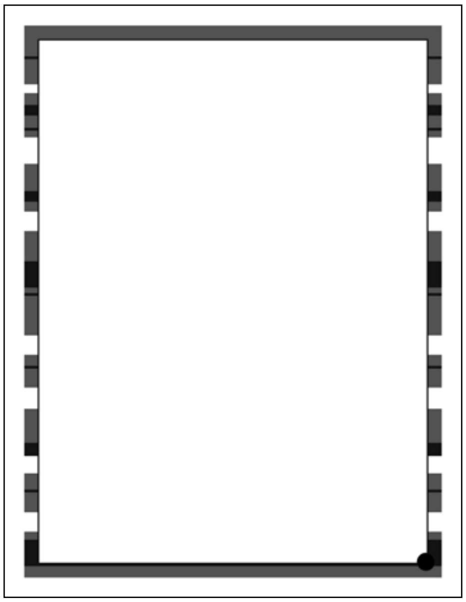
Big or Small: Measure It All!

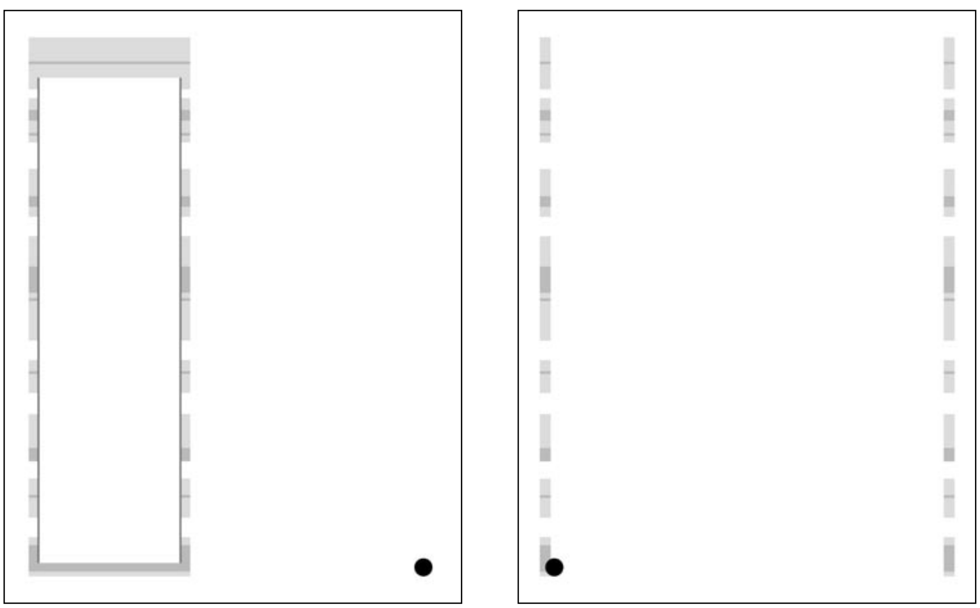
Teacher Guide

WesternReservePublicMedia.org/measure

WESTERN RESERVE PUBLIC MEDIA



Student Pages



Teacher Pages

Contents

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Teacher Guide

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For the complete list of sources used in creating these materials, please visit the ***Big or Small: Measure It All!*** Web site at **www.WesternReservePublicMedia.org/measure**.

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BIG OR SMALL: measure it all!

introduction

Big or Small: Measure It All

Purpose

Western Reserve Public Media's multimedia package ***Big or Small: Measure It All*** was created with a two-fold purpose. First, the videos show students how measurement is used every day in the "real world." Second, the package offers students "hands-on" lessons that require the use of measurement to accomplish a task. It is directed at grades 4 and 6 and is **keyed to mathematics standards for those grades**. The package was created by a team of teachers from school districts in our service area.

How to Use This Package

The components of the ***Big or Small: Measure It All*** multimedia package are listed below. They include videos, a teacher guide, a virtual Ohio tour and a Web site, all of which have been designed for use as either stand-alone educational tools or as a complete package. It is our hope that teachers will use the components to complement their classroom instruction.

Package Contents

Instructional Videos and Teacher Guide Video Supplements

Five 10-minute videos present information on measuring different types of travel. Related lesson plans for each video also are included.

1. **Air** – This episode takes us to Albuquerque to watch the biggest hot air balloon take-off in the United States. Students learn the importance of measuring **weight**, **volume**, **distance** and **degrees** when trying to launch a balloon.

   Lesson Plans

   - **Balloon Design Challenge** – Make a hot air balloon and measure the time it stays in the air and the distance it travels from the starting point.
   - **Pegasus: A Myth About Flight** – Students read the myth about Pegasus and then calculate the amount of food he eats and water he drinks. They will need to do conversions between pounds and ounces and between gallons and quarts.

2. **Land** – Visit the Talladega Speedway and see the need for accurately measuring **distance**, **speed** and **angles** when competing in a NASCAR race.

   Lesson Plans

   - **Watch Out, NASCAR — Here Comes Our Car!** – Make a balloon-powered car and find the area and perimeter of the car body. Also, measure the distance that the car traveled.
   - **The Long, Winding Road** – Plan a "road trip" and determine a car's gas mileage.
   - **I Want a Doughnut!** – Determine all the possible routes to get from the start to the bakery to get a doughnut.

3. **Time** – Find out a little about the history of time and how accurate time is kept. Learn about **elapsed time**, **hours**, **minutes** and **precision**.

   Lesson Plans

   - **Plop, Plop, Fizz, Fizz — Timing Race** – Determine the time difference in using hot and cold water to melt an antacid tablet.
   - **Think Time!** – Compute the elapsed time of an event. This lesson plan includes a PowerPoint presentation.

4. **Sea** – Join in on a visit to the Flying Scot Sailboat Company and find out how necessary it is to use accurate measurements (area, weight, latitude and longitude) when trying to sail a boat.

   Lesson Plans

   - **Can Your Boat Float?** – Make a boat and find the area of the base. Add pennies until it sinks and create a graph to determine if the area makes a difference in the number of pennies that the boat will hold.
   - **Sail Away** – Determine which sailboat has the greater area of sail.
   - **What Measure Will You Use?** – Students decide if they need to find area, perimeter or volume. This lesson includes a PowerPoint presentation.

5. Space – Satellites and telescopes look at distances that are difficult for us to measure (large numbers, areas of circles, angles and altitude).

Lesson Plans

- **Lift Off!** – Make a toilet-paper model of the solar system. Make a straw-powered rocket, measure the distance the rocket will travel and graph the results.
- **How Much Do You Weigh on Other Planets?** – Students calculate what their weight would be on other planets.

Ohio Virtual Tour Lesson Plans

This section features an online activity that uses Google Earth to "visit" various sites in Ohio and conduct measurement activities. Additional chapters offer lesson plans related to the Ohio Virtual Tour sites.

1. Wright-Patterson Air Force Base

- **Wright-Patterson Air Force Base Measures Up** – Present in pictures, words and numbers how to compute the volume of material needed to resurface a runway.
- **Measuring the Aircraft at Wright-Patterson** – Present in pictures, words and numbers how to compute the volume of a cargo plane.

2. Farmland

- **New McDonald's Farm: Planting the Corn** – Determine how much corn could be planted on an acre of field.
- **New McDonald's Farm: Storing the Corn** – Find the volume of a silo and determine how much corn it will take to fill it.
- **New McDonald's Farm: Selling the Corn** – Use surface area to design a container to sell the cereal that you made from the corn.

3. The Landfill

- **The Edible Landfill** – Create an edible landfill and compute perimeter.
- **Design a Landfill for Your School** – Build a sanitary landfill on school grounds and measure area, perimeter and volume.
- **Fill It Up: Design a Landfill** – Draw the layers of a landfill and calculate the volume of each layer and of the whole landfill.
- **Cover It Up and Keep It Green** – Put a "cap" on your landfill and determine how many sprinklers you will need to keep it green.

4. Amusement Park Arcade

- **The Excellent Estimator** – The classroom turns into an amusement park arcade where students find the weight of water squeezed from a sponge, the distance a toy car can travel, the area of a shoe print, the volume of a cube and the time it takes to play a musical clip.

5. The Ohio State University Football Stadium

- **Game Day** – Students solve measurement problems related to a home football game at The Ohio State University.

Web Site

The project Web site, **www.WesternReservePublicMedia.org/measure**, contains all of the topics listed in the teacher guide plus some additions. These include Internet resources, PowerPoint presentations and games. In addition, the videos are available on video on demand so that they can be viewed online.

Resource: The History of Measurement

The Distant Past

For thousands of years, measurement was a very personal thing. Often body parts were the measuring device. Because of this, measurements often meant different things to different people. Here are some examples.

- **Cubit** — This ancient unit of length was based on the distance from the elbow to the tip of the middle finger.
- **Foot** — This measure came into use after the cubit and represented the length of a human foot. Obviously, this length varied a lot.
- **Inch** — An inch was the width of a man's thumb. It was also the distance from the tip of the thumb to the first joint. Twelve times this distance equaled a foot.
- **Yard** — Three times a foot equaled a yard. This was also the distance from the tip of the nose to the end of a man's outstretched arm.
- **Stone** — Babylonians used different stones to measure different items. The stones could weigh from 8 pounds (for selling fish) to 16 pounds (for selling wool).
- **Carat** — Arabs used karob beans to measure the weight of gold. From this, the word carat was derived to quantify the weight of gemstones such as diamonds.
- **Pace** — The Romans influenced many measurements because they traded in many lands. A pace was the distance of two steps or the distance from where one foot touched the ground until that same foot touched the ground again.

Needless to say, these methods of measurement caused confusion. There were no standards that meant the same thing to everyone. In the 13th century, King Edward of England decided that a standard was necessary and decreed a "master yardstick," which is about the same as the current yard. Further, he decreed that a foot was ⅓ of a yard and an inch was $\frac{1}{12}$ of a foot. He later reverted back to the "old system" of using seeds and body parts for measurement.

This "standard" system was brought to America with the colonists when they settled here.

The More Recent Past

In 1793 (during the time of Napoleon), the French adopted a new system of standards, which they called the metric system, using multiples of 10 to make conversions.

- **Meter** — The meter was supposed to be "1 ten-millionth part of the distance from the North Pole to the equator when measured on a straight line running along the surface of the earth through Paris."
- **Liter** — Intended to measure liquid volume, the liter was defined as a cube $\frac{1}{10}$ of a meter on each side.
- **Gram** — A gram was defined as "the mass of 1 cubic centimeter (a cube that is $\frac{1}{100}$ of a meter on each side) of water at its temperature of maximum density."

The Metric System	
kilo	1000
hecto	100
deka	10
standard	1
deci	$\frac{1}{10}$
centi	$\frac{1}{100}$
milli	$\frac{1}{1000}$

Measurement in the United States

The Constitution provided for a money system that was based on multiples of 10. In 1821, John Quincy Adams wrote a report to Congress dealing with the modernization of the measurement system. This is considered the first metric study. In 1855, after some prior laws, the American Yard Standard became the law.

In 1866, the metric system began to be used in the United States. Since that time, several bills have been passed to encourage the use of the metric system because it is the standard in most of the world's countries. In 1975, Congress passed the Metric Conversion Act, but the United States still uses the American Yard Standard measuring system. Some applications where the metric system is in use include bottled soda in two-liter containers and track-and-field events. Manufacturing companies that sell to companies overseas also use the metric system.

Equivalent Measurements

Linear Measures or Measures of Length

Customary or Standard Measures	
1 foot (ft)	12 inches
1 yard (yd)	3 feet or 36 inches
1 mile (mi)	5,280 feet
1 mile (mi)	1,760 yards

Metric Measures	
millimeter (mm)	.001 meter
centimeter (cm)	.01 meter
decimeter (dm)	.1 meter
meter (m)	Standard (1)
dekameter (dkm)	10 meters
hectometer (hm)	100 meters
kilometer (km)	1,000 meters

Comparisons

- A millimeter is about the edge of a paper clip
- A centimeter is about as big as the width of your thumbnail or a flat paper clip
- A meter is approximately 1 yard, or about 39 inches
- A kilometer is about 5/8 of a mile

Measures of Mass or Weight

Customary or Standard Measures	
1 pound (lb)	16 ounces
1 ton (t)	2,000 pounds

Metric Measures	
milligram (mg)	.001 gram
centigram (cg)	.01 gram
decigram (dg)	.1 gram
gram (g)	Standard (1)
dekagram (dkg)	10 grams
hectogram (hg)	100 grams
kilometer (kg)	1,000 grams

Comparisons

- A milligram weighs about the same as a grain of sand
- A gram weighs about the same as a raisin
- A pound is about the same as 454 grams
- A kilogram is 2.2 pounds

Measures of Volume or Capacity (Liquid Measures)

Customary or Standard Measures	
1 gallon	4 quarts
1 quart	2 pints
1 pint	2 cups
1 cup	8 ounces

Metric Measures	
milliliter (ml)	.001 liter
centiliter (cl)	.01 liter
deciliter (dl)	.1 liter
liter (l)	Standard (1)
dekaliter (dcl)	10 liters
hectoliter (hl)	100 liters
kiloliter (kl)	1,000 liters

Comparisons

- Milliliters are used to mark dosages on syringes
- A liter is slightly more than a quart
- Four liters is slightly more than a gallon

Temperatures

Customary or Standard Measures	
Freezing	32° Fahrenheit
Boiling	212° Fahrenheit
Your Body Temp.	98.6° Fahrenheit

Metric Measures	
Freezing	0° Celsius
Boiling	100° Celsius
Your Body Temp	37° Celsius

Time

Customary or Standard Measures	
1 minute	60 seconds
1 hour	60 minutes
1 day	24 hours
1 week	7 days
1 month	4 weeks
1 year	12 months
1 year	365 days
1 decade	10 years
1 century	100 years
1 millennium	1,000 years

Measurement Glossary

Angle: The figure formed by two rays diverging from a common point, expressed in degrees.

Area: The extent of a planar region or of the surface of a solid measured in square units.

Circumference: The boundary line of a circle.

Coordinate plane: A plane spanned by the x-axis and y-axis in which the coordinates of a point are its distances from two intersecting perpendicular axes; also called *Cartesian plane*.

Cube: A regular solid having six congruent square faces.

Cubic measures: A unit, such as a cubic foot, or a system of units used to measure volume or capacity.

Congruent: Corresponding in character or kind; the same.

Customary system: A system of weights and measures based on the foot, pound, second and pint.

- **Foot:** A unit of length in the U.S. Customary and British Imperial systems equal to 12 inches (0.3048 meter)
- **Pound:** A unit of weight equal to 16 ounces (453.592 grams)
- **Length:** The measurement of the extent of something along its greatest dimension
- **Second:** A unit of time equal to the 60th part of a minute
- **Pint:** A unit of volume or capacity in the U.S. Customary System, used in liquid measure, equal to ⅛ gallon or 16 ounces (0.473 liter)

Cylinder: A solid bounded by two parallel planes and such a surface, especially such a surface having a circle as its end pieces.

Estimation: An opinion or a judgment (an educated guess).

Linear measure: A unit or system of units for measuring length.

Measurement: The act or process of measuring; a figure, extent or amount obtained by measuring.

Metric system: A decimal system of units based on the meter as a unit length, the kilogram as a unit mass and the second as a unit time.

- **Meter:** The international standard unit of length, approximately equivalent to 39.37 inches
- **Liter:** A unit of volume equal to 1000 cubic centimeters or one cubic decimeter (1.0567 quarts)
- **Gram:** A metric unit of mass equal to one thousandth (10^{-3}) of a kilogram

Perimeter: The length of the boundary of a closed curve bounding a plane area.

Prism: A solid figure whose bases or ends have the same size and shape and are parallel to one another, and each of whose sides is a parallelogram.

Protractor: A semicircular instrument for measuring and constructing angles.

Square: A plane figure having four equal sides and four equal angles.

Square measure: A system of units used to measure areas.

Surface area: The extent of a two-dimensional surface enclosed within a boundary.

Temperature: The degree of hotness or coldness of a body or environment.

- **Fahrenheit:** A temperature scale that registers the freezing point of water as 32 degrees and the boiling point as 212 degrees
- **Celsius:** A temperature scale that registers the freezing point of water as 0 degrees and the boiling point as 100 degrees

Weight: A measure of the heaviness of an object; a unit measure of gravitational force.

Width: The measurement of the extent of something from side to side.

Volume: The amount of space occupied by a three-dimensional object or region of space, expressed in cubic units.

Centimeter Graph Paper

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Video Supplements

Teacher Guide

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BIG OR SMALL: measure it all!

air

Balloon Design Challenge

Overview

Students design and make a hot air balloon using a plastic bag. They measure the time it stays in the air and its distance from the launch point.

Outcome

Students will understand how to convert time and distance measurements.

Standards Addressed — Mathematics

Grade 5

Use Measurement Techniques and Tools, Benchmark B

05. Make conversions within the same measurement system while performing computations.

Materials

- A variety of plastic bags – dry-cleaning bags work best
- Two or three hair dryers
- String
- Scotch tape
- Paper clips
- Tape measures
- Clock with second hand
- Balloon Design Challenge student handout

Procedure

1. Divide the students into groups of two or three.
2. Have available various types of plastic bags, string and paper clips. Following are some guidelines:
    - Dry-cleaning bags work the best because they are the lightest, but all types should work
    - Students can use paper clips around the bottom to keep some balance
    - Students should use string to tie off the top if they are using a dry-cleaning bag
3. Have one or two people hold the bag while the other teammate blows hot air into the bottom using the hair dryer. The students should hold the bag until they feel a tug on the material. It is helpful to gather the bottom of the balloon so that the hot air remains in the balloon.
4. Students should measure in seconds (and convert to minutes) the time from when they release the balloon until any part of it touches the ground. Students should further measure the distance from the launch site to the landing site in centimeters (and convert to meters).
5. It is a good idea to do this activity outside (if electricity is available). Sometimes the balloons will go as high as the second story of a school. Indoors, the balloons can generally hit the ceiling.

6. **Extension:** Older students can use a clinometer to determine the actual height that the balloon met. For instructions on making a clinometer, go to the School Yard Clinometer Web site at **www.state.nj.us/dep/seeds/syhart/clinom.htm**. The string on the clinometer will show the tangent angle: Tan = Opposite/Adjacent.

7. **Science Connection:** "When air or any other gas gets hot and expands, it gets less dense (lighter) because the same amount of air occupies a larger space. Hot air balloons fly because they contain warmer, lighter air. The air in the balloon, being warm, is less dense (lighter) than the cool air around it so it floats upward, like a cork in water. When the air gets cool, the balloon will sink again." *(Source: NASA)*

Evaluation

Category	4	3	2	1
Balloon Design	Balloon is well-designed and constructed.	Balloon flies well but has some problems.	Balloon needs some design changes.	Balloon didn't fly.
Group Work	Group worked very well together, with each person doing a part of the task.	Group worked well together, but some members were not as involved as others.	Group had some problems working together. Some members were not involved.	Group was dysfunctional.
Measurement	Both the time and distance measures, and their conversions, were accurate.	Both the time and distance measures were accurate, but the conversion had an error.	Either the time or distance measure was inaccurate. The conversion had an error.	Measures were inaccurate.

Balloon Design Challenge (Student Handout)

Names ____

History of Balloon Flight

In 1783 the Montgolfier brothers observed a shirt hanging out to dry over a fire. They started experimenting and building larger and larger balloons. On Sept. 19, 1783, they launched a sheep, a duck and a rooster on an eight-minute balloon ride. (They kept a rope on the balloon so it wouldn't get away.) In October of the same year, Francois Pilatre de Rozier was the first man to have a "lighter-than-air" flight.

Directions

Your group is to design and launch a hot air balloon and to keep track of both how long it stays in the air and the distance it travels from the starting point.

1. Collect materials that you think you will need to make the balloon. There are plastic bags, tape, string and paper clips available. If you would like to use something else, consult with your teacher.
2. Make your balloon. Have one or two people hold the balloon while one team member blows hot air from a hair dryer into it.
3. When the balloon starts to tug, release the balloon. Measure the time the balloon is in the air in seconds and convert to minutes. Mark your release point.
4. When any part of the balloon hits the ground, measure the distance from where you started to where it landed in centimeters and convert to meters.
5. Do a sample flight or two before you try your final design. Add or take things away from your original design to get it to stay in the air the longest time possible.
6. Record your data on this sheet.

Time balloon stayed in the air

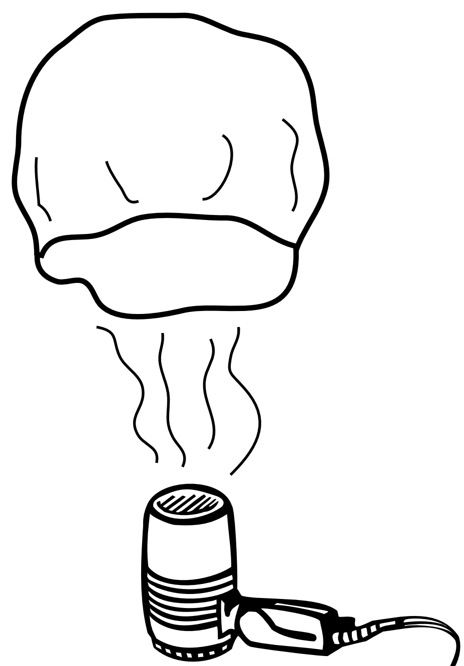
________ sec

________ min

Distance from launch to landing

________ cm

________ m



Pegasus: A Myth About Flight

Overview

Students read the myth about Pegasus and then calculate the amount of food he eats and water he drinks. They convert measurements between pounds and ounces and between gallons and quarts.

Outcome

Students will improve their understanding of simple unit conversions.

Standards Addressed — Mathematics

Grade 4

Use Measurement Techniques and Tools, Benchmark B

05. Make simple unit conversions within a measurement system; e.g., inches to feet, kilograms to grams, quarts to gallons.

Materials

- Calculator
- Pegasus: A Myth About Flight (student handout)

Procedure

1. Introduce the concept of a myth as "a traditional or legendary story, usually concerning some being or hero or event, with or without a determinable basis of fact or a natural explanation, esp. one that is concerned with deities or demigods and explains some practice, rite or phenomenon of nature." *(Source:* ***dictionary.reference.com****)*
2. You might want to ask the students if they know any myths or if they know about the ancient gods and goddesses.
3. Review the fact that there are 16 ounces in a pound and four quarts in a gallon.
4. Pass out the Pegasus: a Myth About Flight student handout and have the students read the story and answer the questions at the end. Allow students to work with a partner.
5. Have the students make their own menu for Pegasus.
6. When students have completed the handout, go over the correct answers. Have students explain their answers. There are several ways students could have calculated them.
7. **Extension:** Ask the students to make up their own myths about how the constellation Pegasus got into the sky. They can do this individually or in groups.

Student Handout Answers

1. 10¼ lbs (10.25 lbs) , 71¾ lbs (71.75 lbs), 3,741¼ lbs (3,741.25 lbs)
2. 164 oz, 1,148 oz, 59,860 oz
3. 51¼ lbs (51.25 lbs), 358¾ lbs (358.75 lbs), 706¼ lbs (706.25 lbs)
4. 20 quarts
5. 100 quarts (25 gal), 700 quarts (175 gal), 36,500 quarts (9,125 gal)

Evaluation for Handout

Have the students calculate their own grades. Allow one point for each answer and two points for their menu. This gives a total of 15 points. They should write their score as a fraction (e.g., 12 correct/15 total). They should divide the number that they got correct by the total number and convert this decimal to a fraction.

Evaluation for Original Myth

Category	4	3	2	1
Focus on Assigned Topic	The entire story is related to the assigned topic and allows the reader to understand more about the topic.	Most of the story is related to the assigned topic. The story wanders off at one point, but the reader can still learn something about the topic.	Some of the story is related to the assigned topic, but a reader does not learn much about the topic.	No attempt has been made to relate the story to the assigned topic.
Setting	Many vivid, descriptive words are used to tell when and where the story took place.	Some vivid, descriptive words are used to tell the audience when and where the story took place.	The reader can figure out when and where the story took place, but the author didn't supply much detail.	The reader has trouble figuring out when and where the story took place.
Action	Several action verbs (active voice) are used to describe what is happening in the story. The story seems exciting.	Several action verbs are used to describe what is happening in the story, but the word choice doesn't make the story as exciting as it could be.	A variety of verbs (passive voice) are used and describe the action accurately, but not in a very exciting way.	Little variety is seen in the verbs that are used. The story seems a little boring.
Spelling and Punctuation	There are no spelling or punctuation errors in the final draft. Character and place names that the author invented are spelled consistently throughout.	There is one spelling or punctuation error in the final draft.	There are two to three spelling and punctuation errors in the final draft.	The final draft has more than three spelling or punctuation errors.

Pegasus: A Myth About Flight (Student Handout)

Name________________________________

Myths developed as a result of man's early observations of flying objects and his attempts to explain the natural phenomena. One such story dealt with Pegasus, the flying horse. There are many versions of this story. One version is given below.

> Pegasus is a winged horse. Poseidon, god of the oceans, was his father and Medusa, who lived by the ocean and whose looks turned men to stone, was his mother. Her head was cut off and the winged horse Pegasus sprang from her body.
>
> Bellerophon, a Greek hero, captured the horse using a golden bridle. Pegasus was then given to Bellerophon because Bellerophon killed the monster, Chimaera. Bellerophon then ordered Pegasus to fly him to Mount Olympus, the home of the gods. Zeus, father of the gods, thought this was very rude and sent an insect to bite the winged horse. Pegasus bucked Bellerophon off his back and Bellerophon fell to the earth and died. Pegasus went on to greatness. He carried lightning bolts to Zeus and eventually became the constellation Pegasus.

