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INSTITUTE *for* EVIDENCE-BASED CHANGE

SLATE Demonstration Curricula

Contextualizing Mathematics and Industrial Technology Education

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INSTITUTE _for_ EVIDENCE-BASED CHANGE

SLATE Demonstration Curricula

Strategic Linking of Academic and Technical Education (SLATE)

Contextualizing Mathematics and Industrial Technology Education

Constructing Mathematical Skills Through Application and Design

Prepared by
Shasta Mathematics and Industrial Technology
Contextualized Learning Council

This project was supported by a grant from The James Irvine Foundation.

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INSTITUTE *for* **EVIDENCE-BASED CHANGE**
Informing Decisions · Improving Practice · Increasing Student Success

Contextualizing Mathematics and Industrial Technology Education

Constructing Mathematical Skills

Through Application and Design

SLATE:
Strategic Linking of Academic and Technical Education

PREFACE

In 2011, the James Irvine Foundation generously committed to funding two years of SLATE with the following objectives:

Each of the councils has its own personality and motivations, and the curriculum reflects that.

1. Establish English and mathematics cross-discipline, intersegmental faculty councils called Contextualized Learning Councils (CLCs) to create teaching materials and methodologies that provide context and links to real-world applications;

2. Develop, publish, and disseminate eight contextualized curricular units, four English and four mathematics, connected to technical education and other academic disciplines; and

3. Develop a model of faculty professional development.

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To achieve the objectives, CLCs were established across California in early 2011. In addition to English and mathematics, the disciplines represented were bio-science, business, environmental science, industrial technologies, mechatronics/manufacturing and product design, public health, public safety, social science, and statistics. Each of the councils had its own personality and motivations, and the curriculum reflects that. The contextualized learning councils were:

*   Contra Costa English, Mathematics, and Environmental Science
*   Los Angeles English and Social Science
*   Placer-Nevada English and Public Safety
*   Placer-Nevada Mathematics, Engineering, and Manufacturing
*   San Bernardino West English and Environmental Science
*   San Francisco Mathematics and Public Health
*   Santa Barbara English, Journalism, and Media Arts
*   Santa Barbara Mathematics and Automotive
*   Shasta English and Small Business
*   Shasta Mathematics and Industrial Technology

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In addition to creating field-test ready curricula through an interdisciplinary and linked approach to improve student learning, SLATE improved professional learning for faculty via the same strategy. The SLATE curriculum design process, involving regional faculty members working across disciplines and segments, proved to be a powerful form of professional development. Participants had the advantage of long-term, ongoing support in a venue where they gained in-depth content knowledge informed by a cross-discipline.

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The teaching strategies developed through SLATE will be extremely valuable as SLATE high school faculty prepare students with 21st century skills that meet the rigor and relevance demanded by the Common Core State Standards. At the same time, their postsecondary partners have a better understanding of these new standards: what they mean in terms of high school students' preparation and what adjustments colleges may need to make regarding aligning curricula, programs, and services to ensure students' continued progress.

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Overall, the game-changing cross-disciplinary curriculum and assessments SLATE participants developed have moved them to the forefront of educational leadership. As evidence grows regarding the link between quality professional development and improved student achievement—and school reform—SLATE stands out as an exemplar of how dialog and reflection in a learning community of colleagues turn into achievement in the classroom.

Sandra Scott, Project Director

COUNCIL BACKGROUND

Shasta County is located in rural northern California. The council's membership included mathematics instructors from middle school, high school, and community college; high school counselors; and community college faculty from welding, automotive, and hydraulics.

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The council members chose to focus on applied mathematics out of concern about students not succeeding in college mathematics, specifically those seeking a career technical education (CTE) degree or certificate.

Council Participants

Kate Mahar, SLATE Regional Coordinator

Kevin Fox, Shasta College

Brian Gaddy, Happy Valley Middle School

Jamie Larson, Shasta College

John Livingston, Shasta College

Shawn Martinez, West Valley High School

Jennifer McCandless, Shasta College

Ray Nicholas, Shasta College

Sherry Rogers, Shasta County Office of Education

Sylvia Ruano, Shasta College

Mark Smith, Shasta College

The ability to successfully complete the math course required at Shasta College has become a barrier for many students seeking to work in industry.

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Furthermore, council members were aware of significant gaps between how math is taught at each segment (high school and community college). They noted that while students leaving area high schools may be well-versed in solving equations, they had little understanding about how to apply what they know to real-world scenarios. At the same time, they were cognizant that CTE students were constantly applying math skills without recognizing the math principles or language behind their efforts.

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To address these issues, and the essential mathematical competencies required to succeed in college CTE courses, the council created the Constructing Mathematical Skills through Application and Design unit. The priorities for the unit included project-based learning with a focus on the application of math skills. Additionally, conceptual understanding has a higher priority than rote memorization. Successful instruction of the unit requires a teacher who is innovative and familiar with kinesthetic learning styles.

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In preparation for developing the unit, council members completed an exploration of vocational education math proficiencies required for welding, hydraulics, and diesel mechanics. Hands-on examples from industry are used as a tool for teaching and enhancing math skills of participants. Success with the unit material will ensure that students have the math skills needed to succeed in technical education courses offered at Shasta College. Conversely, hands-on examples from real work situations will be used as a tool for teaching and enhancing students' mathematical skills.

Constructing Mathematical Skills
Through Application and Design

Lesson ⬢

INTRODUCTION

Grade Level:

11th grade through community college

Time:

This unit will take approximately four weeks.

Cross-Disciplines:

- mathematics
- construction/industrial arts

Instructional Materials:

- Handout Pre-Lesson Activity (Optional): Dimensional Analysis Worksheet
- Handout 1: Concrete Problem
- Handout 2: Electricity Problem
- Handout 3: Solar Panel Problem
- Handout 4A: (summative project) Fountain Problem
- Handout 4B: (summative project) Swimming Pool Problem
- Handout 4C: (summative project) Roofing Problem
- Handout 4D: Bid Scoring Rubric
- Handout 4E: Sample Letter Template
- Handout 4F: Sample Bid Template
- *Elementary Technical Mathematics* (9th Edition) by Dale Ewen and C. Robert Nelson.
- (optional) building supplies, approximately $200 total (If the choice is made to build small models of student projects, necessary supplies may include wood, shingles, flexible hose, an a/c register, tile, paint, drip line, sprinkler, soil, etc.)
- graph paper
- string
- tape measure

This unit includes specific mathematical skills as well as application of those skills to home improvement projects..

Required Technology:

- smart phones, and/or tablets or computers with Internet access
- calculators or smart phones with calculator app.

Unit Overview

This unit promotes pedagogy that enhances conceptual understanding and uses real-world applications. The unit includes specific mathematical skills as well as application of those skills to home improvement projects.

The unit promotes the following concepts that are transferred to a variety of situations.
- Quantities can be expressed in different units.
- The number 1 can be expressed in different ways, e.g., $1 = \dfrac{5}{5} = \dfrac{12 \text{ in.}}{1 \text{ ft.}}$.
- Information is available from multiple sources.
- Solutions to problems can be approximated through visualization.

Essential and Topical Questions

Essential Question:

How is mathematics a tool for problem solving in everyday life?

Post the essential question in a prominent place in the classroom and refer to it frequently. Students will discuss/respond to this question throughout the unit, as appropriate. Note how answers change, or don't change, over time, based on experiences and new knowledge and skills. Answering this question should lead to more questions as students create their own deep knowledge, understandings, and transferable skills.

Topical Questions:

- What type of mathematics is used in construction/remodeling?

- How can we use mathematics to make wise choices when purchasing appliances and/or remodeling?

Use these topical questions with students before, during, and/or after learning experiences, as appropriate, to stimulate discussion and help students use evidence to justify and explain their answers. As students understand that answering these open-ended questions leads to asking more questions, help them make meaning and draw connections between their new knowledge, skills, and understandings.

Learning Objectives

- Students can visualize and approximate an answer to a mathematical problem before performing any calculation, (e.g., what does the unit "one liter" look like?).

