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ABSTRACT

This collection of community mathematics modules, or "math trail", is appropriate for middle grades and high school students (grades 5-12). Collectively, the modules pay attention to all 10 of the National Council of Teachers of Mathematics (NCTM) standards which include five content standards (Number and Operations, Algebra, Geometry, Measurement, Data Analysis, and Probability), and five process standards (Problem Solving, Reasoning and Proof, Communication, Connections, and Representation). Activities include: (1) "The Carousel at Coolidge Park"; (2) "Utilizing Government Regulation Measurements to Demonstrate Algebraic Application"; (3) "A Local Paper Manufacturer's Wood Yard"; (4) "Algebra Is Everywhere-Engel Stadium"; (5) "Bridges of Chattanooga"; (6) "Buckner-Rush Funeral Home-Dying to Do Math"; (7) "Challenger Center-Our Mission to Mars"; (8) "Chattanooga Ducks"; (9) "Chattanooga Riverwalk"; (10) "Coolidge Park"; (11) "Ducks Unlimited Conservation Benefit at Mary McGuire's Restaurant"; (12) "Fall Creek Falls State Resort Park"; (13) "Family Vacation in Chattanooga"; (14) "Fun Facts at Finley Stadium"; (15) "Geometry Is Everywhere! Especially at the Chattanooga Zoo!"; (16) "Hamilton County High Schools' Chattanooga Road Rally"; (17) "Hunter Museum of American Art"; (18) "Lookout Mountain Incline Railway-Into the Clouds"; (19) "McDonald's Math"; (20) "Miniature Golf in Chattanooga-Sir Goony's Family Fun Center"; (21) "Riverbend Festival"; (22) "Sequoyah Nuclear Plant and Training Center"; (23) "Soddy Daisy High School Football Stadium"; (24) "Swimming and Bicycling At Booker T. Washington State Park"; (25) "Tennessee Aquarium (2001)"; (26) "Tennessee Aquarium (2002)"; (27) "The McKenzie Arena"; and (28) "Towing and Recovery Museum". (MVL)

SE SETR 0169

Chattanooga Math Trail: Community Mathematics Modules, Volume 1

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Introduction

This collection of community mathematics modules, or "math trail," is appropriate for middle grades and high school students (grades 5-12). The modules were developed during the fall semesters of 2001 and 2002 by students enrolled in the Education 451 Teaching Strategies and Materials in Secondary and Middle Grades Mathematics course at The University of Tennessee at Chattanooga. Community sites are featured from the perspective of mathematics. Each module includes the mathematics of a particular location within the community, organized around one or more of the National Council of Teachers of Mathematics (NCTM, 2000) standards. Collectively, the modules provide attention to all 10 of the NCTM standards, which include 5 content standards (Number and Operations, Algebra, Geometry, Measurement, Data Analysis and Probability), and 5 process standards (Problem Solving, Reasoning and Proof, Communication, Connections, and Representation).

The community mathematics module is a new type of project for the Education 451 course, which is completed by university-level teacher education students (pre-service teachers) who will teach high school or middle school mathematics. The project has been met with student enthusiasm. It is not an off-the-shelf replication, from a lab manual, or a collection of documents. It takes place outside of a dorm room or home, and includes more than interaction with word processing and spreadsheet software, as in other projects. The students work individually or in small groups, and are responsible for designing a complete, stand-alone module through the process of selecting a site, having the site approved, collecting and analyzing data, and writing a problem set with solutions.

The prototype site module is *The Carousel at Coolidge Park*, developed during summer 2001. Critical mathematics facts, such as time for one rotation of the carousel, radius or diameter of the carousel, radius of each animal's concentric circle for a given row, dimensions of the animal, etc., were gathered through direct measurement. Problems are posed, such as finding the rider's velocity on a given animal, finding the scale factor of the carousel animal as compared to a live animal, etc. Technology connections are provided in the form of Web sites for further exploration of both the mathematics content and the community site. For example, the Annenberg/CPB Exhibits Collection (2003) Web site features information and interactive activities for several amusement park rides.

Given the results of international studies, such as TIMSS (Michigan State University, n.d.), and various media reports, it is known that mathematics is an academic stumbling block for many children and adults. Academic student performance data (Tennessee Department of Education, 2002a, 2002b) for middle grades mathematics suggests there is ample room for growth in teaching and learning experiences at the university pre-service level as a means to improve student academic performance in the K-12 setting. Improved performance in mathematics for the K-12 student may reduce the barrier to career choice, especially in the natural sciences, engineering, and technology.

Making mathematics "relevant to the student" was a phrase echoed many times by session presenters at the 2001 National Council of Teachers of Mathematics national conference, especially those who teach in urban settings. Conference participants are sometimes able to attend a conference session to take a mathematical walking tour of the host city. Chattanooga has many attractions and sites that are rich in mathematics, but not necessarily within walking distance of a central location. The modules pose problems for mathematical solution that are based upon area sites, are relevant to middle grades and high school mathematics, and involve multi-step solutions. Concurrently, this project increases the problem posing flexibility and problem solving fluency of the problem posers themselves, the pre-service teachers, who will soon be mathematics teachers.

Kay Toliver, an educator in New York City, and a speaker at the NCTM national conference, used the writing of a math trail as a class project with middle grades students (Toliver, 1993, 1996; FASE Productions, 2002). At the Alabama Council of Teachers of Mathematics conference, a session was presented for the writing of math trails (Clopton, 2001). After learning about the presenter's work in designing math trails for her students, the group set out on a math trail around the Auburn University-Montgomery campus. Tasks included estimating the height of a building, viewing geometric patterns and angles in the concrete walkways, finding number and letter combinations on automobile license plates, calculating the area beneath the lunch tent, etc., capturing digital photographs as the math trail progressed.

In a session at the NCTM national conference during spring 2001, teaching and learning strategies supported by the NCTM standards were discussed that are important to use when teaching mathematics to inner-city, African American students. Among the nine strategies are (a) reinforcing skills in a variety of ways, including field trips, games, etc., to show mathematical connections; and (b) using mathematical enrichment activities as the norm and not as the exception (Smalley & Moch, 2001).

The students in Education 451 complete an urban field placement for the course, and one 8-week urban placement during the 16-week student teaching field experience. The modules complement the work done in Connected Mathematics (Lappin, Fey, Fitzgerald, Friel, & Phillips, 1998), the textbook series adopted for middle grades mathematics in Hamilton County, TN, as well as in other school districts in the U.S. It is important to design and have relevant resources available for the student to use in pre-service teaching experiences, and for the student to carry forward methods and materials that will lead to a successful classroom teaching career.

References

Annenberg/CPB Exhibits Collection. (2003). *Amusement park physics: Carousel.* Retrieved July 13, 2003, from http://www.learner.org/exhibits/parkphysics/carousel.html

Clopton, S. (2001, October). *Be a trailblazer: Create a math trail for your students.* Paper presented at the Alabama Council of Teachers of Mathematics annual state conference, Montgomery, AL.

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Lappin, G., Fey, J. T., Fitzgerald, W. M., Friel, S. N., and Phillips, E. D. (1998). *Connected mathematics* [3-year series]. Menlo Park, CA: Dale Seymour Publications.

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Table of Contents

Activity 1
The Carousel at Coolidge Park

Deborah A. McAllister and Shirley A. McDonald
Summer 2001
Project Prototype

Description of Module

The carousel at Coolidge Park has become an icon of the downtown revitalization. In this module, which serves as the prototype for this project, the student will explore the restored carousel to solve a variety of mathematics problems. Location: North of the Tennessee River, between the Market Street Bridge and Walnut Street Bridge.

Standards

Number and Operations, grades 6-12
Geometry, grades 6-12
Representation, grades 6-12
Data Analysis and Probability, grades 6-12
Algebra, grades 6-12
Measurement, grades 6-12
Connections, grades 6-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Background Information

The carousel contains 52 animals and 2 chariots (4 seats each):

Tiger	rabbit	turtle
tan horse	tiger	white horse
brown horse	black horse	giraffe
gray horse	black horse	cat
black horse	cream horse	rabbit
gray horse	gray mermaid horse	knight horse
white horse	cream horse	cream horse
pig	cat	white horse
chariot (4 seats)	white horse	ostrich
brown horse	bronco horse	donkey
camel	ram	fish
giraffe	lion	elephant
brown horse	turkey	brown horse
cream horse	cream horse	white horse
cream horse	black horse	white horse
gray horse	bear	black horse
gray horse	frog	zebra
white horse	chariot (4 seats)	ram

The following measurements were taken or calculated:
- radius of the carousel, 286.5 inches;
- radius of the platform ring, 133 inches;
- outer circle of animals, 27 inches from the outer edge;
- middle circle of animals, 73 inches from the outer edge;
- inner circle of animals, 112 inches from the outer edge;
- 15 revolutions per ride; and
- approximately 12 seconds per revolution, at full speed.

Cost per ride:
- Adults: $1.00
- Children: $0.50

Problems

1. What is the area, in square feet, of the platform that is revolving?

2. How far does each animal on the inner circle travel in one revolution? How far does each animal on the inner circle travel in one ride?

3. How far does each animal on the middle circle travel in one revolution? How far does each animal on the middle circle travel in one ride?

4. How far does each animal on the outer circle travel in one revolution? How far does each animal on the outer circle travel in one ride?

5. What is the velocity of an animal on each circle (inner, middle, outer), at full speed?

6. Of the horses on the carousel, 1/30 are tan, 1/5 are black, 1/6 are gray, 7/30 are white, 10/60 are brown and 3/15 are cream. If a friend selects a horse for you to ride without you seeing the color, which color is the horse most likely to be? Which color is the horse least likely to be?

7. Calculate the total number of watts of the carousel's light bulbs (11 watts each). There are 18 bulbs in the center, 15 bulbs on each panel (18 panels), and 7 bulbs on each bar (18 bars). Equate this to a typical household light bulb of 100 watts.

8. At the beginning of summer vacation, Bob plans to ride on the carousel one time on Sunday, two times on Monday, four times on Tuesday, etc., doubling the number of times he rides each day, through Saturday. How many days will he ride on the carousel? How many times will he ride on the carousel each day? What is the total number of times he will ride on the carousel? Write a formula to describe this function.

9. A family of five, consisting of two adults and three children, plans to spend $10.00 riding the carousel. How many times can the entire family ride together? If the family plans to spend $20.00 riding the carousel, how many times can the entire family ride together? If the family plans to spend $30.00 riding the carousel, how many times can the entire family ride together?

10. Lining up the animals:
    a. Can the animals line up by two's? If so, in how many rows?
    b. Can the animals line up by three's? If so, in how many rows?
    c. Can the animals line up by four's? If so, in how many rows?
    d. Can the animals line up by five's? If so, in how many rows?
    e. In what other ways can the animals line up? How many rows are required for each formation?

11. Two groups of students plan to ride the carousel. Each group has 36 students. If 2/3 of the first group and 3/4 of the second group ride the carousel, how many more people in the second group ride than in the first group? How many additional students may take the same ride?

12. There are 18 segments of wood trim around the carousel platform. Each segment is 100 inches in length. Based on this information, calculate the circumference of the carousel.

13. The radius of the carousel is measured to be 286.5 inches. Based on this information, calculate the circumference of the carousel.

