This task was developed by high school and postsecondary mathematics and design/pre-construction educators, and validated by content experts in the Common Core State Standards in mathematics and the National Career Clusters Knowledge & Skills Statements. It was developed with the purpose of demonstrating how the Common Core and CTE Knowledge & Skills Statements can be integrated into classroom learning – and to provide classroom teachers with a truly authentic task for either mathematics or CTE courses.

TASK: ACCESS RAMP

TARGET COMMON CORE STATE STANDARD(S) IN MATHEMATICS:

G.SRT.8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.*

G.MG.3 Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).*

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

6.RP.3d Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.

7.NS.3 Solve real-world and mathematical problems involving the four operations with rational numbers.

7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

TARGET STANDARDS FOR MATHEMATICAL PRACTICES

MP.1 Make sense of problems and persevere in solving them.

MP.2 Reason abstractly and quantitatively.

MP.3 Construct viable arguments and critique the reasoning of others.

MP.4 Model with mathematics.

MP.6 Attend to precision.

TARGET COMMON CORE STATE STANDARD(S) IN ELA/LITERACY:

RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

RST.9-10.5 Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

WHST.9-10.1 Write arguments focused on discipline-specific content.

WHST.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

TARGET CAREER AND TECHNICAL EDUCATION (CTE) KNOWLEDGE & SKILLS STATEMENTS:

ACC01.01 Perform math operations such as estimating and distributing materials and supplies to complete jobsite/workplace tasks.

ACC01.01.02 Use geometric formulas to determine areas and volumes of various structures.

ACC03.01.03 Estimate resources/materials required for a specific project or problem.

ACC03.01.05 Determine alternative solutions for a specific project/problem.

ACC05.01.01 Identify governmental regulations and national, state, and/or local building codes that apply to a given

workplace/jobsite.
ACC05.03.02 Understand the context of the projects.
ACPA06.01.01 Identify client requirements.
ACPA06.02.03 Utilize computer technology when communicating concepts and designs.
ACPA02.01.01 Deliver a presentation that explains a concept of design or preconstruction.

RECOMMENDED COURSE:
Geometry; Integrated Math I or Integrated Math II; Applications in Design & Pre-Construction

ADDITIONAL INSTRUCTIONS:
This task should be completed over an extended period of time, including some time for research of ADA codes.

* Modeling standards appear throughout the CCSS high school standards and are indicated by a star symbol (*).

About the Common Core State Standards in Mathematics
The Common Core State Standards (CCSS) for Mathematics are organized by grade level in grades K–8. At the high school level, the standards are organized by conceptual category (number and quantity, algebra, functions, geometry, and probability and statistics), showing the body of knowledge students should learn in each category to be college and career ready, and to be prepared to study more advanced mathematics. The Standards for Mathematical Practice describe ways in which developing student practitioners of the discipline of mathematics increasingly ought to engage with the subject matter as they grow in mathematical maturity and expertise throughout the elementary, middle and high school years. www.corestandards.org

About the Common Core State Standards in English Language Arts/Literacy
The Common Core State Standards (CCSS) for ELA/Literacy are organized by grade level in grades K–8. At the high school level, the standards are organized by 9-10 and 11-12 grade bands. Across K-12 there are four major strands: Reading, Writing, Speaking and Listening, and Language. The CCSS also include Standards for Literacy in History/Social Studies, Science, and Technical Subjects, with content-specific (Reading and Writing) literacy standards provided for grades 6-8, 9-10, and 11-12, to demonstrate that literacy needs to be taught and nurtured across all subjects. www.corestandards.org

About the Career Cluster Knowledge and Skill Statements
As an organizing tool for curriculum design and instruction, Career Clusters™ provide the essential knowledge and skills for the 16 Career Clusters™ and their Career Pathways. It also functions as a useful guide in developing programs of study bridging secondary and postsecondary curriculum and for creating individual student plans of study for a complete range of career options. As such, it helps students discover their interests and their passions, and empowers them to choose the educational pathway that can lead to success in high school, college and career. www.careertech.org/career-clusters/resources/clusters/architecture.html. Although not included in this template, all Clusters and Pathways have Foundational Academic Expectations and Essential Knowledge & Skills Statements, which, in some cases, overlap with the Common Core State Standards.

KEY TERMS
- Angle of elevation   - Slope   - Horizontal projection   - Rise

ACCESS RAMP – *The Task*

You have been commissioned to design an access ramp, which complies with the Americans with Disabilities Act (ADA) requirements, for an entry that is 3 feet above ground level. Your client has asked you to design the ramp and to determine costs, using local pricing, for two types of ramps, wooden and concrete.

