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Air Traffic Control Lab: Which Runway, Headwind and Crosswind

Grades 9-12 · 45 minutes

Math



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 five winds
- 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 middle school and in physics
- Standards: Common Core math

Air Traffic Control Lab: Which Runway, Headwind and Crosswind

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Level 7 of Air Traffic Control Lab has one runway with two ends, 36 pointing north and 18 pointing south, and a wind from 190 degrees at 16 knots. Airliners land into the wind; with more than 10 knots from behind, most will not land at all. Students split the wind into its two parts on each runway with the right triangle: the headwind is the wind speed times the cosine of the angle between where the wind comes from and the way the runway points, and the crosswind uses the sine. On runway 36 that is a 15.8 knot tailwind, and the first arrival goes around at 1:04. On runway 18 it is a 15.8 knot headwind with 2.8 knots across, and all three land. The starter program prints the numbers, so students check their trigonometry against it, then write the if that chooses the runway for any wind.

At a glance

ESSENTIAL QUESTION

How do you split a wind into the part that helps and the part that pushes sideways?

OBJECTIVES

Students will be able to:

- find the angle between a wind and a runway
- compute headwind and crosswind with cosine and sine
- explain what a negative headwind means
- choose a runway from the numbers and check it in the simulation
- write a condition that chooses the runway for any wind

VOCABULARY

Runway number, Wind direction, Headwind, Tailwind, Crosswind, Component

STANDARDS

HSG-SRT.C.8, MP4

TIME AND MATERIALS

45 minutes, grades 9-12.

- 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
- A scientific calculator, or one on the computer, set to degrees

PREP

Make copies of the worksheet and exit ticket. Before class, open mytekdev.com/try/airtrafficlab?lesson=which-runway-headwind-and-

ASSESSMENT

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

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

crosswind&ref=tpt-airtrafficlab-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.

- Summative: the worksheet, scored with the rubric.

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: the north runway and the north-east wind.	Answer the warm-up on the worksheet.
5 to 15	**Direct instruction (I do)** Model it	Explain runway numbers and wind direction, and draw the triangle. Show the triangle slide and compute together: on 18 the angle is 190 minus 180, 10 degrees; headwind 16 cos 10° = 15.8, crosswind 16 sin 10° = 2.8. On 36 the angle is 190 minus 360, minus 170 degrees: cos is negative, so headwind is minus 15.8, a tailwind. **It's working when:** Check calculators are in degrees: cos 10 in radians is negative and causes confusion.	Compute along on the worksheet.
15 to 22	**Guided practice (We do)** Compute, then check	Students open the link or scan the QR code. The program prints the wind on each runway under the stage, "print: 36: -15.8 -2.8 18: 15.8 2.8", then lands on 36, where the first arrival goes around. The guide has them change one word to land on 18. **Watch for:** Students puzzled by the minus crosswind. The sign says which side the wind comes from; the size is what a pilot cares about.	Follow the guide. Check their numbers against the print line.
22 to 37	**Independent practice (You do)** Five winds, then the if	Students compute headwind and crosswind on both runways for the five winds on the worksheet, and choose a runway for each. Then they replace use_runway("18") with an if: if the headwind on 18 is bigger than on 36, use 18, else 36. To check another wind, Missions, Build your traffic sets the wind; the print line shows the numbers. Walk the room with the What to look for questions. **If they ask:** "Without a calculator, how can you tell which runway has the headwind?" The rule **Watch for:** Students comparing crosswinds instead of headwinds. The crosswind is the same size on both ends of one runway.	Fill in the table, write the if, and answer the questions.
37 to 45	**Closure** A wind straight across, and exit ticket	Show the closure slide. Work it together: cos 90° = 0, so no headwind on either end. Hand out the exit ticket.	Discuss, then answer the exit ticket.

Before you teach: a ten-minute walkthrough

Open mytekdev.com/try/airtrafficlab?lesson=which-runway-headwind-and-crosswind&ref=tpt-airtrafficlab-3. A short guide opens over Level 7, Which runway, with a Python program. The tower view is on the left: the airport from the control tower, the airliners with their landing lights on and a tag with each call sign. The radar is on the right: the runway at the top, the dashed final approach line, and a green dot for each airplane with its data block (call sign,

altitude in hundreds of feet, speed in tens of knots). Under the radar the radio log keeps every word said, marked "you" or "program". Click an airplane on the radar to give it an instruction.