14. Compare the results obtained in problems 12 and 13 by calculating the percent error between the two measurements. Both values are based on observations, but the length of 100 inches in problem 12 is a direct measure of part of the circumference, whereas the circumference found in problem 13 is based on a measure of the radius. Use the circumference calculated in problem 12 as the accepted value and the circumference calculated in problem 13 as the observed value.

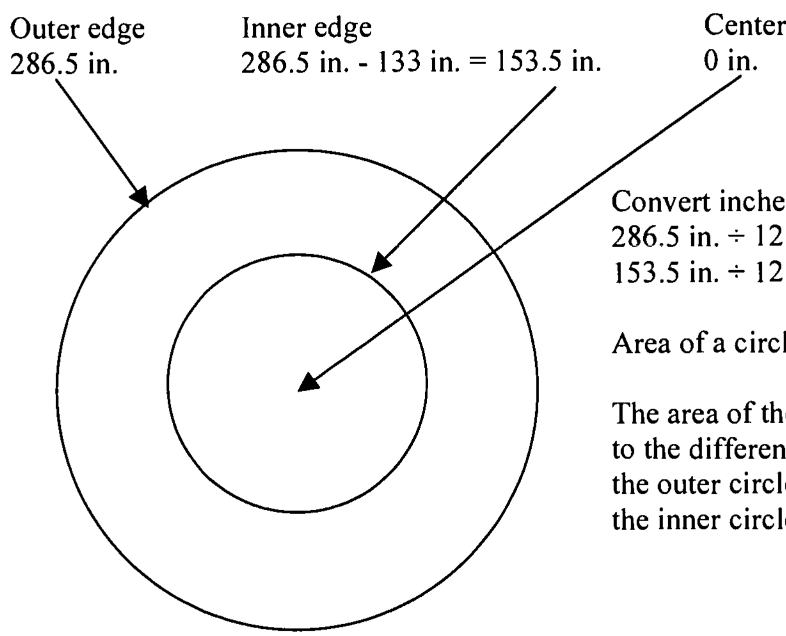
15. If the carousel is divided into 18 segments, what is the angle measure (and arc measure) of each segment?

16. Measure the length, width, and height of one of the carousel animals. Compare the measurements to those for a live animal (collect data or use resource material) or a porcelain figure or a plastic toy. What is the scale of the carousel animal, as compared to the live animal or figure/toy? Is the carousel animal in proportion to the actual animal (i.e., are all three dimensions at the same scale)?

17. Find the equivalent of $3.50 in currency from other countries. Use information found on a Web site containing the current currency exchange rates.

Solutions

1. What is the area, in square feet, of the platform that is revolving?



Convert inches to feet:
286.5 in. ÷ 12 in./ft = 23.88 ft
153.5 in. ÷ 12 in./ft = 12.79 ft

Area of a circle = πr^2

The area of the platform is equal to the difference of the area of the outer circle and the area of the inner circle.

$$\begin{aligned}\text{Area of the platform} &= \text{Area of the outer circle - Area of the inner circle}\\ &= 3.14(23.88\text{ ft})^2 - 3.14(12.79\text{ ft})^2\\ &= 3.14[(23.88\text{ ft})^2 - (12.79\text{ ft})^2]\\ &= 3.14(570.3\text{ ft}^2 - 163.6\text{ ft}^2)\\ &= 3.14(406.7\text{ ft}^2)\\ &= 1{,}277\text{ ft}^2\end{aligned}$$

2. How far does each animal on the inner circle travel in one revolution? How far does each animal on the inner circle travel in one ride?

   Circumference = $2\pi r$
   $C = 2(3.14)(286.5\text{ in.} - 112\text{ in.}) \approx 1{,}096$ in., or approximately 91 ft.
   For one ride of 15 revolutions: 91 ft x 15 ≈ 1,365 ft (a little more than 1/4 mile).

3. How far does each animal on the middle circle travel in one revolution? How far does each animal on the middle circle travel in one ride?

   Circumference = $2\pi r$
   $C = 2(3.14)(286.5\text{ in.} - 73\text{ in.}) \approx 1{,}341$ in., or approximately 112 ft.
   For one ride of 15 revolutions: 112 ft x 15 ≈ 1,680 ft (a little less than 1/3 mile).

4. How far does each animal on the outer circle travel in one revolution? How far does each animal on the outer circle travel in one ride?

   Circumference = $2\pi r$
   C = 2(3.14)(286.5 in. - 27 in.) ≈ 1,630 in., or approximately 136 ft.
   For one ride of 15 revolutions: 136 ft x 15 ≈ 2,040 ft (a little more than 1/3 mile).

5. What is the velocity of an animal on each circle (inner, middle, outer), at full speed?

   velocity = distance / time
   Inner circle: v = 91 ft / 12 s ≈ 7.6 ft/s, or approximately 5.2 mi/hr
   Middle circle: v = 112 ft / 12 s ≈ 9.33 ft/s, or approximately 6.4 mi/hr
   Outer circle: v = 136 ft / 12 s ≈ 11.3 ft/s, or approximately 7.70 mi/hr

   Sample to convert from ft/s to mi/hr:
   7.6 ft/s x 1 mi/5,280 ft x 3,600 s/hr ≈ 5.2 mi/hr

6. Of the horses on the carousel, 1/30 are tan, 1/5 are black, 1/6 are gray, 7/30 are white, 10/60 are brown and 3/15 are cream. If a friend selects a horse for you to ride without you seeing the color, which color is the horse most likely to be? Which color is the horse least likely to be?

   Convert fractions to lowest common denominator (LCD) or decimal form:

Color of horse	**Original fraction**	**Using LCD**	**Using decimal**
tan	1/30	1/30	0.03
black	1/5	6/30	0.20
gray	1/6	5/30	0.17
white	7/30	7/30	0.23
brown	10/60	5/30	0.17
cream	3/15	6/30	0.20

   The horse is most likely to be white. The horse is least likely to be tan.

7. Calculate the total number of watts of the carousel's light bulbs (11 watts each). There are 18 bulbs in the center, 15 bulbs on each panel (18 panels), and 7 bulbs on each bar (18 bars). Equate this to a typical household light bulb of 100 watts.

   Number of bulbs = 18 bulbs + (15 bulbs x 18) + (7 bulbs x 18) = 414 bulbs
   Number of watts = 414 bulbs x 11 watt/bulb = 4,554 watt
   Equate to 100-watt bulbs: 4,554 watts ÷ 100 watt/bulb ≈ 46 bulbs

8. At the beginning of summer vacation, Bob plans to ride on the carousel one time on Sunday, two times on Monday, four times on Tuesday, etc., doubling the number of times he rides each day, through Saturday. How many days will he ride on the carousel? How many times will he ride on the carousel each day? What is the total number of times he will ride on the carousel? Write a formula to describe this function.

Day	Number of days	Rides per day	Running total of rides
Sunday	1	1	1
Monday	2	2	3
Tuesday	3	4	7
Wednesday	4	8	15
Thursday	5	16	31
Friday	6	32	63
Saturday	7	64	127

Total = $2^n - 1$

9. A family of five, consisting of two adults and three children, plans to spend \$10.00 riding the carousel. How many times can the entire family ride together? If the family plans to spend \$20.00 riding the carousel, how many times can the entire family ride together? If the family plans to spend \$30.00 riding the carousel, how many times can the entire family ride together?

Cost per trip = (2 adults x \$1.00/adult) + (3 children x \$0.50/child) = \$3.50
Spending \$10.00, 2 rides: \$10.00 ÷ \$3.50 = 2.86
Spending \$20.00, 5 rides: \$20.00 ÷ \$3.50 = 5.71
Spending \$30.00, 8 rides: \$30.00 ÷ \$3.50 = 8.57

10. Lining up the animals:
    a. Can the animals line up by two's? If so, in how many rows?
    b. Can the animals line up by three's? If so, in how many rows?
    c. Can the animals line up by four's? If so, in how many rows?
    d. Can the animals line up by five's? If so, in how many rows?
    e. In what other ways can the animals line up? How many rows are required for each formation?

There are 52 animals on the carousel. The factors of 52 are 1, 2, 4, 13, 26, and 52. The animals can line up in 1 row of 52, 2 rows of 26, 4 rows of 13, 13 rows of 4, 26 rows of 2, or 52 rows of 1. The animals cannot line up in three's or five's. (Most of these formations are unlikely for a carousel, however, 13 rows of 4 would be a probable formation.)

11. Two groups of students plan to ride the carousel. Each group has 36 students. If 2/3 of the first group and 3/4 of the second group ride the carousel, how many more people in the second group ride than in the first group? How many additional students may take the same ride?

Students in first group: 2/3 x 36 students = 24 students
Students in second group: 3/4 x 36 students = 27 students
There are three more students in the second group than in the first group:
27 students - 24 students = 3 students

There are 52 animals and 2, four-seat chariots.
Total students = 52 students + 2(4 students) = 60 students
Additional students = 60 students - (24 students + 27 students) = 9 students

12. There are 18 segments of wood trim around the carousel platform. Each segment is 100 inches in length. Based on this information, calculate the circumference of the carousel.

C = 18 segments x 100 in./segment = 1,800 in., or 150 ft.

13. The radius of the carousel is measured to be 286.5 inches. Based on this information, calculate the circumference of the carousel.

Circumference = $2\pi r$ = 2(3.14)(286.5 in.) = 1,799.22 in., or 149.94 ft.

14. Compare the results obtained in problems 12 and 13 by calculating the percent error between the two measurements. Both values are based on observations, but the length of 100 inches in problem 12 is a direct measure of part of the circumference, whereas the circumference found in problem 13 is based on a measure of the radius. Use the circumference calculated in problem 12 as the accepted value and the circumference calculated in problem 13 as the observed value.

Percent error = |[(observed – accepted) / accepted]| x 100%
= |[(1,799.22 in. – 1,800 in.) / 1,800 in.]| x 100%
= |(-0.78 in. / 1,800 in.)| x 100%
= 0.00043 x 100%
= 0.043%

15. If the carousel is divided into 18 segments, what is the angle measure (and arc measure) of each segment?

360° ÷ 18 = 20°

16. Measure the length, width, and height of one of the carousel animals. Compare the measurements to those for a live animal (collect data or use resource material) or a porcelain figure or a plastic toy. What is the scale of the carousel animal, as compared to the live animal or figure/toy? Is the carousel animal in proportion to the actual animal (i.e., are all three dimensions at the same scale)?

Answers will vary. Sample data is presented in the table. Data may be added.

Animal	**Height**	**Width**	**Length of torso**	**Ratio of heights**	**Ratio of widths**	**Ratio of lengths**
Carousel horse	60 in.	17 in.	44 in.	0.75	1.19	0.75
Live horse*	80 in.	14.25 in.	59 in.	Using an average of the ratios, the scale is 0.9:1. Two of the ratios are the same (0.75:1); the third ratio shows the carousel horse as larger than the real horse.		
Carousel horse	60 in.	17 in.	44 in.	8.14	8.5	8.38
Porcelain figure	7.375 in.	2 in.	5.25 in.	Using an average of the ratios, the scale is 8.34:1. The ratios are close, but the animals are not quite in proportion.		
Carousel tiger	48 in.	16 in.	40 in.	3.56	3.56	2.86
Live cat, Tom Kitten	13.5 in.	4.5 in.	14 in.	Using an average of the ratios, the scale is 3.33:1. Two of the ratios are the same; the third is slightly lower.		