- Students are able to perform and explain basic calculations as they are applied in industry, such as:

  - apply dimensional analysis (unit conversions), including conversions to and from the metric system and the U.S. customary system, to make decisions and solve real-world problems;

  - apply fractional calculations;

  - measure objects (with precision and accuracy) using appropriate measuring devices that are used in industry, such as a tape measure, calipers, micrometer, etc.;

  - calculate the area of a quadrilateral, triangle, or circle;

  - calculate the volume of a rectangular prism or cylinder; and

  - determine an unknown side of a right triangle using the Pythagorean theorem.

- Students know when and where to look up unknown information, such as formulas and conversions.

Prior Knowledge/Prerequisite Skills

Students must know basic mathematics and geometry, and be able to perform calculations with fractions, percent, and decimals. They must know and be able to use the geometric formulas for perimeter, area, and volume, and they must have a basic understanding of algebra, including labeling unknowns with variables and combining like terms.

Standards

National Common Core State Standards for Mathematics*

Standards for Mathematical Practice:

SMP 1. Make sense of problems and persevere in solving them.
SMP 2. Reason abstractly and quantitatively.
SMP 4. Model with mathematics.
SMP 5. Use appropriate tools strategically.
SMP 6. Attend to precision.

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* National Governors Association Center for Best Practices, Council of Chief State School Officers, Common Core State Standards for Mathematical Practice, (Washington, D.C.: National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf.

Mathematics Standards for High School

Number and Quantity:

N-Q 1. Use units as a way to understand problems and to guide the solution of multistep 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.

Geometry:

G-GMD 3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.

California Career Technical Education Model Curriculum Content Standards*

Building Trades and Construction Industry Sector; Foundation Standards (Academics);
1.1 Mathematics
Specific Applications of Number Sense Standards (Grade 7):

1.3.   Convert fractions to decimals and percents and use these representations in estimations, computations, and applications.

Specific Applications of Mathematical Reasoning Standards (Grade 7):

2.1.   Use estimation to verify the reasonableness of calculated results.

2.2.   Apply strategies and results from simpler problems to more complex problems.

2.6.   Express the solution clearly and logically by using the appropriate mathematical notation and terms and clear language; support solutions with evidence in both verbal and symbolic work.

2.8.   Make precise calculations and check the validity of the results from the context of the problem.

3.1.   Evaluate the reasonableness of the solution in the context of the original situation.

Specific Applications of Geometry Standards (Grades 8–12):

8.0.   Students know, derive, and solve problems involving the perimeter, circumference, area, volume, lateral area, and surface area of common geometric figures.

15.0.   Students use the Pythagorean theorem to determine distance and find missing lengths of sides of right triangles.

2.0 Communications, 2.4 Listening and Speaking:

1.6.   Use appropriate grammar, word choice, enunciation, and pace during formal presentations.

* *Sheila Bruton, ed.,* California Career Technical Education Model Curriculum Standards: Grades Seven through Twelve*, (Sacramento: California Dept. of Education, 2006), http://www.cde.ca.gov/ci/ct/sf/documents/ ctestandards.pdf.*

9.0 Leadership and Teamwork:

9.3.   Understand how to organize and structure work individually and in teams for effective performance and the attainment of goals.

Building Trades and Construction Industry Sector; Pathway Standards

(D) Residential and Commercial Construction Pathway:

D1.1.   Identify design solutions for residential construction problems.

D1.2.   Calculate required materials for residential construction applications.

Student Learning Outcomes

Shasta College Math 100 (Technical Applications of Mathematics):

Students will be able to

- demonstrate understanding of the problem;
- choose an appropriate problem-solving strategy;
- effectively solve the problem using the chosen strategy; and
- clearly state the correct solution to the problem.

Assessments

- performance on Pre-Lesson Activity/Handout (optional) and Activity 1/Handout 1—type: formative
- performance on Activity 2/Handout 2—type: formative
- performance on Activity 3/Handout 3—type: formative
- performance on Activity 4/Handout 4A, 4B or 4C, and bid presentation, including cover letter (Handout 4E) and written bid (Handout 4F)—type: summative

LESSON

Setup

Make copies of handouts to distribute to students. Have available smart phones, tablet computers, or a computer lab, all with Internet access.

For each of the problems, either prebuild a scale model of the problem scenario, invite a guest speaker to share expertise, or take the students to a campus location where they see the problem by observing a real-world model and physically doing the math.

Predetermine sites on campus to visit that would be applicable to the problems. If there are no usable sites on campus for the roofing problem (Handout 4C), the instructor could build a model of a shingled roof to be used to demonstrate pitch and perspective and to help students calculate the cost of shingles. Students can use tablet computers or other technology to calculate the pitch of the model roof as well as calculate how many packs of shingles will be needed to roof the model. For the fountain problem (Handout 4A), there may be a circular planter on campus that can be used as the model for a circular fountain. Students could also use a teacher-made model and cardstock "tiles," manipulating the tiles in order to cover the prescribed area.

Introduction

This unit reinforces the understanding that math is all around us and is essential for aspects of daily living. Students build confidence in their math skills by drawing on their abilities to conceptualize real-world solutions to problems before attempting to answer questions using mathematical formulas.

A significant goal of this unit is to encourage students to explore possible solutions to questions that may have multiple answers and/or for which there may not be one correct answer. The activities are to encourage students to recognize that math is a tool for problem solving.

In-class assignments contain a significant amount of brainstorming about possible solutions and ways in which math is used in daily life. Teachers and students will gather information and draw on current knowledge to predict or anticipate possible answers before applying mathematical concepts; this will encourage linear learners to think more abstractly and provide conceptual and kinesthetic learners the opportunity to assume leadership roles in the math classroom.

Ask students to identify all of the ways that math is used in their homes. Students often overlook the amount of math that they already can do and perform in day-to-day functions. Tell students that the lesson includes hands-on activities, modeling, and visits to campus locations to show them how and why math is used to fulfill essential functions in everyday life.

After brainstorming the many ways math is used in daily living, inform students that the lesson will be embedded into typical home improvement projects. Understanding math conceptually will also be a goal of the unit. For each of the problems listed in the unit, students should perform calculations with scale models of the scenarios being presented, if possible. For all lessons, they should see working models, build models, or sketch designs before attempting the mathematical equations.

Pre-Lesson Activity (Optional)

Dimensional Analysis

If students are not familiar with dimensional analysis, also referred to as "unit conversion," it would be appropriate to teach this lesson first. An optional Handout, Pre-Lesson Activity: Dimensional Analysis*, is included for this purpose. Students may question why it is necessary to use unit conversion, which seems like more work, when they can simply multiply or divide to solve for an answer. Doing calculations in this manner will help students:
- label their answers accurately
- understand when something is in square units vs. cubic units (one example)
- determine which previous problems to refer to when doing more complex problems

One way to begin this practice instruction is to give the students small cardstock pieces with a line down the middle, like blank dominos. Ask them to fill in three of the dominos to show how to convert 40 cm. to inches. Their pieces should look like this:

$$\frac{40\,\text{cm}}{1\,\text{in}}\left(\frac{1\,\text{in}}{2.54\,\text{cm}}\right) = \frac{40}{2.54} \approx 15.75\,\text{in.}$$

For further examples, refer to the Dimensional Analysis Handout.

If students really struggle with the notation, you might want to consider starting out this way:

1. $200\,\text{watts} \times 4\,\text{hours/day} = 800\,\text{Wh/day.}$
2. $800\,\text{Wh/day} \times 120\,\text{days/year} = 96{,}000\,\text{Wh/yr.}$
3. $96{,}000\,\text{Wh/yr} \div 1{,}000\,\text{Wh/kWh} = 96\,\text{kWh/yr.}$
4. $96\,\text{kWh/yr} \times \$0.11/\text{kWh} = \$10.56/\text{yr.}$

Eventually guide them to use the method shown in the cm./in. example above.

Common conversion factors can be found at
http://www.infoplease.com/encyclopedia/science/common-weights-measures-table.html.

Special thanks to Doug Gardner, Rogue Community College, for providing worksheet questions from his book Applied Technical Mathematics*.*

Activity 1

Concrete Problem

Distribute Handout 1; students will complete this handout by the conclusion of this activity.