Every day Pegasus would eat the following:

- 1½ pounds of hay in the morning
- 1 pound of hay in the evening
- ½ pound of oats in the morning and in the evening
- 1¼ pounds of alfalfa
- 4 pounds of apples
- 2 pounds of carrots

He would drink five gallons of the freshest spring water every day.

1. How many pounds of food did Pegasus eat in one day? ____________________

   In one week? ____________________ In one year? ____________________

2. How many ounces of food did Pegasus eat every day? ____________________

   In one week? ____________________ In one year? ____________________

3. Pegasus had four helpers. They each had the same diet as Pegasus. How much altogether did all five horses eat every day? ____________________

   In one week? ____________________ In one year? ____________________

4. How many quarts of water did Pegasus drink every day? ____________________

5. What is the total quarts drunk by all five horses in one day? ____________________

   In one week? ____________________ In one year? ____________________

Your turn: You make a menu for Pegasus. Remember what he did to Bellerophon. Be sure to make it good.

BIG OR SMALL: measure it all!

land

Watch Out, NASCAR — Here Comes Our Car!

Overview

Students have a competition with cars that they build. They measure the distance that their car travels using balloon power and find the area and perimeter of the body of their car, plus the weight of the whole car. Older students compute speed.

Outcome

Students will gain a greater understanding of area, perimeter, distance and estimation.

Standards Addressed

Grade 4

Use Measurement Techniques and Tools, Benchmark B

05. Make simple unit conversions within a measurement system; e.g., inches to feet, kilograms to grams, quarts to gallons.

Use Measurement Techniques and Tools, Benchmark D

04. Develop and use strategies to find perimeter using string or links, area using tiles or a grid and volume using cubes; e.g., count squares to find area of regular or irregular shapes on a grid, layer cubes in a box to find its volume.

Grade 6

Use Measurement Techniques and Tools, Benchmark C

03. Estimate perimeter or circumference and area for circles, triangles and quadrilaterals, and surface area and volume for prisms and cylinders by the following methods:
    - estimating lengths using string or links, areas using tiles or grid and volumes using cubes
    - measuring attributes (diameter, side lengths or heights) and using established formulas for circles, triangles, rectangles, parallelograms and rectangular prisms

Materials

- Styrofoam (grocery meat trays work well)
- Wheel materials — bobbins, empty thread spools, more Styrofoam, etc.
- Heavy paper
- Tape
- Pins
- Balloons
- Flexible straws
- Markers (to decorate cars)
- Cutting device
- Watch Out, NASCAR — Here Comes Our Car student handout

Procedure

1. Divide the students into groups of two or three.
2. Introduce the concept of building a car using Styrofoam and other materials.
3. Have students collect materials including a Styrofoam block, a straw, balloons, tape and materials for wheels such as bobbins, thread holders, Styrofoam, etc.
4. The students start building their cars by cutting the body from a piece of Styrofoam. They can then trace the bottom of the car onto centimeter graph paper and estimate the area. If the car is rectangular, triangular or circular, students can simply use the measurements and apply the formula to find the area of the car.
5. Students can use a piece of string to measure the perimeter of the car in centimeters.
6. Next the students should record the area and perimeter of their car on the handout. They should be sure to measure in square centimeters.
7. Ask the students to cut a piece of heavier paper in the same shape as the car body and attach it to the top of the car. Tape will not easily stick to the Styrofoam, so the paper is needed to attach the straw to the car.
8. Now they can attach the wheels to their car. This will vary depending on the type of wheel used.
9. Have the students tape a balloon to the short end of a flexible straw. They should then attach the straw and balloon to the paper covering on the top of the car.
10. Using the straw, a student blows up the balloon and tapes the open end of the straw closed until they are ready to release the car.
11. Have the students release their car from the start line and measure the distance it travels. (This could also be done as a race with all the cars lined up and released at the same time. Sometimes, however, the cars do not go in straight lines, so students must be very clear on the rules that you set up for a winner.)
12. Students should take at least two test runs to determine what modifications they need to make to their car.
13. Have the students do three trials with their car and find the mean distance in centimeters of the three attempts. Then have them convert the figure to meters.
14. You can create a chart where students can post their distance – either their mean distance or their longest distance.
15. Students should write a summary of how they built the car, what changes they made and their overall results on the back of the student sheet.
16. **Extension #1:** Advanced students can compute speed (rate). Distance divided by time equals rate.
17. **Extension #2:** Students could add weights to their cars (pennies work well) to see if that affects the distance that their car travels. A graph can be made to compare the weight of the car and the distance traveled.
18. **Extension #3:** Students could measure the circumference of the balloon and the distance traveled, and make a scatter plot to show comparison or to make a prediction.

Background Information

Newton's first law states, "An object at rest will remain at rest unless acted upon by an outside force." Releasing the air from the balloon becomes the outside force that causes the movement of the car.

Newton's third law states, "For every action, there is an equal and opposite reaction." Basically this means that when you sit down, your body exerts a downward force on your chair. The chair, in turn, exerts an upward force on your body. There are two forces – on the chair and on the body. These forces are called **action** and **reaction**.

The motion of the car shows the action-reaction forces in practical terms.

Evaluation

Building the car	Up to 25 points
Performing the trials	Up to 25 points
Filling out handout	Up to 25 points
Writing assignment	Up to 25 points

Below is a checklist that students can use to check their writing.

Category	**Responsibilities**
Ideas	__ Ideas are written in my own words.
	__ I understand my topic.
	__ My report is clear and focused. I stayed on topic.
Conventions	__ I use correct grammar.
	__ I use commas, periods, question marks and exclamation points correctly.
	__ My handwriting is legible.
	__ My printout contains no typos.
Organization	__ My report is sequenced in a logical order.
	__ My ideas flow well and are clearly connected to one another.

Watch Out, NASCAR — Here Comes Our Car! (Student Handout)

Names ____

Your challenge today is to design a car using Styrofoam, attach a balloon to it and measure the distance that the car travels. Conduct three trials and determine the mean distance.

Directions

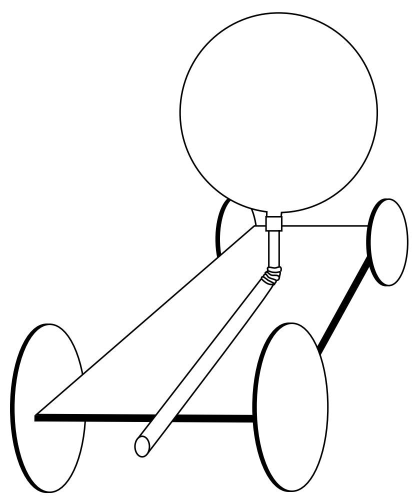
1. Have one person in your group collect a Styrofoam piece, a flexible straw, a ruler, scissors, wheel materials, balloons, tape, pins, markers, etc.
2. Design your car body out of Styrofoam.
3. Find the area of the bottom of your car body. If it is a rectangle, a triangle or a circle, you can use a formula to find the area. If it is an irregular shape, use the centimeter graph paper to estimate the area.
4. Add the wheels to the car body.
5. Glue a piece of paper to the top of the car. (Tape doesn't stick well to Styrofoam.)
6. Tape a balloon to the short end of a flexible straw and attach the straw and balloon to the paper. Blow up the balloon using the straw. Tape the open end of the straw closed until you are ready to let the car go. Add your wheels.
7. Write your group's estimate of how far you think the car will travel. You are permitted to take two trial runs before you begin recording your distance.
8. Record the distance of each run with your car and find the mean distance.
9. Write two sentences that explain if your estimate was accurate and why you think the design of the car had an affect on the distance that the car traveled.

Area of the body of your car = ________________.

How did you find it?

Perimeter of the body of your car = ____________.

How did you find it?



Trials	Trial 1	Trial 2	Trial 3	Mean distance
Area of Body				

The Long, Winding Road

Overview

On a road trip, traveling distance is an important measure of progress. It is also good to know the car's gas mileage. These measurement components are used as students plan a road trip and determine how many miles their car will run on a tank of gas.

Outcome

Students will learn how to make travel computations.

Standards Addressed

Grade 5

Use Measurement Techniques and Tools, Benchmark B

05. Make conversions within the same measurement system while performing computations.

Grade 6

Use Measurement Techniques and Tools, Benchmark E

04. Determine what measure (perimeter, area, surface area, volume) matches the context for a problem situation.

Grade 7

Measurement Units, Benchmark A

01. Select appropriate units for measuring derived measurements; e.g., miles per hour, revolutions per minute.

Materials

- Ohio road maps
- Odometer charts
- Calculators
- The Long, Winding Road student handout

Procedure

1. Divide students into groups.
2. Give each group an Ohio road map.
3. The students plan a road trip, identifying their starting and ending city and the miles it will take to travel to their destination.
4. Using the odometer chart, students calculate how many miles their car ran on a tank of gas. To find their gas mileage, students should divide the number of miles their car ran on a full tank of gas by the number of gallons of gas that their car holds.
5. The groups describe to the class their trip in terms of their destination, miles traveled, type of vehicle driven, gas mileage and how many times they will need to stop for gas.
6. The class analyzes trip data.

7. **Extension #1:** Students will convert the customary units of measure used in their road trip to metric units of measure.
8. **Extension #2:** Students will determine how much money will be spent on gas during their trip.

Evaluation

Category	4	3	2	1
Strategy/ Procedures	Student typically uses an efficient and effective strategy to solve the problem(s).	Student typically uses an effective strategy to solve the problem(s).	Student sometimes uses an effective strategy to solve the problems, but does not do it consistently.	Student rarely uses an effective strategy to solve the problems.
Teamwork	Student was an engaged partner, listening to suggestions of others and working cooperatively throughout lesson.	Student was an engaged partner but had trouble listening to others and/or working cooperatively.	Student cooperated with others but needed prompting to stay on task.	Student did not work effectively with others.
Mathematical Concepts	Student shows complete understanding of the mathematical concepts used to solve the problem(s).	Student shows substantial understanding of the mathematical concepts used to solve the problem(s).	Student shows some understanding of the mathematical concepts needed to solve the problem(s).	Student shows very limited understanding of the underlying concepts needed to solve the problem(s), or did not complete the assignment.

The Long, Winding Road — Odometer Chart

Names ____

Find the number of miles per gallon that each car uses. Round to the nearest tenth.

Type of Car	Miles at Fill-up	Miles When Out of Gas and in Need of Fill-up	Size of Gas Tank	Miles per Gallon
Sport utility	26,732	27,012	15 gallons	
Passenger car	18,525	18,900	17 gallons	
Pickup truck	17,894	18,268	22 gallons	
Compact car	35,342	35,762	12 gallons	
Sports car	26,124	26,344	13 gallons	
Van	28,716	29,088	21 gallons	

1. Name the city from which you are starting. ____________________
2. Name your destination. ____________________
3. What is the number of miles between the cities? ____________________
4. Name the type of car that you will be using. ____________________
5. What are the miles per gallon for that car? ____________________
6. How many gallons of gas will you use on your trip? ____________________ Show how you got that figure.
7. How many times did you have to stop for gas? ____________________ Show how you got that number.
8. On the back of this sheet, tell us about your trip. Why did you select your destination? Did anything exciting happen on the road?

The Long, Winding Road — Odometer Chart
(Answer Key)

Names ______________________________

Find the number of miles per gallon that each car uses. Round to the nearest tenth.

Type of Car	Miles at Fill-up	Miles When Out of Gas and in Need of Fill-up	Size of Gas Tank	Miles per Gallon
Sport utility	26,732	27,012	15 gallons	280/15=18.7 miles per gallon
Passenger car	18,525	18,900	17 gallons	375/17=22.1 miles per gallon
Pickup truck	17,894	18,268	22 gallons	374/22=17 miles per gallon
Compact car	35,342	35,762	12 gallons	420/12=35 miles per gallon
Sports car	26,124	26,344	13 gallons	220/13=16.9 miles per gallon
Van	28,716	29,088	21 gallons	372/21=17.7 miles per gallon

I Want a Doughnut!

Overview

The students use directions to list all of the possible ways to go from one point to another.

Outcome

Students will use problem-solving skills to identify paths on a grid and compare the lengths of different paths.

Standards Addressed — Mathematics

Grade 5

Measurement Units, Benchmark E

02. Identify paths between points on a grid or coordinate plane and compare the lengths of the paths; e.g., shortest path, paths of equal length.

Materials

- I Want a Doughnut student handout

Procedure

1. Divide students into pairs.
2. Introduce the concept of traveling different routes. You might have students who live near each other explain different ways that they might take to get to school.
3. Go over the scenario that follows:

   Jane just earned some money helping her mom do yard work. She is so hungry! Jane got on her bike and left her house to get a doughnut from the bakery. As soon as she left, her mother discovered that Jane forgot the key to get back into the house. Her mother decided to drive to the store and give her the key. But which way should she go?
4. Hand out the lesson's handout and explain that the students must use only the roads (represented by squares) and that the distance between two roads is a block.
5. Each route must be unique.
6. This could also be done as a contest, with the winner being the pair of students who have determined the most routes.

Evaluation

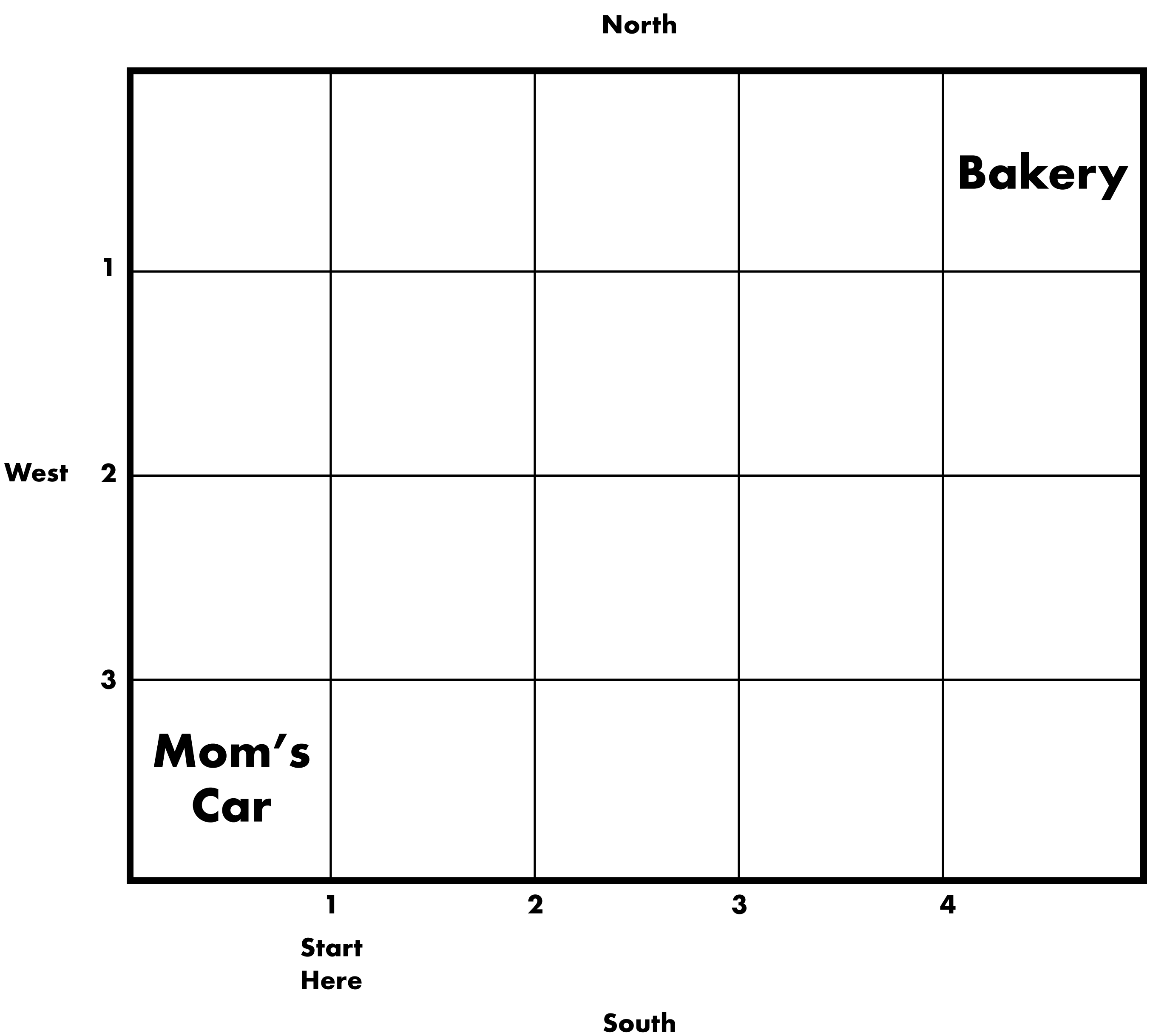
Category	4	3	2	1
Strategy/ Procedures	Student typically uses an efficient and effective strategy to solve the problem(s).	Student typically uses an effective strategy to solve the problem(s).	Student sometimes uses an effective strategy to solve the problems, but does not do it consistently.	Student rarely uses an effective strategy to solve the problems.
Teamwork	Student was an engaged partner, listening to suggestions of others and working cooperatively throughout lesson.	Student was an engaged partner but had trouble listening to others and/or working cooperatively.	Student cooperated with others but needed prompting to stay on task.	Student did not work effectively with others.
Mathematical Concepts	Student shows complete understanding of the mathematical concepts used to solve the problem(s).	Student shows substantial understanding of the mathematical concepts used to solve the problem(s).	Student shows some understanding of the mathematical concepts needed to solve the problem(s).	Student shows very limited understanding of the underlying concepts needed to solve the problem(s), or did not complete the assignment.

I Want a Doughnut! (Student Handout)

Names ____

Jane left her house on her bike to get a doughnut from the bakery. As soon as she left, her mother discovered that she forgot the key to get back into the house. Her mother decided to drive to the store and give her the key. But which way should she go?

Your job is to figure out how many ways Jane's mom can go to find Jane. Jane can only go on the roads. Use ordered pairs to list all possible directions.



How many paths can Jane take to get her doughnut? For each route, list the ordered pairs, the distance and the direction and tell how many blocked you traveled.

	Ordered Pairs	Direction	Number of Blocks
Route 1	Start at (1,0). Go to (1,3). Then go to (4,3).	3 blocks north and then 3 blocks east	6 blocks
Route 2			
Route 3			
Route 4			
Route 5			
Route 6			
Route 7			
Route 8			
Route 9			
Route 10			
Route 11			
Route 12			
Route 13			
Route 14			
Route 15			
Route 16			

BIG OR SMALL: measure it all!

time

Plop, Plop, Fizz, Fizz — Timing Race

Overview

Using the analogy of an upset stomach in quick need of an antacid, this lesson helps students practice calculating time and reading thermometers.

Outcome

Students will measure temperature and practice measurement conversions.

Standards Addressed — Mathematics

Grade 3

Measurement Units, Benchmark A

01. Identify and select appropriate units for measuring temperature in degrees (Fahrenheit or Celsius).
04. Read thermometers in both Fahrenheit and Celsius scales.

Grade 5

Use Measurement Techniques and Tools, Benchmark B

05. Make conversions within the same measurement system while performing computations.

Standards Addressed — Data Analysis and Probability

Grade 4

Data Collection, Benchmark B

02. Represent and interpret data using tables, bar graphs, line plots and line graphs.

Data Collection, Benchmark C

02. Represent and interpret data using tables, bar graphs, line plots and line graphs.

Grade 5

Data Collection, Benchmark E

02. Select and use a graph that is appropriate for the type of data to be displayed; e.g., numerical vs. categorical data, discrete vs. continuous data.

Materials

- Effervescent antacid tablets (such as Alka Seltzer)
- Two water containers per group
- Stop watch or clock with a second hand
- Thermometer
- Eye protection
- Warm and cold water
- Plop, Plop, Fizz, Fizz student handout

Procedure

1. Divide the class into groups of two or three.
2. Ask students if they have ever taken an antacid tablet or know anyone who did. Describe how an antacid is used to give relief from an upset stomach.
3. Discuss the idea of getting relief from your discomfort as quickly as possible. Tell students that we're going to try an experiment to see if we can get quicker comfort.
4. Give each student two antacid tablets and a water container.
5. Ask the students to get water ranging from hot water (but not so hot that the students would get burned) to cold water. Have ice available and perhaps a warming plate. Try to get a wide variety of temperatures. They can take hot water and add a little ice to get a different temperature.
6. Have the students measure the temperature of the water using either the Celsius or Fahrenheit scale, depending upon your preference.
7. Once they have an accurate reading, they should drop the antacid tablet in the water and measure how long it takes to completely dissolve. They should mark the time in seconds.
8. As a separate activity, students can convert the time to minutes.
9. They should record the ordered pair (temperature, time) on the board or overhead.
10. When all temperatures have been recorded, students should make a graph with temperature on the x-axis (the independent variable) and time on the y-axis (the dependent variable). This indicates that the time it takes for the tablet to dissolve is dependent upon the temperature of the water.
11. Students should write a summary telling what the graph is telling them.
12. **Extension #1:** Students can experiment to see if the surface area of an antacid tablet plays a role in how quickly it dissolves. "Students will learn that increasing the surface area of a tablet by crushing it into a powder increases its reaction rate with the water. This is a similar situation to the way a rocket's thrust becomes greater by increasing the burning surface of its propellants." *(Source: NASA, Rockets: An Educator's Guide with Activities in Science, Mathematics and Technology, EG-2003-01-108-HQ)*
13. **Extension #2:** There is a great **science correlation** in this activity. The experiment measures the reaction rate of tablets in different water temperatures. "Tablets in warm water react much more quickly than tablets in cold water. In liquid propellant rockets engines, super cold fuel, such as liquid hydrogen, is preheated before being combined with liquid oxygen. This increases the reaction rate and thereby increases the rocket's thrust." *(Source: NASA, Rockets: An Educator's Guide with Activities in Science, Mathematics and Technology, EG-2003-01-108-HQ)*

Evaluation

Rubric for Graph

Category	4	3	2	1
Accuracy of Plot	All points are plotted correctly and are easy to see. A ruler is used to connect the points neatly or make the bars, if not using a computerized graphing program.	All points are plotted correctly and are easy to see.	All points are plotted correctly.	Points are not plotted correctly, or extra points were included.
Title	The title is creative and clearly relates to the problem being graphed (includes dependent and independent variable). It is printed at the top of the graph.	The title clearly relates to the problem being graphed (includes dependent and independent variable) and is printed at the top of the graph.	The title is present at the top of the graph.	A title is not present.
Labeling of x-axis	The x-axis has a clear, neat label that describes the units used for the independent variable (e.g,, days, months, participants' names).	The x-axis has a clear label that describes the units used for the independent variable.	The x-axis has a label.	The x-axis is not labeled.
Labeling of y-axis	The y-axis has a clear, neat label that describes the units and the dependent variable (e.g,, percentage of dog food eaten; degree of satisfaction).	The y-axis has a clear label that describes the units and the dependent variable (e.g, percentage of dog food eaten; degree of satisfaction).	The y-axis has a label.	The y-axis is not labeled.
Explanation	Explanation is complete. The conclusion is based on the data.	Explanation is satisfactory but could be more specific. The conclusion is based on the data.	Explanation is satisfactory but could be more specific. The conclusion is general and not directly pulled from the graph.	Explanation is weak. The conclusion is general and not directly pulled from the graph.

Plop, Plop, Fizz, Fizz (Student Handout)

Names ______________________________

You just ate a whole pizza from your favorite pizza shop and you feel far too full. You mom suggests that you take an antacid tablet. You want it to work as fast as it possibly can. Your mom suggests that you take it with hot water. Your task is to see if using hot water really makes a difference.

Directions

1. Pick up the materials you need: two antacid tablets, two bowls, a thermometer and water.
2. Fill your containers about half full with water. There are hot water, cold water and ice cubes available. Try to get two very different temperatures.
3. Measure the temperature of water and record it below.
4. Estimate how long you think it will take for the tablet to dissolve.
5. One person should drop the tablet into the bowl while the other person times. The time should be from when the tablet is dropped into the water until it is fully dissolved. Record the time in seconds and in minutes below.
6. Change jobs and do the experiment a second time with a different temperature.
7. Record your temperature and the time on the board for all to see. The temperature is the independent variable, so it should be on the x-axis (horizontal). The time it takes to dissolve depends upon the temperature, so time is the dependent variable and it goes on the y-axis (vertical).
8. Your ordered pair should look like this: (temperature, time).

Trial	Estimated Temperature	Actual Temperature	Time
Trial 1			
Trial 2			

9. Once the ordered pairs have been gathered, make a graph of the data using all of the pairs on your graph. Be careful to do the following:
    a. Have consistent intervals on your graph.
    b. Label each axis.
    c. Put a title on your graph.
10. Write at least three sentences using the data to explain whether temperature will really affect the rate that the antacid tablet dissolves.

Think Time!

Overview

This lesson on elapsed time can be done with groups as a classroom assignment or as a game using the PowerPoint presentation provided. It is differentiated in that problems become exceedingly more difficult and the teacher can assign different sets of problems to different groups of students.

Outcome

Students will improve their ability to compute time.

Standards Addressed — Mathematics

Grade 3

Measurement Units, Benchmark E

03. Tell time to the nearest minute and find elapsed time using a calendar or a clock.

Materials

- Bells (for PowerPoint game)

Classroom Assignment

1. Divide the students into groups.
2. Problems get more difficult as you proceed down the page. You can differentiate by giving some groups the easier and some the more difficult problems.
3. Give a specific time limit (depending on your group of students) and then have the students explain or demonstrate their answers to the class.

