

Elevating Angles, Part 2

Inverse Trigonometry: ADA Accessibility

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Grade Level	9th – 12th Grade	**Time Frame**	75-90 minutes
Subject	Mathematics	**Duration**	2 class periods
Course	Geometry, Precalculus		

Essential Question

How is trigonometry used to find the measures of unknown angles?

Summary

In this lesson, students will explore angles of incline on different wheelchair ramps by measuring side lengths and finding missing angle measures using inverse trigonometric functions. Students will compare their results with the Americans With Disabilities Act (ADA) accessibility standards to determine if their measured ramps are accessible. Prerequisites for this lesson include knowing how to find the angle of elevation using inverse trigonometry. This is the second lesson in the "Elevating Angles" lesson duo.

Snapshot

Engage

Students consider accessibility and learn how civil engineers consider ADA compliance.

Explore

Students recall and use their knowledge of inverse trigonometric functions to find the angles of elevation given ADA accessibility standards for wheelchair ramps.

Explain

Students recall their knowledge of angle of elevation and expand their vocabulary to include angle of depression and the relationship between the two.

Extend

Students measure ramps on their campus and determine if the angles of incline are within the ADA's accessibility standards and complete a report with their findings.

Evaluate

Students reflect on their learning and if they are interested in becoming a civil engineer through the use of the Fist to Five strategy.

Standards

ACT College and Career Readiness Standards - Mathematics (6-12)

G604: Apply basic trigonometric ratios to solve right-triangle problems

Oklahoma Academic Standards Mathematics (Geometry)

G.RT.1.3: Use the definition of the trigonometric functions to determine the sine, cosine, and tangent ratio of an acute angle in a right triangle. Apply the inverse trigonometric functions to find the measure of an acute angle in right triangles.

Attachments

- ADA Compliance Check—Elevating Angles, Part 2.docx
- ADA Compliance Check—Elevating Angles, Part 2.pdf
- Accessibility Standards—Elevating Angles, Part 2.docx
- Accessibility Standards—Elevating Angles, Part 2.pdf
- Compliance Report—Elevating Angles, Part 2.docx
- Compliance Report—Elevating Angles, Part 2.pdf
- Lesson Slides—Elevating Angles, Part 2.pptx
- Ramps on Campus—Elevating Angles, Part 2.docx
- Ramps on Campus—Elevating Angles, Part 2.pdf
- Visual Vocabulary—Elevating Angles, Part 2.docx
- Visual Vocabulary—Elevating Angles, Part 2.pdf

Materials

- Lesson Slides (attached)
- ADA Compliance Check handout (attached; one per pair; printed front only)
- Accessibility Standards handout (attached; one per student; printed front only)
- Visual Vocabulary handout (attached; one per student; printed front only)
- Compliance Report handout (attached; one per pair; printed front only)
- Tape measure (one per pair)
- Scientific calculator (one per student)
- Pencil
- Paper
- Access to wheelchair ramps on campus (alternative activity provided)
- Ramps on Campus handout (optional; attached; one per student; printed front only)

10 minutes

Engage

Introduce the lesson using the attached **Lesson Slides**. Display **slide 3** to share the lesson's essential question with students. Go to **slide 4** to share the lesson's learning objective. Review each of these with students to the extent you feel necessary.

Show **slide 5** and tell students that they are going to be thinking about accessibility today. Share with students the following:

- The American With Disabilities Act (ADA) is a civil rights law that prohibits unjust treatment against individuals with disabilities.
- The U.S. Department of Education is a federal agency that promotes student achievement and educational excellence and is tasked to ensure equal access to education.

Transition to **slide 6** and pose the question: *What types of considerations need to be made to ensure education is is available to everyone?* Have volunteers share their ideas and facilitate a short discussion. Ask guiding questions as needed to encourage the response of needing wheelchair ramps to get to class.

Optional Strategy

If you have a quiet class, consider using a strategy like Commit and Toss to get the discussion started.

ICAP Video Timing

If you have already taught the "Elevating Angles, Part 1" lesson, start the following video at 4:00. The first portion of the video is the same for both lessons.

Display **slide 7** and introduce the video on the slide: "K20 ICAP - Accommodations and Civil Engineering."

The video introduces civil engineer Bobby Williams, who shares his profession and how he takes accessibility into account in his work.

Embedded video
https://youtube.com/watch?v=DD4nSV5eQ00

15 minutes

Explore

Have students find a partner or assign students partners. Give each pair a copy of the attached **ADA Compliance Check** handout which contains the scenario of students being hired as engineers to check if wheelchair ramps on campus are ADA compliant.

After students read the handout, display **slide 8**. Give each pair a copy of the attached **Accessibility Standards** handout and a calculator. Instruct students to read the handout and find the angle of elevation for each given diagram using inverse trigonometric functions.