1. **The program.** The first line prints the headwind and crosswind on each runway, rounded to a tenth of a knot; the line under the stage shows it after "print:". Then use_runway("36") chooses the runway before the shift starts, and a rule clears each arrival at 5 miles.
2. **The signs.** A negative headwind is a tailwind. The crosswind's sign says which side it blows from; its size is the same on both ends of one runway.
3. **The if.** if tower.headwind("18") > tower.headwind("36"): then use_runway("18") on the next line, indented; else: and use_runway("36"). Python needs the colons and the indents.
4. **Other winds.** Level 7 always has the wind from 190 at 16. Missions, Build your traffic sets any wind in 10 degree steps, and the program and its print line run there too; the print line shows as the shift starts, and that is all the check needs, so stop the shift once it shows.
5. **Numbers to expect.** Level 7: 36, headwind -15.8, crosswind -2.8; 18, 15.8 and 2.8. On 36 Fernway 44 goes around at 1:04; on 18 all three land by 10:15. In Build your traffic: 240 at 20 gives 36: -10, -17.3 and 18: 10, 17.3, so the if picks 18; 300 at 12 gives 36: 6, -10.4 and 18: -6, 10.4, so it picks 36.

> The app's crosswind is the wind speed times the sine of the angle between where the wind comes from and the way the runway points, so it is positive from the right and negative from the left. Students who compute it as a size only are right; the sign is a bonus.

Background for the teacher

Runways are numbered by the way they point, in tens of degrees: 36 points north (360), and the same strip seen from the other end is 18, pointing south. Winds are reported by where they blow from. An airplane lands into the wind because the headwind slows it over the ground, so it touches down slower and stops sooner.

The wind makes the hypotenuse of a right triangle with the runway. The side along the runway is the headwind, W cos θ, and the side across is the crosswind, W sin θ, where θ is the angle between the wind's direction and the runway's. Most airliners are not allowed to land with more than 10 knots of tailwind, and every airplane has a crosswind it has been shown to handle.

Choosing the runway is the tower's job. When the wind changes enough, the airport "turns around" and every arrival and departure moves to the other end. Air traffic controllers in the United States are hired by the FAA, which says it hired a record 2,235 trainees in its 2026 fiscal year. Applicants must apply before turning 31, and the median pay was $148,080 a year in 2025 (Bureau of Labor Statistics).

What to look for

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

- What angle do you use, and how do you find it?

- What does a negative headwind mean for the pilot?
- Why is the crosswind the same size on both ends?
- Without a calculator, how can you tell which end has the headwind?
- What does your if do for a wind straight across?

> The fourth question is the one that matters. A student who says "the end that points toward where the wind comes from" has the idea behind the cosine. A student who can only push calculator buttons has the numbers without the picture.

Cross-curricular extensions

- Physics: a 150 knot airliner with a 15.8 knot headwind: what is its groundspeed, and how much shorter is the landing roll, if it goes as the square of the speed?
- Geography: find the runway numbers at your nearest airport, and the wind that usually blows there.
- Careers: look up what a meteorologist at an airport does, and how wind reports reach the tower.
- Computer science: change the if into a function that takes the wind and returns the runway, and test it with five winds.

Vocabulary

Runway number	The way the runway points, in tens of degrees: 36 points to 360 degrees, north; 18 points to 180, south.
Wind direction	Where the wind blows from, in degrees: a wind from 190 blows from just west of south.
Headwind	The part of the wind blowing straight at the front of the airplane. It slows the airplane over the ground, which shortens the landing.
Tailwind	Wind from behind: a negative headwind. It lengthens the landing.
Crosswind	The part of the wind blowing across the runway, from one side.
Component	One of the parts a vector is split into, at right angles to each other.

Differentiation

ENGLISH LEARNERS

- Keep the vocabulary slide up, and point at the radar, the airplane or the radio log as you say each word: the picture carries the meaning.
- Give a sentence frame on a card: The headwind is ____ times the cosine of ____ degrees.
- Draw every wind as an arrow on the same runway picture, and label the two parts in two colors.

STUDENTS WITH IEPS OR 504 PLANS

- Pair students, one at the keyboard and one computing.
- Give the angle for each wind on the worksheet, so the work is the cosine and sine.
- Where the IEP allows a modified assignment, score the first two rubric rows only.

STUDENTS WHO NEED MORE SUPPORT

- Work the first wind of the table together.
- Give the if as a fill-in: if tower.headwind("__") > tower.headwind("__"):
- The print line checks every answer.

STUDENTS READY FOR MORE

- Show that the headwind on 18 is always the negative of the headwind on 36. Why?
- Find the wind from the south that gives exactly 10 knots of tailwind on 36 at 16 knots of wind.
- Change the if so the program refuses to land on a runway with more than 20 knots of crosswind, and prints why.

Adapting for other grades

Younger students: In middle school, use a scale drawing on graph paper instead of trigonometry: draw the wind arrow, and measure the two parts with a ruler. Score the first two rubric rows, total 8, and 6 meets the objectives.

Older students: In physics, write the wind as a vector and the runway as a unit vector, and find the headwind as a dot product. Then explain why the landing roll is shorter into the wind, from the groundspeed.

