

This task was developed by high school and postsecondary mathematics and health sciences 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: DENTAL IMPRESSIONS

TARGET COMMON CORE STATE STANDARD(S) IN MATHEMATICS:

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.*

A-CED.1: Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions.**

A-REI.6: Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.

7.RP3: Use proportional relationships to solve multistep ratio and percent problems.

TARGET STANDARDS FOR MATHEMATICAL PRACTICES:

MP1: Make sense of problems and persevere in solving them.

MP2: Reason abstractly and quantitatively.

MP3: Construct viable arguments and critique the reasoning of others.

MP4: Model with mathematics.

MP6: Attend to precision.

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

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

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

HLPD01.01.01: Perform administrative tasks following established internal and external guidelines.

HLPD03.01.01 Utilize financial information and data to make appropriate decisions regarding purchase and maintenance of equipment and materials.

HLPD03.01.02 Apply principles and organizational protocols when acquiring and distributing equipment and materials.

HLC05.01.02: Explain the health care delivery system.

RECOMMENDED COURSE(S):

Algebra I or Integrated Math I; Health Science or Business Management

ADDITIONAL INSTRUCTIONS:

This task could be completed over a class period.

* 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. <http://www.careertech.org/career-clusters/resources/clusters/health.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

- Gypsum powder
- Stone models
- Digital impression technology
- Break-even point

DENTAL IMPRESSIONS – *The Task*

To fabricate a stone model from a dental impression, you need 30 mL of water to 100 grams of gypsum powder. In your orthodontic office, in an average week, you make 75 impressions. It is most cost effective to order the powder in 50-lb boxes. (Remember: 1 gram = .0022 pounds)

1. How many stone models can you make with one 50-lb box? Show your work and mathematical thinking.
2. How frequently will you need to re-order your powder supply? Show your work and mathematical thinking.
3. What is your office's annual demand for the gypsum powder? Show your work and mathematical thinking.
4. Your office is considering purchasing digital impression technology, but only if it proves to be more cost effective within two years. Assuming the initial investment in technology and training for the digital impression scanner is \$115,000, the technology will eliminate the number of manual/non-digital impressions by 60%, and manual impressions cost your office \$30 on average, create equations to determine your break-even point on this investment. *Support your solution both algebraically and graphically.*
5. Write a recommendation to your office encouraging or discouraging the purchase of the digital impression technology based on your findings above.

DENTAL IMPRESSIONS – Possible Solutions

1. How many stone models can you make with one 50-lb box?

Since 100 grams of gypsum powder are needed per impression, we can first determine how many 100-gram units are in 50 pounds:

$$\frac{100 \text{ grams}}{1 \text{ impression}} \times \frac{.0022 \text{ lbs}}{1 \text{ gram}} = 0.22 \text{ lbs per impression}$$

Then to find how many impressions per 50lb box:

$$\frac{50 \text{ lbs}}{1 \text{ box}} \times \frac{1 \text{ impression}}{0.22 \text{ lbs}} = 227.27 \text{ impressions per box}$$

OR if we first convert the 50-pound box into grams:

$$50 \text{ lbs} \times \frac{1 \text{ g}}{.0022 \text{ lbs}} = 22,727.27 \text{ g (in one 50-lb box)}$$

If we divide into 100-gram units we need for each impression, we get: 227.27 impressions per box

227 impressions are possible using one 50-lb box of gypsum powder

2. How frequently will you need to re-order your powder supply?

We found that we can make 227 impressions per box and we know that the office creates 75 impressions per week. Using dimensional analysis we find that:

$$\frac{227 \text{ impressions}}{1 \text{ box}} \times \frac{1 \text{ week}}{75 \text{ impressions}} = 3.03 \text{ weeks per box}$$

The office would need to reorder once every 3 weeks, on average. This assumes prompt delivery of your order and assumes that you do not want to maintain excess boxes in your inventory.

3. What is your office's annual demand for the gypsum powder?

There are 52 weeks in a year, and the office must order a box every 3 weeks, therefore the office must order: $52 / 3 = 17.3$

The office should order 18 boxes per year.

(Students should round up to ensure the office doesn't ever run out).

4. Your office is considering purchasing digital impression technology, but only if it proves to be more cost effective within two years. Assuming the initial investment in technology and training for the digital impression scanner is \$115,000, the technology will eliminate the number of manual/non-digital impressions by 60%, and manual impressions cost \$30 on average, create equations to determine your break-even point on this investment. Show your work algebraically and graphically.