Teacher's Note: Guiding the Activity

If students are unsure of what this information really means, help give them some context. Ask them to consider why that angle of elevation might matter if they were in a wheelchair trying to go up a ramp. Have students think about an old building—possibly your school building—and how there may not be enough room to renovate to put in an ideal ramp, so exceptions exist to ensure accessibility.

Students should conclude that the angle of elevation of a ramp should be less than or equal to 4.764° unless there are space limitations, then the angle of elevation should be less than or equal to 7.125°.

10 minutes

Explain

Display **slide 9** and give each student a copy of the attached **Visual Vocabulary** handout. Use this handout and the slide to review the definition of *angle of elevation* with the class and tell them that *angle of incline* or *inclination* are alternatives to *angle of elevation*. Direct students to label the picture on their handout to match what they see on the slide. Consider having the class write a definition in their own words for *angle of elevation*.

Transition to **slide 10** and repeat with the vocabulary: *angle of depression*. Let students know that it is also known as the *angle of decline* or *declination*.

Teacher's Note: Guiding the Lesson

It is often helpful to explain to students that the angle of **elevat**ion is the angle one would need to **elevate** their chin to view something above them, while the angle of de**press**ion is angle formed when one **press**es their chin toward their chest to see something below them.

Precalculus vs. Geometry

If this lesson is for a Geometry class, introduce slide 11, explain that the angle of elevation and angle of depression are equivalent, then ask the class to explain why this must be true.

If this lesson is for a Precalculus class, ask the class what the relationship between the angle of elevation and angle of depression is before showing slide 11. After the class has concluded that they are congruent and why, show slide 11 to ensure everyone is understanding.

For either class, facilitate a discussion and guide the class to the conclusion that those two angles are congruent because they are alternate interior angles from two parallel lines (the two horizontal lines) cut by a transversal (the line of sight).

Use the note above to determine how to best use **slide 11** and help students see that the angle of elevation and angle of depression are congruent.

Have students add this handout to their math notebooks if that is a classroom norm.

35 minutes

Extend

Display **slide 12** and give pairs a tape measure and scratch paper. Then have pairs find two wheelchair ramps on campus to measure. Instruct them to record their measurements on scratch paper.

Options: Finding and Measuring Ramps

There may not be many ramps in your building or on your campus. If this is the case, you may encourage students to measure the same ramp while using different methods.

If there are not any ramps on your campus to measure, use the attached **Ramps on Campus** handout which gives students a description of the measurements of two ramps.

Teacher's Note: Guiding the Activity

Monitor students as they measure; remind them to be mindful of those who may need to use the ramp. Also help students keep track of time; consider giving them a specific time to report back to the classroom.

Students may find it difficult to measure ramps with some sides that are not exposed. In this case, allow extra time for students to brainstorm multiple methods of measuring. Encourage them to start by using the sides they can see, then have them look for a way to measure the height or the base without directly measuring.

Using a tape measure, students may measure any sides they wish, but they need to know and remember which sides so they can apply the correct inverse trigonometric function.

Have students apply the appropriate inverse trigonometric function to the ratios they measured. The result should be an angle that is either less than, equal to, or greater than the angle recommended by the ADA. Ask students to record their findings, explain whether the ramp meets the ADA's standards, and justify their reasoning. If they are unsure, encourage them to remeasure to be certain.

After students record their findings, show **slide 13**. Have two pairs who measured the same ramp work together as a group of four to check one another's work and discuss what was discovered.

Move to **slide 14** and give each group a copy of the attached **Compliance Report** handout. Have students work in their groups to complete the handout.

Have the original pairs of students find another pair of students who both measured the same second ramp form a new group. Give the new groups a clean copy of the Compliance Report and repeat these steps for their second measured ramp.

Sample Responses:

Use the hidden **slide 15** for an idea of what the completed Compliance Report might look like.

If using the Ramps on Campus handout, the ramp at the North entrance has an angle of elevation of 6.776°, which is ADA compliant due to its limited space. The ramp on the second floor has an angle of elevation of 4.005°, which also meets ADA guidelines.

Collect the compliance report handouts to assess student understanding.

Optional Digital Submission

Consider having students digitally submit their report by writing an email to you, addressing it to the U.S. Department of Education, and attaching the report to an email.

5 minutes

Evaluate

Display **slide 16** and have students use the Fist to Five strategy to reflect on what they've learned during the lesson and see who is interested in becoming a civil engineer. As time allows, ask for a few volunteers with differing opinions to share their reasoning.

Resources

- K20 Center. (n.d.). Fist to Five. Strategies. https://learn.k20center.ou.edu/strategy/68
- K20 Center. (n.d.). Commit and Toss. Strategies. https://learn.k20center.ou.edu/strategy/119
- K20 Center. (May 2023). K20 ICAP - Accommodations and Civil Engineering. YouTube. https://youtu.be/DD4nSV5eQ00
- Department of Justice. (2010, September 15). 2010 ADA Standards for Accessible Design. https://archive.ada.gov/regs2010/2010ADAStandards/2010ADAStandards.pdf