Students do some basic math to find the cost of materials needed to pour a concrete walkway. Students may find an existing curved walkway on campus or design their own. Have them use graph paper to do a scaled drawing, with the scale clearly indicated. Demonstrate the necessary skills to calculate the cost of the cement and the gravel underlay, or students can research how to do this. One way to approximate the square footage of a curved walkway is to measure both the inner and outer portions of the curve and find the average of the two. The length can be measured using a tape measure (students can use a piece of string when not on campus, marking the length of the inner and outer portions of the curve on the string. When back in the classroom, they can measure their string with a tape measure).

After walking around campus examining walkways, students determine how much concrete and gravel are needed to pave a walkway. Students calculate the cost of labor for this project. Extend the assignment, if desired, by asking students to determine the cost of materials.

A good resource for students is http://www.ehow.com/how_6362026_measure-calculate-gravel.html.

Activity 2

Electricity Problem

Distribute Handout 2; students will complete this handout by the end of the activity.

Have students brainstorm a list of all the appliances in a typical home that use electricity. Ask students to identify which appliances are used for many hours and which are used for only a few hours. Write the list on the class whiteboard.

Research how many watts appliances consume and their average usage cycles. For homework, have students find the wattage of three appliances in their home. They may find labels on the appliance, or they can go to the website of the manufacturer to find this information. Alternatively, students can research typical wattage for an appliance in class. The U.S. Department of Energy is a great resource for this information: http://energy.gov/energysaver/articles/estimating-appliance-and-home-electronic-energy-use. Demonstrate how to find the annual consumption in kilowatt-hours. Using the U.S. Department of Energy's formula for estimating energy consumption (also found on the above web page), calculate the annual consumption in kilowatt-hours (kWh) per year for three appliances, including a refrigerator.

Students use the following steps:

1. (wattage × hours used per day) ÷ 1,000 = daily kilowatt-hour (kWh) consumption;
    1 kilowatt (kW) = 1,000 watts.

2. Multiply this by the number of days you use the appliance during the year for the annual consumption in kWh per year.

3. Estimate the annual cost to run an appliance:
    Multiply the annual consumption in kWh per year (that you calculated in step 1) by the local utility's rate per kWh consumed to calculate the annual cost to run an appliance. Note: To estimate the number of hours that a refrigerator actually operates at its maximum wattage, divide the total time the refrigerator is plugged in by 3. Refrigerators, although turned "on" all the time, actually cycle on and off as needed to maintain interior temperatures.

    Example—window fan:

$$\frac{200 \text{ watts}}{1} \times \frac{4 \text{ hours}}{\text{day}} \times \frac{120 \text{ days}}{\text{year}} \times \frac{1 \text{ kw}}{1000 \text{ w}} \times \frac{.11}{\text{kwh}} = \$10.56 / \text{year}.$$

Activity 3

Solar Panel Problem

Distribute Handout 3; this handout will be completed by the end of this activity.

Inform students that appliances in stores often have a label such as the one on Handout 3 and that consumers typically consider the cost of running that appliance as one of the factors when choosing which appliance to buy. Students read the label and calculate the number of solar panels of a given size that will be needed to supply the necessary energy to run the appliance. An extension for this exercise would be to split up all the appliances, as well as lights, etc., among small groups so that the whole class can calculate the typical energy needed in an entire home. Invite an expert to come to the class to demonstrate how solar panels could be used to provide this energy and discuss the costs involved in purchasing a solar panel system.

Activity 4

Summative Project

Inform students that they will be assuming the role of a contractor who has been asked to submit a bid for a home improvement job. The students will create a bid for one of the projects listed below.

Put students in teams of two to prepare a written presentation of their bid for one of the projects. The target audience for their presentation is a homeowner. Their score will be based on appearance, format, content, clarity, and accuracy of information they include in their presentation.

Complete the blank bidding rubric (Handout 4D) for this bidding process BEFORE students begin their work. Fill in the rubric using your judgment about appropriate criteria descriptions so that students know what excellent, proficient, competent, and less-than-competent look like related to the required elements of bidding. A more effective practice is to have students research this topic and participate in creating the rubric with you.

Provide students with a sample bid cover letter form (see Handout 4E) and bid template (Handout 4F). Encourage students to conduct Internet searches regarding "construction bidding forms" and "construction bid sample letters" for other examples. Students will also need to research the cost of labor wages per hour in their local area, and some projects require researching the cost of materials.

If you wish, give students a choice of projects tiered by grade ceiling linked to the complexity of the project:
1. fountain project (most complex), highest grade is A;
2. swimming pool project, highest grade is B; and
3. roof project (least complex), highest grade is C.

Activity 4A—Fountain Problem:

Distribute Handouts 4A, 4D (completed), 4E, and 4F.

This problem will require more time and more conversions than the other summative tasks. Have students check their work with you along the way. Clarify that the 4-inch foundation is for the entire fountain, not just the wall. If possible, take students to a similar object on campus. Even if you do not have a fountain, there may be a cylindrical planter around a tree. If a model is not available, provide students with Styrofoam or clay to make one. Use the picture provided in the unit to help students visualize the fountain area. See the pool problem for ideas on tiered water rates and converting cubic feet to gallons.

Activity 4B—Swimming Pool Problem:

Distribute Handouts 4B, 4D (completed), 4E, and 4F.

Prior to doing this problem, have students bring in a water bill (either from home with permission, or have students search "images" online for "sample water bill") or locate water rates from the local water agency's Internet site. Explain how water usage tiers work, and ask the students to decide and discuss which tier will apply to this problem. (The local water agency should have literature or information about this issue to use in class.)

Students may have difficulty visualizing the shape of the hole for the pool, which is a rectangular prism on top of a right triangular prism, starting ⅓ of the way from the edge of the rectangular prism. A model made from wood, Styrofoam, or paper would be helpful. If not using a model, indicate to students that the depth change runs lengthwise.

For question 3, students will need to know the conversion factor:

$$\frac{.765 \, m^3}{1 \, yd^3}.$$

When calculating how many dump trucks they will need to haul away dirt, remind students that you cannot use a fraction of a dump truck. An entire truck will be needed for even a partial load. For question 4, they will need to know there are approximately 7.4805 fluid gallons in 1 cubic foot. Note: If you choose to have students look up the calculation online, many sites will do the calculation for them without telling them the conversion factor. Also, the conversion factor is different for dry vs. liquid gallons. Ask the class: Why are there more fluid gallons than dry gallons in a cubic foot? Let them practice constructing viable arguments and critiquing the reasoning of others. It would be good to have some containers, water, and dirt or gravel to test their theories.

Activity 4C: Roofing Problem:

Distribute Handouts 4C, 4D (completed), 4E, and 4F.

Most calculations are straightforward; however, there are some possible mistakes to watch for, such as: Students may use 18 ft. (½ of 36) for the base of their triangle when calculating the hypotenuse. Make sure they notice the extra 2 feet where the roof extends beyond the house in the picture provided. Also, students may use the area of the house, not the roof, to calculate the hours it will take the contractor to shingle. Make sure they read the problem carefully.

Handouts ⬢

Name: _____

 PRE-LESSON

Contextualizing Mathematics and Industrial Technology Education

DIMENSIONAL ANALYSIS*

Length Conversions:

1. Convert 38 inches into a measurement in centimeters, rounded to one decimal place.

2. Convert 51 inches into a measurement in millimeters, rounded to one decimal place.

3. Convert 9,456 feet into a measurement in miles, rounded to two decimal places.

* *Special thanks to Doug Gardner, Rogue Community College, for providing worksheet questions from* Applied Technical Mathematics, *Section 1.4 "Dimensional Analysis," pp. 41–43.*

Area Conversions:

4. Convert 17 square inches into a measurement in square centimeters, rounded to two decimal places.

5. Convert 236 square inches into a measurement in square feet, rounded to two decimal places.

6. Convert 78 square feet into a measurement in square yards, rounded to two decimal places.

Volume Conversions:

7. Convert 4 cubic feet into a measurement in cubic inches.

8. Convert 5 cubic feet into a measurement in gallons, rounded to two decimal places.

9. Convert 167 cubic feet into a measurement in cubic yards, rounded to two decimal places.

Rate Conversions:

10. Convert a rate of 18 feet per second into miles per hour (mph), rounded to one decimal place.

11. Convert 23 gallons per minute (GPM) into cubic feet per day, rounded to the nearest whole number.

2013, www.iebcnow.org

Name: _____

1 Contextualizing Mathematics and Industrial Technology Education

CONCRETE PROBLEM

Activity 1

1. You are to design a curved concrete walkway. Individually, draw a sketch of the project. In your design, include the dimensions of your walkway. Give all measurements in metric dimensions (either meters or centimeters). Note: To estimate the length of a curved walkway, take the average of the lengths of the inner and outer curves. You will need a tape measure to measure the curve.