17. Find the equivalent of $3.50 in currency from other countries. Use information provided on a Web site containing the current currency exchange rates.

Answers will vary.
* "Just about measures" provided by Fran Lockhart.

Web Sites for Further Exploration

The Carousel at Coolidge Park
http://www.chattanooga.gov/cpr/parks/CoolidgeParkCarousel.htm

Horsin' Around: Coolidge Park Carousel
http://www.carouselcarvingschool.com/CoolidgeParkCarousel.htm

University of California, Berkeley: Lawrence Hall of Science - Tower of Hanoi
http://www.lhs.berkeley.edu/Java/Tower/towerhistory.html

Ask Dr. Math - Doubling Pennies
http://mathforum.org/dr.math/faq/faq.doubling.pennies.html

Universal Currency Converter
http://www.xe.com/ucc/

Yahoo! Finance - Currency Conversion
http://finance.yahoo.com/m3

How Light Bulbs Work
http://home.howstuffworks.com/light-bulb.htm

Annenberg/CPB: Amusement Park Physics - Carousel
http://www.learner.org/exhibits/parkphysics/carousel.html

National Carousel Association
http://www.nca-usa.org/

National Carousel Association: Links to Other Carousel Sites
http://www.nca-usa.org/NCAlinks.html

A Little about Carousel History and Terms
http://carouselfigures.tripod.com/carouselminiatures/id3.html

International Museum of Carousel Art
http://www.carouselmuseum.com/

International Museum of Carousel Art: Some Carousel Research Ideas
http://www.carouselmuseum.com/research.html

Crossroads Village Carousel Coloring Book
http://www.stuckinside.com/coloring/cbookchorse.shtml

Activity 2
Utilizing Government Regulation Measurements to Demonstrate Algebraic Application

Peggy Moyer and John Peoples
October 23, 2002

Description of Module

This module contains an exercise set in which the student will deal mainly with finding the slope of a line; other mathematical topics are incorporated. The topics are illustrated using facilities, four stairways and a ramp, at the University of Tennessee at Chattanooga. In addition, regulatory codes from various sources provide real-life applications for mathematics. Location: UTC campus.

Standards

Algebra, grades 6-8 Problem Solving, grades 6-8 Connections, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org
National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/
Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm
Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

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* BOCA information:

Background Information

The following is an exercise set dealing mainly with finding the slope (rise over run) of a line, but also incorporating other mathematical topics. It is our contention that these exercises are most appropriate for the 6-8 grade band, although they may also be of interest to more advanced students in a lower band. Moreover, there is one problem involving trigonometry, a higher-level topic; however, this can be used as a preview, especially for more advanced pupils in this grade band. We have illustrated these topics using facilities, four stairways and a ramp, at the University of Tennessee at Chattanooga. In addition, we have provided a list of regulatory codes from various sources (OSHA, BOCA, and ADA) to provide real-life applications for mathematics.

Founded in 1915, Building Officials and Code Administrators International, Inc. is a nonprofit membership association comprised of more than 16,000 members who work in the building community, from code enforcement officials to materials manufacturers. Their mission is to preserve the public health, safety, and welfare in the built environment through the effective, efficient use and enforcement of model codes. Members of BOCA are professionals who are in the construction and regulatory process. For more information on BOCA please check the following website:
http://www.bocai.org/about_boca.asp

Since this is a nonprofit organization, the codes must be purchased. Utilizing a 1-day free membership from Madcad, codes may be obtained from this website:
http://www.madcad.com/madcad//01101400.htm#s1014_6

The mission of the Occupational Safety and Health Administration (OSHA) is to save lives, prevent injuries, and protect the health of America's workers. Federal and state governments work in partnership with more than 100 million working people and their 6.5 million employers who are covered by the Occupational Safety and Health Act of 1970. OSHA and its state partners have approximately 2,100 inspectors, plus complaint discrimination investigators, engineers, physicians, educators, standards writers, and other technical and support personnel located in 200 offices throughout the country. This staff establishes protective standards, enforces those standards, and supplies employers and employees with technical assistance and consultation programs. Almost everyone in the country falls under OSHA's jurisdiction (with some exceptions such as miners, transportation workers, many public employees, and the self-employed). More information on OSHA may be found at this website: http://osha.gov/

The stair codes used for this unit may be found at this website:
http://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9716&p_text_version=FALSE

The Americans with Disabilities Act was passed in 1990. It gives civil rights protections to individuals with disabilities similar to those provided to individuals on the basis of race, color, sex, national origin, age, and religion. It guarantees equal opportunity for individuals with disabilities in public accommodations, employment, and transportation.

Building codes have been modified to allow wheel chair and other access for all people. For general information on ADA, please check this website:
http://www.usdoj.gov/crt/ada/adahom1.htm

The ADA code for ramps was found at this website:
http://www.usdoj.gov/crt/ada/reg3a.html#Anchor-19425

The ADA code for stairs was found at this website:
http://www.usdoj.gov/crt/ada/reg3a.html#Anchor-17104

Summary of Codes

(Web addresses are listed above.)

OSHA 1910.24(e)
"'Angle of stairway rise.' Fixed stairs shall be installed at angles to the horizontal of between 30 deg. and 50 deg." (U.S. Department of Labor, 2003, ¶ 5).

*BOCA National Building Code 1014.5**
"Vertical rise: A means of egress stairway shall not have a height of vertical rise of more than 12 feet between landings and intermediate platforms" (MAD CAD, n.d., ¶ 1014.5).

*BOCA National Building Code 1014.6**
"Treads and risers: Maximum riser height shall be seven inches and minimum riser height shall be four inches. The riser height shall be measured vertically between the leading edges of the adjacent treads. Minimum tread depth shall be 11 inches, measured horizontally between the vertical planes of the foremost projection of adjacent treads and at a right angle to the tread's leading edge" (MAD CAD, n.d., ¶ 1014.6).

*BOCA National Building Code 1014.6.2**
"Dimensional uniformity: There shall not be variation exceeding 3/16 inch in the depth of adjacent treads or in the height of adjacent risers. The tolerance between the largest and smallest riser or between the largest and smallest tread shall not exceed 3/8 inch in any flight of stairs" (MAD CAD, n.d., ¶ 1014.6.2).

*BOCA National Building Code 1016.3**
"Maximum slope: The maximum slope of means of egress ramps in the direction of travel shall be 1 unit vertical in 12 units horizontal (1:12); except the maximum slope shall be 1 unit vertical in 8 units horizontal (1:8) if the rise is limited to 3 inches; 1 unit vertical (1:10) if the rise is limited 6 inches" (MAD CAD, n.d., ¶ 1016.3).

*BOCA National Building Code 1016.4**
"Landings: Ramp slopes of 1 unit vertical in 12 units horizontal (1:12) or steeper shall have landing at the top, bottom, all points of turning, entrance, exit, and at doors. Ramps shall not have a vertical rise greater than 30 inches between landings" (MAD CAD, n.d., ¶ 1016.4).

ADA 4.9.2
"Treads and Risers: On any given flight of stairs, all steps shall have uniform riser heights and uniform tread widths. Stair treads shall be no less than 11 in (280 mm) wide, measured from riser to riser" (U.S. Department of Justice, 2002, ¶ 4.9.2).

ADA 4.8.1
"General: Any part of an accessible route with a slope greater than 1:20 shall be considered a ramp and shall comply with 4.8" (Ramps) (U.S. Department of Justice, 2002, ¶ 4.8.1).

ADA 4.8.2
"Slope and Rise: The least possible slope shall be used for any ramp. The maximum slope of a ramp in new construction shall be 1:12. The maximum rise for any run shall be 30 in" (U.S. Department of Justice, 2002, ¶ 4.8.2).

References

MAD CAD. (n.d.). *Building codes online*. Retrieved July 7, 2003, from http://www.madcad.com/madcad//01101400.htm - s1014_6

U.S. Department of Justice. (2002). *ADA Title III regulation 28 CFR part 36*. Retrieved July 7, 2003, from http://www.usdoj.gov/crt/ada/reg3a.html

U.S. Department of Labor. (2003). *Occupational safety and health administration: Fixed industrial stairs*. Retrieved July 7, 2003, from http://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9716&p_text_version=FALSE

Problems

Refer to the Summary of Codes page when solving these problems.

Note: All numbers above staircase refer to riser (vertical height); all numbers below staircase refer to run (horizontal depth). All measurements are in inches.

For problems 1-3, use Figure 1.

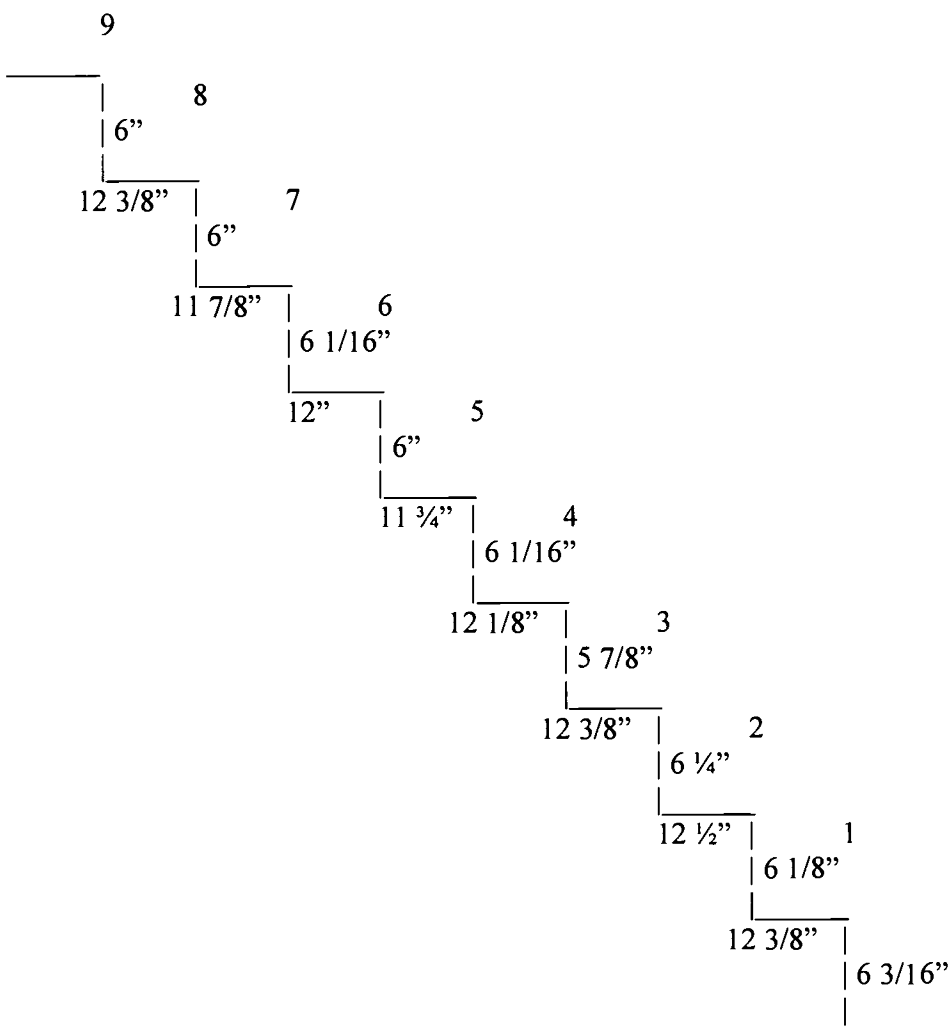


Figure 1. Stairs outside Fletcher Hall facing Development Office.