Student worksheet

Name: _____ Date: _____

Open the app: scan the QR code, or go to mytekdev.com/try/airtrafficlab?lesson=which-runway-headwind-and-crosswind

Essential question: How do you split a wind into the part that helps and the part that pushes sideways?

Warm-up: A runway points north, and the wind is from the north-east at 20 knots. How much blows straight down the runway? _____

1. **Vocabulary.** Runway number, wind direction, headwind, tailwind, crosswind, component: write each in your own words.

2. **Level 7.** Wind from 190 at 16. Runway 18: angle ____, headwind ____, crosswind ____. Runway 36: angle ____, headwind ____, crosswind ____. Land on: ____ .

3. **My table.** Wind / headwind on 36 / headwind on 18 / crosswind / runway. 240 at 20: ____. 300 at 12: ____. 150 at 18: ____. 360 at 8: ____. 090 at 15: ____.

4. **My if.** Write it: _____

1. Why do airplanes land into the wind?

2. What should a program do when neither runway has a headwind?

Exit ticket

Name: _____

1. A wind from 200 at 10 knots on runway 18. The headwind is: (A) 10 × cos 20° (B) 10 × sin 20° (C) 10 × cos 200°

2. A headwind of -12 knots means: (A) 12 knots from the front (B) 12 knots from behind (C) 12 knots across

3. A friend lands on runway 36 in a wind from 170 at 15 knots. Use what you learned today to say what will happen, and what to change.

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Exit ticket

Name: _____

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3. A friend lands on runway 36 in a wind from 170 at 15 knots. Use what you learned today to say what will happen, and what to change.

Answer key: exit ticket

QUESTION	ANSWER	WHY
1	A	The angle between 200 and 180 is 20 degrees; the part along the runway uses cosine.
2	B	A negative headwind is a tailwind.
3	Open answer	On 36 the headwind is 15 cos 170°, about -14.8: a tailwind over 10 knots, so the pilot will go around. Use 18, where it is a headwind.

Worksheet: what students should find

BLANK	WHAT THE APP SHOWS
Level 7	Runway 18: 10°, 15.8, 2.8. Runway 36: 170° (or -170°), -15.8, 2.8 in size (-2.8 in the app). Land on 18.
My table	240 at 20: 36 -10.0, 18 10.0, crosswind 17.3, runway 18. 300 at 12: 36 6.0, 18 -6.0, crosswind 10.4, runway 36. 150 at 18: 36 -15.6, 18 15.6, crosswind 9.0, runway 18. 360 at 8: 36 8.0, 18 -8.0, crosswind 0, runway 36. 090 at 15: 0 and 0, crosswind 15, either.
My if	if tower.headwind("18") > tower.headwind("36"): use_runway("18"), else: use_runway("36"), indented.
Question 1	The headwind slows the airplane over the ground, so it lands slower and stops in a shorter distance.
Question 2	Open: either runway works for wind; real airports use other reasons, such as length or traffic, and check the crosswind limit.

> Level 7 is always the same wind, so the print line and the result are the same on any computer. In Build your traffic the wind is set in 10 degree steps.

Rubric

Score each row from 1 to 4.

Name: _____

CRITERIA	4 EXCEEDS	3 MEETS	2 APPROACHING	1 BEGINNING
Computing the components	Computes headwind and crosswind for all five winds on both runways, with the signs explained.	Computes the components for most winds.	Finds the angle but not the components.	No computation.
Choosing the runway	Chooses the right runway for every wind and checks one in the simulation.	Chooses the right runway for most winds.	Chooses by guessing.	No choice.
Writing the condition	Writes the if, tests it on two winds, and explains what it does for a wind straight across.	Writes the if and it chooses 18 in Level 7.	Writes an if that does not run.	No if.

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

Standards

The lesson is built for HSG-SRT.C.8: students use cosine and sine to solve the right triangle a wind makes with a runway, an applied problem, and check the result against the simulation. Writing the condition that chooses the runway is a short step into programming.

FRAMEWORK	CODE	GRADES	STANDARD	HOW THE LESSON MEETS IT
Common Core Math	**HSG-SRT.C.8**	9-12	Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.	Students solve the right triangle made by the wind and the runway for the headwind and crosswind, for six winds, and use the result to choose the runway.
Common Core Math	**MP4**	9-12	Model with mathematics.	Students model the wind as a right triangle, check the model against the simulation, and write it as a condition in a program.

Checked November 2026 against: Common Core State Standards for Mathematics: High School Geometry, Similarity, Right Triangles, and Trigonometry, Common Core State Standards for Mathematics: Standards for Mathematical Practice.

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/air-traffic-control-lab/lessons/which-runway-headwind-and-crosswind/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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