2. The walkway consists of a 4-inch deep layer of gravel and then a 4-inch deep layer of concrete. Based on the dimensions of your design, you will need to decide how much gravel and how much concrete will need to be delivered in order to make your walkway. Gravel and concrete are both measured in cubic yards.

3. Work in small groups to share individual designs and solicit feedback from peers. Revise designs as necessary.

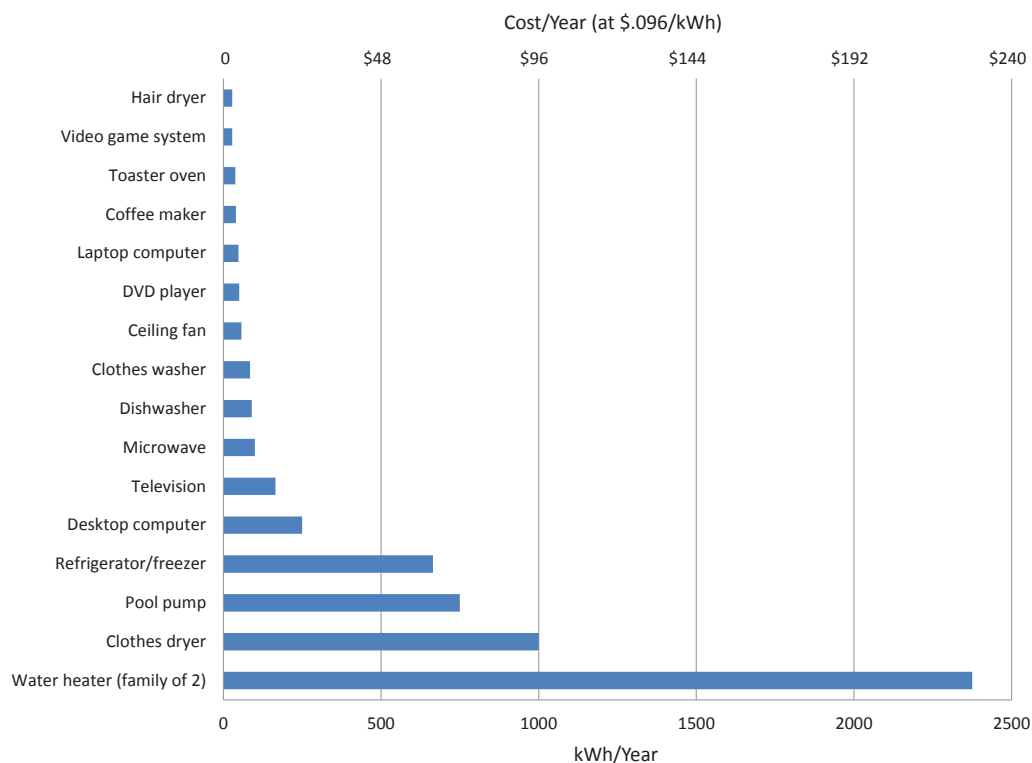*2013, www.iebcnow.org*

Name: _____

2 Contextualizing Mathematics and Industrial Technology Education

ELECTRICITY PROBLEM

Activity 2

How Much Electricity Do Appliances Use?

Cost/Year (at $.096/kWh)

This graph shows how much energy a typical appliance uses per year and its corresponding cost based on national averages.

Source: http://energy.gov/energysaver/articles/tips-appliances

1. List all the appliances in your home that use electricity. Which ones are used for many hours? Which ones are used for only a few hours?

2. Research how many watts appliances consume along with average usage cycles. Suggested website: http://energy.gov/energysaver/articles/estimating-appliance-and-home-electronic-energy-use.

3. Estimate the annual cost to run an appliance. Choose a refrigerator and two other appliances that you frequently use. Research the number of watts each appliance uses and convert this to kWh. For each appliance, multiply the annual consumption in kWh per year by your local utility's rate (e.g., $0.15) per kWh consumed to calculate the annual cost to run an appliance. Note: To estimate the number of hours that a refrigerator actually operates at its maximum wattage, divide the total time the refrigerator is plugged in by 3. Refrigerators, although turned "on" all the time, actually cycle on and off as needed to maintain interior temperatures.

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3 Contextualizing Mathematics and Industrial Technology Education
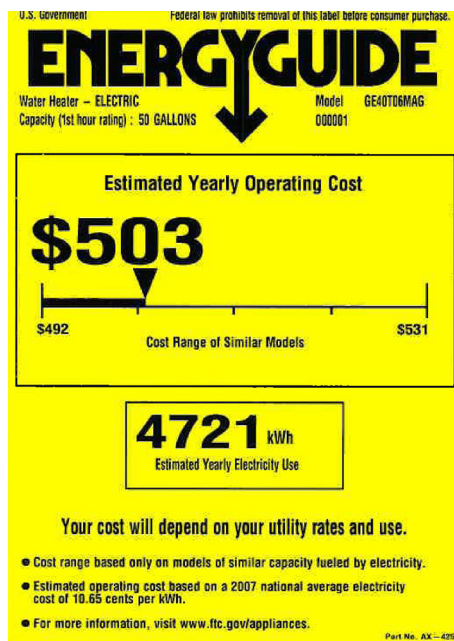
SOLAR PANEL PROBLEM

Activity 3

Your customer is interested in installing photovoltaic (solar) panels to provide hot water via an electric hot water heater. You need to decide whether the installation of solar panel(s) is a good investment. The customer has a 40-gallon electric hot water heater.

The average solar panel size is 3.5 ft. by 6 ft.
In the Redding area, a solar panel produces 5 kWh per square meter per day. This rate will be used for this lesson.

1. Use the EnergyGuide label (at left) to find the energy usage for a base model GE 40-gallon electric water heater.

2. Do all conversions to determine the number of panels required to provide hot water for one year.

Name: _____

4A Contextualizing Mathematics and Industrial Technology Education
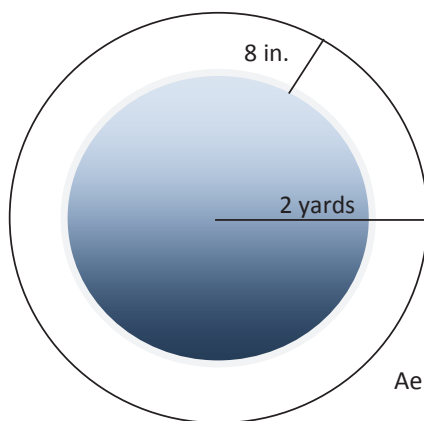
FOUNTAIN PROBLEM

Activity 4

Answer questions 1 through 7. Prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. Use the bid and letter templates (Handouts 4E and 4F) and include the price of labor to build and tile the base of the fountain (XX hrs. at the local hourly rate) and the cost of water to fill the fountain. You will need to conduct research to determine local labor rates, the approximate length of time it would take to build and tile the base of the fountain, and local water rates.

Copyright: zanira_zm-Fotolia

You are to build a circular fountain with an outer radius of 2 yards and a foundation that is 4 inches thick. The width of the circular retaining wall will be 8 inches, as shown from the aerial view of the fountain (not to scale). The height of the wall will be 1 foot.

8 in.

2 yards

Aerial view of fountain base.

1. Draw a scale drawing of your fountain base. Label the dimensions. (Use graph paper.)

2. Compute how many cubic yards of concrete would be required to pour the foundation as well as the circular retaining wall that will be poured on top of the foundation.

3. Mosaic tile will be used to tile the inside floor and wall of the fountain and is sold in square feet. Calculate the square footage of mosaic tile required to tile the inside floor and wall. Be sure to add in 5% overage for waste.

4. You would like to use 12-inch tiles to lay flat outside of the fountain as a border between the fountain and the lawn (see diagram below). Each tile will touch the concrete wall at its midpoint and will touch the corner of the other two tiles at each side. How many tiles will be required to "ring" the fountain?

8 in.