Specifications: Here are the relevant excerpts from Section 4.8 "Ramps" of the ADA Guidelines for Buildings and Facilities:

1.8.1.   General. Any part of an accessible route with a slope greater than 1:20 shall be considered a ramp and shall comply with 4.8.

1.8.2.   Slope and Rise. The least possible slope shall be used for any ramp. The maximum slope of a ramp in new construction shall be 1:12.

4.8.3   Clear Width. The minimum clear width of a ramp shall be 36 in (915 mm).

4.8.5.   Handrails. If a ramp run has a rise greater than 6 in (150 mm) or a horizontal projection greater than 72 in (1830 mm), then it shall have handrails on both sides.

Ramp Surface

Height

Θ
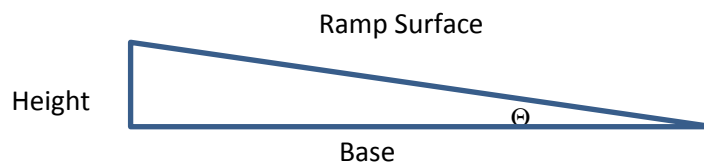
Base

Tasks:

1.   Based on your design and the space available for the run for your ramp, calculate the length of the ramp itself (in inches and feet, in fraction form, and in decimal form) and show that your slope falls within the ADA guidelines.

2.   Calculate the angle of elevation (Θ) for the ramp.

3.   Calculate the number of 4' x 8' plywood sheets, 1" thick, which are needed to build this ramp with a width of 3'. Verify your calculations with a diagram showing the arrangement of the 4' x 8' sheets for both the sides and the top. Consider other ramp widths if practical, making sure your width meets the ADA Guideline 4.8.3. Explain your choices.

4.   Your client may prefer a concrete ramp. Calculate how much concrete – in cubic yards – is needed to build this ramp. If you consider widths other than 3', explain your reasoning.

5.   Write a recommendation letter to your client with an explanation of your calculations and the advantages and disadvantages of each type of ramp. Based on design and maintenance considerations, give reasons for why you would suggest one type over the other. Include a scaled 3-D sketch of the ramp you are offering for consideration.

Source: Adapted from Hawai'i American Diploma Project tasks

ACCESS RAMP – *Possible Solution(s)*

1. For this sample solution we will use the 1:12 slope due to space constraints.
   First calculate length of the triangle's base:

$$slope = \frac{rise}{run} = \frac{1}{12} = \frac{3}{x} \qquad x = 36 \text{ feet}$$

This slope is between 1:12 and 1:20 since it equals 1:12.

Then calculate length of the ramp:
Using the Pythagorean Theorem -

$$3^2 + 36^2 = z^2$$

$$1305 = z^2 \qquad\qquad z = 36.12478 \text{ rounded to } \textbf{36.125 ft. or } 36\frac{1}{8} \textbf{ ft. or 36' 1.5''}$$

2. Calculate the angle of elevation:

$$\tan\theta = \frac{opposite}{adjacent} = \frac{3}{36}$$

$$\arctan\left(\frac{3}{36}\right) = 4.7636° \qquad \theta = 4.76°$$

3. The number of sheets of plywood for the SIDES of the ramp:
   Dividing the length of the top by the length of a sheet of plywood:

$$\frac{36.125\, ft}{8\dfrac{ft}{sheet}} = 4.5156...sheets \qquad\qquad \textbf{Round to 5 sheets of plywood for the two sides}$$

To verify this calculation we can use the arrangement in the diagram below of five 4' x 8' sheets of plywood. We would need to trim all sheets to 3' widths. Then with the sheets laid end-to-end, we can see that cutting on the diagonal will form two congruent triangles, each serving as one side of the ramp. This plan has the least amount of waste with the fewest number of joints.
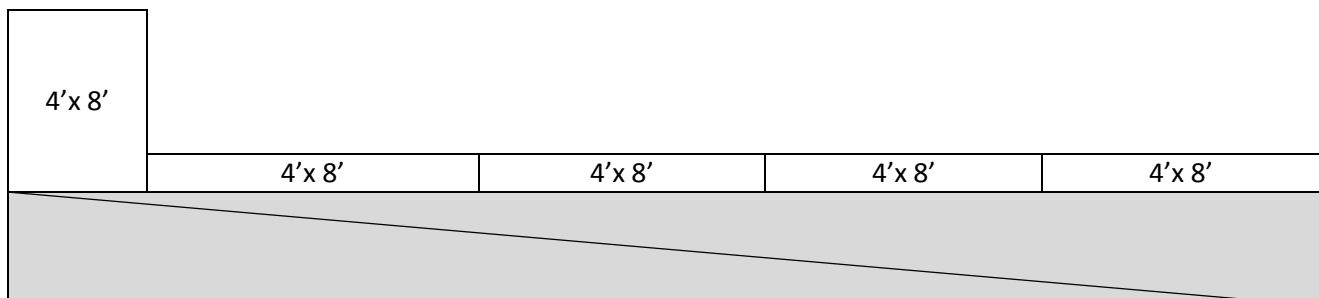
The number of sheets of plywood for the TOP of the 3-ft wide ramp:

The area of the top is:
    3' x 36.125' = 108.375 sq ft

Dividing the area of the top by the area of a sheet

> Each sheet is 4' x 8' = 32 sq ft … 108.375 ÷ 32 = 3.387 sheets

Round to 4 sheets of plywood for the 3-foot wide top.

We can consider the same diagram to verify this calculation. The layout for the top will be similar to that of the shaded area for the sides in the diagram above. However the top is 1.5 inches longer than the sides. We need to turn the fifth sheet in the same direction as the other four and trim four of the sheets to 3' wide by 8' long and the fifth to a width of 3' by 4' 1.5" long.

If the width of the ramp is 3 feet, there will be the extra partial sheet of plywood left from the end sheet that is standing vertically in the diagram above. That "waste" would measure 4' x 5' and can be used to complete the ramp top. We can complete the 3-foot wide ramp with one less sheet of plywood.

Total number of sheets for the top of a 3-foot wide ramp: 4

**TOTAL NUMBER OF SHEETS OF PLYWOOD (3' width) = 9**

4. Volume of concrete (triangular-base prism) = Area of triangular base x height (Imagine the ramp turned onto its side to figure the volume.) Concrete is sold/ordered in cubic yards.

If the width of the ramp is 3 feet:

$$\left\lfloor \frac{1}{2}(3)(36) \right\rfloor (3) = 162 ft^3 \qquad 162 ft^3 \bullet \frac{1 yd^3}{27 ft^3} = 6 yd^3$$

TOTAL AMOUNT OF CONCRETE: 6 cubic yards

5. *Recommendation letters will vary depending on the individual design. All students should consider the maintenance, safety, and ease of use for their ramp design.*
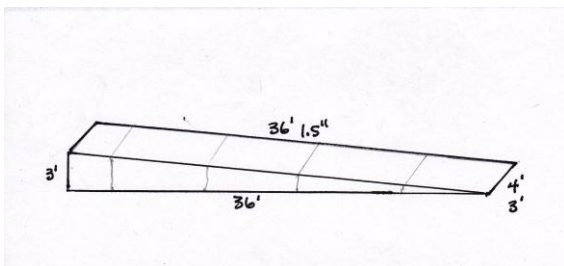
ACCESS RAMP – *Possible Extensions*

The extensions below represent potential ways in which mathematics and/or CTE teachers can build on the task above. All of the extensions are optional and can be used in the classroom, as homework assignments, and/or as long-term interdisciplinary projects.

1. Research the building codes in your area for ramps built with wood and concrete to determine what kind of support will be required. Research the current cost of materials (lumber, plywood, rebar, and concrete). Show comparison costs for both types of ramps.

2. Since a handrail will be required (per code 4.8.5), design the rail for both the wood and concrete ramps and include it in your cost analysis.

3. Research local prices for plywood and concrete. Which material is more cost effective if the slope is 1:12? 1:20?

4. Measure the base, height, slope and angle of TWO different ramps in your community (and take photos of the ramps). Do they meet ADA regulations?

5. Based on your local community's codes, have students re-write design specifications in their own words (i.e., design brief/problem statement).

6. Review the full set of codes for ADA-compliant ramps; what other elements are required for the construction of this ramp (e.g., handrail, landing, supports, etc.)?

ACCESS RAMP – *Appendix: Alignment Ratings*

The rating system used in the following charts is as follows:

3   EXCELLENT ALIGNMENT:

The content/performance of the task is clearly consistent with the content/performance of the Common Core State Standard.

2   GOOD ALIGNMENT:

The task is consistent with important elements of the content/performance of the CCSS statement, but part of the CCSS is not addressed.

1   WEAK ALIGNMENT:

There is a partial alignment between the task and the CCSS, however important elements of the CCSS are not addressed in the task.

N/A:

For Mathematical Practices a content rating does not apply.