PowerPoint Game

1. Divide the class into teams and give one bell to each team.
2. Begin the PowerPoint presentation "Think Time." It is available at **www.WesternReservePublicMedia.org/measure**.
3. The first group to ring the bell gets to answer and explain its solution. If they answer correctly, their team gets a point. If they are incorrect, another team can ring the bell and give an answer.

Evaluation

Evaluation can be done using the correctness of the answer as well as the explanation. Correct answers:

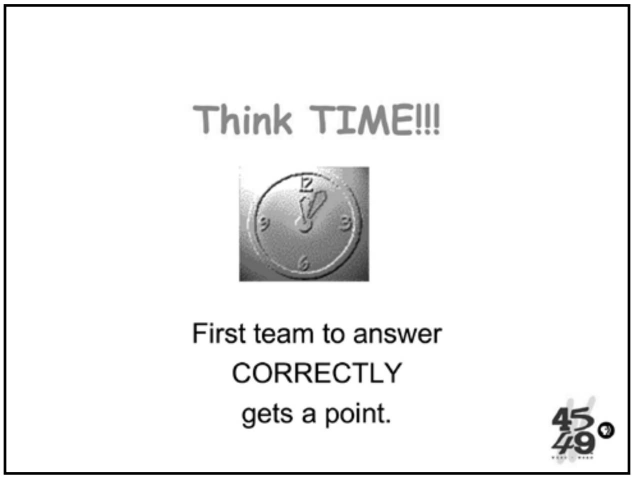
1. One hour
2. Noon
3. 5:30 p.m.
4. 8 a.m.
5. 4:15 p.m.
6. 1 p.m.
7. Six hours
8. 1:55 p.m.
9. 45 minutes
10. 17 hours
11. Two hours and 45 minutes

Think Time! (Student Handout)

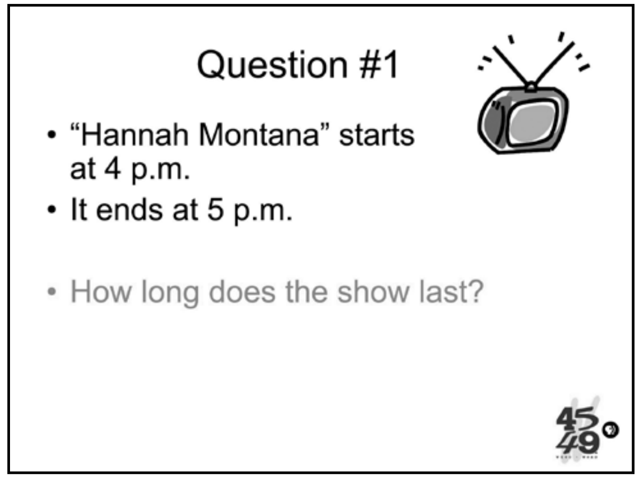
Names ____

Problem	Solution
1. "Hannah Montana" starts at 4 p.m. It ends at 5 p.m. How long does the show last?	
2. Math class starts at 10:30 a.m. It lasts 1½ hours. At what time does math class end?	
3. Soccer practice starts at 3:30 p.m. It lasts two hours. At what time does soccer practice end?	
4. You got up at 7:15 a.m. It took you 45 minutes to get dressed. At what time were you ready to leave for school?	
5. Your mom made you clean your room. You started at 3:30 p.m. It took you 45 minutes to finish. At what time were you finished cleaning your room?	
6. You're allowed to talk on the phone for two hours. You start talking at 11 a.m. At what time must you be off the phone?	
7. The video store is open from 8 a.m. to 2 p.m. on Saturdays. How many hours do you have to get to the video store?	
8. You want to get in shape, so you jog for 40 minutes. You started at 1:15 p.m. When will you be finished jogging?	
9. You start your homework at 3:10 p.m. You finish your homework at 3:55 p.m. For how long were you doing your homework?	
10. You're going to a sleepover at your friend's house. You get there at 5 p.m. You leave at 10 a.m. the next morning. For how long were you at your friend's house?	
11. You go to the mall on Saturday to get new shoes. You leave at 10:15 a.m. You return at 1 p.m. For how long were you gone?	

Think Time! PowerPoint Presentation



Slide 1



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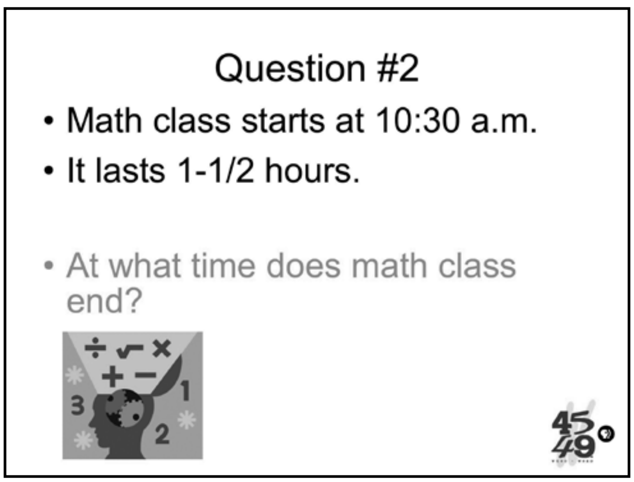
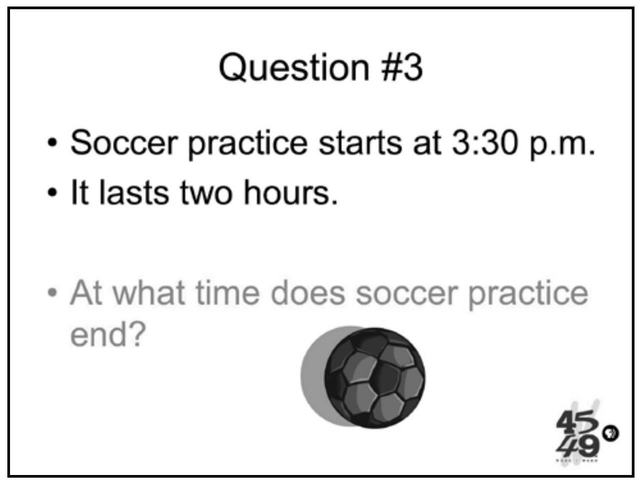
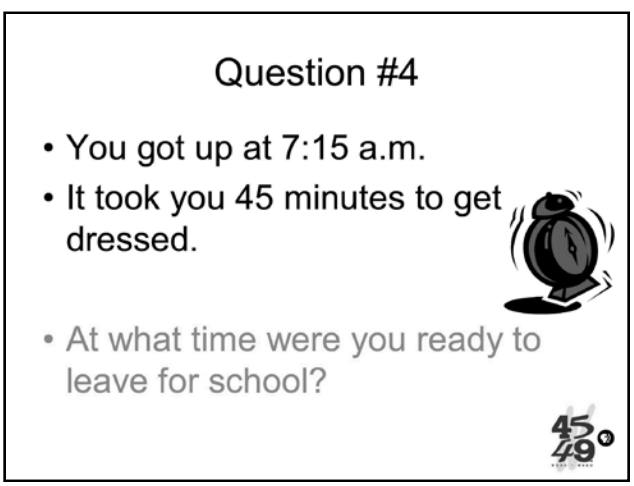


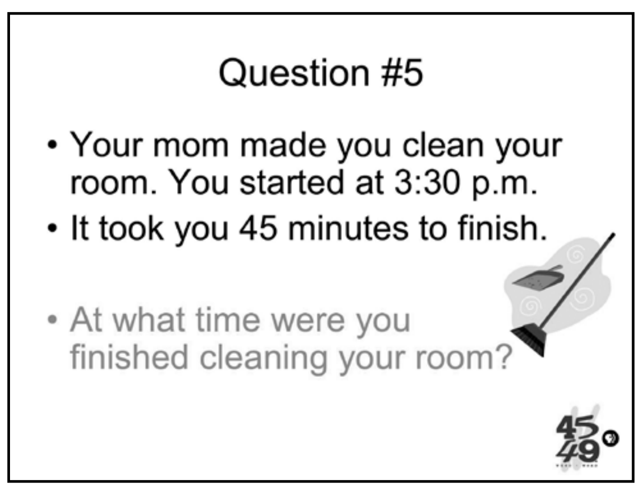
Slide 3



Slide 4



Slide 5



Slide 6

Question #6

- You're allowed to talk on the phone for two hours.
- You start talking at 11 a.m.

- At what time must you be off the phone?

Slide 7

Question #7

- The video store is open on Saturdays from 8 a.m. to 2 p.m.

- How many hours do you have to get to the video store?

Slide 8

Question #8

- You want to get in shape, so you jog for 40 minutes.
- You start at 1:15 p.m.

- When will you be finished jogging?

Slide 9

Question #9

- You start your homework at 3:10 p.m.
- You finish at 3:55 p.m.

- For how long were you doing homework?

Slide 10

Question #10

- You're going to a sleepover at your friend's house. You get there at 5 p.m.
- You leave at 10 a.m. the next morning.
- For how long were you at your friend's house?

Slide 11

Question 11

- You go to the mall on Saturday to get new shoes. You leave at 10:15 a.m.
- You return home at 1 p.m.

- For how long were you gone?

Slide 12

BIG OR SMALL: measure it all!

sea

Can Your Boat Float?

Overview

Students build several boats using aluminum foil, measuring the length and width of the bottom of the boat. They then see how many pennies it takes to sink the boat and determine if the area of the bottom makes a difference.

Outcome

Students will apply knowledge of perimeter and surface area, plus they will gain an understanding of the concept of buoyancy.

Standards Addressed — Mathematics

Grade 4

Use Measurement Techniques and Tools, Benchmark D

04. Develop and use strategies to find perimeter using string or links, area using tiles or a grid and volume using cubes; e.g., count squares to find area of regular or irregular shapes on a grid, layer cubes in a box to find its volume.

Grade 5

Measurement Units, Benchmark F

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.

Grade 6

Measurement Units, Benchmark F

01. Understand and describe the difference between surface area and volume.

Use Measurement Techniques and Tools, Benchmark G

05. Understand the difference between perimeter and area, and demonstrate that two shapes may have the same perimeter, but different areas or may have the same area, but different perimeters.

Standards Addressed — Data Analysis

Grade 4

Data Collection, Benchmark C

02. Represent and interpret data using tables, bar graphs, line plots and line graphs.

Grade 5

Data Collection, Benchmark E

02. Select and use a graph that is appropriate for the type of data to be displayed; e.g., numerical vs. categorical data, discrete vs. continuous data.

Grade 6

Data Collection, Benchmark E

02. Select, create and use graphical representations that are appropriate for the type of data collected.

Standards Addressed — Physical Science

Grade 3

Forces and Motion, Benchmark C

04. Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).

Grade 6

Nature of Matter, Benchmark A

01. Explain that equal volumes of different substances usually have different masses.

Materials

- Aluminum foil
- Scissors (students can cut 6-inch squares from the foil)
- Pennies
- Container half-filled with water
- String
- Can Your Boat Float? student handout

Procedure

1. Break students into groups of two or three.
2. Demonstrate the concept of building a boat by bending the foil.
3. Have the students cut three 16 cm squares from the foil and create a flat-bottomed boat with each piece. Instruct the students to vary the sizes of the boats.
4. Have the students write a hypothesis about what they think will happen.
5. Students can trace the bottom of their boat using centimeter graph paper (provided with this guide) or a ruler. Students find the closest measurement for the area of the bottom of the boat. (If the boat is rectangular, triangular or circular, students can simply use the measurements and apply the formula to find the area of the bottom of the boat.)
6. They place the boat in a container half-full of water and add pennies to it until the boat sinks. They should include the penny that sank the boat in their count.
7. Each group should record the area of the bottom of the boat and the number of pennies required to sink the boat on the student handout. Students should be sure that they measure using square centimeters.
8. Have the students make two more models of boats and do the same experiment with each model.
9. They then construct a graph with area on the x-axis (independent variable) and number of pennies (dependent variable) on the y-axis.
10. Reviewing their results, students can make an observation of what worked best. **They should come up with the conclusion that the bigger the area, the more pennies it will hold.**
11. Be sure to mention that when measuring the bottom of the boat, we are using part of the surface area of the boat. The water that would fit inside the boat is a measure of the volume of the boat.
12. It is important to make sure that the students understand the science behind this experiment. The science concept involves **buoyancy**. When a boat sits in the water, it is pushing the water aside and pushing downward. The water is pushing up on the bottom and the sides of the boat. The more water that the boat pushes aside, the more water that is pushing back on the boat and keeping it afloat. This is why the size and shape of the boat are important.
13. **Extension #1:** Try this same experiment using 32 cm squares of foil.
14. **Extension #2:** Try adjusting the placement of the pennies. Determine the effect of stacking the pennies or spreading them out.
15. **Extension #3:** Assign the task of making a "flinker," which is something that will not float but will not sink for at least 10 seconds. A complete lesson plan is at **pbskids.org/zoom/activities/sci/flinker.html**.

Evaluation

Rubric for evaluating graph

Category	4	3	2	1
Accuracy of Plot	All points are plotted correctly and are easy to see. A ruler is used to neatly make the bars, if not using a computerized graphing program.	All points are plotted correctly and are easy to see.	All points are plotted correctly.	Points are not plotted correctly, or extra points are included.
Labeling of x-axis	The x-axis has a clear, neat label that describes the units used for the independent variable.	The x-axis has a clear label that describes the units used for the independent variable.	The x-axis has a label.	The x-axis is not labeled.
Labeling of y-axis	The y-axis has a clear, neat label that describes the units and the dependent variable.	The y-axis has a clear label that describes the units and the dependent variable.	The y-axis has a label.	The y-axis is not labeled.
Title	The title is creative and clearly relates to the problem being graphed (includes dependent and independent variables). It is printed at the top of the graph.	Title clearly relates to the problem being graphed (includes dependent and independent variables) and is printed at the top of the graph.	A title is present at the top of the graph.	A title is not present.

Can Your Boat Float? (Student Handout)

Names ____

Your challenge today is to design a boat made of aluminum foil and see how many pennies it will take to sink it. You need to try three different designs, make a hypothesis about your design and graph the results of your experiment.

The Task

1. Have one person in your group collect aluminum foil, a ruler, scissors, pennies, a container half-filled with water and graph paper.
2. Cut three (or more, if you have time) 16-cm-square pieces of foil.
3. Create a boat with each piece. Each boat must have a flat bottom.
4. Find the area of the bottom of your boat. If it is a rectangle, a triangle or a circle, you can use a formula to find the area. If it is an irregular shape, use graph paper to estimate the area.
5. Record the area on this handout and draw the shape of the bottom in the space below.
6. Write your group's estimate of how many pennies it will take to sink the boat.
7. Put your boat in the water and add pennies until it sinks. Count the pennies as you add them. Record the number of pennies it takes. Include the penny that sinks the boat in your count.
8. Create a graph of your data. Put the area of the boat on the horizontal axis (the x-axis or independent variable) and the number of pennies on the vertical axis (the y-axis or dependent variable).
9. Write two sentences that explain if your estimate was accurate and why you think the design of the boat had an effect on the number of pennies you could add to the boat.

Trials	Boat 1	Boat 2	Boat 3
Boat Design			
Area of Bottom			
Number of Pennies — Estimate			
Number of Pennies — Actual			

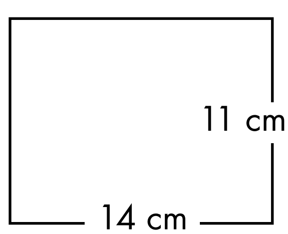
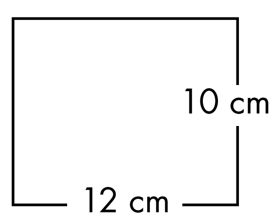
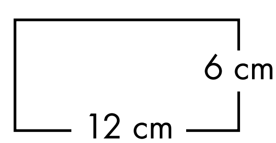
Can Your Boat Float? Sample Answer Sheet

Your challenge today is to design a boat made of aluminum foil and see how many pennies it will take to sink it. You need to try three different designs, make a hypothesis about your design and graph the results of your experiment.

The Task

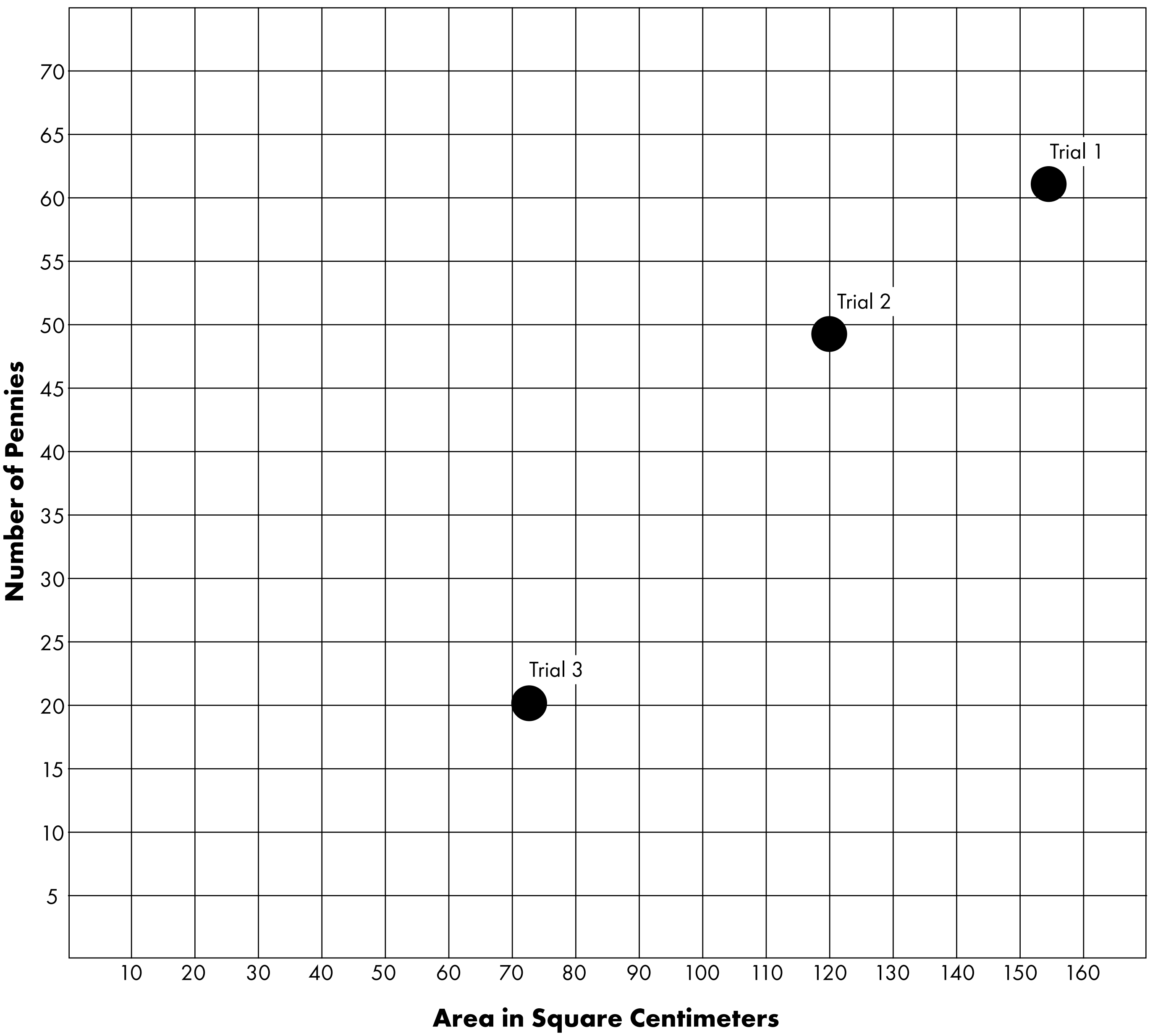
1. Have one person in your group collect aluminum foil, a ruler, scissors, pennies, a container half-filled with water and graph paper.
2. Cut three (or more, if you have time) 16-cm-square pieces of foil.
3. Create a boat with each piece. Each boat must have a flat bottom.
4. Find the area of the bottom of your boat. If it is a rectangle, a triangle or a circle, you can use a formula to find the area. If it is an irregular shape, use graph paper to estimate the area.
5. Record the area on this handout and draw the shape of the bottom in the space below.
6. Write your group's estimate of how many pennies it will take to sink the boat.
7. Put your boat in the water and add pennies until it sinks. Count the pennies as you add them. Record the number of pennies it takes. Include the penny that sinks the boat in your count.
8. Create a graph of your data. Put the area of the boat on the horizontal axis (the x-axis or independent variable) and the number of pennies on the vertical axis (the y-axis or dependent variable).
9. Write two sentences that explain if your estimate was accurate and why you think the design of the boat had an effect on the number of pennies you could add to the boat.

Example

Trials	Boat 1	Boat 2	Boat 3
Boat Design			
Area of Bottom	154 cm^2	120 cm^2	72 cm^2
Number of Pennies — Estimate			
Number of Pennies — Actual	61	49	20

Number of pennies to sink ship compared to area of the bottom.

The bigger the area, the more pennies it will hold. This is because more water is displaced so more water is pushing up therefore keeping the boat from sinking.



Sail Away

Overview

Given the dimensions of two sailboats with different sails, students estimate which boat has a bigger sail area and then calculate the total area of the sails. When finished, they can go on the Web and virtually sail a boat through a race course.

Outcome

Students will understand how to compute the area of various shapes.

Standards Addressed — Mathematics

Grade 5

Use Measurement Techniques and Tools, Benchmark C

06. Use strategies to develop formulas for determining perimeter and area of triangles, rectangles and parallelograms, and volume of rectangular prisms.

Materials

- Sail Away student handouts

Procedure

1. Have students work with a partner for this lesson.
2. Ask if they have ever been on a sailboat. Let them tell what they know about sailing. Talk about the fact that the wind is what makes a sailboat go and the bigger the sail, the more the wind can push it.
3. Distribute the handout and ask the students to circle which boat they believe will have a greater sail area.
4. Review the formulas for finding the area of a rectangle (length times width equals area) and the area of a triangle (½ times length times width equals area).
5. Review that the measure of area is always a square measure, so the area of the sails will be in square feet.
6. An excellent sailing activity is on the Web site for "Dragonfly TV," **pbskids.org/dragonflytv/games/game_sailing.html**. Students can either use the computer to do this activity after they complete their work or at some other time as directed by the teacher.
7. **Extension:** A second handout is available for students who can do more difficult work. In this activity, they must find the area of two ships but the sails are trapezoids and Cat R16-shaped.

Evaluation

Area of Triangular Sail #1	10
Area of Triangular Sail #2	10
Area of Rectangular Sail	5
Total Area	5
Work Shown	20
Total	**50**

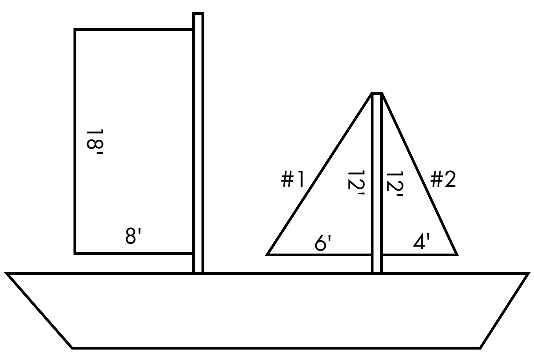
Sail Away (Student Handout)

Names ____

A sailboat uses wind as the primary means of propulsion. There are many types of sailboats, from small boats with one sail to the giant tall ships with sails of many sizes and shapes. There are three common shapes of sails: triangles, rectangles and trapezoids. The greater the area of the sail, the more wind the boat can use.

Below are two boats. Before you start, put a circle around the boat you think will have the greatest sail area. Now calculate the sail area. Be sure to show your work.

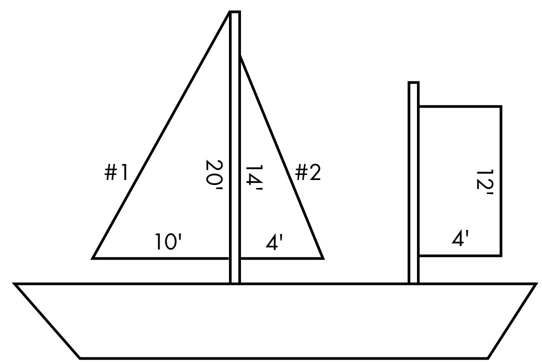
Boat 1



Area of Triangular Sail #1	
Area of Triangular Sail #2	
Area of Rectangular Sail	
Total Area	

Please show work here.

Boat 2



Area of Triangular Sail #1	
Area of Triangular Sail #2	
Area of Rectangular Sail	
Total Area	

Please show work here.

For a fun game about sailing, visit the "Dragonfly TV" Web site at **pbskids.org/dragonflytv/games/game_sailing.html**. The game allows you to sail a boat using the wind to guide your course.

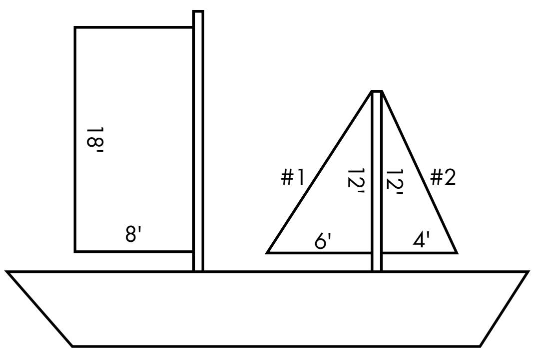
Sail Away (Answer Key)

Names ____

A sailboat uses wind as the primary means of propulsion. There are many types of sailboats, from small boats with one sail to the giant tall ships with sails of many sizes and shapes. There are three common shapes of sails: triangles, rectangles and trapezoids. The greater the area of the sail, the more wind the boat can use.