2 yards
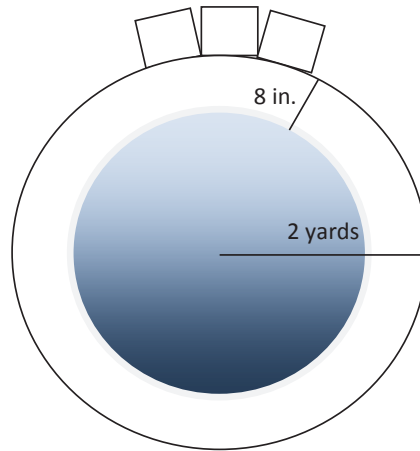
5. In order to purchase chlorine and other chemicals to keep the water clean and clear, it is necessary to know the volume of water. Calculate the number of gallons of water it takes to fill the fountain to the top of the wall.

6. The pump of the fountain pumps water through a pipe at 8 gallons/minute. How long will it take to fill the fountain to the very top of the concrete wall? (Use next page if more space required for calculations.)

Copyright: Otto Durst-Fotolia

7. Look up water usage rates from your city and use them to calculate the cost of the water to fill the fountain.

8. Prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. The bid you are presenting here is only for the cost of labor and the water to fill the fountain.

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Name: _____

4B Contextualizing Mathematics and Industrial Technology Education

SWIMMING POOL PROBLEM

Activity 4

A homeowner wants to install a prefabricated swimming pool and needs your company to excavate the hole and fill the pool with water. From an aerial view, the pool is a rectangle measuring 15 feet by 30 feet. The shallow end is dug down 3 feet and continues for 10 feet; the bottom of this section is completely horizontal. At the farthest end of the pool, it is dug down 10 feet. The pool then slopes upward linearly to meet the leading edge of the shallow portion of the pool.

Answer questions 1 through 5, then prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. Use the bid and letter templates (Handouts 4E and 4F) and include the cost of labor (XX hours at the local hourly rate) and the cost of water to fill the pool. Look up water usage rates from your city and use them to calculate the cost of the water. You will need to research labor costs and the length of time it would take to excavate a hole of this size.

1. Draw two scale drawings of the pool (top view and side view). Use graph paper for your drawings.

2. How much dirt will be removed in cubic yards?

3. A dump truck holds 9 cubic meters of dirt. How many dump trucks are needed to haul the dirt away? (Note: you cannot use a fraction of a dump truck. An entire truck will be needed for even a partial load.)

4. When the prefabricated pool has been installed, it will need to be filled with water to a level 8 inches below the top lip of the pool. Your customer's garden hose can fill the pool at a rate of 6 gallons per minute.

    a. How many gallons of water does it take to fill the pool?

    b. How long will it take (in hours) to fill the pool with water?

5. Look up the city's water usage rates and use them to calculate the cost of the water to fill the pool.

6. Prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. The bid you are presenting will be for labor to excavate the hole and the cost of the water to fill the pool.

Name: _____

4C Contextualizing Mathematics and Industrial Technology Education
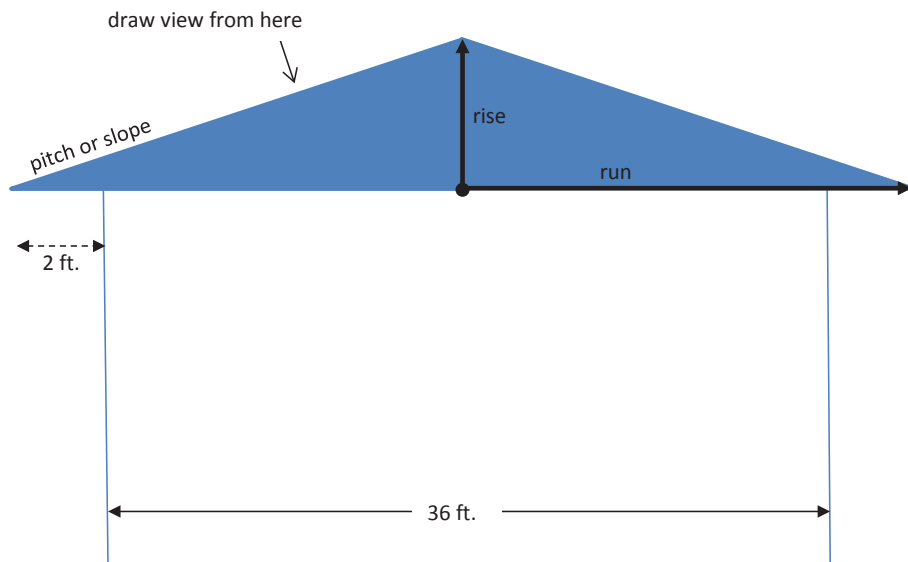
ROOFING PROBLEM

Activity 4

You have been asked to furnish a quote for the cost of putting shingles on a house.

Answer questions 1 through 4, and then prepare a presentation as if you were a contractor presenting your services to a homeowner. Use the bid and letter templates (Handouts 4E and 4F), and include the cost of shingles, the cost of labor (XX hours at $30/hour), and a total price for the project.

Copyright: Seagames50-Fotolia

The house measures 36 feet wide by 60 feet long (length not shown). The pitch of the roof is "4/12." This pitch dimension means that the roof rises 4 feet (note "rise" in the drawing below) for every 12 feet it runs (note "run" in the drawing below).

draw view from here

pitch or slope

rise

run

2 ft.

36 ft.

1. Determine the dimensions of the roof.

   a. Make a scale drawing on graph paper of half of the roof from an aerial view (see illustration on previous page).

   b. Label the drawing with the correct measurements.

2. One square (box) of shingles covers 100 ft.² and costs, on average, $80 per square.
   a. Find the number of squares required to shingle the roof if it is common to order 10% extra for waste.

   b. Find the total cost for the shingles.

3. It takes about 2 hours to shingle 100 ft.² of roof.
   a. How many hours would it take to shingle this roof?

   b. Calculate the cost of labor if the contractor charges $30 per hour.

4. Calculate the total cost of labor and supplies.

5. Prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. The bid you are presenting will be for the cost of the shingles and labor.

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4D Contextualizing Mathematics and Industrial Technology Education

BID SCORING RUBRIC

Activity 4

Required elements of a bid will include labor at XX hours to complete the project at the local hourly rate, materials (if applicable), and a total price.

	APPEARANCE	FORMAT	CONTENT	CLARITY	ACCURACY
EXCELLENT					
PROFICIENT					

	APPEARANCE	FORMAT	CONTENT	CLARITY	ACCURACY
COMPETENT					
LESS THAN COMPETENT					

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4E Contextualizing Mathematics and Industrial Technology Education

SAMPLE LETTER TEMPLATE

Activity 4

A simple cover letter to the homeowner noting technical qualifications/experience and contact information is required. See the sample letter template below to help you get started. You can find free sample cover letters online. In order to improve your presentation, you can also contact local businesses to examine what they commonly use.

Client Name
Address
City, State, Zip

Date

Dear [Client Name]:

[Write your letter]

Sincerely,

Name
Title
Company

Phone

Enclosure: Bid

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4F Contextualizing Mathematics and Industrial Technology Education

BID TEMPLATE

Activity 4

Date

Company Name
Company Address
Company Phone

Bid Number
Project Description

ITEM DESCRIPTION	QUANTITY	MATERIAL COST	LABOR COST
Total			
Grand Total			

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Answer Keys ⬡

Answer Key

PRE-LESSON Contextualizing Mathematics and Industrial Technology Education

DIMENSIONAL ANALYSIS*

Length Conversions:

1. Convert 38 inches into a measurement in centimeters, rounded to one decimal place.

$$\left(\frac{38 \text{ in.}}{1}\right)\left(\frac{2.54 \text{ cm.}}{1 \text{ in.}}\right) \approx 96.5 \text{ cm.}$$

2. Convert 51 inches into a measurement in millimeters, rounded to one decimal place.

$$\left(\frac{51 \text{ in.}}{1}\right)\left(\frac{25.4 \text{ mm.}}{1 \text{ in.}}\right) \approx 1295.4 \text{ mm.}$$

3. Convert 9,456 feet into a measurement in miles, rounded to two decimal places.

$$\left(\frac{9456 \text{ ft.}}{1}\right)\left(\frac{1 \text{ mi.}}{5280 \text{ ft.}}\right) \approx 1.79 \text{ mi.}$$