1. Calculate the average rise of the stairs.

2. Calculate the average run of the stairs.

3. Calculate the slope (rise/run) of the stairs.

Real Life Application
Using BOCA 1014.6.2, check the dimensional uniformity of the stairs. Do any adjacent risers or treads (run) differ by more than 3/16"? Is there a difference between the smallest and the largest rise or treads of 3/8"?

For problems 4-6, use Figure 2.

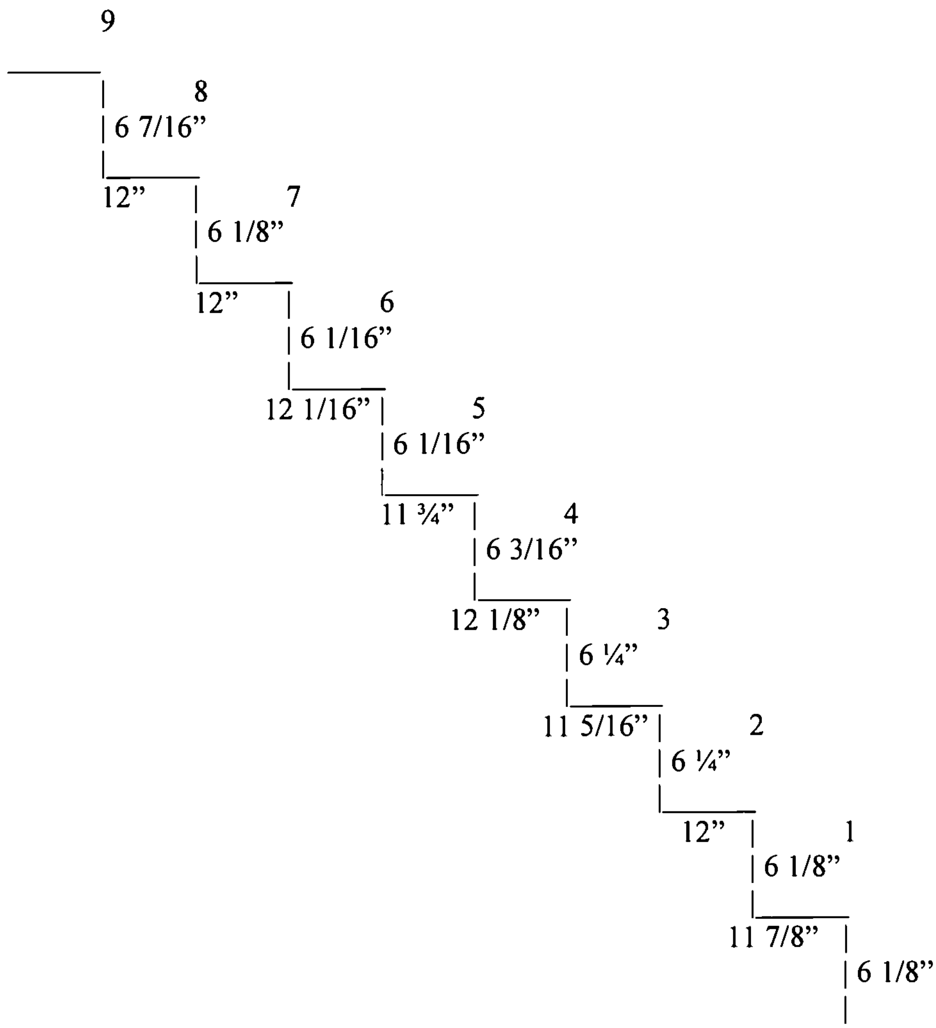


Figure 2. Stairs inside Fletcher Hall by exit toward McCallie Avenue.

4. Calculate the average rise of the stairs.

5. Calculate the average run of the stairs.

6. Calculate the slope (rise/run) of the stairs.

Real Life Application
Using BOCA 1014.6, check the riser height and tread depth (run) to make sure they meet code specifications.

For problems 7-10, use Figure 3.

```
           6

   |_____
11 7/8"  |      5
         | 6 7/8"
         |_____
      11 5/8"  |      4
               | 6 1/2"
               |_____
            11 3/4"  |      3
                     | 6 1/2"
                     |_____
                  11 5/8"  |      2
                           | 6 5/8"
                           |_____
                              12"  |      1
                                   | 6 7/16"
                                   |_____
                                   11 ½"  |
                                          | 7 5/16"
                                          |
```

Figure 3. Stairs on side of Guerry Hall adjacent to food court.

7. Calculate the average rise of the stairs.

8. Calculate the average run of the stairs.

9. Calculate the slope (rise/run) of the stairs.

10. There exist 20 steps. What is the total rise of the staircase? Assuming 30 steps, what would be the total rise of the staircase?

Real Life Application
Using BOCA 1014.5, determine if either staircase is required to have a landing or intermediate platform (12 feet).

For problems 11-13, use Figure 4.

```
| 6 7/8"
|____
14"  | 6 7/8"
     |____
     14"  | 6 15/16"
          |____
       14 1/8"  | 6 13/16"
                |____
                14    | 6 7/8"
                      |____
                      14"  | 6 13/16"
                           |____
                       14 1/8"  | 6 3/4"
                                |____
                           14 1/8"  | 6 7/8"
                                    |____
                               14 1/8"  | 6 13/16"
                                        |____
                                   14 1/8"  | 6 7/8"
                                            |____
                                            14"  | 6 7/8"
                                                 |___(continued)___

______________________
       36"           | 7"
                     |____
                     14"  | 6 7/8"
                          |______________________
                               32 7/8"          | 6 1/8"
                                                |____
```

Figure 4. Inside Founders Hall facing Fletcher Hall.

11. Use the upper section (above the landing) to calculate the average rise and run.

12. Calculate the slope (rise/run).

13. Calculate the angle of the staircase to the horizon: sin (angle) = slope.

Real Life Application
Using OSHA 1910.24 (e), determine if the angle of the stairway rise lies between 30 and 50 degrees.

For problems 14-15, use Figure 5.

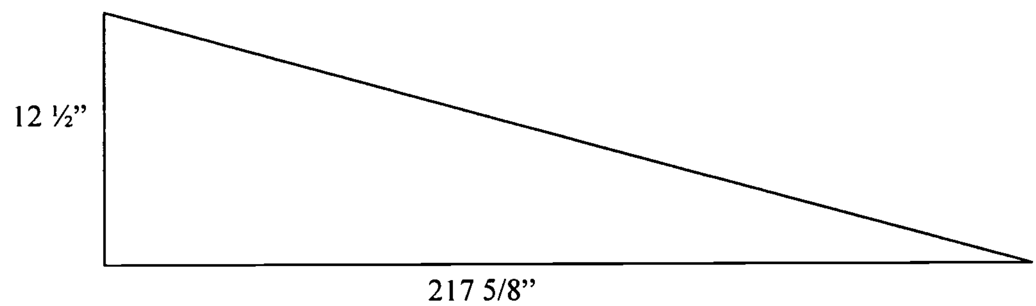


Figure 5. Ramp outside Development Office facing Fletcher Hall (not to scale).

14. Calculate the length of the walking surface using the Pythagorean theorem.

15. Calculate the slope of the ramp (rise/run).

Real Life Application
Using ADA 4.8.2, determine if the slope and rise meet code. The total rise must be less than 30", and the slope must be less than 1:12 (1 unit rise per 12 units run).

Solutions

1. Calculate the average rise of the stairs.

   6.0625"

2. Calculate the average run of the stairs.

   12.172"

3. Calculate the slope (rise/run) of the stairs.

   0.498

Real Life Application
Using BOCA 1014.6.2, check the dimensional uniformity of the stairs. Do any adjacent risers or treads (run) differ by more than 3/16"? Is there a difference between the smallest and the largest rise or treads of 3/8"?

   Stairs 3 and 4 have more than 3/16" difference in rise. Stairs 7 and 8, and 5 and 4 have more than 3/16" difference in run. Stairs 2 and 7 differ by more than 3/8".

4. Calculate the average rise of the stairs.

   6.181"

5. Calculate the average run of the stairs.

   11.9688"

6. Calculate the slope (rise/run) of the stairs.

   0.516

Real Life Application
Using BOCA 1014.6, check the riser height and tread depth (run) to make sure they meet code specifications.

   Riser heights were between 4" and 7". Run was more than 11".

7. Calculate the average rise of the stairs.

   6.7"

8. Calculate the average run of the stairs.

   11.740"

9. Calculate the slope (rise/run) of the stairs.

   0.571

10. There exist 20 steps. What is the total rise of the staircase? Assuming 30 steps, what would be the total rise of the staircase?

    For 20 steps, 134" or 11.16 ft. For 30 steps, 201" or 16.75 ft.

Real Life Application
Using BOCA 1014.5, determine if either staircase is required to have a landing or intermediate platform (12 feet).

Thirty steps needs a landing.

11. Use the upper section (above the landing) to calculate the average rise and run.

    6.852", 14.065"

12. Calculate the slope (rise/run).

    0.4872

13. Calculate the angle of the staircase to the horizon: sin (angle) = slope.

    29.16 degrees

Real Life Application
Using OSHA 1910.24 (e), determine if the angle of the stairway rise lies between 30 and 50 degrees.

Angle of the stairs is just under 30 degrees; therefore these do not meet specifications.

14. Calculate the length of the walking surface using the Pythagorean theorem.

    315 ¼"

15. Calculate the slope of the ramp (rise/run).

    0.0599

Real Life Application
Using ADA 4.8.2, determine if the slope and rise meet code. The total rise must be less than 30", and the slope must be less than 1:12 (1 unit rise per 12 units run).

The rise is obviously under 30" and the slope (0.0599) is less than 1:12 (0.0833).

Web Sites for Further Exploration

The following websites contain valuable tutorials/information on finding slope.

LearningWave Online: How to Find the Slope of a Line
http://www.learningwave.com/lwonline/algebra_section2/slope3.html

Finding the Slope of a Line Segment
http://www.bonita.k12.ca.us/schools/ramona/teachers/carlton/tutorialinteractives/inS-V/slope/graphing2.html

How to Calculate the Slope of a Line in a Graph
http://www.udayton.edu/~physics/lhe/HELPslope.htm

Project Interactive
http://www.shodor.org/interactivate/

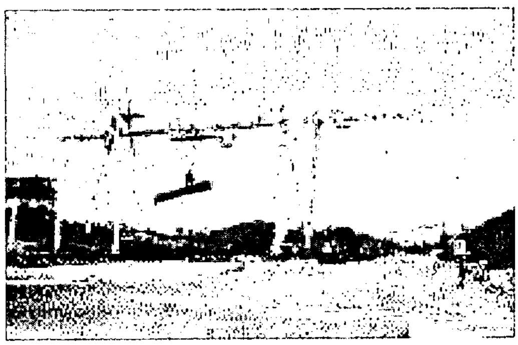
Project Interactive - Slope Slider
http://www.shodor.org/interactivate/activities/slopeslider/index.html

Project Interactive - Function Flyer
http://www.shodor.org/interactivate/activities/flyall/index.html

Project Interactive - Linear Function Machine
http://www.shodor.org/interactivate/activities/lfm/index.html

Activity 3
A Local Paper Manufacturer's Wood Yard

Danny Warren
November 11, 2001



Description of Module

This module provides mathematical examples and applications that are found at a local paper manufacturer's wood yard, where logs are processed into chips for pulp and paper production. In this module, the middle school or high school student will apply algebra and geometry skills to problems centered on a log crane.

