on the outside of the curve: the cylinders on that side extend a little further each stroke, so the machine swings toward the inside. It is an unbalanced force making a change in motion, a little every millimeter bored. Real machines add a hinge in the shield for tight curves; the app leaves it out.

Underground there is nothing to see by. A laser fixed in the finished tunnel shines on a target on the machine, and a computer works out where its head and tail are against the line. Real drives are built to about the same limit as here: Crossrail's tunnels under London were held to about 50 mm.

Do it together

1. Open mytekdev.com/try/tunnelboringlab?lesson=stay-on-the-line-steering-by-thrust&ref=fam-tunnelboringlab-1 together and press play, then `Speed up` twice. Watch the dot on the round guidance screen.

   > **You'll know it worked when:** The machine goes straight while the line curves left, and ends ring 20 about 342 mm off. The limit is 50.

2. Open `Blocks`, and in the push block make the right number bigger than the left one. Go back to `Simulator` and press play.

   > **If you get stuck:** If it turned right, the left number is the bigger one. The four numbers are top, bottom, left, right.
   >
   > **You'll know it worked when:** At 80 on the right the result is green: on the line, 15 mm low.

3. Try 60, 90 and 100 on the right, and write where ring 20 ended each time.

   > **You'll know it worked when:** 60 ends 228 mm right; 90 ends 114 mm left; 100 ends 228 mm left.

4. Ask: why does pushing harder on the right turn it left?

   > **You'll know it worked when:** The right side moves forward more each stroke than the left, so the front swings left, the way a desk pushed harder on one corner turns.

Talk about it

Ask these while you work together. A child who has understood it can answer them without help:

- Which side do you push harder to turn left, and why?
- How does the machine know where it is underground?
- Why is it fair to compare your push with your friend's?

- How far did each 10 more on the right move the end of ring 20?
- 100 on the right is the biggest push. Why does it fail?

> The fourth question is the one that matters. A child who says "about 114 mm each time" has found a pattern and can use it. A child who found 80 by guessing has the result but not the reason.

For younger and older kids

Younger: For a younger child, stop after the first green result and act it out with a box pushed from behind.

Older: For an older child, open `Level 3` and steer the same curve with rings turned left instead of the push.

Keep going

- Open Level 3: steer the same curve with the push the same all round, using rings turned left. How many in five?
- Find a push that ends ring 20 within 10 mm of the line sideways.
- Open the Python tab and find tbm.push. Which of the four numbers is the right side?

Bring it into other subjects

- Math: plot where ring 20 ended against the right push, and find the slope. Is it a straight line?
- Science: why does a rowboat turn when one oar pulls harder? Compare it with the machine.
- Careers: look up what a tunnel engineer or a surveyor does on a tunnel project.
- Geography: find a tunnel under your nearest city, and find out what it carries.

For your records

Ready to copy into an hour log, a portfolio or a transcript.

LESSON	Tunnel Boring Lab: Stay on the Line, Steering by Thrust
SUBJECTS	Engineering, Physical science
TIME	45 minutes
WHAT WE DID	Steered a simulated tunnel boring machine round a curve by pushing harder on one side, tested five pushes and found the pattern in the results.
SKILLS PRACTICED	Unbalanced forces; Testing one variable; Finding a pattern

Activity sheet (optional)

Name: _____ Date: _____

Open the app: scan the QR code, or go to mytekdev.com/try/tunnelboringlab?lesson=stay-on-the-line-steering-by-thrust

Essential question: How do you steer a machine that has nothing at the front to turn?

Warm-up: How could a machine with no wheels go round a curve? _____

1. **Vocabulary.** Tunnel boring machine, thrust cylinders, unbalanced push, line, guidance screen, tolerance: write each in your own words.

2. **The starter.** Push 50 on every side. Ring 20 ended ____ mm off the line, on the ____ side. The limit is ____ mm.
3. **My table.** Left at 50. Right push / mm off at ring 20 / which side. 60: ____ / ____. 70: ____ / ____. 80: ____ / ____. 90: ____ / ____. 100: ____ / ____.

4. **The pattern.** Each 10 more on the right moved the end about ____ mm to the ____ .

1. Why does pushing harder on the right turn the machine left?

2. What do you predict for 30 on the left and 80 on the right? Why?

Quick check

Name: _____

1. To turn the machine left, push harder on the: (A) left (B) right (C) top

2. The machine knows where it is underground from: (A) a camera at the front (B) a laser in the tunnel behind it (C) the driver looking out

3. A friend pushes 90 on the right and ends 114 mm left of the line. Use what you learned today to say what to change, and why.

Answers

QUESTION	ANSWER	WHY
1	B	The right side moves forward more each stroke, so the front swings left.
2	B	A laser fixed in the finished tunnel measures where the head and tail are against the line.
3	Open answer	Make the right push smaller, about 80: each 10 points moved the end about 114 mm, so 10 less brings it back.

If your state or umbrella school asks, this lesson covers NGSS MS-PS2-2, NGSS MS-ETS1-4.

Terms of use

This lesson was made by mytekDev. You may print and copy it for the children you teach at home, and change it for them. You may not sell it, share it with other families, or post it publicly.

The app this lesson uses is free and runs in the browser, with nothing to install and no account needed. It is at mytekdev.com.

© 2026 mytekDev. All rights reserved.