Below are two boats. Before you start, put a circle around the boat you think will have the greatest sail area. Now calculate the sail area. Be sure to show your work.

Boat 1



Area of Triangular Sail #1	36 sq. ft.
Area of Triangular Sail #2	24 sq. ft.
Area of Rectangular Sail	144 sq. ft.
Total Area	**204 sq. ft.**

Please show work here.

Square $l \times w = a$

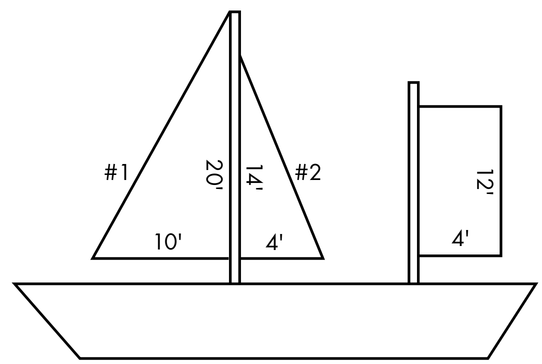
$18 \times 8 = 144$ sq. ft.

Triangle $\frac{1}{2}\, b \times h = a$

#1 $\frac{1}{2} \bullet 12 \bullet 6 = 36$ sq. ft.

#2 $\frac{1}{2} \bullet 12 \bullet 4 = 24$ sq. ft.

Boat 2



Area of Triangular Sail #1	100 sq. ft.
Area of Triangular Sail #2	28 sq. ft.
Area of Rectangular Sail	48 sq. ft.
Total Area	**176 sq. ft.**

Please show work here.

Square $l \times w = a$

$12 \times 4 = 48$ sq. ft.

Triangle $\frac{b \times h}{2} = a$

#1 $\frac{10 \bullet 20}{2} = 100$ sq. ft.

#2 $\frac{14 \bullet 4}{2} = 28$ sq. ft.

For a fun game about sailing, visit the "Dragonfly TV" Web site at **pbskids.org/dragonflytv/games/game_sailing.html**. The game allows you to sail a boat using the wind to guide your course.

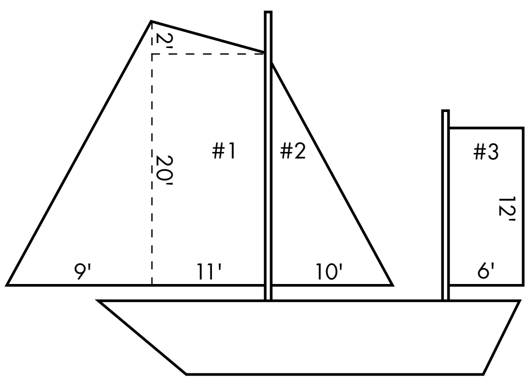
Sail Away II — Sailboats Enrichment
(Student Handout)

Names ____

A sailboat uses wind as the primary means of propulsion. There are many types of sailboats, from small boats with one sail to the giant tall ships with sails of many sizes and shapes. There are three common shapes of sails: triangles, rectangles and trapezoids. The greater the area of the sail, the more wind the boat can use.

Below are two boats. Before you start, put a circle around the boat you think will have the greatest sail area. Now calculate the sail area. Be sure to show your work.

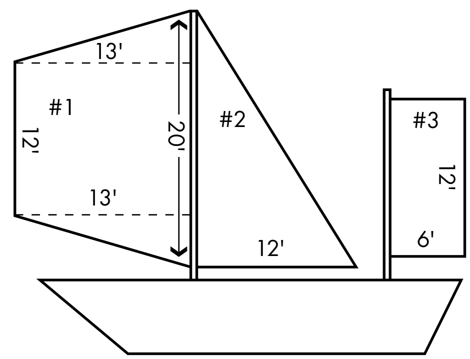
Boat 1



Area of Sail #1	
Area of Sail #2	
Area of Sail #3	
Total Area	

Please show work here.

Boat 2



Area of Sail #1	
Area of Sail #2	
Area of Sail #3	
Total Area	

Please show work here.

For a fun game about sailing, visit the "Dragonfly TV" Web site at **pbskids.org/dragonflytv/games/game_sailing.html**. The game allows you to sail a boat using the wind to guide your course.

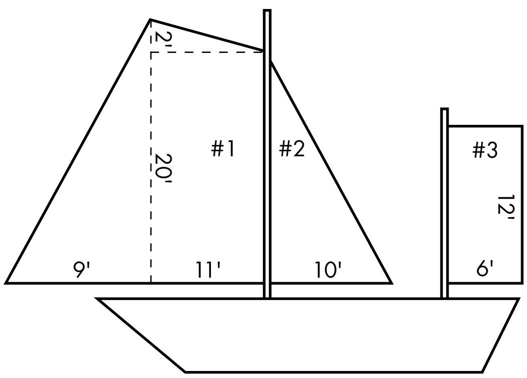
Sail Away II — Sailboats (Answer Key)

Names ____

A sailboat uses wind as the primary means of propulsion. There are many types of sailboats, from small boats with one sail to the giant tall ships with sails of many sizes and shapes. There are three common shapes of sails: triangles, rectangles and trapezoids. The greater the area of the sail, the more wind the boat can use.

Below are two boats. Before you start, put a circle around the boat you think will have the greatest sail area. Now calculate the sail area. Be sure to show your work.

Boat 1



Area of Sail #1	330 sq. ft.
Area of Sail #2	100 sq. ft.
Area of Sail #3	72 sq. ft.
Total Area	**502 sq. ft.**

Please show work here.

Sail #1 $\frac{1}{2} \times 9 \times 22 =$ 99 sq. ft.

$\frac{1}{2} \times 11 \times 2 =$ 11 sq. ft.

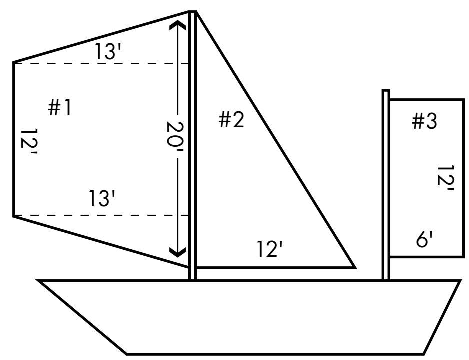
$11 \times 20 =$ 220 sq. ft.

330 sq. ft.

Sail #2 $\frac{1}{2} \times 20 \times 10 = 100$ sq. ft.

Sail #3 $6 \times 12 = 72$ sq. ft.

Boat 2



Area of Sail #1	208 sq. ft.
Area of Sail #2	120 sq. ft.
Area of Sail #3	72 sq. ft.
Total Area	**400 sq. ft.**

Please show work here.

Sail #1 $12 \times 13 =$ 156 sq. ft.

$\frac{1}{2} \times 4 \times 13 =$ 26 sq. ft.

$\frac{1}{2} \times 4 \times 13 =$ 26 sq. ft.

OR

$\frac{20 + 12}{2} \times 13 = 208$ sq. ft.

Sail #2 $\frac{12 \times 20}{2} = 120$ sq. ft.

Sail #3 $6 \times 12 = 72$ sq. ft.

For a fun game about sailing, visit the "Dragonfly TV" Web site at **pbskids.org/dragonflytv/games/game_sailing.html**. The game allows you to sail a boat using the wind to guide your course.

What Measure Will You Use?

Overview

Students look at a scenario and determine whether to use area, perimeter or volume to solve the problem. This quick activity can be done with a handout or using a PowerPoint presentation.

Outcome

Students will apply their knowledge of measures to find area, perimeter and volume.

Standards Addressed — Mathematics

Grade 5

Measurement Units, Benchmark G

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.

Grade 6

Use Measurement Techniques and Tools, Benchmark E

04. Determine which measure (perimeter, area, surface area, volume) matches the context for a problem situation; e.g., perimeter is the context for fencing a garden, surface area is the context for painting a room.

Materials

- PowerPoint presentation (optional)
- Projector (optional)
- What Measure Will You Use? student handout

Procedure

There are three approaches that could be used to do this assignment.

First Option

1. Put the students in groups of two or three.
2. Review what area, perimeter and volume are by having the students give an example of each.
3. Pass out the handout and have students answer the questions.
4. Go over the answers with the students.

Second Option

1. Have students number a paper from 1 to 9.
2. Use the related PowerPoint program, found at **WesternReservePublicMedia.org/measure**, and have the students answer the questions individually.
3. Go over the answers.

Third Option

1. Divide the class into three teams.
2. Using the PowerPoint program, play a game where students can work as a team to get the correct answers.
3. Go over the answers and declare a winner.
4. You could also do it as an individual competition where the first person to respond gets to answer the question and then meets the next challenger.

Evaluation

Evaluate the students' work by the number of items that were correct.

Answers

1. Volume
2. Perimeter
3. Area
4. Area
5. Perimeter
6. Volume
7. Volume
8. Area
9. Volume

What Measure Will You Use? (Student Handout)

Names ____

You're out at sea and the captain has asked you to help his men do their work. Read each item and tell what measure they should use — area, perimeter or volume.

1. Your ship has been asked to carry manufactured furniture to England. To do this, you need to know the size of the cargo area.

   What measure will you use? ______________________________

2. You have eight guests on board. You want to know if you have enough room around the table to accommodate your guests.

   What measure will you use? ______________________________

3. You want to catch the most wind possible, so you want to have a large sail. You need to know the measure of the sail.

   What measure will you use? ______________________________

4. You want to know if the deck is large enough to put your lunch table on it.

   What measure will you use? ______________________________

5. You want to put some Velcro around the border of your tablecloth so that the wind doesn't blow it off. You need to buy Velcro.

   What measure will you use? ______________________________

6. There is a chest on the deck that has life jackets in it. You need to know how many life jackets you can put in the chest.

   What measure will you use? ______________________________

7. Just in case the wind isn't blowing, your ship has a gas engine in it. You need to know how much gas fits into the tank to run the engine.

   What measure will you use? ______________________________

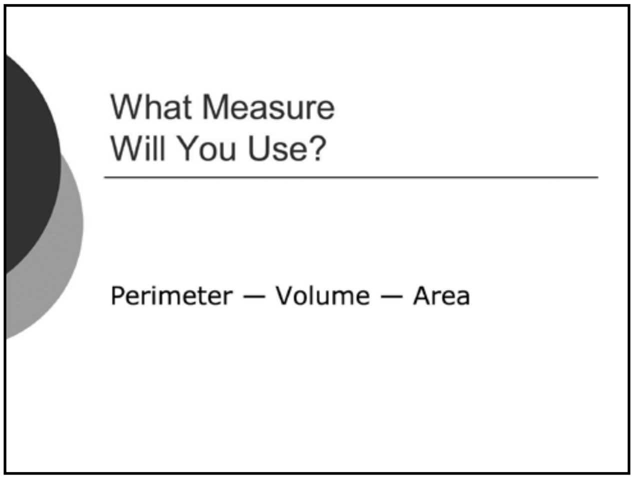
8. You want to hang a picture of your dog in the cabin. You want to know if you have enough space on the wall.

   What measure will you use? ______________________________

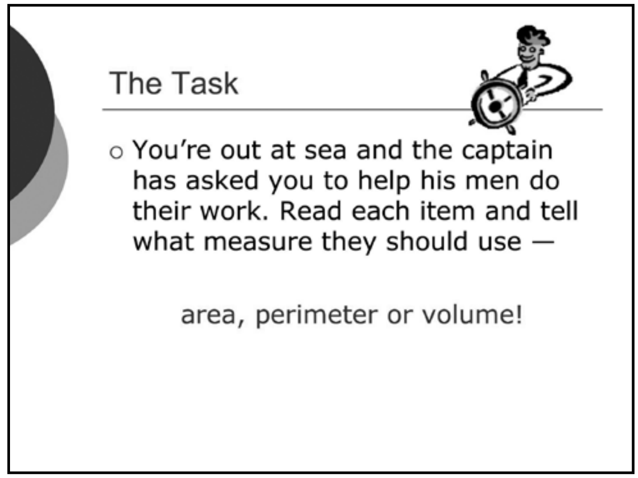
9. You are going to fish while you're cruising around. You want to know how many fish your storage container will hold.

   What measure will you use? ______________________________

What Measure Will You Use? PowerPoint Presentation



Slide 1



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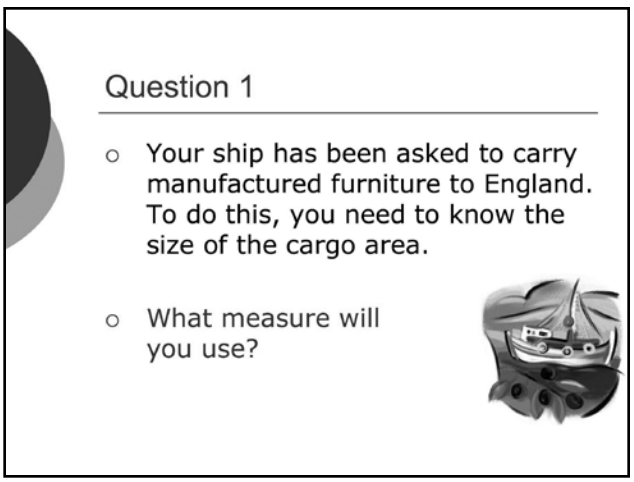
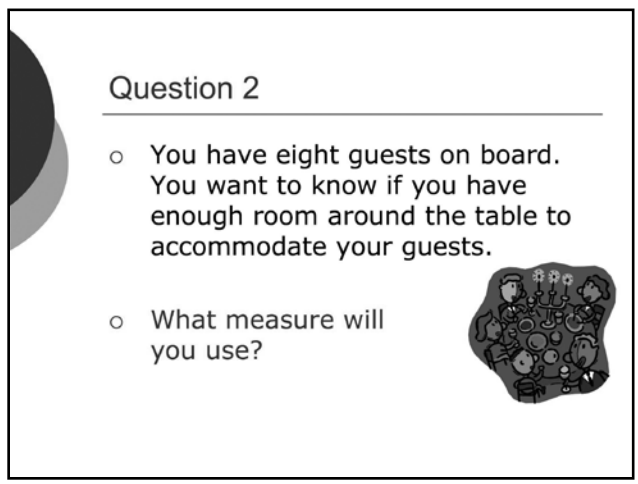
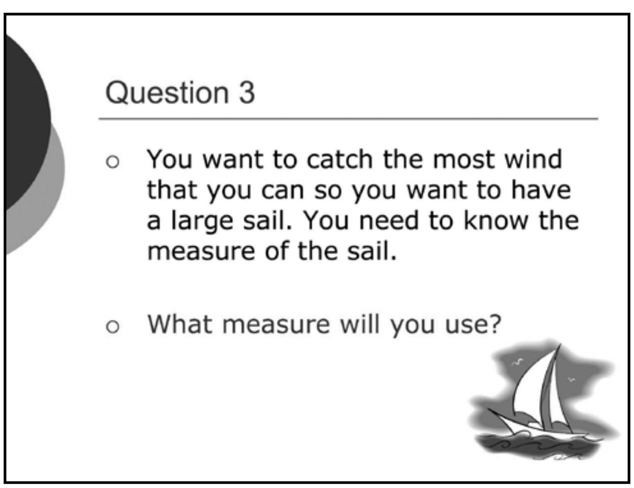


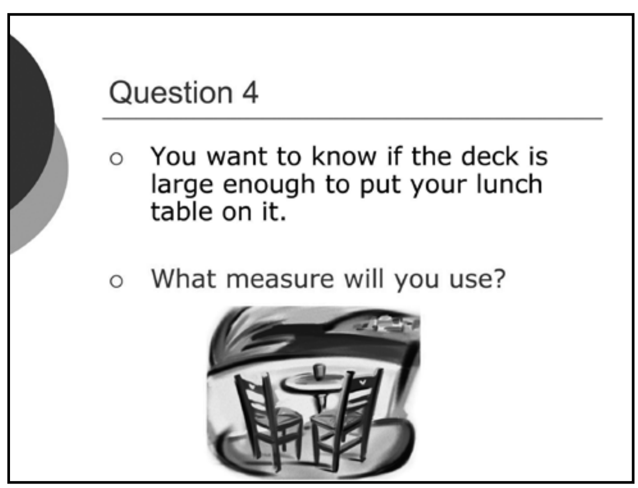
Slide 3



Slide 4



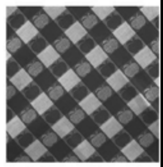
Slide 5



Slide 6

Question 5

- You want to put some Velcro around the border of your table cloth so that the wind doesn't blow it off. You need to buy Velcro.
- What measure will you use?



Slide 7

Question 6

- There is a chest on the deck that has life jackets in it. You need to know how many life jackets you can put in the chest.
- What measure will you use?

Slide 8

Question 7

- Just in case the wind isn't blowing, your ship has a gas engine in it. You need to know how much gas fits into the tank to run the engine.
- What measure will you use?

Slide 9

Question 8

- You want to hang a picture of your dog in the cabin. You want to know if you have enough space on the wall.
- What measure will you use?

Slide 10

Question 9

- You are going to fish while you're cruising around. You want to know how many fish your storage container will hold.
- What measure will you use?

Slide 11

BIG OR SMALL: measure it all!

space

Lift Off!

Overview

Students use a very long hall and a roll of toilet paper to illustrate the vastness of the solar system. They then make rockets and shoot them off to measure the distance of their flight.

Outcome

Students will gain an understanding of the distance between planets. They also will see how variables affect how far a simple rocket will fly. In measuring the distance, students will gain practice in converting measurements from centimeters to meters.

Standards Addressed — Mathematics

Grade 4

Use Measurement Techniques and Tools, Benchmark B

05. Make simple unit conversions within a measurement system; e.g., inches to feet, kilograms to grams, quarts to gallons.

Grade 5

Use Measurement Techniques and Tools, Benchmark B

05. Make conversions within the same measurement system while performing computations.

Materials

Part One:

- Toilet paper
- Cards or pictures with the names or pictures of the planets and sun
- Tape
- Lift Off student handout

Part Two:

- Paper
- Tape
- Film canister, toilet paper roll or some other small, cylindrical object
- Straws
- Measuring device
- Scissors

Procedure

Part One: Laying Out the Solar System

1. Tell students that the planets are very far away and that each sheet of toilet paper represents 10 million miles.
2. Tape the sun to the floor at one end of a very long hallway. Tape the end of a toilet paper to the floor by the sun.
3. Carefully unroll the toilet paper. You may want to tape the paper down at various points. Count 3.6 sheets from the sun and place the planet Mercury.

4. Continue as follows:

   - Venus is 3.1 sheets from Mercury
   - Earth is 2.6 sheets from Venus
   - Mars is 3.3 sheets from Earth
   - Jupiter is 34.3 sheets from Mars
   - Saturn is 40.3 sheets from Jupiter
   - Uranus is 90 sheets from Saturn
   - Neptune is 101 sheets from Uranus
   - If you want to include poor old Pluto – which lost its status as a planet – it is 86.4 sheets from Neptune

5. Double-check: The earth is 3.6 +3.1 +2.6 = 9.3 sheets from the sun. Each sheet is 10 million miles, so the earth is 93 million miles from the sun.

6. Ask students what other way they could measure the distance. What would they use – centimeters, meters or kilometers?

7. **Extension #1:** Have the students make a scale model of the planets using graph paper with accurate distances. This is a good use of proportion.

8. **Extension #2:** Using the scale model, the solar system could be hung from the ceiling.

9. **Extension #3:** A light year is 5,880 billion miles (5.88×10^{12} miles). A toilet paper sheet represents 10 million miles. The nearest star is 4.3 light years away. Have the students determine how many toilet paper sheets away the nearest star is. (Answer: The nearest star is $4.3 \times 5.88 \times 10^{12}$ miles away or 25.3×10^{12} miles away. Divide that by 10 million to get the number of toilet paper sheets, and you get 2.53 million sheets.)

Distances of Planets from the Sun

Object	Distance (millions of miles)	Distance (millions of kilometers)
Mercury	36	59
Venus	67	108
Earth	93	150
Mars	140	225
Jupiter	484	780
Saturn	884	1425
Uranus	1,786	2,880
Neptune	2,799	4,515

(Source: This part of the lesson is adapted from one presented by Dr. Alan Pringle, University of Missouri-Rolla.)

Evaluation

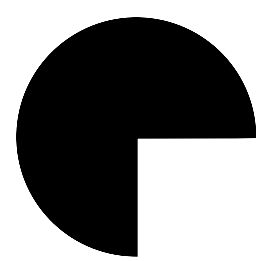
This is a group activity and participation is the key element.

Part 2: Building and Shooting a Rocket

1. Divide the students into groups of two or three.

2. Each group will gather necessary materials and build a rocket. Demonstrate building a rocket with the class as follows:

   - Wrap a piece of paper around a film canister or the end of a roll of toilet paper. (You should have some empty toilet paper rolls if you did the top part of this activity.) Tape it shut. This is the body of the rocket. You will use a straw as the shooting device, so you don't want to make the body of your rocket longer than the straw.
   - Cut out a circle of any size and cut away ¼ of it.
   - Make the circle into a cone that fits on the top of the rocket.
   - Add fins to the rocket.



3. Insert a straw into the bottom of your rocket and shoot it. (It is suggested that safety goggles be worn to prevent eye damage.) Practice a few times.
4. Have a class discussion about the variables and the effect that the variables will have on the distance the rocket flies. Some variables include these:
   - Diameter of rocket
   - Size of cone
   - Flap location and size
   - Amount of air blown through the straw
   - Weight of the rocket (how much tape is used, how heavy the paper is)
   - Angle of the launch
5. After some practice, ask the students to estimate the distance that they think the rocket will go.
6. Have them shoot the rocket on the solar system course that was laid out on the floor. Measure the distance in centimeters that the rocket flew. As another option, shoot the rocket and simply measure the distance it flew without the solar system course. Centimeters can then be converted to meters.
7. Have students complete the handout.
8. You could make this a contest and give a prize for the farthest distance.

Evaluation

Category	**4**	**3**	**2**	**1**
Construction — Materials	Appropriate materials were selected and creatively modified in ways that made them even better.	Appropriate materials were selected and there was an attempt at creative modification to make them even better.	Appropriate materials were selected.	Inappropriate materials were selected and contributed to a product that performed poorly.
Modification/ Testing	There was clear evidence of troubleshooting, testing and refinements based on data or scientific principles.	There was clear evidence of troubleshooting, testing and refinements.	There was some evidence of troubleshooting, testing and refinements.	There was little evidence of troubleshooting, testing or refinement.
Function	The rocket functions extraordinarily well, holding up under atypical stresses.	The rocket functions well, holding up under typical stresses.	The rocket functions, but deteriorates under typical stresses.	The rocket has fatal flaws in function, with complete failure under typical stresses.
Accuracy of Student Handout	The scale drawing is accurate. Distances are accurately measured.	There is some distortion in the scale drawing. Distances are accurately measured.	There is some distortion in scale drawing and some error in measuring distances.	Little attempt is made to do an accurate job on either scale drawing or measurements.

(Source: Rocket idea adapted from NASA – An Educator's Guide With Activities in Science, Mathematics and Technology, EG-2003-01-06-108-HQ)

Lift Off! (Student Handout)

Names ____

Directions

1. You've built your rocket. Give it two or three test launches. Determine if you need to make changes in your design. For example, you might change the size or location of your fins.
2. Draw a diagram of your finished rocket. Make it to scale.
3. Make a prediction as to how far you think your modified rocket will fly. Write the prediction below.
4. Launch your rocket three times, measuring the distance each time and recording it on this handout.
5. Find your average or mean distance.

Rocket Name

____

Estimated distance in cm ____________

Trial 1 ______________________

Trial 2 ______________________

Trial 3 ______________________

Average distance in cm ____________

Average distance in meters____________

How Much Do You Weigh on Other Planets?

Overview

Students discuss the difference between mass and weight and find what various weights would be on different planets.

Outcome

Students will understand the concepts of mass and gravity. They also will practice measurement conversion.

Standards Addressed — Mathematics

Grade 5

Use Measurement Techniques and Tools, Benchmark B

05. Make conversions within the same measurement system while performing computations.

Materials

- Calculators
- How Much Do You Weigh on Other Planets? student handout

Procedure

1. Review the concepts of mass and weight. This explanation is on the student handout:

   *The **mass** of an object is a fundamental property of the object; a numerical measure of its inertia; a fundamental measure of the amount of matter in the object.*

   *The **weight** of an object is the force of gravity on an object.*

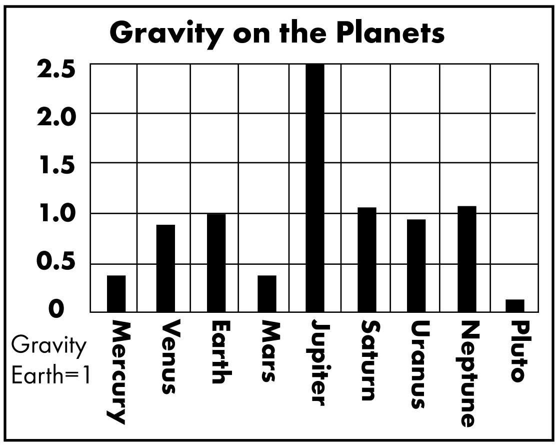
   If you had a mass of 100 pounds on earth, your mass would not change on any of the planets. But your weight would change because weight is the result of the pull of gravity. The greater the gravity, the more the object weighs. Each planet has more or less gravity than Earth.