Standards

Number and Operations, grades 6-8, grades 9-12
Geometry, grades 6-8, grades 9-12
Measurement, grades 6-8, grades 9-12
Problem Solving, grades 6-8, grades 9-12
Connections, grades 6-8, grades 9-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Background Information

A local paper manufacturer has a facility (wood yard) that processes about 300 tractor-trailer loads of logs per day. An average load of logs weighs about 25 tons. These logs are unloaded by one of two similar cranes. The loads are divided roughly equally between the two cranes. Each log storage area is about 500 feet in length.

Each crane has four mounting legs and is about 100 feet tall. The cranes straddle the log storage area and travel on rails that are similar to those used by the railroad. The cranes travel at variable speeds of up to 500 feet per minute. They are electrically powered and have self-tensioning power cable spools that travel with the crane and feed out or retract cable, as needed.

Each crane has one operator who rides in a cab near the top of the crane. Each operator works a 12-hour shift, but rotates with two other operators on the ground every 2 hours. The crane grapple (claw that grabs the load) and the cab are manufactured as one modular unit that moves back and forth on rails to cover the entire 500-foot storage area. The log storage area is wide enough to hold two lengths of logs stacked side-by-side. The crane operator works in conjunction with each individual truck driver on the ground to safely unload an entire load of logs with one lift.

Listed below are additional facts about the crane that need to be known to solve the associated problems. These facts could be determined by direct measurement.

- The crane's mounting legs are separated at a 48° angle.
- The distance between the mounting legs on one side of the crane at ground level is 932 inches.
- Each traveling wheel of the crane is 22.5 inches in diameter.
- The power cable is 2.5 inches in diameter.
- The power cable spool has an outside diameter of 225 inches.
- The power cable spool has an inner diameter of 18 inches.

Problems

1. How many pounds of logs are unloaded in an average day?

2. What is the instantaneous RPM of the power cable spool if the crane is traveling at 350 feet per minute and the outside diameter of the cable piled in the spool is 3 feet?

3. In problem 2, what is the instantaneous tip speed of the spool (the speed of a point on the cable spool at the outside edge of the spool)?

4. The time needed to position the grapple over a load of logs on a truck is 45 seconds. An additional 10 seconds are needed to lift the logs to a traveling position. It takes 15 seconds to set a load of logs down and return to a traveling position. Once the crane lifts the logs, a new truck can replace the empty truck before the crane returns. Logs are being stored at a point that is 250 feet from the unloading point. If the average crane travel speed is 400 feet per minute, what is the cycle time for one load of logs (time from one lift to the next lift)?

5. If 10 minutes every 2 hours are required to change crane operators, what is the maximum number of pounds of logs that can be unloaded by one crane in one 12-hour shift? Express your answer in tons and pounds. (Use the cycle time calculated in problem 4.)

6. If one crane breaks down, would it be possible to unload all of the trucks with the remaining crane during one 24-hour work day (two 12-hour shifts)?

7. Use geometric principles to determine the true height of the crane.

8. Use geometric principles to determine the length of a mounting leg.

9. If the crane is traveling at a speed of 300 feet per minute, how many RPM are made by the traveling wheels? What is the tip speed of the traveling wheels? (Consider only one wheel.)

10. Assume that the power cable winds in a single column of concentric circles. (In reality, the cable winds in multiple columns, each parallel to the previous, then in multiple layers on the drum.) Estimate the total length of cable that the spool is holding when the diameter of the rolled cable is 53 inches.

11. The maximum travel speed of the crane is 500 feet per minute. Convert this to miles per hour.

Solutions

1. How many pounds of logs are unloaded in an average day?

   300 loads x 25 tons/load x 2,000 lb/ton = 15,000,000 lb or 1.5×10^7 lb

2. What is the instantaneous RPM of the power cable spool if the crane is traveling at 350 feet per minute and the outside diameter of the cable piled in the spool is 3 feet?

   C = ∏d = ∏ x 3 ft = 9.4248 ft
   350 ft/min ÷ 9.4248 ft/revolution = 37.14 revolutions/min

3. In problem 2, what is the instantaneous tip speed of the spool (the speed of a point on the cable spool at the outside edge of the spool)?

   C = ∏d = ∏ x 225 in. x 1 foot/12 in. = 58.905 ft
   37.14 revolutions/min x 58.905 ft/revolution = 2,187.73 ft/min
   2,187.73 ft/min ÷ 5,280 ft/mi x 60 min/hr = 24.86 mi/hr

4. The time needed to position the grapple over a load of logs on a truck is 45 seconds. An additional 10 seconds are needed to lift the logs to a traveling position. It takes 15 seconds to set a load of logs down and return to a traveling position. Once the crane lifts the logs, a new truck can replace the empty truck before the crane returns. Logs are being stored at a point that is 250 feet from the unloading point. If the average crane travel speed is 400 feet per minute, what is the cycle time for one load of logs (time from one lift to the next lift)?

   Crane travel time = 250 ft ÷ 400 ft/min x 60 s/min = 0.625 min = 37.5 s
   Cycle time = 45 s+ 10 s + 15 s + (2 x 37.5 s) = 145 s

5. If 10 minutes every 2 hours are required to change crane operators, what is the maximum number of pounds of logs that can be unloaded by one crane in one 12-hour shift? Express your answer in tons and pounds. (Use the cycle time calculated in problem 4.)

   Time required to change operators: 12 hr ÷ 2 hr x 10 min ÷ 60 min/hr = 1 hr
   Time available for transporting logs: 12 hr – 1 hr = 11 hr
   11 hr ÷ 145 s/load x 3,600 s/hr ≈ 273 loads
   273 loads x 25 tons/load = 6,825 tons
   273 loads x 25 tons/load x 2,000 lb/ton = 13,650,000 lb

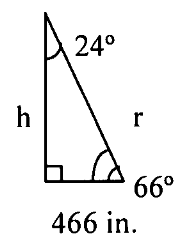
6. If one crane breaks down, would it be possible to unload all of the trucks with the remaining crane during one 24-hour work day (two 12-hour shifts)?

   300 trucks/day ÷ 22 hr/day = 13.6 trucks/hr
   3,600 s/hr ÷ 13.6 trucks/hr = 264.7 s/truck
   Since the cycle time of the crane is 145 s (from problem 4), all the trucks can be unloaded with a single crane, however, this numerical solution does not reflect the arrival schedule of trucks.

7. Use geometric principles to determine the true height of the crane.

   The angle of leg separation is 48°, so the angle to the vertical is 24°. The distance between legs is 932 inches. A right triangle can be constructed with a base of 466 inches, and angles that measure 90°, 24°, and 66°.

   tan 66° = h/466, where h is height of the crane
   h = 466 in. x tan 66° = 466 in. x 2.246 = 1046.64 in.
   1046.64 in. x 1 ft/12 in. = 87.22 ft
   (See diagram at right.)



8. Use geometric principles to determine the length of a mounting leg.

   cos 66° = 466 in./r, where r is length of the leg
   r = 466 in./cos 66° = 466 in./0.4067 = 1145.8 in.
   1145.8 in. x 1 ft/12 in. = 95.48 ft
   (See diagram above.)

9. If the crane is traveling at a speed of 300 feet per minute, how many RPM are made by the traveling wheels? What is the tip speed of the traveling wheels? (Consider only one wheel.)

   Diameter of traveling wheel: 22.5 in. x 1 ft/12 in. = 1.875 ft
   RPM = v/C = v/∏d = 300 ft/min ÷ (3.14 x 1.875 ft/revolution) ≈ 51 revolutions/min

   Since the traveling wheels touch the rail and drive the crane, the tip speed must equal the traveling speed, and would also be 300 feet per minute.

10. Assume that the power cable winds in a single column of concentric circles. (In reality, the cable winds in multiple columns, each parallel to the previous, then in multiple layers on the drum.) Estimate the total length of cable that the spool is holding when the diameter of the rolled cable is 53 inches.

    Storage space on reel being used: 53 in. - 18 in. = 35 in.
    Concentric circles of cable: 35 in. ÷ 5 in. = 7

    The first layer of cable has a diameter of 23 inches (18-inch core + 2 widths of 2.5-inch cable). Using $C = \Pi d$, the 7 layers of cable would have the following diameters and lengths:

    d_1 = 23 in.; C_1 = 6.02 ft
    d_2 = 28 in.; C_2 = 7.33 ft
    d_3 = 33 in.; C_3 = 8.64 ft
    d_4 = 38 in.; C_4 = 9.94 ft
    d_5 = 43 in.; C_5 = 11.25 ft
    d_6 = 48 in.; C_6 = 12.56 ft
    d_7 = 53 in.; C_7 = 13.87 ft

    The total length of cable stored on the spool is the sum of the circumferences (69.61 ft), or approximately 70 ft.

11. The maximum travel speed of the crane is 500 feet per minute. Convert this to miles per hour.

    500 ft/min x 60 min/hr ÷ 5,280 ft/mi = 5.68 mi/hr

Reference

Andritz. (2003). Retrieved July 7, 2003, from: http://www.andritz.com/

Web Sites for Further Exploration

Forest industry network
http://www.forestindustry.com/

Forestweb
http://www.forestweb.com/

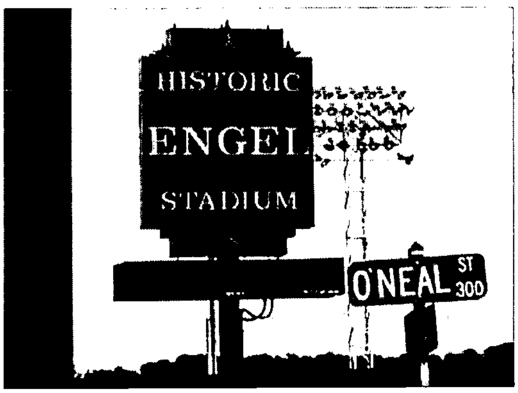
Technical Association of the Pulp and Paper Industry (TAPPI)
http://www.tappi.org/

Dave's Short Trig Course
http://aleph0.clarku.edu/~djoyce/java/trig/

MathWorld: Trigonometry
http://mathworld.wolfram.com/Trigonometry.html

Activity 4
Algebra is Everywhere - Engel Stadium

Adam Crowley
October 23, 2002



Description of Module

Engel Stadium was, for many years, the home of minor league baseball. It is now part of the UTC campus. In this module, the student will read word problems, use basic algebra skills, and use multiple steps to solve problems. Location: East 3rd St., Chattanooga, TN 37402.

Standards

Algebra, grades 6-8
Problem Solving, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. There are eight light poles containing a total of 184 lights. Each of six light poles has four rows of lights with the same number of lights in each row. The other two poles have two rows of lights, each with four lights. How many lights per row are contained on the first set of poles?