---

* *Special thanks to Doug Gardner, Rogue Community College, for providing worksheet questions from* Applied Technical Mathematics*, Section 1.4 "Dimensional Analysis," pp. 41–43.*

Area Conversions:

4. Convert 17 square inches into a measurement in square centimeters, rounded to two decimal places.

$$\left(\frac{17 \text{ in.}^2}{1}\right)\left(\frac{2.54 \text{ cm.}}{1 \text{ in.}}\right)\left(\frac{2.54 \text{ cm.}}{1 \text{ in.}}\right) \approx 109.68 \text{ cm.}^2$$

5. Convert 236 square inches into a measurement in square feet, rounded to two decimal places.

$$\left(\frac{236 \text{ in.}^2}{1}\right)\left(\frac{1 \text{ ft.}}{12 \text{ in.}}\right)\left(\frac{1 \text{ ft.}}{12 \text{ in.}}\right) \approx 1.64 \text{ ft.}^2$$

6. Convert 78 square feet into a measurement in square yards, rounded to two decimal places.

$$\left(\frac{78 \text{ ft.}^2}{1}\right)\left(\frac{1 \text{ yd.}}{3 \text{ ft.}}\right)\left(\frac{1 \text{ yd.}}{3 \text{ ft.}}\right) \approx 8.67 \text{ yd.}^2$$

Volume Conversions:

7. Convert 4 cubic feet into a measurement in cubic inches.

$$\left(\frac{4 \text{ ft.}^3}{1}\right)\left(\frac{12 \text{ in.}}{1 \text{ ft.}}\right)\left(\frac{12 \text{ in.}}{1 \text{ ft.}}\right)\left(\frac{12 \text{ in.}}{1 \text{ ft.}}\right) \approx 6912 \text{ in.}^3$$

8. Convert 5 cubic feet into a measurement in gallons, rounded to two decimal places.

$$\left(\frac{5 \text{ ft.}^3}{1}\right)\left(\frac{7.48 \text{ gal.}}{1 \text{ ft.}^3}\right) \approx 37.40 \text{ gal.}$$

9. Convert 167 cubic feet into a measurement in cubic yards, rounded to two decimal places.

$$\left(\frac{167 \text{ ft.}^3}{1}\right)\left(\frac{1 \text{ yd.}}{3 \text{ ft.}}\right)\left(\frac{1 \text{ yd.}}{3 \text{ ft.}}\right)\left(\frac{1 \text{ yd.}}{3 \text{ ft.}}\right) \approx 6.19 \text{ yd.}^3$$

Rate Conversions:

10. Convert a rate of 18 feet per second into miles per hour (mph), rounded to one decimal place.

$$\left(\frac{18 \text{ ft.}}{\text{sec.}}\right)\left(\frac{1 \text{ mi.}}{5280 \text{ ft.}}\right)\left(\frac{60 \text{ sec.}}{1 \text{ min.}}\right)\left(\frac{60 \text{ min.}}{1 \text{ hr.}}\right) \approx 12.3 \text{ mph.}$$

11. Convert 23 gallons per minute (GPM) into cubic feet per day, rounded to the nearest whole number.

$$\left(\frac{23 \text{ gal.}}{\text{min.}}\right)\left(\frac{1 \text{ ft.}^3}{7.48 \text{ gal.}}\right)\left(\frac{60 \text{ min.}}{1 \text{ hr.}}\right)\left(\frac{24 \text{ hr.}}{1 \text{ day}}\right) \approx 4428 \text{ ft.}^3/\text{day.}$$

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Answer Key

1 Contextualizing Mathematics and Industrial Technology Education

CONCRETE PROBLEM

Activity 1

1. You are to design a curved concrete walkway. Individually, draw a sketch of the project. In your design, include the dimensions of your walkway. Give all measurements in metric dimensions (either meters or centimeters). Note: To estimate the length of a curved walkway, take the average of the lengths of the inner and outer curves. You will need a tape measure to measure the curve.

   Answers will vary.

2. The walkway consists of a 4-inch deep layer of gravel and then a 4-inch deep layer of concrete. Based on the dimensions of your design, you will need to decide how much gravel and how much concrete will need to be delivered in order to make your walkway. Gravel and concrete are both measured in cubic yards.

   Sample answer:

   After averaging the inner and outer curve of the walkway, the length of the walkway is estimated to be ≈ 8 feet, the width is 33 inches.

   Convert all measurements in inches to feet:

   $$\frac{33 \text{ in.}}{1} \times \frac{1 \text{ ft.}}{12 \text{ in.}} = 2.75 \text{ ft. (width of sidewalk);}$$

   $$\frac{4 \text{ in.}}{1} \times \frac{1 \text{ ft.}}{12 \text{ in.}} = \frac{1}{3} \text{ or } \approx .33 \text{ ft. (depth of gravel layer as well as concrete layer).}$$

Gravel needed: Typically, gravel is sold in cubic yards. Another conversion is necessary.

$$\frac{7.33 \text{ ft.}^3}{1} \times \frac{1 \text{ yd.}^3}{3^3 \text{ ft.}^3} \approx .272 \text{ yd.}^3$$

Since the depth of the concrete is equal to that of the gravel, you would need this same amount of concrete. Students should inquire at a local business how the quantities can be purchased. For example, a business may only sell in ¼ yards, so to ensure full coverage, ½ yard of each would need to be purchased.

3. Work in small groups to share individual designs and solicit feedback from peers. Revise designs as necessary.

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Answer Key

2 Contextualizing Mathematics and Industrial Technology Education

1. List all the appliances in your home that use electricity. Which ones are used for many hours? Which ones are used for only a few hours?

   Answers will vary.

2. Research how many watts appliances consume along with average usage cycles. Suggested website: http://energy.gov/energysaver/articles/estimating-appliance-and-home-electronic-energy-use.

3. Estimate the annual cost to run an appliance. Choose a refrigerator and two other appliances that you frequently use. Research the number of watts each appliance uses and convert this to kWh. For each appliance, multiply the annual consumption in kWh per year by your local utility's rate (e.g., $0.15) per kWh consumed to calculate the annual cost to run an appliance. Note: To estimate the number of hours that a refrigerator actually operates at its maximum wattage, divide the total time the refrigerator is plugged in by 3. Refrigerators, although turned "on" all the time, actually cycle on and off as needed to maintain interior temperatures.

   Sample answers:

   Refrigerator:

   725 watts per hour. (Note: A refrigerator cycles on and off so that it effectively runs the equivalent of 8 hours per day.)

   $$\frac{725\,W}{1} \times \frac{1\,kW}{1000\,W} \times \frac{8\,hrs.}{1\,day} \times \frac{365\,days}{1\,yr.} \times \frac{\$0.15}{kWh} = \$317.55.$$

   Coffeemaker:

   1,200 watts, 1 hour/day.

   $$\frac{1200\,W}{1} \times \frac{1\,kW}{1000\,W} \times \frac{1\,hr.}{1\,day} \times \frac{365\,days}{1\,yr.} \times \frac{\$0.15}{kWh} = \$65.70.$$

   Dryer:

   5,000 watts, 8 hours/week.

   $$\frac{5000\,W}{1} \times \frac{1\,kW}{1000\,W} \times \frac{8\,hrs.}{1\,wk.} \times \frac{52\,wks.}{1\,yr.} \times \frac{\$0.15}{kWh} = \$156.04.$$

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Answer Key

3 Contextualizing Mathematics and Industrial Technology Education
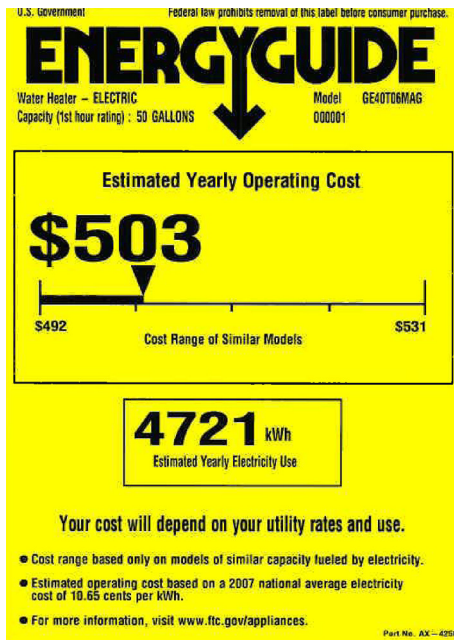
SOLAR PANEL PROBLEM

Activity 3

Your customer is interested in installing photovoltaic (solar) panels to provide hot water via an electric hot water heater. You need to decide whether the installation of solar panel(s) is a good investment. The customer has a 40-gallon electric hot water heater.