2. Distribute the student handout and talk about what a person who weighs 100 pounds on Earth would weigh on the other planets. Discuss why this is so. Discussion could lead to the size or density of the planet and the effect on the gravitational pull.
3. Make sure the students are aware that 1 pound equals 16 ounces.
4. Have students fill in the Gravity on the Planets graph. Discuss if there is an association between the gravity of the planet and their weight on that planet. (The more gravitational pull, the greater the weight.)
5. Have the students compute their weight on each planet and convert the pounds to ounces. Don't give specific directions, such as "multiply by the number given in the table." Let the students figure out how to do this. The sights listed below will calculate weights on the other planets for you. You can have the students check their work online.
   - How Much Would You Weigh on Another Planet? — **www.solarviews.com/eng/edu/weight.htm**
   - What Do You Weigh on Other Planets? — **www.enchantedlearning.com/subjects/astronomy/weight.shtml**

- Your Weight on Other Worlds **www.exploratorium.edu/ronh/weight/index.html**

A word of caution: Some students may be very sensitive about their weight. If this appears to be the case, you could have the students work with a partner and use one of the weights instead of having the students do individual handouts.

6. Have the students complete the other weight problems.



Answers for Student Handout

1. 3.15 pounds
2. 844.6 pounds
3. 519 pounds
4. 1.08 pounds
5. 17.9 pounds

Evaluation

The teacher should work through the first part of the handout with the students. The second part can be checked by the students going online and inputting the weights and comparing them with their answers.

How Much Do You Weigh on Other Planets?
(Student Handout)

Name____

The **mass** of an object is a fundamental property of the object; a numerical measure of its inertia; a fundamental measure of the amount of matter in the object. The **weight** of an object is the force of gravity on an object.

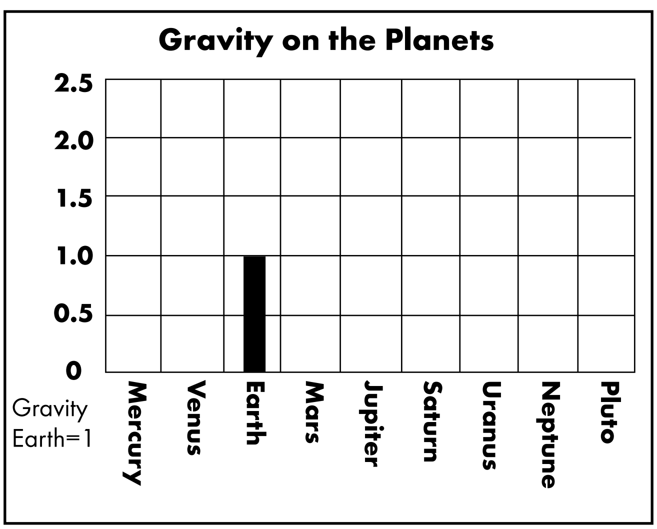
If you had a mass of 100 pounds on Earth, your mass would not change on any of the planets, but your weight would change because weight is the result of the pull of gravity. The greater the gravity, the more the object weighs. Each planet has more or less gravity than Earth.

The largest planet is Jupiter. It is followed by Saturn, Uranus, Neptune, Earth, Venus, Mars and Mercury. Jupiter is so big that all the other planets could fit inside it.

A 100-pound person on Earth would weigh:

- 37.8 pounds on Mercury
- 90.6 pounds on Venus
- 37.9 pounds on Mars
- 253.3 pounds on Jupiter
- 106.6 pounds on Saturn
- 90.5 pounds on Uranus
- 113.3 pounds on Neptune

Please graph the gravitation



Planets and the Moon	Gravitation Factor Relative to Earth	Your Weight in Pounds on ...	Your Weight in Ounces on ...
Mercury	0.38		
Venus	0.91		
Earth	1		
Moon	0.17		
Mars	0.38		
Jupiter	2.54		
Saturn	1.08		
Uranus	0.91		
Neptune	1.19		

Let's figure out some other weights. Round to the nearest tenth.

1. On Earth, one gallon of water weighs 8.3 pounds. What does it weigh on Mars? ____________________

2. In 2005, Lemuel Grayson from the United States won the world weightlifting championship by lifting a total of 332.5 pounds in the Snatch and the Clean and Jerk competitions. How much is that on Jupiter? ____________________

3. A Honda Accord weighs 3,053 pounds. How much does it weigh on the moon? ____________________

4. A container of butter weighs 1 pound on earth. How much does it weigh on Saturn? ____________________

5. A Boston terrier weighs an average of 15 pounds on Earth. What does it weigh on Neptune? ____________________

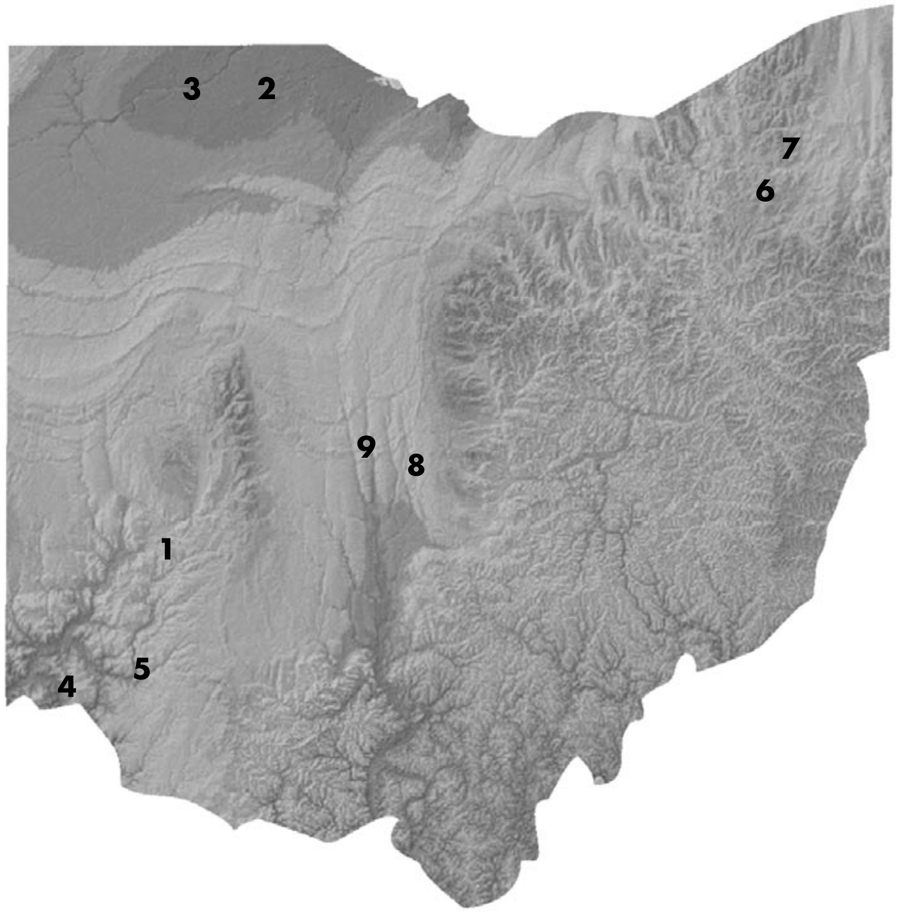
Ohio Virtual Tour

Teacher Guide

WesternReservePublicMedia.org/measure

WESTERN
RESERVE
PUBLIC MEDIA

Map of the Google Earth Virtual Tour



Stops in order:

1. Wright-Patterson Air Force Base
2. Toledo Express Airport
3. Toledo farmland
4. Cincinnati airport
5. Kings Island
6. Akron-Canton Airport
7. Landfill
8. Columbus Airport
9. The Ohio State University Football Stadium

Google Earth

What Is Google Earth?

Google Earth is a free Internet program from Google that lets you and your students explore our world in new, exciting ways. Detailed photographs from satellites and aircraft are combined with a 3-D model of our planet, allowing you to see our world from as far away as outer space, or as close up as the driveway in front of your house ... all in smooth, 3-D motion.

And that's not all. With Google Earth you can do the following and much more:

- Tilt the Earth to see the ground from different angles
- View 3-D models of the buildings in many major cities
- View 3-D models of mountains, valleys and other major landforms
- View political boundaries
- View roads
- See animated 3-D driving directions from one place to another
- View points of interested including businesses, cities, restaurants and more
- Measure distances

Google Earth is an excellent tool for instructing students in all content areas. Examples of practical uses include these:

- **Earth science:** Search for mountains, volcanoes, glaciers, weather patterns and more
- **History:** Visit the sites of famous battles
- **Literature:** Visit the sites of famous novels, settings and authors
- **Math:** Measure distances and areas, determine travel time, study angles and intersecting lines
- **World languages:** Visit the landmarks and cities of foreign countries
- **Geography:** See the cities, countries and geographic features of the world
- **Civics:** Learn about the layout and businesses of your home town

How to Get Google Earth

Google Earth is a free download; however, you need to make sure your computer meets the requirements to run the program. To use Google Earth you will need an Internet connection and a computer with these minimum specifications:

PC computers

- Operating System: Windows 2000 or Windows XP
- CPU: Pentium 3,500Mhz
- System Memory (RAM): 128MB
- Hard Disk: 400MB free space
- Network Speed: 128 Kbits/sec
- Graphics Card: 3-D-capable with 16MB of VRAM
- Screen: 1024x768, "16-bit High Color"

Mac Computers

- Operating System: Mac OS X 10.3.9
- CPU: G3 500Mhz
- System Memory (RAM): 256MB
- Hard Disk: 400MB free space
- Network Speed: 128 Kbits/sec
- Graphics Card: 3-D-capable with 16MB of VRAM
- Screen: 1024x768, "Thousands of Colors"

Linux Computers

- Kernel: 2.4 or later
- glibc: 2.3.2 w/ NPTL or later
- XFree86-4.0 or x.org R6.7 or later
- CPU: Pentium 3, 500Mhz
- System Memory (RAM): 128MB
- Hard Disk: 400MB free space
- Network Speed: 128 Kbits/sec
- Screen: 1024x768, 16 bit color
- Tested and works on the following OSs: Ubuntu 5.10, Suse 10.1, Fedora Core 5, Linspire 5.1, Gentoo 2006.0, Debian 3.1, Red Hat 9

Once you know your computer will be able to run Google Earth, you can download it from:

http://earth.google.com/download-earth.html

Simply choose your type of computer (Windows, Mac or Linux) and select the option labeled "Download Google Earth."

How to Use Google Earth

Once you have Google Earth downloaded and installed, you can begin using it. Below are instructions for the basic use of the program:

Manual Navigation

You can navigate the entire globe using the manual controls in Google Earth. Following are examples:

- To zoom in or out, use the scroll wheel on your mouse, or click the onscreen plus and minus buttons
- To move north, south, east or west, select and drag the globe with your mouse, or select an onscreen directional arrow
- To change the viewing angle, click the onscreen angle buttons

Searching for Locations

Instead of manually navigating to a location, you can have Google Earth find your destination for you.

1. In the "Search" panel, go to the "Fly To" box on the top left of the screen.
2. Type in an address or name of a location.
3. Press "Enter."
4. Google Earth will now take you to that location, or will show you multiple options if there were several matches for your search.

Going to Placemarked Locations

Google Earth can save common locations for you in the "Places" panel. This is also where the measurement activity will load its locations. Do the following to go to such locations:

1. Use the plus and minus buttons to expand the list of places as needed.
2. When you find a location you wish to visit, double-click its name in the "Places" panel.
3. Google Earth will now fly you to that location.
4. On the globe, click on the location's placemark icon to get more details about that location (if provided).

Using Layers

Google Earth can put additional information on top of the globe. This information is contained in different "layers." Layers can contain information such as these:

- Terrain
- 3-D buildings
- Roads
- Borders
- Dining locations
- Transportation
- Geographic features
- Government locations

Turning Layers Off and On

1. Look in the “Layers” panel to find the available layers.
2. Use the plus and minus buttons to expand the list of layers as needed.
3. Check or uncheck each layer as desired to turn its information on or off. As you do this, the Google Earth globe will change to reflect this information.

Measuring With Google Earth

Google Earth has a built-in measurement tool that can be very useful.

1. To open the measurement tool, select “Tools,” then “Ruler” (or “Measure” in older versions).
2. Choose your desired measurement unit.
3. Select the globe icon to begin measuring.
4. Select the globe a second time to mark the end of the line you are measuring.
5. The distance will be displayed.
6. You can select the “Clear” button to remove the line and begin again.

Google Earth Measurement Tour of Ohio

To help you use Google Earth in your class, we have developed a measurement activity. The activity takes the students around Ohio to visit, and measure, several Ohio locations. Each location addresses a different measurement topic, as explained below. You can open the measurement in two ways.

From the Internet:

1. Go to the following Web address: **www.WesternReservePublicMedia.org/earth**.
2. Select the link for the Google Earth Measurement Activity.
3. Google Earth will automatically open and load the activity into the "Places" panel.

From the CD:

1. Start Google Earth.
2. Select "File" and then "Open."
3. Browse to the CD for this unit and locate the file named "mto.kmz."
4. Open that file.
5. The activity will load into the "Places" panel.

You can work through the activity by navigating through each item in the Measurement Tour of Ohio folder in the "Places" panel.

1. Use the plus and minus buttons to expand the list of places as needed.
2. For each item, double-click its name in the "Places" panel.
3. Google Earth will now fly you to that location.
4. On the globe, select the location's placemark icon to get instructions for that location.

Below is a brief explanation of the content covered in the "Measurement Tour of Ohio."

1. **Wright-Patterson Air Force Base** – Wright-Patterson Air Force Base is improving its runways. They need to replace asphalt with concrete – and they need your help. Find the volume of concrete and stones needed to complete the job.
2. **Farmland** – Travel to the Toledo area and measure the area of farmland, using skills for estimating the area of an irregular shape.
3. **An Amusement Park Arcade** – Next they fly down to Cincinnati and Kings Island Amusement Park. Here they take measurements of the giant fountain at the entrance, gaining an understanding of the perimeter of a rectangle and volume of a rectangular prism.
4. **Landfill** – Then they head up to Akron and visit a landfill and water treatment plant to measure holding tanks. The topics covered are measuring the radius, diameter, circumference and area of a circle.
5. **The Ohio State University Football Stadium** – Next it is off to Columbus and The Ohio State University football stadium, where students measure the length of the field and convert measurements between customary units.
6. **Rock and Roll Hall of Fame** – The last stop is in Cleveland at the Rock and Roll Hall of Fame. Because of its unique design, students are able to take measurements of its glass walls, gaining practice in finding the area of a triangle.
7. **Conclusion** – At the end of the activity, students are encouraged to think of more ways such as the following that Google Earth could be used to do measurements:
    - Find geometical shapes from land, roads and buildings
    - Measure the perimeter, area or volume of those shapes
    - Measure distances between locations and determine the time it would take to travel or the cost it would take for gas
    - Map out a walking path of a neighborhood and determine the length

BIG OR SMALL: measure it all!

wright-patterson air force base

Wright-Patterson Air Force Base Measures Up — Making a Runway

Overview

The runways at Wright-Patterson Air Force Base need to be resurfaced. Students draw diagrams, write reports and use calculations to determine the quantity of surface materials that are needed for the project.

Outcome

Students will use a real-life scenario to practice finding perimeter, surface area and volume.

Standards Addressed — Mathematics

Grade 4

Measurement Units, Benchmark C

02. Demonstrate and describe perimeter as surrounding and area as covering a two-dimensional shape, and volume as filling a three-dimensional object.

Use Measurement Techniques and Tools, Benchmark D

06. Write, solve and verify solutions to multi-step problems involving measurement.

Grade 5

Measurement Units, Benchmark G

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.
04. Demonstrate understanding of the differences among linear units, square units and cubic units.

Materials

- Optional poster paper and art supplies to construct displays of work
- Wright-Patterson Air Force Base student handouts

Procedure

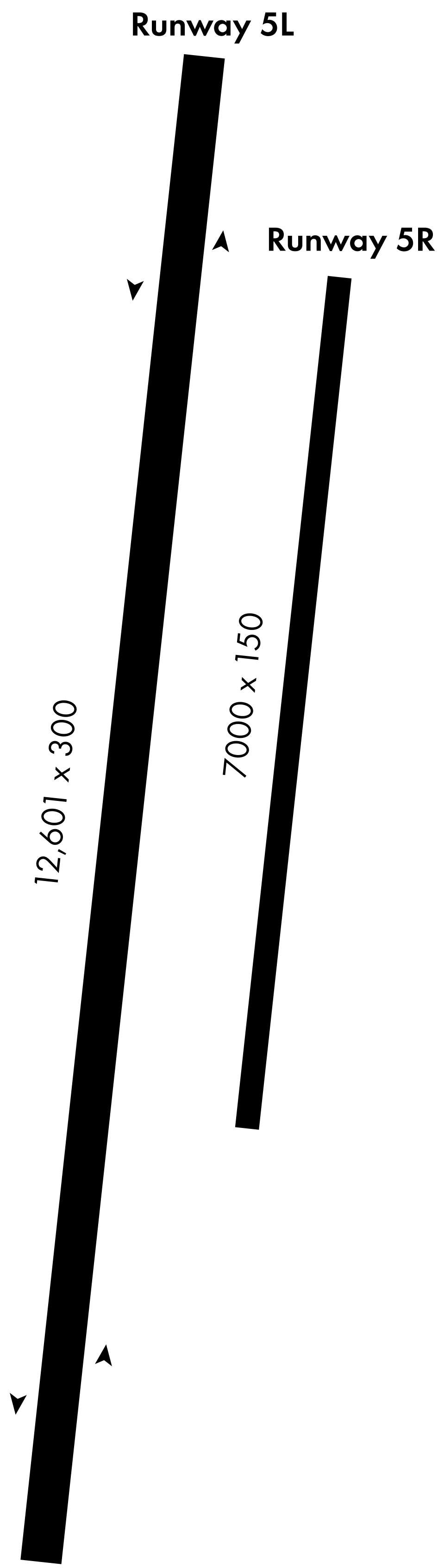
1. On a map of Ohio, show the class Wright-Patterson Air Force Base and/or use the Google Earth feature to find the satellite view.
2. Reference the History of Wright-Patterson Air Force Base handout as a resource for teaching the class about its history.
3. Hand out the Airport Diagram page and discuss how the shorter of the two runways is surfaced with asphalt and the longer is part concrete and part asphalt. It might be worthwhile to take students outside to show them the difference between asphalt and concrete, if possible.
4. Tell the class that Wright-Patterson has decided to resurface its runways so that they are entirely concrete. The class is going to act as if they are various companies competing for the job, which would pay a great deal of money.
5. Divide the class into teams, each of which represents a concrete company. If you'd like, have the students decide on a company name.

6. Describe how the jets that land there are particularly heavy and will need a very solid base. Airport runways are generally 1 foot of concrete with 2 feet of base material beneath that.
7. Model the drawing of a three-dimensional rectangle, with the top third scored to represent a different material. Leave that drawing visible for students as a pattern while you are working. (You could also make a sample by using a shoe box with clear wrap on one side and three layers of different types of material.)
8. Students should be told that the Wright-Patterson people are Air Force people, not concrete workers. Therefore, when the students present their information, they must do it in three separate ways — pictures, words and numbers — to make sure the Wright-Patterson people will understand what they are talking about.
9. Use the classroom floor's dimensions as a model, using pictures, words and numbers to depict how it would be resurfaced with 1 foot of stone and 1 foot of concrete. (The students can help determine the measurements.) This example also can be used to set the standard for what is necessary in order to complete the project correctly.
10. If necessary, work through the shorter runway together as a class to model the procedure and processes again. Then remind students that the second runway is already part concrete, so there will be some necessary new steps in that example.
11. Allow the teams to work together to complete their drawings, descriptions and computations.
12. Have students present findings to the class and discuss results.
13. **Enhancement:** Students who have a good grasp of this might convert their square foot measurements to square yards of cement. They can do the "How Much Cement?" handout.

Evaluation

Category	**4**	**3**	**2**	**1**
Diagrams and Sketches	Diagrams and/or sketches are clear and greatly add to the reader's understanding of the procedure(s).	Diagrams and/or sketches are clear and easy to understand.	Diagrams and/or sketches are somewhat difficult to understand.	Diagrams and/or sketches are difficult to understand or are not used.
Explanation	Explanation is detailed and clear.	Explanation is clear.	Explanation is a little difficult to understand, but includes critical components.	Explanation is difficult to understand and is missing several components OR was not included.
Mathematical Concepts	Explanation shows complete understanding of the mathematical concepts used to solve the problem(s).	Explanation shows substantial understanding of the mathematical concepts used to solve the problem(s).	Explanation shows some understanding of the mathematical concepts needed to solve the problem(s).	Explanation shows very limited understanding of the underlying concepts needed to solve the problem(s), or is not written.
Neatness and Organization	The work is presented in a neat, clear, organized fashion that is easy to read.	The work is presented in a neat and organized fashion that is usually easy to read.	The work is presented in an organized fashion but may be hard to read at times.	The work appears sloppy and unorganized. It is hard to know what information goes together.

Airport Runway Diagram



History of Wright-Patterson Air Force Base

In 1917 during World War I, a large airfield was created in southern Ohio. It was used as a place to train pilots and the people who would fire the weapons on an aircraft. The field was called Wilbur Wright Field in honor of the man who, with his brother Orville, built and flew the first airplane.

In 1918, a training pilot was killed there. He had been testing machine guns on airplanes. The men working there were trying to see if the timing of two things, the bullets and the propeller, could be fixed so that it was possible to shoot straight ahead. The unfortunate testing pilot's name was Lt. Frank Patterson. He was the nephew of the man who ran the National Cash Register Company. The Patterson family was very rich and had donated a lot of money to the testing field and now had lost a family member to tragedy there.
In 1924, more land was purchased. It was a huge area, all dedicated to the testing and training of pilots. Six years later, in 1931, part of the area was called Patterson Field, to thank that family for all that they had given.

In 1948, the two fields were combined and formally named Wright-Patterson. The Air Force continued to use the area for testing and training. Weapons are tested there today, as are new aircraft such as the F-22 Raptor, the United States Air Force's newest and fastest jet. New forms of technology are developed there, too.

The Wright-Patterson base also has a wonderful museum of flight called the National Museum of the United States Air Force. In the past, the base has been the site where captured enemy planes have been brought, taken apart and studied.

Some people will tell you that Wright-Patterson has a secret place called "Hanger 18." They say the remains of an alien from outer space are kept there. That's only a legend, though!

Wright-Patterson Air Force Base "Pictures"
(Student Handout)

Names ____

Runway 5R is 7,000 feet long and 150 feet wide. It is made of asphalt. A company is going to come to tear out all the asphalt and your company will have to put in a concrete runway. There will have to be 2 feet of base material (usually large stones) and then 1 foot of concrete above that. Draw a picture to show what you need to do to figure out how much stone and concrete you'll need.

Runway 5L is 12,501 feet long and 300 feet wide. The first 2,600 feet are already concrete, but the rest is asphalt. Draw a picture showing what you will need to do to figure out how much stone and concrete you'll need for this runway.

Wright-Patterson Air Force Base "Words"

(Student Handout)

Names ____

Runway 5R is 7,000 feet long and 150 feet wide. It is made of asphalt. A company is going to come to tear out all the asphalt and your company will have to put in a concrete runway. There will have to be 2 feet of base material (usually large stones) and then 1 foot of concrete above that. Use your drawing to help you write in words how you will decide how much of each material you will need.

Runway 5L is 12,501 feet long and 300 feet wide. The first 2,600 feet are already concrete, but the rest is asphalt. Use your drawing to help you write in words how you will decide how much of each material you will need.

Wright-Patterson Air Force Base "Numbers"

(Student Handout)

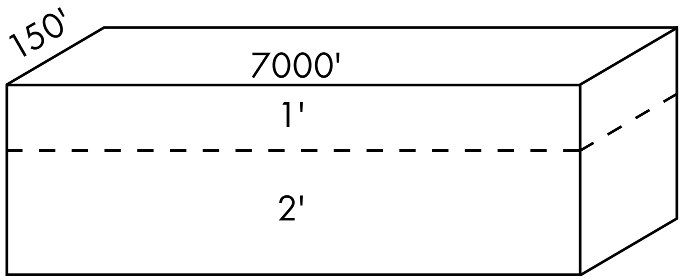
Names ____

Runway 5R is 7,000 feet long and 150 feet wide. It is made of asphalt. A company is going to come to tear out all the asphalt and your company will have to put in a concrete runway. There will have to be 2 feet of base material (usually large stones) and then 1 foot of concrete above that. Using your picture and your words handouts, figure out in numbers exactly how much stone and how much concrete you'll need.

Runway 5L is 12,501 feet long and 300 feet wide. The first 2,600 feet are already concrete but the rest is asphalt. Using your picture and your words handouts, figure out in numbers exactly how much stone and how much concrete you'll need.

Wright-Patterson Air Force Base "Numbers"
(Answer Key)

Runway 5R is 7,000 feet long and 150 feet wide. It is made of asphalt. A company is going to come to tear out all the asphalt and your company will have to put in a concrete runway. There will have to be 2 feet of base material (usually large stones) and then 1 foot of concrete above that. Using your picture and your words handouts, figure out in numbers exactly how much stone and how much concrete you'll need.