2. Section E has 11 rows of seats. Each of the lower five rows has 12 seats. The upper six rows have varying numbers of seats: one row has 13 seats, two rows have 15 seats, and three rows have 14 seats. What is the total of number of seats in Section E?

3. Section M has 11 rows of seats. Each of the lower five rows has 5 seats; the upper six rows have a total of 36 seats. In the upper six rows, each row has at least five seats and no more than eight seats. Within the six rows of seats, one number is used once, another number is used twice, and the last number is used three times; the number 7 is not used. What is the number of seats in each row of the upper area? What is the total number of seats in Section M?

4. Section A has 11 rows of seats. Each of the lower five rows has five seats; the upper six rows have an equal number of seats in each row. There are a total of 73 seats in the section. What is the number of seats per row in the upper area?

5. Sections D and G, located in the box seating sections, each have 11 rows of seats split into two areas. Each of the lower five rows has 20 seats; the upper six rows contain a total of 132 seats. Within the upper six rows, no row has less than 21 seats and no row has more than 23 seats. The number of seats in each row can repeat only once. How many seats are in each row of the upper area? What is the combined total of seats in Sections D and G?

6. If there are approximately 7,000 seats at Engel Stadium, and 1,608 seats are in the box seating sections, how many seats are in the general admission sections? What is the average number of seats per section, if there are 12 sections of box seating and 16 sections of general admission?

7. Engel Stadium was opened in 1930. At that time, ticket price was 1/6 of the current price. The current ticket prices are $12 for a box seat and $6 for a general admission seat. What would have been the total amount of ticket money collected at a game if the stadium sold out in 1930? How much more ticket money is collected now for a sold-out game now? (Use the seating information provided in problem 6.)

8. There are approximately 7,000 seats at Engel Stadium. If the Chattanooga Mocs play a baseball game on a hazy day and there is an average of one person for every eight seats, how many people are at the game?

9. There are 1,608 seats in the box seating sections; each ticket costs $12. How much ticket money would be collected if 2/3 of the box seating tickets were sold?

10. Suppose that $55,000 had to be collected on box seat ticket sales ($12 per ticket) before the end of the season for the stadium to remain out of debt. The two games prior to the last game sold out, but only 7/8 of the tickets were sold at the last game. With a total of 1,608 seats in the box seating sections, was the budget met? By how much money were ticket sales over or under the budget?

Solutions

1. There are eight light poles containing a total of 184 lights. Each of six light poles has four rows of lights with the same number of lights in each row. The other two poles have two rows of lights, each with four lights. How many lights per row are contained on the first set of poles?

   2 poles x 2 rows/pole x 4 lights/row) = 16 lights
   Lights remaining: 184 lights - 16 lights = 168 lights
   168 lights ÷ (6 poles x 4 rows/pole) = 7 lights/row

2. Section E has 11 rows of seats. Each of the lower five rows has 12 seats. The upper six rows have varying numbers of seats: one row has 13 seats, two rows have 15 seats, and three rows have 14 seats. What is the total of number of seats in Section E?

   Lower area: 5 rows x 12 seats/row = 60 seats
   Upper area: 13 seats + (2 rows x 15 seats/row) + (3 rows x 14 seats/row) = 85 seats
   Total number of seats: 60 seats + 85 seats = 145 seats

3. Section M has 11 rows of seats. Each of the lower five rows has 5 seats; the upper six rows have a total of 36 seats. In the upper six rows, each row has at least five seats and no more than eight seats. Within the six rows of seats, one number is used once, another number is used twice, and the last number is used three times; the number 7 is not used. What is the number of seats in each row of the upper area? What is the total number of seats in Section M?

   Lower area: 5 rows x 5 seats/row = 25 seats
   Total number of seats: 25 seats + 36 seats = 61 seats
   Through trial and error, the upper six rows contain one row of eight seats, two rows of five seats, and three rows of six seats.

4. Section A has 11 rows of seats. Each of the lower five rows has five seats; the upper six rows have an equal number of seats in each row. There are a total of 73 seats in the section. What is the number of seats per row in the upper area?

   Lower area: 5 rows x 5 seats/row = 25 seats
   Upper area: 73 seats - 25 seats = 48 seats
   48 seats ÷ 6 rows = 8 seats/row

5. Sections D and G, located in the box seating sections, each have 11 rows of seats split into two areas. Each of the lower five rows has 20 seats; the upper six rows contain a total of 132 seats. Within the upper six rows, no row has less than 21 seats and no row has more than 23 seats. The number of seats in each row can repeat only once. How many seats are in each row of the upper area? What is the combined total of seats in Sections D and G?

   Sections D and G contain the same number of seats.
   Section D, lower area: 5 rows x 20 seats/row = 100 seats
   Section D, upper area: Each of the six rows contains 21, 22, or 23 seats; each number of seats can be repeated only once. Therefore, the rows contain 21, 21, 22, 22, 23, and 23 seats (total of 132 seats).
   Section D: 100 seats + 132 seats = 232 seats
   Combined total of Sections D and G: 232 seats x 2 = 464 seats

   Note: For the upper area, the rows could be arranged in several ways. Disregarding barriers, steps, etc., stadium rows are essentially concentric rings of seats. The circumference of a circle is directly proportional to its radius, so as the distance from the center of the field increases, the rings of seats become larger. Therefore, the lower rows would likely have fewer seats than the upper rows, within the section and within the stadium.

6. If there are approximately 7,000 seats at Engel Stadium, and 1,608 seats are in the box seating sections, how many seats are in the general admission sections? What is the average number of seats per section, if there are 12 sections of box seating and 16 sections of general admission?

   Seats in general admission: 7,000 seats - 1,608 seats = 5,392 seats
   Box seating: 1,608 seats ÷ 12 sections = 134 seats/section
   General admission: 5,392 seats ÷ 16 sections = 337 seats/section

7. Engel Stadium was opened in 1930. At that time, ticket price was 1/6 of the current price. The current ticket prices are $12 for a box seat and $6 for a general admission seat. What would have been the total amount of ticket money collected at a game if the stadium sold out in 1930? How much more ticket money is collected now for a sold-out game now? (Use the seating information provided in problem 6.)

   Ticket money collected in 1930:
   [1,608 box seats x (1/6)($12/box seat)] + [5,392 ga seats x (1/6)($6/ga seat)] = $8,608
   Difference from 1930 to 2002:
   [(1,608 box seats x $12/box seat) + (5,392 ga seats x $6/ga seat)] - $8,608 = $43,040

8. There are approximately 7,000 seats at Engel Stadium. If the Chattanooga Mocs play a baseball game on a hazy day and there is an average of one person for every eight seats, how many people are at the game?

   1/8 x 7,000 people = 875 people

9. There are 1,608 seats in the box seating sections; each ticket costs $12. How much ticket money would be collected if 2/3 of the box seating tickets were sold?

   2/3 x 1,608 tickets x $12/ticket = $12,864

10. Suppose that $55,000 had to be collected on box seat ticket sales ($12 per ticket) before the end of the season for the stadium to remain out of debt. The two games prior to the last game sold out, but only 7/8 of the tickets were sold at the last game. With a total of 1,608 seats in the box seating sections, was the budget met? By how much money were ticket sales over or under the budget?

    [2 gm x 1,608 tk/gm x $12/tk] + [1 gm x 7/8 x 1,608 tk/gm x $12/tk] = $55,476
    The budget was met because $55,476 > $55,000
    Ticket sales were over the budget by $476.

Web Sites for Further Exploration

Engel Stadium
  http://www.minorleagueballparks.com/enge_tn.html

FunBrain.com - Math Baseball
  http://www.funbrain.com/math/

Batter's Up Baseball
  http://www.prongo.com/math/

Math Forum: Baseball Math
  http://mathforum.org/midpow/POW/July.07.html

Scholastic: Baseball Math
  http://teacher.scholastic.com/products/instructor/baseballmath.htm

Exploratorium: Science of Baseball
  http://www.exploratorium.edu/baseball/

ThinkQuest: Baseball - The Game and Beyond
  http://library.thinkquest.org/11902/

Learning from Baseball
  http://www.teachersfirst.com/baseball.htm

Activity 5
Bridges of Chattanooga

Sarah Armes and Jason Wohlers
December 2001

Walnut Street Bridge

Description of Module

There are four main bridges in downtown Chattanooga which most people use to cross the Tennessee River. They are the Olgiati Bridge, Veterans Bridge, Chief John Ross Bridge (or Market Street Bridge), and Walnut Street Bridge (or the Walking Bridge). This module gives the student an opportunity to see physics in action by dropping a stone from a bridge to find its height, and by applying the formula v=d/t to determine the time required to cross the river.

Standards

Number and Operations, grades 6-8
Connections, grades 6-8
Problem Solving, grades 6-8
Data Analysis and Probability, grades 6-8
Measurement, grades 6-8
Communication, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

Market Street Bridge

Objective: To find the height of each of the four bridges through experimentation.

1. Briefly describe the weather conditions on your sheet of paper.
2. Drop the pebble and count the number of seconds it takes to hit the water.
3. Use the formula height=1/2 * gravity * time^2 to find height (gravity = 32 ft/s^2).
4. Compare these heights to fill in the chart.
5. For which bridge was your estimate closest to the actual value?
6. What conditions could affect these results?
7. Place the bridges in order of height from shortest to tallest (from actual results).
8. Consider a previous time in history when the only bridges were the Market Street Bridge and Walnut Street Bridge. Could a ship 55 feet tall pass safely under the bridges? Repeat the problem for a ship 80 feet tall and a ship 110 feet tall. Assume a constant water level.

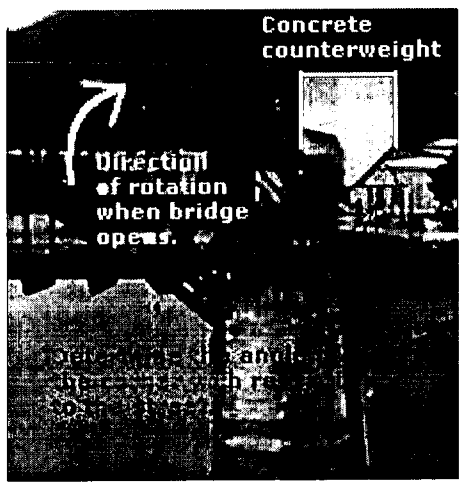
Objective: To find the length of each of the four bridges through experimentation.

1. Ask someone drive you across the bridges. Set the car's odometer (trip meter) at 0.00.
2. Note the speed limit for each bridge on your paper.
3. Check the odometer at the beginning and at the end of each bridge, and record this data.
4. Fill in the length of each bridge on the chart.
5. What was the difference between your measurement and the actual length of each bridge?
6. Using your data, which bridge is the longest?
7. Using your data, which bridge is the shortest?

8. Using the actual length of each bridge, how much time would be needed to cross each bridge traveling at the speed limit? Record in the table.
9. Which is the fastest route across the river?
10. Using the actual length for a bridge and the distance between bridges, draw three routes that a jogger may take. What is the length of each route?
11. Determine your rate of speed (velocity) by using the length of the walking bridge and the time needed to walk across the bridge (velocity = distance/time).
12. Assuming a car length of 10 feet and a safe distance between cars of 15 feet, estimate the number of cars could fit on each bridge. (Hint: remember the lanes.)

The Market Street Bridge is a drawbridge through which tall ships may pass.
Objective: To determine the angle to which the Market Street Bridge opens.