Let x = time, in years
 Let y = cost, in dollars

The student must create two equations, one for the office without the technology and one for the office with the technology.

Without Technology:

The office makes 75 impressions a week for 52 weeks a year at a cost of \$30.00 per impression. Therefore the annual cost per year of impressions is:

$$\frac{75 \text{ impressions}}{1 \text{ week}} \times \frac{52 \text{ weeks}}{1 \text{ year}} \times \frac{\$30}{1 \text{ impression}} = \$117,000 \text{ per year}$$

So the equation representing the cost per year without technology is:
 $y = 117,000x$

With Technology:

The office still must make 40% of impressions manually (at the cost of \$30 per impression). The office makes 75 impressions a week, at 52 weeks a year so the number of impressions per year is:

$$75 \times 52 = 3900 \text{ impressions per year}$$

The office now only needs to manually make 40% of this amount, therefore
 40% of 3900 = $0.4 \times 3900 = 1,560$ impression will be made manually.

At \$30 an impression the annual cost for manual impressions would now be:
 $1,560 \times 30 = \$46,800$

Therefore, the equation will be the total cost of the technology plus \$46,800 each year:
 $y = 46,800x + 115,000$

To solve for the break-even point we can solve the system of equations:

$$y = 117,000x$$

$$y = 46,800x + 115,000$$

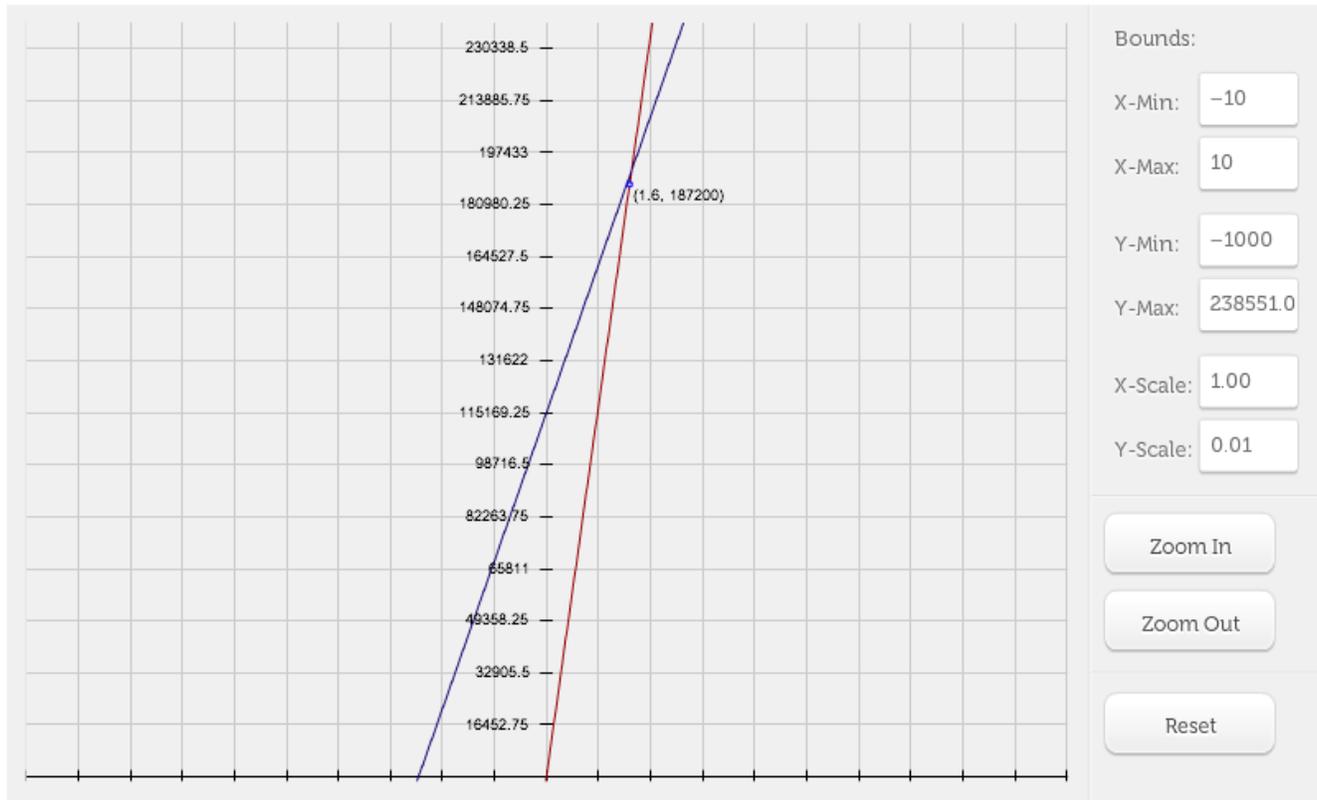
$$117,000x = 46,800x + 115,000$$

$$70,200x = 115,000$$

$$x = 115,000/70,200 = 1.64 \text{ years or approximately 1 year, 8 months}$$

Therefore, the break-even point on this investment will be after 1.64 years, or approximately 1 year, 8 months.

The student must also solve graphically and show the intersection point. (This graph was created using the online graphing calculator tool: [Meta-Calculator](#).)



5. Write a recommendation to your office encouraging or discouraging the purchase of the digital impression technology based on your findings above.

Answers may vary, but the investment in the digital impression technology pays off after 1.64 years, or in about 1 year and 8 months, making it cost effective within two years. It is, therefore, a cost effective decision for the office to purchase this technology if they are planning to use it for 2 years or more.

DENTAL IMPRESSIONS - *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 additional costs associated with man-made and digital impressions (e.g., staff, maintenance contracts, software updates) and re-calculate the cost/impression for man-made and digital impressions and the new breakeven point.
2. Research the actual costs of digital impression technology with vendors. How do the costs compare to those described in Question 4?

DENTAL IMPRESSIONS – *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)
DENTAL IMPRESSIONS	MP1: 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?” While the task requires routine math, the student must persevere to answer all 5 questions.	This is a multi-stage problem with real life applications and considerations. Students must identify quantities and other measures to determine costs, using practical situations, and accurate quantitative calculations. They must support their reasoning at each step of the process and make a recommendation based on their findings.