Volume concrete = length x width x height

V = 7,000 x 150 x 1 =

V = 1,050,000 cubic ft of concrete OR

V = 1,050,000 ft^3

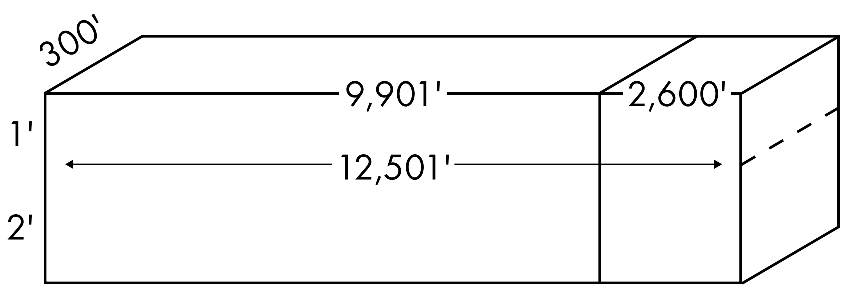
Volume base = l x w x h

V = 7,000 x 15 x 2 =

V = 2,100,000 cubic ft of stone OR

V = 2,100,000 ft^3

Runway 5L is 12,501 feet long and 300 feet wide. The first 2,600 feet are already concrete but the rest is asphalt. Using your picture and your words handouts, figure out in numbers exactly how much stone and how much concrete you'll need.



	12,501 ft	total
-	2,600 ft	concrete
	9,901 ft	needed to make concrete

Volume concrete = l x w x h

V = 300 x 9,901 x 1 =

V = 2,970,300 ft^3 of concrete

Volume base = l x w x h

V = 9,901 x 300 x 2 =

V = 5,940,600 ft^3 of stone

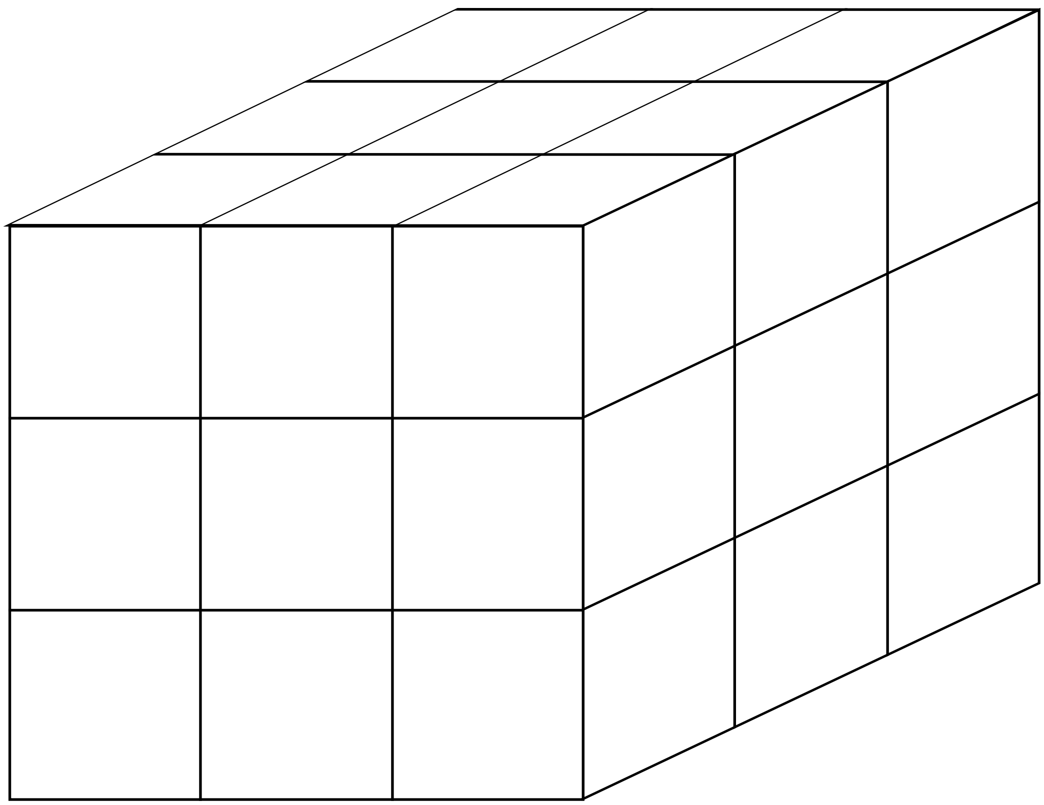
How Much Cement?

Names ____

The average cement truck holds 9 cubic yards of concrete. Draw a cubic yard of concrete in comparison to your earlier pictures. What will you have to do to figure out how far a cubic yard of concrete will spread when you need concrete only 1 foot deep? Once again, draw the picture, write out the words and then do the math with numbers to see if you can figure out how many cement trucks will be sent to the airport. Good luck!

How Much Cement? (Answer Key)

The average cement truck holds 9 cubic yards of concrete. Draw a cubic yard of concrete in comparison to your earlier pictures. What will you have to do to figure out how far a cubic yard of concrete will spread when you need concrete only 1 foot deep? Once again, draw the picture, write out the words and then do the math with numbers to see if you can figure out how many cement trucks will be sent to the airport. Good luck!



1 cubic yd = 3 x 3 x 3 = 27 ft^3

27 x 9 = 243 ft^3 in one truck

Runway 5R needs 1,050,000 ft^3 of cement

1,050,000/243 in each truck = 4,320.98 trucks or 4,321 trucks

Runway 5L needs 2,970,300 ft^3 of cement

2,970,300/243 in each truck = 12,223.45 trucks or 12,224 trucks

Measuring the Aircraft at Wright-Patterson — Cargo Carriers

Overview

This lesson practices measurement skills by asking students to compute perimeter, surface area and volume in three different cargo aircraft used by the United States Air Force.

Outcome

Students will practice calculating volume when given length, width and depth measurements. They will present their thinking in pictures, words and numbers in order to ensure comprehension of the concept as well as the process.

Standards Addressed — Mathematics

Grade 4

Measurement Units, Benchmark C

02. Demonstrate and describe perimeter as surrounding and area as covering a two-dimensional shape, and volume as filling a three-dimensional object.

Use Measurement Techniques and Tools, Benchmark D

06. Write, solve and verify solutions to multi-step problems involving measurement.

Grade 5

Measurement Units, Benchmark F

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.

Measurement Units, Benchmark G

04. Demonstrate understanding of the differences among linear units, square units and cubic units.

Materials

- Optional poster paper and art supplies to construct displays of work
- Wright-Patterson Air Force Base student handouts

Procedure

1. As a class, discuss why cargo aircraft are needed by the military.
2. Review the Wright-Patterson Aircraft Fact Sheet handout. Pictures of these aircraft may be found at **www.af.mil/factsheets**.
3. As an optional lesson, have students decide if the aircraft are able to land on both runways at Wright-Patterson. This would require information from the previous lesson on resurfacing the runways.
4. Have students, alone or in pairs, figure the cargo space of each aircraft. You might want to model this procedure with something visual and smaller in the classroom, like a desk drawer or a cabinet.

5. Remind students of their work in pictures, words and then numbers on the previous Wright-Patterson Air Force Base work. Ask them to do the same three activities as they compute the cargo space.
6. Have the students check their work and then present their findings to the class.

Evaluation

Category	4	3	2	1
Diagrams and Sketches	Diagrams and/or sketches are clear and greatly add to the reader's understanding of the procedure(s).	Diagrams and/or sketches are clear and easy to understand.	Diagrams and/or sketches are somewhat difficult to understand.	Diagrams and/or sketches are difficult to understand or are not used.
Explanation	Explanation is detailed and clear.	Explanation is clear.	Explanation is a little difficult to understand, but includes critical components.	Explanation is difficult to understand and is missing several components, or is not included.
Mathematical Concepts	Explanation shows complete understanding of the mathematical concepts used to solve the problem(s).	Explanation shows substantial understanding of the mathematical concepts used to solve the problem(s).	Explanation shows some understanding of the mathematical concepts needed to solve the problem(s).	Explanation shows very limited understanding of the underlying concepts needed to solve the problem(s), or is not written.
Neatness and Organization	The work is presented in a neat, clear, organized fashion that is easy to read.	The work is presented in a neat and organized fashion that is usually easy to read.	The work is presented in an organized fashion but may be hard to read at times.	The work appears sloppy and unorganized. It is hard to know what information goes together.

Wright-Patterson Aircraft Fact Sheet

The letter "C" in each plane's name designates it as a cargo plane.

The C-5 Galaxy

- Can carry military troops and all of their equipment
- Can be loaded or unloaded from both the back and the front
- Needs 8,300 feet to take off and 4,900 feet to land
- Has landing gear (wheels) that can "kneel" so the cargo area can be reached more easily
- Has four turbofan jet engines that are each 27 feet long
- Holds 51,150 gallons of fuel when full and can be refueled while in the air
- Began operating in 1970
- Has a wing span of almost 223 feet
- Is 247 feet long
- Stands 65 feet high
- Has a cargo compartment that measures 13 feet high, 19 feet wide and 143 feet long
- Can fly at the speed of 518 miles per hour
- Cost $179 million in 1998

The C-130 Hercules

- Can carry military troops or equipment
- Has turboprop engines (propellers)
- Can operate on rough runways (such as Antarctica, where there are no runways)
- Has inner equipment that is removable or changeable so the aircraft can be used for many different purposes
- Is 112 feet long
- Stands 39 feet high
- Has a wing span of almost 133 feet
- Has a cargo department that measures 35 feet long, 10 feet wide and 9 feet high
- Can fly at the speed of 410 miles per hour
- Needs a basic crew of five people
- Cost $48.5 million in 1998

The C-17 Globemaster III

- Is the newest cargo aircraft used by the Air Force
- Delivers troops or cargo
- Is much more mobile and flexible in the air, so may not be as dangerous to fly as slower cargo planes, which are very vulnerable
- Has four turbofan jet engines
- Can be refueled in the air
- Is 174 feet long
- Has a wingspan of 170 feet
- Stands 55 feet high
- Has a cargo compartment that measures 88 feet long, 18 feet wide and 12 feet high
- Needs a crew of three people
- Can take off and land on runways that are 3,000 feet long and 90 feet wide
- Was first flown in 1993
- Cost $180 million in 1998

Aircraft "Pictures" (Student Handout)

Names ____

Using the fact sheet, draw and label a diagram of the cargo area inside each aircraft.

The C-5 Galaxy

The C-130 Hercules

The C-17 Globemaster III

Aircraft "Words" (Student Handout)

Names ____

Use your diagram of the aircraft cargo areas to help you write in words how you will decide how much volume each area has. You can do this once and it will work for all three aircrafts.

Aircraft "Numbers" (Student Handout)

Names ____

Use your diagrams, paragraph and fact sheet to figure out with numbers the exact cargo area of each aircraft.

The C-5 Galaxy

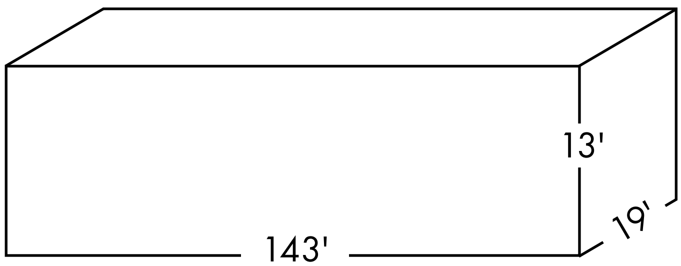
The C-130 Hercules

The C-17 Globemaster III

Aircraft "Numbers" (Answer Key)

Using the fact sheet, draw and label a diagram of the cargo area inside each aircraft.

The C-5 Galaxy

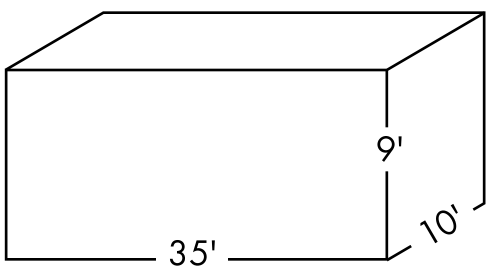


V = l × w × h

V = 143 x 19 x 13

V = 35,321 ft^3

The C-130 Hercules

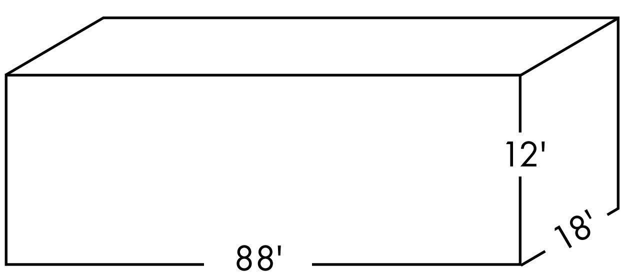


V = l × w × h

V = 35 x 10 x 9

V = 3,150 ft^3

The C-17 Globemaster III



V = l × w × h

V = 88 x 18 x 12

V = 19,008 ft^3

BIG OR SMALL: measure it all!

farmland

New McDonald's Farm — Planting the Corn

Overview

In this lesson students determine how many corn plants can be planted in an acre of land.

Outcome

Students will gain practice in calculating perimeter and area.

Standards Addressed — Mathematics

Grade 4

Measurement Units, Benchmark A

03. Identify and select appropriate units to measure:
    - perimeter — string or links (inches or centimeters)
    - area — tiles (square inches or square centimeters)
    - volume — cubes (cubic inches or cubic centimeters)

Use Measurement Techniques and Tools, Benchmark D

06. Write, solve and verify solutions to multi-step problems involving measurement.

Grade 6

Use Measurement Techniques and Tools, Benchmark E

04. Determine which measure (perimeter, area, surface area, volume) matches the context for a problem situation; e.g., perimeter is the context for fencing a garden, surface area is the context for painting a room.

Materials

- Calculator
- Planting the Corn student handout

Procedure

1. Divide students into groups of two or three.
2. Review the corn information that is found in the student handout.
3. Using the bottom side of the rectangle, students should figure the number of rows they could plant. Using the length of the vertical side, students should compute the number of plants they can put in each row. They would then calculate how many plants should go in that field.

Evaluation

Rubric for Evaluating Student Handout

Category	4	3	2	1
Mathematical Concepts	Computation shows complete understanding of the mathematical concepts used to solve the problem(s).	Computation shows substantial understanding of the mathematical concepts used to solve the problem(s).	Computation shows some understanding of the mathematical concepts needed to solve the problem(s).	Computation shows very limited understanding of the underlying concepts needed to solve the problem(s), or is not written.
Mathematical Errors	Ninety to 100 percent of the steps and solutions have no mathematical errors.	Almost all (85 percent to 89 percent) of the steps and solutions have no mathematical errors.	Most (75 percent to 84 percent) of the steps and solutions have no mathematical errors.	More than 75 percent of the steps and solutions have mathematical errors.
Teamwork	Student is an engaged partner, listening to suggestions of others and working cooperatively throughout the lesson.	Student is an engaged partner but had trouble listening to others and/or working cooperatively.	Student cooperates with others, but needed prompting to stay on task.	Student does not work effectively with others.

New McDonald's Farm — Planting the Corn
(Student Handout)

Names ____

Old McDonald would certainly be surprised if he could see the strides made in farming today. We're going to take a look at a modern farm and use what science has taught us to determine how much corn we can grow on a plot of land.

We are, however going to talk about acres of land, which is a very old concept. An acre was originally the amount of land that could be plowed in a single day with oxen. Actually, the oxen only worked until midafternoon because they were put out to pasture in the afternoon to "refuel." Today we know an acre is 4,840 square yards or about 70 yards on each side.

1. It is helpful to know that corn grows well when: 1) the rows are 2 feet apart, and 2) the plants in each row are 1 foot apart.
2. Your job is to determine how many corn plants you can plant on an acre of land. Use the actual measure of an acre, which is 4,840 square yards. Each side of the cornfield is about 70 yards.
3. Draw a picture that shows how you solved the problem.

What is the measurement of each side of the acre in feet? ______________

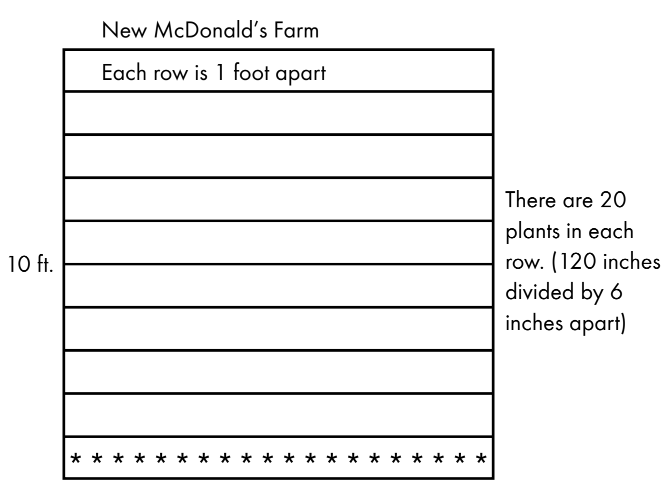
Number of rows ______________________________

Number of plants in one row ______________________

Total number of plants______________________________

Sample

Let's look at planting. New McDonald has a garden that is 10 feet by 10 feet. His plants need to be 6 inches apart. The rows need to be 1 foot apart.



Corn Information

New McDonald can plant 10 rows each with 20 plants in each row. That means he can plant 200 plants in his garden. (The measurement in feet must be changed to inches.)

10 x 20 = 200 plants

New McDonald's Farm — Planting the Corn
(Answer Key)

Old McDonald would certainly be surprised if he could see the strides made in farming today. We're going to take a look at a modern farm and use what science has taught us to determine how much corn we can grow on a plot of land.

We are, however going to talk about acres of land, which is a very old concept. An acre was originally the amount of land that could be plowed in a single day with oxen. Actually, the oxen only worked until midafternoon because they were put out to pasture in the afternoon to "refuel." Today we know an acre is 4,840 square yards or about 70 yards on each side.

1. It is helpful to know that corn grows well when: 1) the rows are 2 feet apart, and 2) the plants in each row are 1 foot apart.
2. Your job is to determine how many corn plants you can plant on an acre of land. Use the actual measure of an acre, which is 4,840 square yards. Each side of the cornfield is about 70 yards.
3. Draw a picture that shows how you solved the problem.

What is the measurement of each side of the acre in feet? 70 yds x 3 ft = 210 ft

Number of rows: 210/2 ft apart = 105 rows

Number of plants in one row: 210 x 1 ft apart = 210 plants

Total number of plants: 105 rows x 210 plants = 22,050 plants on one acre of land

* * * * * * * * * * * * (70 yds = 210 ft = 210 plants)
70 yds = 210' 210/2' = 105 rows 105 rows x 210 plants = 22,050 plants on one acre of land

New McDonald's Farm — Storing the Corn

Overview

The first lesson dealt with growing the corn. Now we have to store it. The purpose of this lesson is to find out how much corn will fit in a silo. Students need to find the volume of the corn grown and then the volume of the silo to make their determination.

Outcome

Students will understand how to calculate surface area and volume.

Standards Address — Mathematics

Grade 4

Measurement Units, Benchmark A

03. Identify and select appropriate unites to measure the following:
    - perimeter – string or links (inches or centimeters)
    - area – tiles (square inches or square centimeters)
    - volume – cubes (cubic inches or cubic centimeters)

Grade 5

Measurement Units, Benchmark G

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.

Grade 6

Measurement Units, Benchmark F

01. Understand and describe the difference between surface area and volume.

Measurement Units, Benchmark G

01. Understand and describe the difference between surface area and volume.

Use Measurement Techniques and Tools, Benchmark C

02. Use strategies to develop formulas for finding circumference and area of circles, and to determine the area of sectors.

Grade 7

Use Measurement Techniques and Tools, Benchmark E

05. Analyze problem situations involving measurement concepts, select appropriate strategies and use an organized approach to solve narrative and increasingly complex problems.

Grade 8

Use Measurement Techniques and Tools, Benchmark B

4. Derive formulas for surface area and volume and justify them using geometric models and common materials. For example, find the following:
   - the surface area of a cylinder as a function of its height and radius
   - that the volume of a pyramid (or cone) is one-third of the volume of a prism (or cylinder) with the same base area and height

Materials

- Calculator
- Storing the Corn student handout

Procedure

1. Divide the students into groups of two or three.
2. Review the following concepts:

   a. The volume of a cylinder is π x height x radius x radius. (The radius is ½ of the diameter.)

   b. The volume of a cone is ⅓ height x π x radius x radius.

   or $$\frac{\pi \cdot r \cdot r \cdot h}{3}$$

   c. There are 12 inches in a foot. It is easier to do the conversion at the beginning of the lesson than to convert from cubic feet to cubic inches.
3. Have each group of students compute the calculations on the handout. This is a difficult assignment, so you might want to review the concepts again.
4. **Enhancement:** You could bring in your own corn for measurement. This gives one additional hands-on activity, but you would then have to check the calculations yourself or give the papers to another group to check.

Evaluation

Cubic inches of corn produced	15
Conversions from feet to inches	5
Volume of the cylinder	5
Volume of the top cone	5
Total volume of the silo	5
Correct number of silos	5
Total	**40 pts.**

New McDonald's Farm — Storing the Corn

(Student Handout)

Names ____

Whew! You just got finished planting and harvesting all of that corn. What in the world are you going to do with it? You decide you're going to have drying silos built. These are silos with open spaces so the cob will dry while it's being stored. How many silos are you going to need for the corn you grew in lesson one?

One acre of corn held about 22,000 corn plants. There are about 37 acres of land. How many silos will you build?

One acre of corn held about 22,000 corn plants. There are about 37 acres of land. The mean measure of an ear of corn is 15 cubic inches. What is the volume of the corn produced?

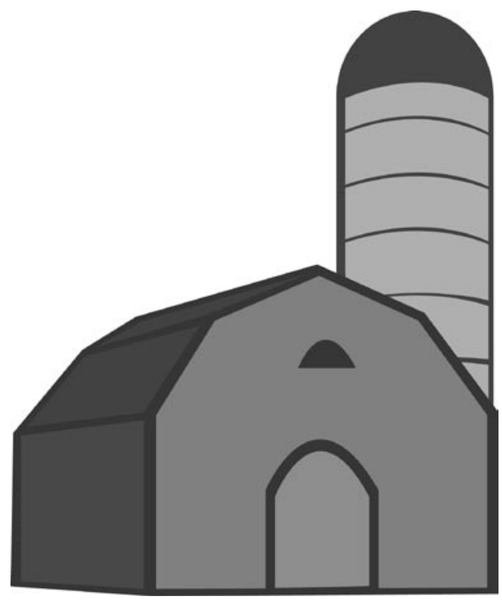
Silo Dimensions

Diameter = 16 feet or________ inches

Radius = ________ feet or________ inches

Height of cylinder = 30 feet or________ inches

Height of cone = 4 feet or _________ inches



Directions (please show all work):

1. Find the volume of the silo

   a. Volume of cylinder = __________

   b. Volume of top cone = __________

   c. Total volume of silo = __________

How many silos do you need to have built? _________ Explain your answer.

New McDonald's Farm — Storing the Corn
(Answer Key)

Whew! You just got finished planting and harvesting all of that corn. What in the world are you going to do with it? You decide you're going to have drying silos built. These are silos with open spaces so the cob will dry while it's being stored. How many silos are you going to need for the corn you grew in lesson one?

One acre of corn held about 22,000 corn plants. There are about 37 acres of land. How many silos will you build?

One acre of corn held about 22,000 corn plants. There are about 37 acres of land. The mean measure of an ear of corn is 15 cubic inches. What is the volume of the corn produced?

22,000 plants x 37 acres x 15 cubic inches = 12,210,000 cubic inches of corn produced

Silo Dimensions

Diameter = 16 feet or 192 inches

Radius = 8 feet or 96 inches

Height of cylinder = 30 feet or 360 inches

Height of cone = 4 feet or 48 inches

Directions (please show all work):

1. Find the volume of the silo

   a. Volume of cylinder = 10,417,766 cubic inches
   volume of cylinder = π x radius^2 x height
   3.14 x 96 x 96 x 360 = 10,417,766 cubic inches

   b. Volume of top cone = 463,011 cubic inches
   volume of cone = (4π x radius^2 x height)/3
   (3.14 x 96 x 96 x 48)/3 = 463,011 cubic inches

   c. Total volume of silo = 10,880,777 cubic inches

How many silos do you need to have built? Two. Explain your answer.

Each silo will hold 10,880,777 cubic inches of corn. The field produced 12,210,000 cubic inches of corn. You will need to buy two silos to have all of the corn fit.

New McDonald's Farm — Selling the Corn

Overview

In this lesson, students learn how to compute both surface area and volume for a container that will be used to process a product made from corn.

Outcome

Students will understand and calculate both surface area and volume.

Standards Addressed — Mathematics

Grade 5

Measurement Units, Benchmark F

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.

Measurement Units, Benchmark G

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.

Grade 6

Measurement Units, Benchmark F

01. Understand and describe the difference between surface area and volume.

Measurement Units, Benchmark G

01. Understand and describe the difference between surface area and volume.

Use Measurement Techniques and Tools, Benchmark E

04. Determine which measure (perimeter, area, surface area, volume) matches the context for a problem situation; e.g., perimeter is the context for fencing a garden, surface area is the context for painting a room.

Grade 7

Use Measurement Techniques and Tools, Benchmark A

05. Analyze problem situations involving measurement concepts, select appropriate strategies and use an organized approach to solve narrative and increasingly complex problems.

Use Measurement Techniques and Tools, Benchmark F

09. Describe what happens to the surface area and volume of a three-dimensional object when the measurements of the object are changed; e.g., length of sides are doubled.