The average solar panel size is 3.5 ft. by 6 ft.

In the Redding area, a solar panel produces 5 kWh per square meter per day. This rate will be used for this lesson

1. Use the EnergyGuide label (at left) to find the energy usage for a base model GE 40-gallon electric water heater.

   4,721 kWh.

1. Do all conversions to determine the number of panels required to provide hot water for one year.

    Convert to meters:

    1 foot = .3048 meters;
    3.5 × .3048 = 1.0668;
    6 × .3048 = 1.8288.

    Determine the square meters of the solar panel: $1.0668\,m \times 1.8288\,m = 1.9509\,m^2$.
    Round up to $2\,m^2$.
    If a $1\,m^2$ panel generates 5 kWh per day, then a $2\,m^2$ panel should generate 10 kWh per day, which equates to 3,650 kWh per year: $(365 \times 10 = 3,650)$.

    According to the label on the water heater, it requires 4,721 kWh per year to run the heater.
    $$\frac{4721\,kWh}{3650\,kWh} = 1.3 \text{ panels.}$$

    You would need two panels, which is a little over what you need, but you can't buy a portion of a panel.

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Answer Key

4A Contextualizing Mathematics and Industrial Technology Education
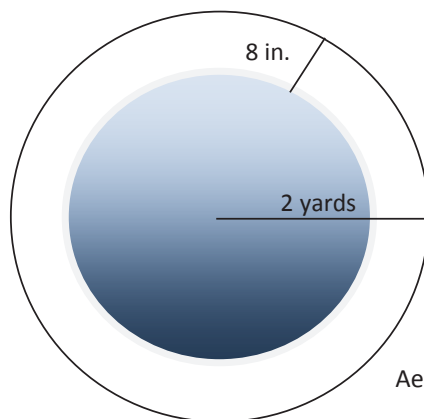
FOUNTAIN PROBLEM

Activity 4

Answer questions 1 through 7. Prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. Use the bid and letter templates (Handouts 4E and 4F) and include the price of labor to build and tile the base of the fountain (XX hrs. at the local hourly rate) and the cost of water to fill the fountain. You will need to conduct research to determine local labor rates, the approximate length of time it would take to build and tile the base of the fountain, and local water rates.

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You are to build a circular fountain with an outer radius of 2 yards and a foundation that is 4 inches thick. The width of the circular retaining wall will be 8 inches, as shown from the aerial view of the fountain (not to scale). The height of the wall will be 1 foot.

8 in.

2 yards

Aerial view of fountain base.

1. Draw a scale drawing of your fountain. Label the dimensions. (Use graph paper.)

   Answers will vary.

2. Compute how many cubic yards of concrete would be required to pour the foundation as well as the circular retaining wall that will be poured on top of the foundation.

   Foundation:

   $$\left(72 \text{ in.}\right)^2 \times \pi \approx 16286 \text{ in.}^2 \times 4 \text{ in.} \approx 65144 \text{ in.}^3,$$

   $$\frac{65144 \text{ in.}^3}{1} \times \frac{1 \text{ yd.}^3}{\left(36 \text{ in.}\right)^3} = \frac{65144 \text{ yd.}^3}{46656 \text{ in.}^3} \approx 1.39 \text{ yd.}^3$$

   Retaining Wall:

   Volume of big cylinder: $\left(72 \text{ in.}\right)^2 \times \pi \times 12 \text{ in.} \approx 195432.2 \text{ in.}^3$

   Volume of small cylinder: $\left(64 \text{ in.}\right)^2 \times \pi \times 12 \text{ in.} \approx 154415.6 \text{ in.}^3$

   Volume of retaining wall: $195432.2 \text{ in.}^3 - 154415.6 \text{ in.}^3 \approx 41016.6 \text{ in.}^3$

   Convert to cubic yards: $\dfrac{41016.6 \text{ in.}^3}{1} \times \dfrac{1 \text{ yd.}^3}{46656 \text{ in.}^3} \approx .88 \text{ yd.}^3$

   **Total amount of concrete needed**: 2.27 cubic yards.

3. Mosaic tile will be used to tile the inside floor and wall of the fountain and is sold in square feet. Calculate the square footage of mosaic tile required to tile the inside floor and wall. Be sure to add in 5% overage for waste.

   $$\left(64 \text{ in.}\right)^2 \times \pi \approx 12868 \text{ in.}^2 \to \frac{12868 \text{ in.}^2}{1} \times \frac{1 \text{ ft.}^2}{\left(12 \text{ in.}\right)^2} \approx 89.4 \text{ ft.}^2 \to 89.4\left(1.1\right) = 98.3 \text{ ft.}^2 \text{ of tile.}$$

4. You would like to use 12-inch tiles to lay flat outside of the fountain as a border between the fountain and the lawn (see diagram below). Each tile will touch the concrete wall at its midpoint and will touch the corner of the other two tiles at each side. How many tiles will be required to "ring" the fountain?

$$\cancel{ZZZZZZZZZZZZZZZZZ} \times \pi \approx \qquad \frac{452 \text{ in.}}{12} \approx$$

Allowing for overage, $37.6(1.1) \approx 41$ tiles.
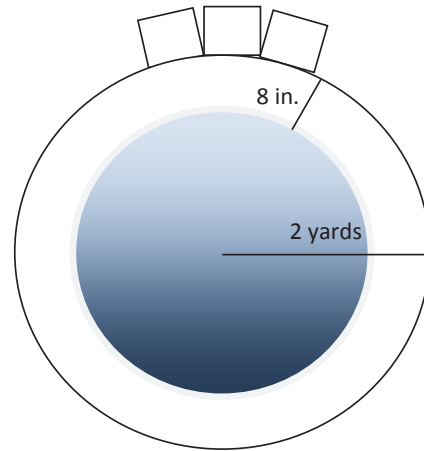
8 in.

2 yards

5. In order to purchase chlorine and other chemicals to keep the water clean and clear, it is necessary to know the volume of water. Calculate the number of gallons of water it takes to fill the fountain to the top of the wall.

$$(64 \text{ in.})^2 (12 \text{ in.})(\pi) \approx 154415.6 \text{ in.}^3 ; \quad \frac{154415.6 \text{ in.}^3}{1} \times \frac{1 \text{ ft.}^3}{(12 \text{ in.})^3} \times \frac{7.48 \text{ gal.}}{1 \text{ ft.}^3} \approx 668.4 \text{ gallons.}$$

6. The pump of the fountain pumps water through a pipe at 8 gallons/minute. How long will it take to fill the fountain to the very top of the concrete wall?

$$\frac{668.4}{8} \approx 83.6 \text{ minutes.}$$

7. Look up water usage rates from your city and use them to calculate the cost of the water to fill the fountain.

Example: 748 gallons = 1 unit; at tier 2, water is $1.35 per unit.

$$\frac{668.4 \text{ gal.}}{1} \times \frac{1 \text{ unit}}{748 \text{ gal.}} \times \frac{\$1.35}{\text{unit}} = \$1.21.$$

8. Prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. The bid you are presenting here is only for the cost of labor and the water to fill the fountain.

Use the bid scoring rubric to grade the bid presentations.

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Answer Key

4B Contextualizing Mathematics and Industrial Technology Education

SWIMMING POOL PROBLEM

Activity 4

A homeowner wants to install a prefabricated swimming pool and needs your company to excavate the hole and fill the pool with water. From an aerial view, the pool is a rectangle measuring 15 feet by 30 feet. The shallow end is dug down 3 feet and continues for 10 feet; the bottom of this section is completely horizontal. At the farthest end of the pool, it is dug down 10 feet. The pool then slopes upward linearly to meet the leading edge of the shallow portion of the pool.