	MP2: Reason abstractly and quantitatively.	N/A	2	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 in their solution pathway. While strong quantitative reasoning is required, the task lacks expectations for abstraction.	
	MP3: Construct viable arguments and critique the reasoning of others.	N/A	2	Students are asked for a written recommendation based on their mathematical findings, but are not asked to critique the reasoning of others.	
	MP4: Model with mathematics.	N/A	3	This task requires that students translate constraints into equations and extract information from both the algebraic solution and the graph.	
	MP6: Attend to precision.	N/A	3	Students must use precise units of measure, convert units, label the axes, and perform calculations precisely. Rounding and estimation are a key part of the thinking that students must use to accurately answer the questions. Students need to calculate accurately and express answers with a degree of precision appropriate for the problem.	

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.)
DENTAL IMPRESSIONS	NQ1: 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.*	3	3	Throughout the task, students must use units to reach conclusions and to support their results.	This complex real-world task combines systems of equations and calculation with work shown to support results.
	A-CED1: Create equations and inequalities in one variable and use them to solve problems. <i>Include equations arising from linear and quadratic functions, and simple rational and exponential functions.*</i>	2	3	Question 4 requires a system of equations to be created and used to answer the questions that follow. There are no inequalities used in this task. Equations are limited to linear equations.	
	A-REI.6: Solve systems of linear equations (e.g., with graphs) exactly and approximately, focusing on pairs of linear equations in two variables.	3	3	Students are asked to solve the system of linear equations algebraically and graphically.	
	7.RP3: Use proportional relationships to solve multistep ratio and percent problems.	3	3	Proportional relationships are used throughout the task in the dimensional analysis required to answer the rate questions. Percentage is used in Question 4.	

* 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	Task Comments
DENTAL IMPRESSIONS	HLPD01.01.01: Perform administrative tasks following established internal and external guidelines.	1	1	Working with vendors/identifying orders to place is an assumed part of the task scenario.	The context of the task provides an integrated understanding of both Health Sciences and some business decision principles to support a deeper integration across content areas.
	HLPD03.01.01 Utilize financial information and data to make appropriate decisions regarding purchase and maintenance of equipment and materials.	2.5	3	The task utilizes financial information to make decisions and is enhanced in the extension through addressing the maintenance component.	
	HLPD03.01.02 Apply principles and organizational protocols when acquiring and distributing equipment and materials.	3	3	The task requires students to assess and offer recommendations about resource allocation.	
	HLC05.01.02: Explain the health care delivery system.	1	1	The task requires students to predict how factors such as costs influence the decision is present. The extensions provide a stronger demonstration of this expectation.	