In the charts **C = Content Rating** and **P = Performance Rating**

COLOR KEY

- **Black** = Part of CCSS/K&S Statement aligned to task
- *Gray* = Part of CCSS/K&S Statement *__not__* aligned to task

Task-to-Mathematical Practice Alignment Recording Sheet

Task Name	Aligned CCSS Mathematical Practice Standards	C	P	Alignment Comments (Standards selection, partial alignments, reasons for rating, etc)	Task Comments (Strengths, weaknesses, possible improvements, effectiveness, etc)
ACCESS RAMP	**MP.1** Make sense of problems and persevere in solving them.	N/A	3	For this task students analyze givens, constraints, relationships, and goals. They must make conjectures about the form and meaning of the solution and plan a solution pathway. They must check the reasonableness of their solution, continually asking themselves, "Does this make sense?"	This is a multi-stage problem with real life applications and considerations. Students must identify measurements and lengths to make sure their design meets the specifications. They must use both abstract reasoning and quantitative calculations.
	MP.2 Reason abstractly and quantitatively.	**N/A**	**3**	This task involves quantitative relationships. It requires that students make sense of quantities and their relationships in the problem situation. They must attend to the meaning of the quantities and pay attention to units as they represent the quantities and measures in the design, work, and their report.	
	MP.3 Construct viable arguments and critique the reasoning of others.	**N/A**	**2**	Students must present their design with a written report describing their findings and making a recommendation. There is no requirement to critique the reasoning of others.	
	MP.4 Model with mathematics.	**N/A**	**3**	This task is an application from everyday life requiring that the student create a geometric representation (model) that can replace the situation described in the prompt. Students must identify important quantities in the practical situation and use them to answer the questions posed. Students are required to explain their decisions and assumptions.	
	MP.6 Attend to precision.	N/A	3	This task requires that students communicate precisely, organizing their information, as they show their mathematical thinking.	

Task-to-Common Core State Standards Alignment Recording Sheet

Task Name	Aligned CCSS Content Standards	C	P	Alignment Comments (Standards selection, partial alignments, reasons for rating, etc.)	Task Comments (Strengths, weaknesses, possible improvements, effectiveness, etc.)
ACCESS RAMP	**G.SRT.8** Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.*	3	3	Students must determine the measure of the angle of elevation of the ramp and use the Pythagorean Theorem to determine the ramp length.	This task combines planning, design, calculating, comparing, and presentation with writing and using communication skills.
	G.MG.3 Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).*	3	3	Students must consider the ADA specifications when planning this geometric design project.	
	N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.	2	3	This task requires that students convert from cubic feet to cubic yards. Graphs and data displays are not required in this task.	
	N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	3	3	Students must decide the number of sheets of plywood and the number of cubic yards of concrete with appropriate levels of accuracy.	
	6.RP.3d Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.	3	3	Unit conversions are required in changing from cubic feet to cubic yards and in comparing the square feet of the ramp's plywood to the square footage of the 4' x 8' sheets.	
	7.NS.3 Solve real-world and mathematical problems involving the four operations with rational numbers.	3	3	Calculations include work with fraction and decimal units.	
	7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.	3	2	A scale drawing is required as a diagram. There is no requirement to reproduce at another scale. This CCSS identifies a foundational skill required in the task.	

* Modeling standards appear throughout the CCSS high school standards and are indicated by a star symbol (*).

Task-to-National Career Cluster Knowledge & Skills Statements Alignment Recording Sheet

Task Name	Aligned National Career Cluster Knowledge & Skills Statements	C	P	Alignment Comments
ACCESS RAMP	**ACC01.01** Perform math operations such as estimating and distributing materials and supplies to complete jobsite/workplace tasks.	1	1	The task provides specific information on resources and materials
	ACC01.01.02 Use geometric formulas to determine areas and volumes of various structures.	3	3	The task requires use of geometric formulas to determine area and volume.
	ACC03.01.03 Estimate resources/materials required for a specific project or problem.	2	2	The task provides specific information on resources and materials but students must estimate the amount of resources/materials needed to complete the project.
	ACC03.01.05 Determine alternative solutions for a specific project/problem.	3	3	The task requires design and costs for two types of materials for the project.
	ACC05.01.01 Identify governmental regulations and national, state, and/or local building codes that apply to a given workplace/jobsite.	1	1	The codes are provided but students must utilize them in designing the ramp.
	ACC05.03.02 Understand the context of the projects.	3	3	The task requires compliance for a specific demographic.
	ACPA06.01.01 Identify client requirements.	3	3	The task requires a recommendation to the client with calculations and pros and cons of each project.
	ACPA06.02.03 Utilize computer technology when communicating concepts and designs.	3	3	The task requires a scaled 3-D sketch.
	ACPA02.01.01 Deliver a presentation that explains a concept of design or preconstruction.	2	1	The task does not require a presentation to the client, but written communications.