Answer questions 1 through 5, then prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. Use the bid and letter templates (Handouts 4E and 4F) and include the cost of labor (XX hours at the local hourly rate) and the cost of water to fill the pool. Look up water usage rates from your city and use them to calculate the cost of the water. You will need to research labor costs and the length of time it would take to excavate a hole of this size.

1. Draw two scale drawings of the pool (top view and side view). Use graph paper for your drawings.

2. How much dirt will be removed in cubic yards?

Volume of rectangular prism: $3 \times 15 \times 30 = 1350$ ft.^{3}

Volume of triangular prism: $\dfrac{20 \times 7}{2} \times 15 = 1050$ ft.^{3}

Total volume: 2400 ft.^{3}

Convert to cubic yards: $\dfrac{2400 \text{ ft.}^3}{1} \times \dfrac{1 \text{ yd.}^3}{27 \text{ ft.}^3} \approx 89$ yd.^{3}

3. A dump truck holds 9 cubic meters of dirt. How many dump trucks are needed to haul the dirt away? (Note: you cannot use a fraction of a dump truck. An entire truck will be needed for even a partial load.)

$\dfrac{8 \text{ yd.}^3}{1} \times \dfrac{.765 \text{ m}^3}{1 \text{ yd.}^3} \approx 68 \text{ m}^3 \rightarrow \dfrac{68}{9} \approx 7.6 \rightarrow 8$ trucks.

4. When the prefabricated pool has been installed, it will need to be filled with water to a level 8 inches below the top lip of the pool. Your customer's garden hose can fill the pool at a rate of 6 gallons per minute.

   a. How many gallons of water does it take to fill the pool?

   $\dfrac{8}{12}(15)(30) = 300$ ft.^{3}; 2400 ft.$^3 - 300$ ft.$^3 = 2100$ ft.^{3},

   $\dfrac{2100 \text{ ft.}^3}{1} \times \dfrac{7.48 \text{ gals.}}{1 \text{ ft.}^3} = 15,700$ gallons.

   b. How long will it take (in hours) to fill the pool with water?

   $\dfrac{6 \text{ gals.}}{1 \text{ min.}} = \dfrac{15700 \text{ gals.}}{x \text{ mins.}} \rightarrow 2616.7$ minutes or 43.6 hours.

5. Look up the city's water usage rates and use them to calculate the cost of the water to fill the pool.

   Example: 748 gallons $= 1$ unit; at tier 2, water is $1.35 per unit.

   $\dfrac{15700 \text{ gals.}}{1} \times \dfrac{1 \text{ unit}}{748 \text{ gals.}} \times \dfrac{\$1.35}{\text{unit}} = \$28.35.$

6. Prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. The bid you are presenting will be for labor to excavate the hole and the cost of the water to fill the pool.

   Use the bid scoring rubric to grade bid presentations.

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Answer Key

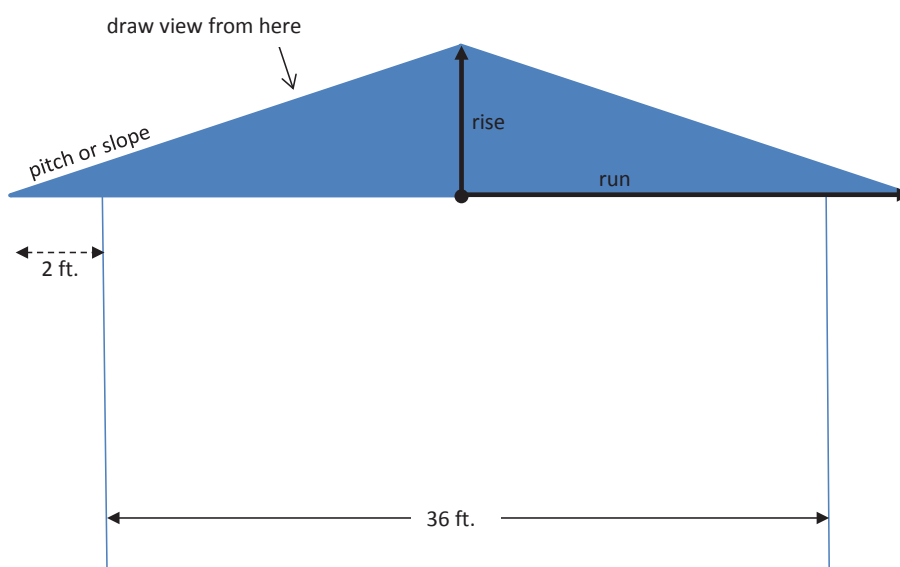# Contextualizing Mathematics and Industrial Technology Education

ROOFING PROBLEM

Activity 4

You have been asked to furnish a quote for the cost of putting shingles on a house.

Answer questions 1 through 4, and then prepare a presentation as if you were a contractor presenting your services to a homeowner. Use the bid and letter templates (Handouts 4E and 4F), and include the cost of shingles, the cost of labor (XX hours at $30/hour), and a total price for the project.

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The house measures 36 feet wide by 60 feet long (length not shown). The pitch of the roof is "4/12." This pitch dimension means that the roof rises 4 feet (note "rise" in the drawing below) for every 12 feet it runs (note "run" in the drawing below).

draw view from here

pitch or slope

rise

run

2 ft.

36 ft.

1. Determine the dimensions of the roof.

   In order to determine the dimensions of the roof, students will need to determine the length of the slope—or the length of the slanted side—of the roof. To do that, the first step is to determine the length of the roof's run. The run is equal to half the width of the house (36/2=18) plus the overhang of 2 ft. (18+2=20 ft.).

   The length of the run is 20 ft.

   Next, students need to determine the rise of the roof based on a 4/12 pitch:

   $$\frac{4}{12} = \frac{x}{20},$$
   $$\frac{4}{12} \times \frac{20}{1} = x,$$
   $$\frac{80}{12} = x,$$
   $$6.67 = x.$$

   The rise of the roof is 6.67 ft.

   Students should then use the Pythagorean theorem to determine the length of the slope based on the height of the rise (6.67 ft.) and the length of the run (20 ft.):

   $$6.67^2 + 20^2 = x^2,$$
   $$44.49 + 400 = x^2,$$
   $$444.49 = x^2,$$
   $$\sqrt{444.49} = x,$$
   $$21.08 = x.$$

   The length of the slope of the roof is 21.08 ft.

   a. Make a scale drawing on graph paper of half of the roof from an aerial view (see illustration on previous page).

      Drawings will vary, but the scale should be in proportion to the measurements above.

   b. Label the drawing with the correct measurements.

      The dimensions should be 21.08 ft. wide by 60 feet long (the length is given in the directions).

2. One square (box) of shingles covers 100 ft.^{2} and costs, on average, $80 per square.

   a. Find the number of squares required to shingle the roof if it is common to order 10% extra for waste.

     First, students need to determine the area of the entire roof.

     $21.08 \text{ ft.} \times 60 \text{ ft.} = 1{,}264.8 \text{ ft.}^2$ (half the roof),

     $1{,}264.8 \text{ ft.}^2 \times 2 = 2{,}529.6 \text{ ft.}^2$, or approximately $2{,}530 \text{ ft.}^2$ (entire roof).

     Next, students need to determine how many squares (boxes) of shingles are required for the roof, including 10% extra for waste:

     $\dfrac{2530}{100} = 25.30$; $25.30 \times 1.1 = 27.83$, or 28 squares (you can't order a partial box).

   b. Find the total cost for the shingles.
     The cost of the shingles will be:

     $28 \times \$80 = \$2{,}240.$

3. It takes about 2 hours to shingle 100 ft.^{2} of roof.

   a. How many hours would it take to shingle this roof?

     $\dfrac{2530 \text{ ft.}^2}{100 \text{ ft.}^2} = 25.30$ (100 ft.^{2} sections);

     $25.30 \times 2 \text{ hrs.} = 50.60 \text{ hrs.}$

   b. Calculate the cost of labor if the contractor charges $30 per hour.

     $50.60 \text{ hrs.} \times \$30/\text{hr.} = \$1{,}518.$

4. Calculate the total cost of labor and supplies.

   $\$1{,}518 + \$2{,}240 = \$3{,}758.$

5. Prepare a presentation of your results as if you were a contractor presenting your services to a homeowner. The bid you are presenting will be for the cost of the shingles and labor.

   Use the bid scoring rubric to grade bid presentations.

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