1. Look at the angle on the corner of the big concrete weight at each end of the bridge. What is the measure of the angle?
2. If the line of the counterweight is parallel to the street, to what angle will the bridge open?



Objective: To determine estimated use of each bridge.

1. Record time and date in the table.
2. For 1 minute, count the number of cars that drive by in one direction. Record in the table for the Olgiati, Market Street, and Veterans bridges.
3. Estimate the number of cars would drive by in 1 hour.
4. Do the same for the other direction. Record in the table.
5. Are the values similar? Why or why not?
6. For 5 minutes, count the pedestrians that pass by on the Walnut Street, Veterans, and Market Street bridges. Record in the table.
7. Estimate the number of pedestrians that pass by in 1 hour. Record in the table.
8. What is the ratio of pedestrians to cars that pass by in 1 hour on the Veterans and Market Street bridges?

Height

	Experimental height	Actual height	Difference
Olgiati			
Market Street			
Walnut Street			
Veterans			

Length

	Odometer Reading: Beginning	Ending	Length	Actual length	Difference	Speed limit	Time across
Olgiati							
Market Street							
Walnut Street							
Veterans							

Estimate

	Time/date	Cars (1 min)	Cars (1 hr)	Pedestrians (5 min)	Pedestrians (1 hr)
Olgiati					
Market Street					
Walnut Street					
Veterans					

	Ratio of pedestrians to cars	
Veterans		
Market Street		

Solutions

Height
1. – 5. Answers will vary.

Actual data

Bridge	Height	Drop time
Olgiati	72 ft	2.1 s
Veterans	78 ft	2.2 s
Market Street	75 ft	2.2 s
Walnut Street	105 ft	2.6 s

6. Wind, rain, other weather conditions.
7. From shortest to tallest: Olgiati, Market Street, Veterans, Walnut Street.
8. Yes. Only if the Market Street Bridge is opened. No.

Length
1. – 7. Answers will vary.
8. Veterans Bridge, 45.05 s; Market Street Bridge, 71.42 s; Olgiati Bridge, 33.28 s.
9. The Olgiati Bridge is the fastest route across the river.
10. Answers will vary.
11. Answers will vary.
12. Olgiati Bridge, 422 cars (four lanes); Market Street Bridge, 400 cars (four lanes); Veterans Bridge, 520 cars (five lanes).

Market Street Bridge
1. 45 degrees
2. 45 degrees

Estimation and Use
1. – 8. Answers will vary, but look for consistency with time of day and interpreted results. For example, if it is 7:30 a.m., the traffic going into the city should be more highly concentrated than the traffic going out of the city.

Actual Data from Chattanooga – Hamilton County Bicentennial Library

Bridge	Height	Length
Olgiati	72 ft	2,641 ft
Veterans	78 ft	2,600 ft
Market Street	75 ft	2,500 ft
Walnut Street	105 ft	2,370 ft

Web Sites for Further Exploration

Map of Downtown Chattanooga
http://chattanoogasports.org/map.html

RiverCity Company: Walnut Street Bridge
http://www.rivercitycompany.com/ddvelop/public_places/walnut.asp

NOVA: Super Bridge—Suspension Bridge
http://www.pbs.org/wgbh/nova/bridge/meetsusp.html

Alameda County Drawbridges
http://users.rcn.com/kenseq/bridges/

Math Forum Problems Library: Middle School, Distance-Rate-Time
http://mathforum.org/library/problems/sets/middle_distance-rate-time.html

Math Forum: Leonard Euler and the Bridges of Königsberg
http://mathforum.org/isaac/problems/bridges1.html

John Carroll University: Graph Theory and the Bridges of Königsberg
http://www.jcu.edu/math/vignettes/bridges.htm

WQED Pittsburgh: Bridges and Buildings
http://www.wqed.org/erc/pghist/units/build/index.html

New York City Marathon: The Course
http://www.nyrrc.org/nyrrc/mar01/about/course-detailed.html

Activity 6
Buckner-Rush Funeral Home – Dying to Do Math

Laura Hale
October 2002

Description of Module

This module presents a snapshot of 1 month in the funeral business. The student will analyze data from tables or lists, and calculate ratios and averages. Location: 220 Wildwood Ave., Cleveland, TN 37311; 2600 N. Ocoee St., Cleveland, TN 37311.

Standards

Data Analysis and Probability, grades 6-8
Representation, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. Four funeral homes operate in Bradley County, Tennessee. Sixty-seven people died in Bradley County in September 2002. The distribution of bodies between the funeral homes was:

Ralph Buckner Funeral Home	24
Buckner-Rush Funeral Home	15
Fike Funeral Home	14
Grissom Funeral Home	14

   a. What percentage of bodies did each funeral home receive?

   b. Create a pie chart as a graphical representation of the percentages.

   c. How many more bodies did Ralph Buckner Funeral Home receive than Buckner-Rush Funeral Home?

   d. On average, how many bodies per week did Ralph Buckner Funeral Home receive?

2. Seventy percent of people have life insurance when they die. The average funeral costs $6,000.00. The rate of a $100,000.00 policy varies as follows:
   Chris is 20 years old and pays $ 38.00 per month
   Mark is 40 years old and pays $ 59.00 per month
   Bob is 60 years old and pays $120.00 per month

   a. If each man dies at 80 years old, who would get the best value on his policy?

   b. If each man dies at 70 years old, who would get the best value on his policy?

   c. If Chris dies at 80 years old, how much will Chris' estate net on his policy?

   d. If Bob dies at 80 years old, how much will Bob's estate net on his policy?

3. Funeral proceedings usually last over a period of 3 days from death to interment. The funeral director has personal contact with the family in the following time frames:

First Call	2 hours	Visitation	5 hours
Arrangements	1 hour	Funeral Chapel	1 hour
Embalming	2 hours	Cemetery	1 hour

   a. If a funeral costs $6,000.00 and the non-hourly costs total $4,500.00, what is the funeral director's hourly fee during personal contact?

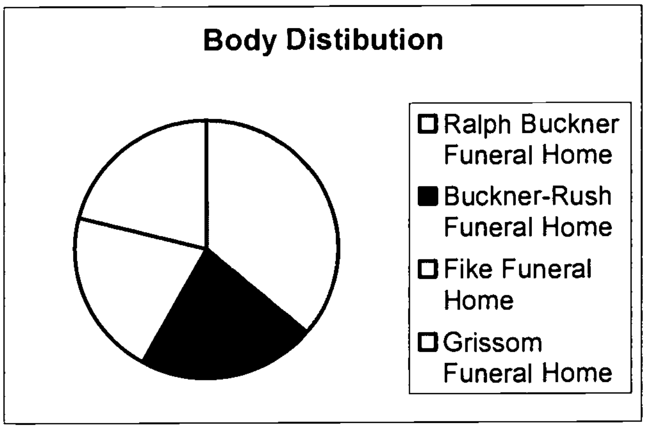
   b. What is the average number of hours the funeral director spends with the family per day?

Solutions

1a. What percentage of bodies did each funeral home receive?

Ralph Buckner Funeral Home	24/67 x 100% = 36%
Buckner-Rush Funeral Home	15/67 x 100% = 22%
Fike Funeral Home	14/67 x 100% = 21%
Grissom Funeral Home	14/67 x 100% = 21%

1b. Create a pie chart as a graphical representation of the percentages.



1c. How many more bodies did Ralph Buckner Funeral Home receive than Buckner-Rush Funeral Home?

24 bodies – 15 bodies = 9 bodies

1d. On average, how many bodies per week did Ralph Buckner Funeral Home receive?

24 bodies / 4 wk = 6 bodies/wk

2a. If each man dies at 80 years old, who would get the best value on his policy?

Chris pays: 60 yr x ($38.00 x 12 mo/yr) = $27,360.00
Mark pays: 40 yr x ($59.00 x 12 mo/yr) = $28,320.00
Bob pays: 20 yr x ($120.00 x 12 mo/yr) = $28,800.00
Chris would get the best value on his policy.

2b. If each man dies at 70 years old, who would get the best value on his policy?

Chris pays: 50 yr x ($38.00 x 12 mo/yr) = $22,800.00
Mark pays: 30 yr x ($59.00 x 12 mo/yr) = $21,240.00
Bob pays: 10 yr x ($120.00 x 12 mo/yr) = $14,400.00
Bob would get the best value on his policy.

2c. If Chris dies at 80 years old, how much will Chris' estate net on his policy?

$100,000.00 - $27,360.00 - $6,000.00 = $66,640.00

2d. If Bob dies at 80 years old, how much will Bob's estate net on his policy?

$100,000.00 - $28,800.00 -$6,000.00 = $65,200.00

3a. If a funeral costs $6,000.00 and the non-hourly costs total $4,500.00, what is the funeral director's hourly fee during personal contact?

$6,000.00 – $4,500.00 = $1,500.00
$1500.00 / 12 hr = $125.00/hr

3b. What is the average number of hours the funeral director spends with the family per day?

12 hr / 3 day = 4 hr/day

Web Sites for Further Exploration

Buckner Rush
http://www.virtualbradley.com/features/bucknerrush.cfm

MetLife: Helping Your Child Understand Money
http://www.metlife.com/Applications/Corporate/WPS/CDA/PageGenerator/0,1674,P1193,00.html

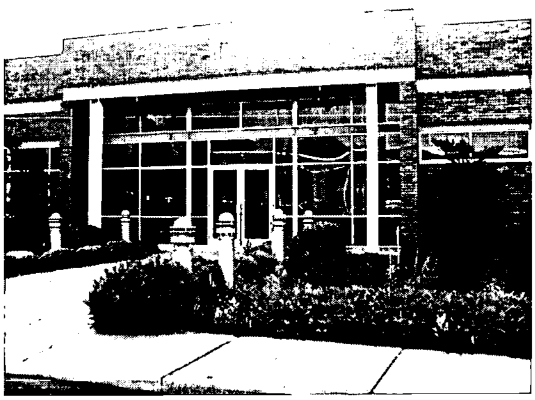
FEMA for Kids
http://www.fema.gov/kids/

Centers for Disease Control and Prevention: Body and Mind
http://www.bam.gov/

Institute for Business & Home Safety
http://www.ibhs.org/

Activity 7
Challenger Center - Our Mission to Mars

Heather Emerling and Christy Kiefer
November 7, 2001



Description of Module

The Challenger Center, at The University of Tennessee at Chattanooga, immerses the student in an environment described as situated cognition, in which the student learns mathematics, science, and technology while solving problems within the context of the simulation. Prior to participating in a mission, the student prepares for a role on a team, for example, communication, medical, isolation, life support, data, navigation, probe, or remote. One of four missions, Voyage to Mars, Rendezvous with a Comet, Encounter Earth, and Return to the Moon, is completed. Location: UTC campus, 5th and Palmetto Sts., Chattanooga, TN 37403

Standards

Number and Operations, grades 6-8
Data and Analysis Probability, grades 6-8
Connections, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Background Information

Distance from the Sun:	Average: 228,000,000 km (1.52 times as far as Earth)
Eccentricity of Orbit:	0.0935 vs. 0.0167 for Earth
Distance from Earth:	Minimum: 55,000,000 kilometers Maximum: 401,000,000 kilometers
Year:	1.88 Earth years = 669 Martian days = 687 Earth days
Solar Day:	24.7 hours
Tilt of Rotation Axis:	25.2° vs. 23.5° for Earth
Size:	Diameter: 6,794 kilometers vs. 12,756 kilometers for Earth Surface Gravity: 0.397 of the Earth's gravity Mass: 6.4 x 10^{23} kg vs. 59.8 x 10^{23} kg for Earth Density: 3.933 x 10^3 kg/m^3 vs. 5.515 x 10^3 kg/m^3 for Earth
Surface Temperature:	Cold Average Surface Temperature: -63°C Diurnal Temperature Range: -89°C to -31°C
Atmosphere:	Mars contains 95% carbon dioxide, 3% nitrogen, 1.6% argon, 0.1% oxygen, 0.1% carbon monoxide, ~ 0.03% water. Earth contains 78% nitrogen, 21% oxygen, 1% argon, ~ 1% water, 0.03% carbon dioxide.
Surface Pressure:	6.36 millibars, or about 1/159th of the Earth's (1,014 mb)
Moons:	Phobos ("Fear") (diameters): 27 km x 22 km x 18 km Deimos ("Panic") (diameters): 15 km x 12 km x 10 km
Orbital Parameters:	Mean orbital velocity: 24.13 km/s Maximum orbital velocity: 26.5 km/s Minimum orbital velocity: 21.97 km/s

Problems

Given the following launch and landing dates: Earth launch, May 11, 2018; Mars landing, November 27, 2018; Mars departure, May 30, 2020; and Earth arrival, December 16, 2020.