Grade 8

Use Measurement Techniques and Tools, Benchmark B

4. Derive formulas for surface area and volume and justify them using geometric models and common materials. For example, find the following:
   - the surface area of a cylinder as a function of its height and radius

Materials

- Cereal box or round cereal container
- Paper to cover the boxes
- Markers or crayons
- Cereal (to be used to measure weight)
- Selling the Corn student handout

Procedure

1. Students should have a partner or be in a group of three.
2. Each group needs a cereal box or a round cereal container. This will be the container for their new product.
3. They must first find the volume of the container.
4. Then they must find the surface area. They can do this by covering each of the sides or the outside of the cylindrical container.
5. They may name their cereal and decorate the box.
6. Using some type of corn cereal that you have in the classroom, they can fill the container and find the weight (mass).
7. If you feel the students need some help in understanding the concept, a master list of measurements could be kept so that the formulas could be generated using the data gathered.
8. Have another group check the work of each group and sign the assignment sheet.
9. **Extension:** Have a corn festival. Have each group make a corn dish to pass. The items can be made at home or at school. Recipes can be put into a book to be shared with the class. Creation of the recipe book could be an extra-credit project. Some recipe sources are:

   www.basic-recipes.com/veget/cn/

   http://whatscookingamerica.net/vegetables/cornrecipes.htm

   www.doityourself.com/stry/cornrecipes

Evaluation

Measurement

Volume measure is accurate.	10 points
Surface area measure is accurate.	10 points
Weight of the cereal is accurate.	10 points

Container

Container is creative.	10 points
Group worked together effectively.	10 points
TOTAL	**50 points**

New McDonald's Farm — Selling the Corn
(Student Handout)

Names ______________________________

Corn, corn, corn! We planted it; we stored it. Now it's time to sell it and make a nice little profit. Your job is to create a new cereal with corn as the main ingredient. This will be "virtual" cereal, so you can be as creative as you like.

Here's the job:

1. Use a cereal or oatmeal box as a container. With your partner, find the volume of the box.
2. Now make a new cover for the box. That will require finding the surface area. Use your creativity and paper, markers and glue to make the cover something that people would like to buy.
3. When your cover is complete, paste it on. Then use cereal and weigh the box both separately and with cereal in it. Subtract the weight of the box and list the weight of the cereal (only) on your cover.

Evaluation

Measurement

Volume measure is accurate.	10 points
Surface area measure is accurate.	10 points
Weight of the cereal is accurate.	10 points

Container

Container is creative.	10 points
Group worked together effectively.	10 points
TOTAL	**50 points**

Cereal Box: Please show how you got the volume and surface area.

Length ________ Width ________ Height ________

Volume = ______________________________

Surface Area = ______________________________

Oatmeal Box: Please show how you got the volume and surface area.

Diameter ____________ Height ____________

Volume = ______________________________

Surface Area = ______________________________

Measurement checkers (sign here): ______________________________

BIG OR SMALL: measure it all!

landfill

The Edible Landfill

Overview

Students create an edible landfill. Each layer of the landfill corresponds to a layer of a sanitary landfill. Students note the role of each layer of the landfill and see the comparison with the edible landfill. They also enjoy the tasty fruits of their labor at the end of class.

Outcome

Students will learn how a landfill is built.

Materials

- Square or rectangular dishes with 2" sides
- Graham crackers (crushed)
- Vanilla wafers (crushed)
- Fruit leathers (such as Fruit Roll-ups)
- Licorice (red or black)
- Vanilla pudding (pudding snack packs)
- Chocolate pudding (pudding snack packs)
- Coconut (dye with green food color)
- M&Ms (represent waste)
- Chocolate chips (represent waste)
- Oreo cookies (represent dirt)
- Marshmallows (represent plastic waste)
- Raisins (represent waste)
- Large serving spoon
- Paper plates
- Spoon for each student
- The Edible Landfill student handout

Procedure

1. Have the students discuss what happens to garbage in the school and in the neighborhood. Ask if they know what happens after the garbage is carried away. Discuss packaging of everyday products.
2. Distribute copies of the Typical Anatomy of a Landfill handout and review it.
3. Explain to the students that they will be creating an edible landfill. The layers of the edible landfill will represent the layers of a real landfill.
4. Before proceeding, determine if this lesson might affect any students who have food allergies.
5. Divide the students into groups. Give each group a clear dish.
6. Have the students spread a layer of graham cracker crumbs in the bottom of the dish. This represents the clay liner that prevents liquids (or leachate) from seeping through to the groundwater.

7. The next layer is fruit leathers, which represents the plastic liner. The plastic liner creates a barrier and prevents any liquid or trash from touching the ground.
8. Have the students place licorice horizontally on top of the fruit leathers to represent the leachate collection system.
9. The next layer is crushed vanilla wafers, which represent the sand and gravel layers.
10. A thin layer of the vanilla pudding topped with M&Ms, chocolate chips and raisins completes the first layer of solid waste.
11. A thin layer of chocolate pudding represents the soil used to cover the waste daily.
12. Have the students repeat alternating layers of vanilla and chocolate pudding, ending with a top layer of chocolate pudding.
13. Finally, they can sprinkle green coconut over the top of the chocolate pudding. This represents grass planted to prevent erosion.
14. The edible landfills may be chilled or eaten immediately.
15. **Extension:** If multiple dishes were used, compare the differences in area and perimeter. Have students calculate the volume of the edible landfill. Have students calculate the volume of each layer of the landfill.

Evaluation

Fill in the blanks (5 points each)	20 points
Area diagram with correct scale	25 points
Side view of landfill	25 points
Listing of layers of landfill	25 points
Bonus (use of color/clarity of drawing)	5 points
TOTAL	**100 points**

Typical Anatomy of a Landfill

Protective Cover

1 Cover Vegetation
As portions of the landfill are completed, native grasses and shrubs are planted and the areas are maintained as open spaces. The vegetation is visually pleasing and prevents erosion of the underlying soils.

2 Top Soil
Helps to support and maintain the growth of vegetation by retaining moisture and providing nutrients.

3 Protective Cover Soil
Protects the landfill cap system and provides additional moisture retention to help support the cover vegetation.

Composite Cap System

4 Drainage Layer
A layer of sand or gravel or a thick plastic mesh called a geonet drains excess precipitation from the protective cover soil to enhance stability and help prevent infiltration of water through the landfill cap system. A geotextile fabric, similar in appearance to felt, may be located on top of the drainage layer to provide separation of solid particles from liquid. This prevents clogging of the drainage layer.

5 Geomembrane
A thick plastic layer forms a cap that prevents excess precipitation from entering the landfill and forming leachate. This layer also helps to prevent the escape of landfill gas, thereby reducing odors.

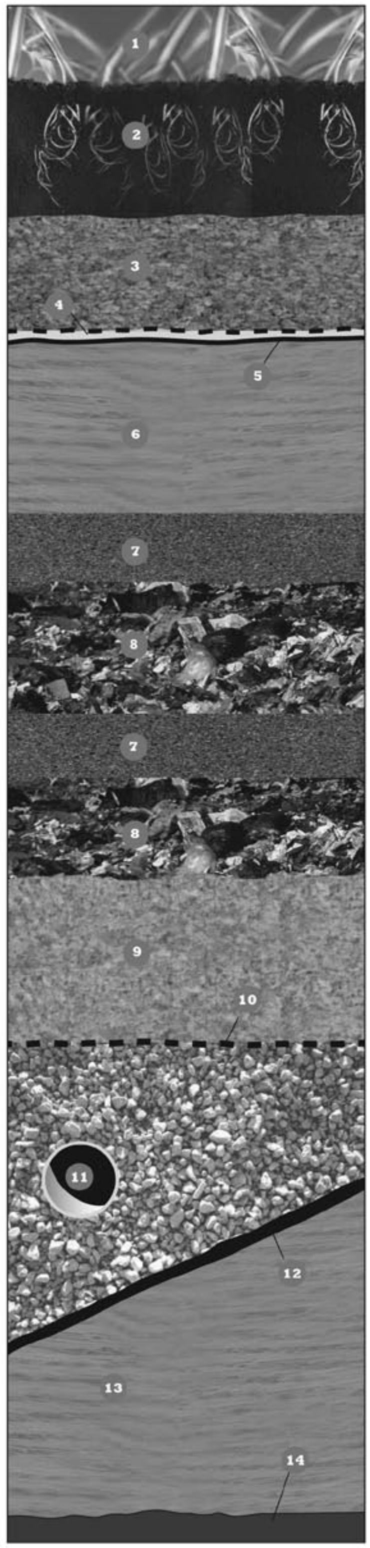
6 Compacted Clay
Is placed over the waste to form a cap when the landfill reaches the permitted height. This layer prevents excess precipitation from entering the landfill and forming leachate and helps to prevent the escape of landfill gas, thereby reducing odors.

Working Landfill

7 Daily Cover
At the end of each working period, waste is covered with six to twelve inches of soil or other approved material. Daily cover reduces odors, keeps litter from scattering and helps deter scavengers.

8 Waste
As waste arrives, it is compacted in layers within a small area to reduce the volume consumed within the landfill. This practice also helps to reduce odors, keeps litter from scattering and deters scavengers.

Please Note: This illustration depicts a cross section of the standard environmental protection technologies of modern landfills. While the technologies used in most landfills are similar, the exact sequence and type of materials may differ from site to site depending on design, location, climate and underlying geology.



(Not to scale)

Leachate Collection System

Leachate is a liquid that has filtered through the landfill. It consists primarily of precipitation with a small amount coming from the natural decomposition of the waste. The leachate collection system collects the leachate so that it can be removed from the landfill and properly treated or disposed of. The leachate collection system has the following components:

9 Leachate Collection Layer
A layer of sand or gravel or a thick plastic mesh called a geonet collects leachate and allows it to drain by gravity to the leachate collection pipe system.

10 Filter Geotextile
A geotextile fabric, similar in appearance to felt, may be located on top of the leachate collection pipe system to provide separation of solid particles from liquid. This prevents clogging of the pipe system.

11 Leachate Collection Pipe System
Perforated pipes, surrounded by a bed of gravel, transport collected leachate to specially designed low points called sumps. Pumps, located within the sumps, automatically remove the leachate from the landfill and transport it to the leachate management facilities for treatment or another proper method of disposal.

Composite Liner System

12 Geomembrane
A thick plastic layer forms a liner that prevents leachate from leaving the landfill and entering the environment. This geomembrane is typically constructed of a special type of plastic called high-density polyethylene or HDPE. HDPE is tough, impermeable and extremely resistant to attack by the compounds that might be in the leachate. This layer also helps to prevent the escape of landfill gas.

13 Compacted Clay
Is located directly below the geomembrane and forms an additional barrier to prevent leachate from leaving the landfill and entering the environment. This layer also helps to prevent the escape of landfill gas.

14 Prepared Subgrade
The native soils beneath the landfill are prepared as needed prior to beginning landfill construction.

WASTE MANAGEMENT

www.wm.com

The Edible Landfill (Student Handout)

Name______________________________ Date ______________

You created an edible landfill! Before you eat the landfill, take some measurements.

The dish the landfill is in is _________ inches wide by _________ inches long.

The perimeter of the dish is _________ inches.

The area of the dish is _________ square inches.

On the graph paper, draw the landfill the way it looks from above.

Each square represents one inch.

Draw the landfill the way it looks from the side.
Each square represents one inch.

Label each of the layers of the landfill. Below, write what food is in the layer.

Then write what material in a real landfill the food represents. You might not use all the lines.

Top layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Bottom layer: *Food:* ______________________________

Represents in a real landfill: ______________________

Design a Landfill for Your School

Overview

The premise of the activity is that teachers at your school want to have a small sanitary landfill built on school grounds. The students in your class have been chosen to design the landfill for your school.

Outcome

Students will understand how to calculate surface area and perimeter measurements.

Standards Addressed — Mathematics

Grade 4

Measurement Units, Benchmark C

02. Demonstrate and describe perimeter as surrounding and area as covering a two-dimensional shape, and volume as filling a three-dimensional object.

Use Measurement Techniques and Tools, Benchmark D

04. Develop and use strategies to find perimeter using string or links, area using tiles or a grid and volume using cubes; e.g., count squares to find area of regular or irregular shapes on a grid, layer cubes in a box to find its volume.

06. Write, solve and verify solutions to multi-step problems involving measurement.

Grade 6

Measurement Units, Benchmark F

01. Understand and describe the difference between surface area and volume.

Use Measurement Techniques and Tools, Benchmark E

04. Determine which measure (perimeter, area, surface area, volume) matches the context for a problem situation; e.g., perimeter is the context for fencing a garden, surface area is the context for painting a room.

Materials

- Graph paper
- Tape
- Markers and colored pencils
- Design a Sanitary Landfill student handout

Procedure

1. Students can work in groups, pairs or alone.
2. Explain to students that they will design a landfill.
3. Distribute copies of the handout and graph paper.
4. Students may tape together several pieces of graph paper in order to have enough squares.

5. Check students' progress.
6. When they have finished, have them share their drawings.
7. List the landfill sizes on the board.
8. Determine if any students have landfills with the same area and/or the same perimeter.
9. Challenge students to generate rules (formulas) for finding area and perimeter of rectangles.
10. Collect designs. Students will need them for the next lesson.
11. **Extension #1**: Discuss the concept that rectangles may have the same area, but different perimeters.
12. **Extension #2**: Suggest that rectangles may have the same perimeter, but different areas.
13. **Extension #3**: Challenge students to find the length or width of a rectangle if they are only given either the length or width.

Evaluation

The shape of the landfill is a rectangle.	10 points
The landfill is at least 120 square feet but no more than 180 square feet.	10 points
There is a fence around the landfill.	10 points
The measurements are correct on the handout.	25 points
The sanitary landfill meets all criteria.	25 points
TOTAL	**80 points**

Design a Landfill for Your School
(Student Handout)

Name ______________________________ Date: ______________

To teach students about waste management, the teachers at your school want to have a small sanitary landfill built on school grounds. The students in your classroom have been chosen to design the landfill for your school.

- Your landfill must be at least 120 square feet. It may not be more than 180 square feet.
- The landfill must be a rectangle.
- It needs to have a leachate collection system. Leachate is liquid waste. The collection system consists of pipes with tiny holes in them to collect the leachate as it drains through the sanitary landfill.
- A fence must surround your landfill.

Today you will design the outline of your landfill.

Directions

1. Think about how big you want your landfill to be. Each square on the graph paper equals 1 foot.
2. Use a black marker to draw the outline of the sanitary landfill on the graph paper. This outline is the fence around the landfill.
3. Lightly shade in the squares inside the fence.
4. Draw the leachate collection system (pipes). Start in one corner of the landfill and draw the pipes. The pipes must cross each square and may not cross over each other. You will need to zigzag back and forth.

Checklist

__________ The shape of the landfill is a rectangle.

__________ The landfill is at least 120 square feet.

__________ The landfill is no more than 180 square feet.

__________ There is a fence around the landfill.

Measurements

The perimeter (length of the fence) of the landfill is ________________ feet.

The landfill is ______________ feet wide and ___________________ feet long.

The area of the landfill is ________________ square feet.

The total length of the leachate collection pipe is _________________ feet.

Fill It Up — Design a Landfill

Overview

In the last lesson, students designed the outline of the landfill. In this lesson, they add the required layers to a working landfill. They design a cross-section of the the landfill, as if they were looking at it from the side.

Outcome

Students will understand how to measure length, width and depth, and calculate volume.

Standards Addressed — Mathematics

Grade 4

Measurement Units, Benchmark C

02. Demonstrate and describe perimeter as surrounding and area as covering a two-dimensional shape, and volume as filling a three-dimensional object.

Use Measurement Techniques and Tools, Benchmark D

04. Develop and use strategies to find perimeter using string or links, area using tiles or a grid and volume using cubes; e.g., count squares to find area of regular or irregular shapes on a grid, layer cubes in a box to find its volume.

06. Write, solve and verify solutions to multi-step problems involving measurement.

Grade 6

Measurement Units, Benchmark F

01. Understand and describe the difference between surface area and volume.

Materials

- Colored pencils and markers
- Completed drawings from The Edible Landfill lesson
- Graph paper
- Typical Anatomy of a Landfill student handout
- Fill It Up: Design a Landfill student handout
- Sanitary Landfill: Final Report student handout

Procedure

1. Pass out copies of the handout Typical Anatomy of a Landfill and review it with students.
2. Have the students draw layers two through 14. These are the layers in a working landfill.
3. Explain to students that in the previous lesson, they designed the landfill as if they were looking down on it. In this lesson, they will be looking at a cross section, or side, of the landfill.
4. Pass out copies of the Fill It Up: Design a Landfill handout.
5. Review the directions.

6. Monitor students as they begin to draw their landfills. Remind them that they are adding length, width and depth.

7. When students have finished, have them share their drawings.

8. Distribute copies of the Sanitary Landfill: Final Report handout. Students should record their measurements. Alternatively, students could record their measurements as they draw them. Tell them to leave the volume column blank for now.

9. Discuss how the volume might be calculated. Have students generate strategies for getting the volume.

10. Have students calculate the volume of each layer to complete their reports.

11. **Extension:** Ask groups of students to use their understanding of ratio and proportion to draw murals of their sanitary landfill designs. Murals could show aerial views and side views of landfills.

Evaluation

Assess each student's understanding by checking handouts. The depth of the landfill is 12 feet, but the volume will vary according to the length and width of each student's design.

Wrote the length, width and volume of each of eight areas (3 points each).	24 points
Wrote the length, width and area of two areas (3 points each).	6 points
Final measurements of the landfill (3 points each).	12 points
TOTAL	**42 points**

Fill It Up — Design a Landfill (Student Handout)

Name______________________________

You have designed the outline of your landfill. Now you need to add the required layers to have a working landfill. In the last lesson, your design showed what your landfill would look like if you were looking at it from above. In your drawing today, you will design the cross section of your landfill, as if you were looking at it from the side.

Directions

1. Look at the drawing of your landfill. What is the length of your landfill? ____________________ .
2. Remember that each square on the graph paper represents 1 foot. Near the bottom of the graph paper, draw a line that represents the length of your landfill. The line should be the same number of squares long as your drawing.
3. From each end of the line, draw a line up. These lines are the sides of your landfill.
4. Now you are ready to add the layers of your landfill. Remember that each square represents 1 foot. Each layer must be a certain depth. When you add a layer, record how much material you added.
5. Use colored pencils to show each layer.

Layers of the landfill

1. Draw the bottom layer of compacted clay. It is 2 feet (or two squares) deep. Color it brown.
2. On the line above the clay, use a black marker to draw the plastic liner.
3. Draw the sand and gravel layer. It is 1 foot deep. Color it tan.
4. Oh no! Some students dumped 2 feet of waste on your landfill. Draw in the waste and color it red.
5. You need to cover the waste with soil. The soil is 1 foot deep. Color it grey.
6. Another 2 feet of waste has been dumped in your landfill. Draw in the waste and color it red.
7. Cover this waste with soil. The soil is 1 foot deep. Color it grey.
8. You have decided to close the landfill. Use a black marker to draw a line on top of the last layer. This line represents a drainage layer for the landfill.
9. Cover the drainage layer with a layer of protective soil. This layer is 2 feet deep. Draw the soil and color it tan.
10. Cover this layer of protective soil with topsoil. This layer is 1 foot deep. Draw the layer and color it brown.
11. Complete your final report about your sanitary landfill.

Sanitary Landfill: Final Report

Name ______________________________ Date: ____________

Layer	Length	Width	Depth	Volume
Topsoil	______	______	______	______
Protective soil	______	______	______	______

Drainage layer Length ________ Width ________ Area ________

Layer	Length	Width	Depth	Volume
Soil	______	______	______	______
Waste	______	______	______	______
Soil	______	______	______	______
Waste	______	______	______	______
Sand and gravel	______	______	______	______

Plastic liner Length________ Width ________ Area________

Layer	Length	Width	Depth	Volume
Clay	______	______	______	______

Landfill Measurements:

Length ______ Width________ Depth________ Volume________

Cover It Up and Keep It Green

Overview

Students have looked at creating a landfill in the previous lessons. In this lesson they have to "cap" it. They first determine how many times they need to pass the grass seeder over their fill. The second part asks them to determine how many sprinkling systems they need to keep the grass green.

Outcome

Students will understand how to calculate the area of rectangles and circles.

Standards Addressed — Mathematics

Grade 4

Measurement Units, Benchmark A

03. Identify and select appropriate units to measure the following:
    - perimeter – string or links (inches or centimeters)
    - area – tiles (square inches or square centimeters)
    - volume – cubes (cubic inches or cubic centimeters)

Grade 6

Use Measurement Techniques and Tools, Benchmark C

02. Use strategies to develop formulas for finding circumference and area of circles, and to determine the area of sectors.

03. Estimate perimeter or circumference and area for circles, triangles and quadrilaterals, and surface area and volume for prisms and cylinders by estimating lengths using string or links, areas using tiles or grid and volumes using cubes.

Materials

- Graph paper (two sheets per student)
- Compass
- Tape measures or string
- Scissors
- Landfill design from the previous lesson (area and perimeter)
- Cover It Up student handout
- Keep It Green student handout (for Grade 6)

Procedure

1. Students will need the landfill designs from the previous lesson.
2. Distribute the Cover It Up student handout.
3. Review the handout, discuss the task and discuss how the task can be accomplished.
4. When students finish, have them share their findings.
5. Sixth grade students can review parts of a circle and vocabulary associated with circles including circumference, diameter, radius and sector. They should review the amount of degrees in ¼ circle, ½ circle and ⅔ circle.

6. Distribute the Keep It Green handout and discuss the task.

7. Review the relationship between the diameter of a circle and its circumference. (The circumference is about three times the diameter.)

Evaluation

Cover It Up

Area of landfill	5 points
Number of passes with seeder	10 points
Explanation of seeder	5 points
How far traveled	10 points
Explanation of distance	20 points
TOTAL	**50 points**

Keep It Green

Landfill correctly placed on grid	10 points
Correct circumference of circle	10 points
Area of circle	10 points
Area of $\frac{1}{2}$ circle	5 points
Area of $\frac{1}{4}$ circle	5 points
Area of $\frac{1}{3}$ and $\frac{2}{3}$ circle	10 points
TOTAL	**50 points**

Keep It Green (Student Handout)

Names ______________________________

Now that you have planted grass, you need to water it to help it grow.

The sprinkler sprays water in a circle. With the sprinkler at the center of the circle, the spray reaches 4 feet.

Directions

1. On grid paper, copy the outline of your landfill. Remember each square on the grid paper is 1 foot.
2. On another piece of grid paper, use a compass to draw a circle that represents the spray of the sprinkler. How many squares long is the spray? This is the radius.
3. Remember the sprinkler sprays in a circle. How many squares wide is the circle? This is the diameter.
4. Use string or a tape measure to measure the distance around the circle. This is the circumference. About how many inches around is the circle? By about what amount would you need to multiply the diameter to get the circumference?
5. Use scissors to cut the circle out. Lay the circle on top of your landfill's outline. About how many sprinklers would you need to spray the landfill?
6. Fold your circle in half. Determine the area of half of the circle.
7. Fold the circle in half again. You now have ¼ of the circle. What is the area of this part of the circle?
8. Determine how you would find the area of ⅓ and ⅔ of a circle. Explain your method.

Cover It Up (Student Handout)

Names ____

You have closed the landfill and the principal wants to use the space for a small park. You will need to plant grass seed and water the seed so the grass will grow.

You will start by planting the grass seed.

1. Look at your first drawing of your landfill.

2. The length of the landfill is ___________. The width of the landfill is ___________. The area of the landfill is ___________.

3. The grass seed spreader is 12 inches wide. You need to plant grass over the landfill. How many passes with the spreader will you need to make to cover the landfill?

   ____

4. Explain how you found the answer.

   ____

   ____

   ____

   ____

5. When you have finished planting the grass seed, how far will you have traveled? ___________ feet.

6. Explain how you found the answer.

   ____

   ____

   ____

   ____

BIG OR SMALL: measure it all!

amusement park arcade

The Excellent Estimator

Overview

The classroom turns into a measurement arcade with activities at different stations around the room. Students estimate the requested measurement and then actually measure it and record the results. A contest could be held to determine the best estimator.

Outcome

Students will practice estimation skills and calculate weight, distance, area, volume and time.

Standards Addressed — Mathematics

Grade 3

Use Measurement Techniques and Tools, Benchmark C

05. Estimate and measure length, weight and volume (capacity), using metric and U.S. customary units, accurate to the nearest or unit as appropriate.

Grade 4

Use Measurement Techniques and Tools, Benchmark B

05. Make simple unit conversions within a measurement system; e.g., inches to feet, kilograms to grams, quarts to gallons.

Grade 5

Use Measurement Techniques and Tools Benchmark B

05. Make conversions within the same measurement system while performing computations.

Grade 6

Use Measurement Techniques and Tools, Benchmark E

04. Determine which measure (perimeter, area, surface area, volume) matches the context for a problem situation.

Materials

- Sponge Squeeze: sponge, scale, bucket of water, deep dish to be used on the scale, paper towels to dry the dish
- Car Push: toy cars, tape measure or yard stick
- Shoe Size Challenge: centimeter graph paper
- Building Volume Contest: box, cube
- Time Trial: music audiotape, tape recorder, stopwatch or clock with second hand
- The Excellent Estimator student handout

Procedure

1. Cut apart the game instructions. Post one at each of five stations, as indicated in step four below.
2. Divide the students into pairs.

3. Give each student an Excellent Estimator student handout. Have them fill out the handout as they go along.

4. Go over each station with the students and give specific directions about each contest, as follows:

   a. *Sponge Squeeze*: Students wring out a sponge that is sitting next to a pail of water. They then estimate and record how much they think the water that is captured by the sponge will weigh. They should dip the sponge in the pail and then wring it out into a dish and weigh it to get the actual weight of the water in grams.

   b. *Car Push*: Students put a toy car on a table. They make an estimate of how far they can push the car. They then push the car and record how far it went in centimeters. This needs to be measured in a straight line from the starting point.

   c. *Shoe Size Challenge*: Students are given a sheet of centimeter graph paper. They need to estimate the area of their shoe in square centimeters. Then they draw the bottom of their shoe on the graph paper and get a closer estimate of the actual area.

   d. *Building Volume Contest*: Place a box and a cube on the table. Students need to estimate how many cubic inches or centimeters (depending on what type of cube you have to set next to the box) are in the box. Then will then measure the length, width and height of the box using the cube as a measuring tool and find the actual volume of the box.

   e. *Time Trial*: Have a tape recorder handy with a piece of music that is approximately 30 seconds in length. Have the students listen to the music, estimate the amount of time that the music played and record their answers. Then they should listen a second time and measure the time using a stopwatch or the second hand on a clock. A 30-second clip of music is available on the Web site for ***Big or Small: Measure It All***.

5. Once handouts have been filled in, students should find the differences between the estimates and the actual measurements.

6. A prize could be given in each category for the person who was the best estimator in that area. Discuss with the students if they would like to add all of the differences together.

Evaluation

Category	**4**	**3**	**2**	**1**
Completion of Required Sections	All required activities are complete.	One required activity is missing.	Two or three required activities are missing.	More than three required activities are missing.
Organization	Records were kept for all activities.	Records were kept for four or three activities.	Records were kept for only two activities.	One or no records were kept for the activity.
Cooperation	Worked well with partner(s) at all times.	Generally worked well with partner, but had some disagreement or "down time."	Had difficulty staying on task or getting along with partner(s).	Had difficulty staying on task or getting along with partners and distracted other students.

Game Instructions

Sponge Squeeze

1. Wring the sponge out before you begin. Make sure there is no water in it.
2. Dip the sponge in the bucket and try to soak up as much water as possible.
3. Wring the sponge out into the dish that is provided.
4. Estimate the weight (mass) in grams of that amount of water squeezed from the sponge and record the estimate on the record sheet.
5. Weigh the container with the water and record the weight (mass) in grams.
6. Calculate the difference between your estimate and the actual weight.

Car Push

1. On the table are a meter stick and a car.
2. Estimate in centimeters how far you can push the car down the meter stick and write your estimate on the record sheet.
3. Without picking the car up, give it a push.
4. Measure how far you pushed the car. The measurement needs to be in a straight line from the starting point. Record your measure in centimeters on the record sheet.
5. Calculate the difference between your estimate and the actual distance.

Shoe Size Challenge

1. Look at the bottom of your shoe. Estimate the area of in square centimeters and record it on your record sheet.
2. Take a piece of cubic centimeter graph paper and trace around the bottom of your shoe. Use your estimation skills to calculate the area of the bottom of your shoe. (Count the full boxes you have covered and then calculate how many partial boxes you've used.)
3. Write this information on the record sheet.
4. Calculate and record the difference between your estimate and your calculated area.

Building Volume Contest

1. On the table is a box that has been made to look like a building and a centimeter cube.
2. Estimate the volume of the building (box) in cubic centimeters. Record the estimate on the record sheet.
3. Pick up the cube and measure the number of cubes in the height, length and width and calculate the volume of the building (box).
4. Record the calculated volume on the record sheet.
5. Calculate the difference between your estimate and your calculated volume.

Time Trial

1. On the table is a tape recorder with a music tape in it.
2. Listen to the tape and record how many seconds that you think the music played.
3. Record your estimate on the handout.
4. Listen to the taped music again and use a timer to record in seconds the actual length of time that the music played.
5. Record the actual time on your record sheet.
6. Calculate the difference between your estimate and the actual time that the music played.

The Excellent Estimator (Student Handout)

Name ____

1. Be sure to write your estimate before you complete the task.
2. Write the actual measurement.
3. Calculate the difference between the two. Use the absolute value for the difference OR take the smaller number from the larger number.
4. Be sure that you label the type of measurement, such as feet or square feet.

Game	Your Estimate	Actual	Difference
Sponge Squeeze			
Car Push			
Shoe Size Challenge			
Building Volume Challenge			
Time Trial			

BIG OR SMALL: measure it all!

the ohio state university football stadium

Game Day

Overview

Students conduct measurement activities that are based on scenarios that take place during an Ohio State football game.

Outcome

Students will understand how to compare and convert customary units of measure, and construct problems using measurement skills.

Standards Addressed — Mathematics

Grade 6

Measurement Units, Benchmark F

01. Understand and describe the difference between surface area and volume.

Use Measurement Techniques and Tools, Benchmark E

04. Determine which measure (perimeter, area, surface area, volume) matches the context for a problem situation; e.g., perimeter is the context for fencing a garden, surface area is the context for painting a room.

Use Measurement Techniques and Tools, Benchmark F

06. Describe what happens to the perimeter and area of a two-dimensional shape when the measurements of the shape are changed; e.g. length of sides are doubled.

Use Measurement Techniques and Tools, Benchmark G

05. Understand the difference between perimeter and area, and demonstrate that two shapes may have the same perimeter, but different areas or may have the same area, but different perimeters.

Materials

- Background Information Cards
- Problem Cards
- O.S.U. Stadium Seating Chart

Procedure

1. Divide students into "home groups" of four members.
2. Give each student in each group a different Problem Card. This student will become an "expert" on that particular Game Day problem. Each student is therefore responsible for completing and understanding his or her Game Day problem and then sharing this knowledge with members of the home group.
3. Have the students regroup with other classmates who are experts for the same problems. Give each member of the expert group their corresponding Background Information Card.

4. Have the expert groups work together to solve their assigned problem.

5. After solving their problem, instruct each expert group to develop a new measurement problem based on their topic and Background Information Card.

6. Ask the students to return to their home groups. Have each expert take a turn to explain his or her Game Day problem and shares its solution.

7. Next, have each expert read the new problem that he or she created in the expert group, which the home group should then solve.

Evaluation

A two-part evaluation could be used:

1. A participation score could be assessed as expert groups work together to solve their Game Day Problem.

2. Problems created by expert groups could be evaluated for the content and concepts they represent.

Background Information Cards

Concession Stands

A typical game day concessions order might include:

60,000 hot dogs (six miles' worth, laid end to end)

10,000 bratwurst

70,000 buns

30,000 to 40,000 souvenir cups

15,000 soft pretzels

15,000 boxes of popcorn

8,000 packages of candy

The football field is 100 yards between goal lines and 160 feet between the side lines. There is a distance of 10 yards from the goal line to the posts.

Source: Ohio State Alumni Magazine/July-August, 2006

Stadium Design

Built in 1922, the horseshoe-shaped stadium of the Ohio State Buckeyes is located on the banks of the Olentangy River.

The football field is 100 yards between goal lines and 160 feet between the side lines. There is 10 yards from the goal line to the posts.

The stadium's capacity is 101,568 people.

Background Information Cards

Buckeye Leaves

The night before a home game, the players have dinner together and then stay at the Blackwell Inn on campus. This gives them a chance to relax and have a final meeting before going to sleep. During the game, players can earn buckeye leaf stickers for their helmets by demonstrating exceptional play, such as catching a pass for a touchdown, running a touchdown or blocking an opponent so that a teammate can score. The offensive players can all earn buckeye leaves if they keep the other team's score to below 10 points. This tradition of placing buckeye leaves on the helmets of Ohio State players started in 1968.

Block "O"

Built in 1922, the horseshoe-shaped stadium is located on the banks of the Olentangy River. Block "O" is the student pep section located on the south side of the horseshoe. Members meet on Thursday to review their cheers and stunt card maneuvers. Pep members sort through the reams of colored paper they will display creating designs by holding up different colored cards which can be seen from the opposite side of the stadium. Block "O" was formed in 1938. It is Ohio State's largest campus student organization.

Problem Cards

Concession Stands

What is the area of the field?

What is the perimeter of the field?

If 60,000 hot dogs laid end to end equal 6 miles, how many hot dogs would it take to go around the perimeter of the field?

If hot dogs were used to mark the yard lines, how many hot dogs would it take?

Stadium Design

What is the area of the field?

What is the perimeter of the field?

If you were to redesign the field, how could you change the shape of the field and keep the same area? Create several shapes maintaining the current area. Don't forget the end zones and yard markers.

Problem Cards

Buckeye Leaves

The surface area of a football helmet measures 400 square inches. The buckeye sticker measures ¾ inch. How many stickers could be placed on a helmet?

Design a new helmet sticker, changing its shape. How will it look? What size is it? How many would fit on a helmet?

Block “O”

Block “O” is 20 yards wide by 15 yards.

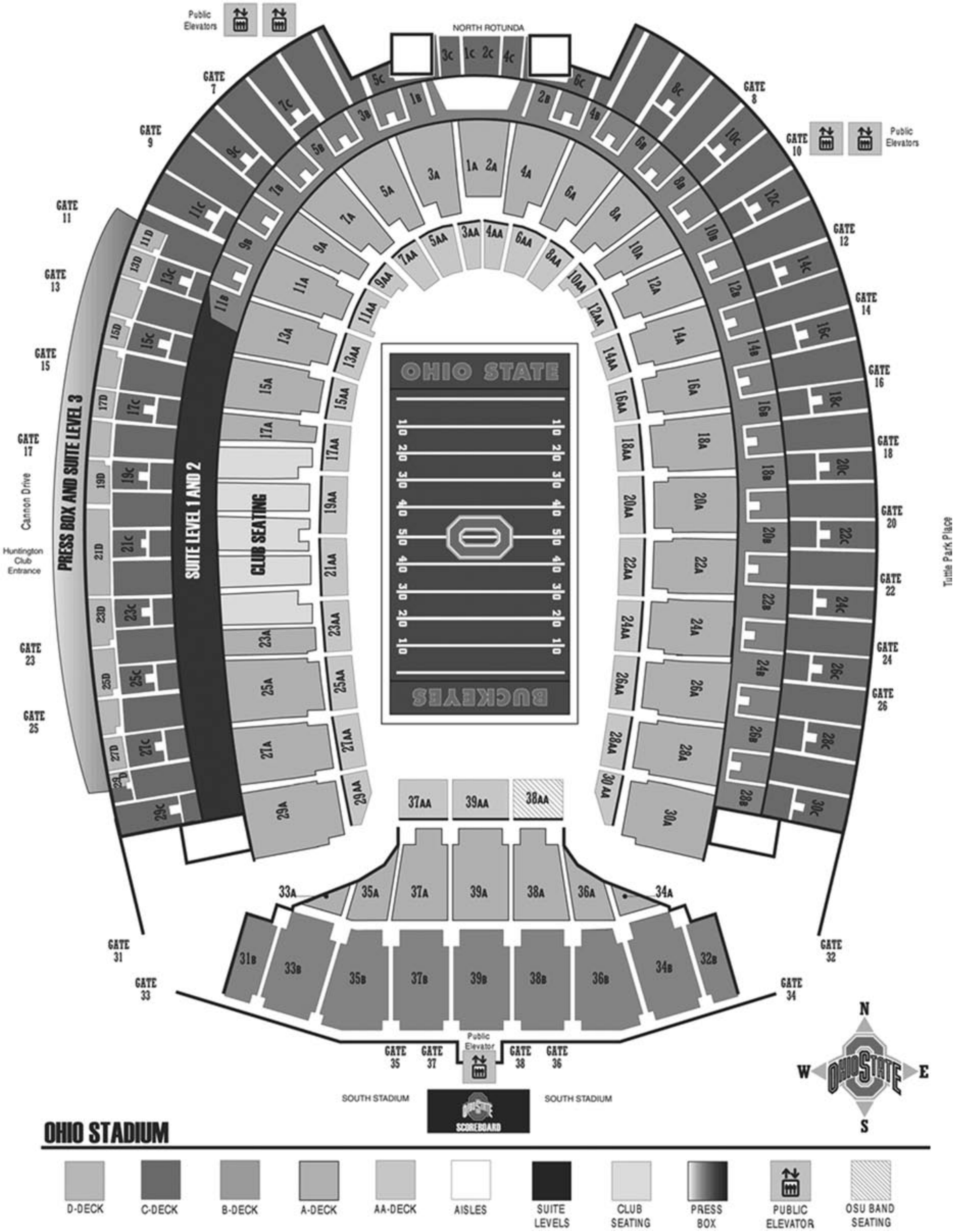
What is the perimeter of Block “O”?

What is the area of Block “O”?

Create a plan to fill the area of Block “O” with grid tiles (colored cards). What size tiles would you use?

What would your design be?

O.S.U. Stadium Seating Chart



BIG OR SMALL: measure it all!

standards addressed

Mathematics — Measurement Standards

Grade 3

03-04 Benchmark A: *Select appropriate units for perimeter, area, weight, volume (capacity), time and temperature, using:*

Measurement Units / Y2003.CMA.S02.G03-04.BA.L03.I01

01. Identify and select appropriate units for measuring the following:
    - temperature – degrees (Fahrenheit or Celsius)

Plop, Plop, Fizz, Fizz — Timing Race, p. 41

Measurement Units / Y2003.CMA.S02.G03-04.BA.L03.I04

04. Read thermometers in both Fahrenheit and Celsius scales.

Plop, Plop, Fizz, Fizz — Timing Race, p. 41

03-04 Benchmark E: *Tell time to the nearest minute.*

Measurement Units / Y2003.CMA.S02.G03-04.BE.L03.I03

03. Tell time to the nearest minute and find elapsed time using a calendar or a clock.

Think Time! p. 45

03-04 Benchmark C: *Develop common referents for units of measure for length, weight, volume (capacity) and time to make comparisons and estimates.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G03-04.BC.L03.I05

05. Estimate and measure length, weight and volume (capacity), using metric and U.S. customary units, accurate to the nearest or unit as appropriate.

The Excellent Estimator, p. 139

Grade 4

03-04 Benchmark A: *Select appropriate units for perimeter, area, weight, volume (capacity), time and temperature using:*

Measurement Units / Y2003.CMA.S02.G03-04.BA.L04.I03

03. Identify and select appropriate units to measure the following:
    - perimeter — string or links (inches or centimeters).
    - area — tiles (square inches or square centimeters).
    - volume — cubes (cubic inches or cubic centimeters).

Cover It Up and Keep It Green, p. 133

New McDonald's Farm — Planting the Corn, p. 107

New McDonald's Farm — Storing the Corn, p. 111

03-04 Benchmark *C: Develop common referents for units of measure for length, weight, volume (capacity) and time to make comparisons and estimates.*

Measurement Units / Y2003.CMA.S02.G03-04.BC.L04.I02

02. Demonstrate and describe perimeter as surrounding and area as covering a two-dimensional shape, and volume as filling a three-dimensional object.

Design a Landfill for Your School, p. 126

Fill It Up — Design a Landfill, p. 129

Measuring the Aircraft at Wright-Patterson — Cargo Carriers, p. 97

Wright-Patterson Air Force Base Measures Up — Making a Runway, p. 87

03-04 Benchmark *B: Know that the number of units is inversely related to the size of the unit for any item being measured.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G03-04.BB.L04.I05

05. Make simple unit conversions within a measurement system; e.g., inches to feet, kilograms to grams, quarts to gallons.

The Excellent Estimator, p. 139

Lift Off!, p. 69

Pegasus: A Myth About Flight, p. 22

Watch Out, NASCAR — Here Comes Our Car! p. 27

03-04 Benchmark *D: Identify appropriate tools and apply counting techniques for measuring side lengths, perimeter and area of squares, rectangles and simple irregular two-dimensional shapes, volume of rectangular prisms and time and temperature.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G03-04.BD.L04.I04

04. Develop and use strategies to find perimeter using string or links, area using tiles or a grid, and volume using cubes; e.g., count squares to find area of regular or irregular shapes on a grid, layer cubes in a box to find its volume.

Can Your Boat Float? p. 51

Design a Landfill for Your School, p. 126

Fill It Up — Design a Landfill, p. 129

Watch Out, NASCAR — Here Comes Our Car! p. 27

Use Measurement Techniques and Tools / Y2003.CMA.S02.G03-04.BD.L04.I06

06. Write, solve and verify solutions to multi-step problems involving measurement.

Design a Landfill for Your School, p. 126

Fill It Up — Design a Landfill, p. 129

Measuring the Aircraft at Wright-Patterson — Cargo Carriers, p. 97

New McDonald's Farm — Planting the Corn, p. 107

Wright-Patterson Air Force Base Measures Up — Making a Runway, p. 87

Grade 5

05-07 Benchmark E: *Use problem solving techniques and technology as needed to solve problems involving length, weight, perimeter, area, volume, time and temperature.*

Measurement Units / Y2003.CMA.S02.G05-07.BE.L05.I02

02. Identify paths between points on a grid or coordinate plane and compare the lengths of the paths; e.g., shortest path, paths of equal length.

I Want a Doughnut! p. 35

05-07 Benchmark F: *Analyze and explain what happens to area and perimeter or surface area and volume when the dimensions of an object are changed.*

Measurement Units / Y2003.CMA.S02.G05-07.BF.L05.I03

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.

Can Your Boat Float? p. 51

Measuring the Aircraft at Wright-Patterson — Cargo Carriers, p. 97

New McDonald's Farm — Selling the Corn, p. 115

05-07 Benchmark G: *Understand and demonstrate the independence of perimeter and area for two-dimensional shapes and of surface area and volume for three-dimensional shapes.*

Measurement Units / Y2003.CMA.S02.G05-07.BG.L05.I03

03. Demonstrate and describe the differences between covering the faces (surface area) and filling the interior (volume) of three-dimensional objects.

New McDonald's Farm — Selling the Corn, p. 115

New McDonald's Farm — Storing the Corn, p. 111

What Measure Will You Use? p. 62

Wright-Patterson Air Force Base Measures Up — Making a Runway, p. 87

Measurement Units / Y2003.CMA.S02.G05-07.BG.L05.I04

04. Demonstrate understanding of the differences among linear units, square units and cubic units.

Wright-Patterson Air Force Base Measures Up — Making a Runway, p. 87

05-07 Benchmark *B: Convert units of length, area, volume, mass and time within the same measurement system.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BB.L05.I05

05. Make conversions within the same measurement system while performing computations.

Balloon Design Challenge, p. 19

The Excellent Estimator, p. 139

How Much Do You Weigh on Other Planets? p. 73

Lift Off! p. 69

The Long, Winding Road, p. 31

Plop, Plop, Fizz, Fizz — Timing Race, p. 41

05-07 Benchmark *C: Identify appropriate tools and apply appropriate techniques for measuring angles, perimeter or circumference and area of triangles, quadrilaterals, circles and composite shapes, and surface area and volume of prisms and cylinders.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BC.L05.I06

06. Use strategies to develop formulas for determining perimeter and area of triangles, rectangles and parallelograms, and volume of rectangular prisms.

Sail Away, p. 57

Grade 6

05-07 Benchmark *F: Analyze and explain what happens to area and perimeter or surface area and volume when the dimensions of an object are changed.*

Measurement Units / Y2003.CMA.S02.G05-07.BF.L06.I01

01. Understand and describe the difference between surface area and volume.

Can Your Boat Float? p. 51

Design a Landfill for Your School, p. 126

Fill It Up — Design a Landfill, p. 129

Game Day, p. 147

New McDonald's Farm — Selling the Corn, p. 115

New McDonald's Farm — Storing the Corn, p. 111

05-07 Benchmark *G: Understand and demonstrate the independence of perimeter and area for two-dimensional shapes and of surface area and volume for three-dimensional shapes.*

Measurement Units / Y2003.CMA.S02.G05-07.BG.L06.I01

01. Understand and describe the difference between surface area and volume.

New McDonald's Farm — Selling the Corn, p. 115

New McDonald's Farm — Storing the Corn, p. 111

05-07 Benchmark *C: Identify appropriate tools and apply appropriate techniques for measuring angles, perimeter or circumference and area of triangles, quadrilaterals, circles and composite shapes, and surface area and volume of prisms and cylinders.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BC.L06.I02

02. Use strategies to develop formulas for finding circumference and area of circles, and to determine the area of sectors.

Cover It Up and Keep It Green, p. 133

New McDonald's Farm — Storing the Corn, p. 113

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BC.L06.I03

03. Estimate perimeter or circumference and area for circles, triangles and quadrilaterals, and surface area and volume for prisms and cylinders by performing the following:
    - estimating lengths using string or links, areas using tiles or grid, and volumes using cubes;
    - measuring attributes (diameter, side lengths, or heights) and using established formulas for circles, triangles, rectangles, parallelograms and rectangular prisms.

Cover It Up and Keep It Green, p. 133

Watch Out, NASCAR — Here Comes Our Car! p. 27

05-07 Benchmark *E: Use problem solving techniques and technology as needed to solve problems involving length, weight, perimeter, area, volume, time and temperature.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BE.L06.I04

04. Determine which measure (perimeter, area, surface area, volume) matches the context for a problem situation; e.g., perimeter is the context for fencing a garden, surface area is the context for painting a room.

Design a Landfill for Your School, p. 126

The Excellent Estimator, p. 139

Game Day, p. 147

The Long, Winding Road, p. 31

New McDonald's Farm — Planting the Corn, p. 107

New McDonald's Farm — Selling the Corn, p. 115

What Measure Will You Use? p. 62

05-07 Benchmark *F:* *Analyze and explain what happens to area and perimeter or surface area and volume when the dimensions of an object are changed.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BF.L06.I06

06. Describe what happens to the perimeter and area of a two-dimensional shape when the measurements of the shape are changed; e.g. length of sides are doubled.

Game Day, p. 147

05-07 Benchmark *G:* *Understand and demonstrate the independence of perimeter and area for two-dimensional shapes and of surface area and volume for three-dimensional shapes.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BG.L06.I05

05. Understand the difference between perimeter and area, and demonstrate that two shapes may have the same perimeter, but different areas or may have the same area, but different perimeters.

Can Your Boat Float? p. 51

Game Day, p. 147

Grade 7

05-07 Benchmark *A:* *Select appropriate units to measure angles, circumference, surface area, mass and volume.*

Measurement Units / Y2003.CMA.S02.G05-07.BA.L07.I01

01. Select appropriate units for measuring derived measurements; e.g., miles per hour, revolutions per minute.

The Long, Winding Road, p. 31

05-07 Benchmark *E:* *Use strategies to develop formulas for finding circumference and area of circles, and determine the area of sectors.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BE.L07.I05

05. Analyze problem situations involving measurement concepts, select appropriate strategies, and use an organized approach to solve narrative and increasingly complex problems.

New McDonald's Farm — Selling the Corn, p. 115

New McDonald's Farm — Storing the Corn, p. 111

05-07 Benchmark *F: Analyze and explain what happens to area and perimeter or surface area and volume when the dimensions of an object are changed.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G05-07.BF.L07.I09

09. Describe what happens to the surface area and volume of a three-dimensional object when the measurements of the object are changed; e.g., length of sides are doubled.

New McDonald's Farm — Selling the Corn, p. 115

Grade 8

08-10 Benchmark *B: Use formulas to find surface area and volume for specified three-dimensional objects accurate to a specified level of precision.*

Use Measurement Techniques and Tools / Y2003.CMA.S02.G08-10.BB.L08.I04

04. Derive formulas for surface area and volume and justify them using geometric models and common materials. For example, find:
    - the surface area of a cylinder as a function of its height and radius

New McDonald's Farm — Selling the Corn, p. 115

New McDonald's Farm — Storing the Corn, p. 111

Other Standards Addressed

Data Analysis and Probability

Grade 4

03-04 Benchmark *B: Read and interpret tables, charts, graphs (bar, picture, line, line plot) and timelines as sources of information; identify main idea, draw conclusions and make predictions.*

Data Collection / Y2003.CMA.S05.G03-04.BB.L04.I02

02. Represent and interpret data using tables, bar graphs, line plots and line graphs.

Plop, Plop, Fizz, Fizz — Timing Race, p. 41

03-04 Benchmark *C: Construct charts, tables and graphs to represent data, including picture graphs, bar graphs, line graphs, line plots and Venn diagrams.*

Data Collection / Y2003.CMA.S05.G03-04.BC.L04.I02

02. Represent and interpret data using tables, bar graphs, line plots and line graphs.

Can Your Boat Float? p. 51

Plop, Plop, Fizz, Fizz — Timing Race, p. 41

Grade 5

05-07 Benchmark *E: Collect, organize, display and interpret data for a specific purpose or need.*

Data Collection / Y2003.CMA.S05.G05-07.BE.L05.I02

02. Select and use a graph that is appropriate for the type of data to be displayed; e.g., numerical vs. categorical data, discrete vs. continuous data.

Can Your Boat Float? p. 51

Plop, Plop, Fizz, Fizz — Timing Race, p. 41

Grade 6

05-07 Benchmark *E: Collect, organize, display and interpret data for a specific purpose or need.*

Data Collection / Y2003.CMA.S05.G05-07.BE.L06.I02

02. Select, create and use graphical representations that are appropriate for the type of data collected.

Can Your Boat Float? p. 51

Science — Physical Science

Grade 3

3-5 Benchmark

C: *Describe the forces that directly affect objects and their motion.*

Forces and Motion / Y2003.CSC.S03.G03-05.BC.L03.I04

04. Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).

Can Your Boat Float? p. 51

Grade 6

6-8 Benchmark

A: *Relate uses, properties and chemical processes to the behavior and/or arrangement of the small particles that compose matter.*

Nature of Matter / Y2003.CSC.S03.G06-08.BA.L06.I01

01. Explain that equal volumes of different substances usually have different masses.

Can Your Boat Float? p. 51

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