1. How many days did the voyage from Earth to Mars last (include launch and landing dates)?

2. How many days would you be on Mars? Do not include the landing or launch dates. HINT: 2020 is a leap year.

3. How many days did the voyage from Mars to Earth last (include launch and landing dates)?

4. How many days did you travel altogether?

5. How many days did the entire voyage last?

Use the Background Information sheet about Mars to answer the following questions:

6. What is the average distance from the Sun to Mars, expressed in scientific notation?

7. What is the mean distance of Mars from the Earth? Express the answer in standard form and in scientific notation.

8. What would the age of a 12-year-old from Earth be in Martian years? What would your age be if you lived on Mars?

9. How many minutes are in a Martian day? How many seconds are in a Martian day?

10. What is the ratio comparing the tilt of the rotation axis of Mars to that of Earth?

11. What is the average surface temperature in degrees Fahrenheit? What is the typical range of surface temperature in degrees Fahrenheit?

12. How much below freezing is the average surface temperature in degrees Celsius? How much below freezing is the average surface temperature in degrees Fahrenheit?

13. What is the degree range in temperature in Celsius and Fahrenheit?

14. Using pie graphs, show the distribution of the various components of the atmospheres of Earth and Mars. Label each section.

15. How much larger is the volume of Earth than Mars (density = mass / volume)? Write the answer in scientific notation.

16. What is the mean orbital velocity in kilometers per hour?

Solutions

1. How many days did the voyage from Earth to Mars last (include launch and landing dates)?

   May 11, 2018 to Nov. 27, 2018
   May 11-31, Jun. 1-30, Jul. 1-31, Aug. 1-31, Sep. 1-30, Oct. 1-31, Nov. 1-27
   (21 + 30 + 31 + 31 + 30 + 31 + 27) days = 201 days

2. How many days would you be on Mars? Do not include the landing or launch dates. HINT: 2020 is a leap year.

   Nov. 28, 2018 to May 29, 2020
   Nov. 28-30, Dec. 1-31, 2019, Jan. 1-31, Feb. 1-29, Mar. 1-31, Apr. 1-30, May 1-29
   (3 + 31 + 365 + 31 + 29 + 31 + 30 + 29) days = 549 days

3. How many days did the voyage from Mars to Earth last (include launch and landing dates)?

   May 30, 2020 to Dec. 16, 2020
   May 30-31, Jun. 1-30, Jul. 1-31, Aug. 1-31, Sep. 1-30, Oct. 1-31, Nov. 1-30, Dec. 1-16
   (2 + 30 + 31 + 31 + 30 + 31 + 30 + 16) days = 201 days

4. How many days did you travel altogether?

   201 days + 201 days = 402 days

5. How many days did the entire voyage last?

   201 days + 549 days + 201 days = 951 days

6. What is the average distance from the Sun to Mars, expressed in scientific notation?

   228,000,000 km = 2.28×10^8 km

7. What is the mean distance of Mars from the Earth? Express the answer in standard form and in scientific notation.

   Mean distance = (55,000,000 km + 401,000,000 km) / 2 = 228,000,000 km
   228,000,000 km = 2.28×10^8 km

8. What would the age of a 12-year-old from Earth be in Martian years? What would your age be if you lived on Mars?

   12 yr on Earth ÷ 1.88 Martian yr/Earth yr = 6.38 Martian years old
   Answers will vary.

9. How many minutes are in a Martian day? How many seconds are in a Martian day?

   24.7 hr/Martian day x 60 min/hour = 1,482 min
   24.7 hr/Martian day x 3,600 sec/hr = 88,920 sec

10. What is the ratio comparing the tilt of the rotation axis of Mars to that of Earth?

    25.2° Mars tilt to 23.5° Earth tilt
    $25.2^{\circ} \div 23.5^{\circ} = 1.07$

11. What is the average surface temperature in degrees Fahrenheit? What is the typical range of surface temperature in degrees Fahrenheit?

    Average: -63° C x 9/5 + 32° C = -81.4° F
    Range: -89° C x 9/5 + 32° C to -31° C x 9/5 + 32° C = -128.2° F to -23.8° F

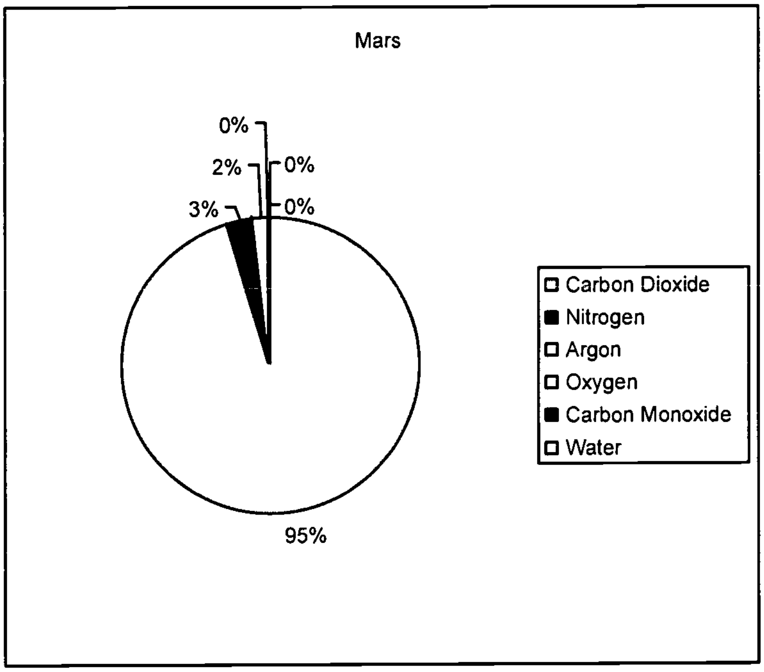
12. How much below freezing is the average surface temperature in degrees Celsius? How much below freezing is the average surface temperature in degrees Fahrenheit?

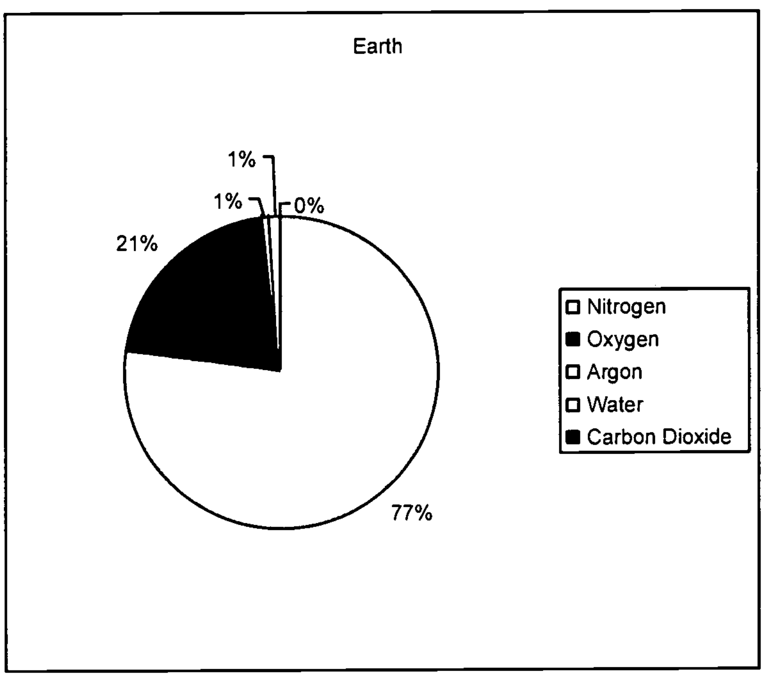
    0° C – (-63° C) = 63° C (63 C$^{\circ}$, or 63 Celsius degrees)
    32° F – (-81.4° F) = 113.4° F (113.4 F$^{\circ}$, or 113.4 Fahrenheit degrees)

13. What is the degree range in temperature in Celsius and Fahrenheit?

    -31° C – (-89° C) = 58° C (58 C$^{\circ}$, or 58 Celsius degrees)
    -23.8° F – (-128.2° F) = 104.4° F (104.4 F$^{\circ}$, or 104.4 Fahrenheit degrees)

14. Using pie graphs, show the distribution of the various components of the atmospheres of Earth and Mars. Label each section.





15. How much larger is the volume of Earth than Mars (density = mass / volume)? Write the answer in scientific notation.

Density = mass / volume
Volume = mass/ density
Volume of Mars = 6.4×10^{23} kg ÷ 3.933×10^{3} kg/m^3 = 1.627×10^{20} m^3
Volume of Earth = 59.8×10^{23} kg ÷ 5.515×10^{3} kg/m^3 = 10.843×10^{20} m^3
Ratio of Earth volume to Mars volume = 10.843×10^{20} m^3 ÷ 1.627×10^{20} m^3 = 6.664

16. What is the mean orbital velocity in kilometers per hour?

24.13 km/sec x 3,600 sec/hr = 86,868 km/hr

References

Challenger Center for Space Science Education. (2000). *Mars*.

National Space Science Data Center. (2003). *Earth fact sheet*. Retrieved July 7, 2003, from http://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html

National Space Science Data Center. (2003). *Mars fact sheet*. Retrieved July 7, 2003, from http://nssdc.gsfc.nasa.gov/planetary/factsheet/marsfact.html

National Space Science Data Center. (2003). *Planetary fact sheet*. Retrieved July 7, 2003, from http://nssdc.gsfc.nasa.gov/planetary/factsheet/index.html

National Space Science Data Center. (2003). *Planetary fact sheet - Ratio to Earth values*. Retrieved July 7, 2003, from http://nssdc.gsfc.nasa.gov/planetary/factsheet/planet_table_ratio.html

Web Sites for Further Exploration

Challenger Center - UTC
http://www.utc.edu/~challctr/

Challenger Center Online
http://www.challenger.org/

NASA - National Space Science Data Center
http://nssdc.gsfc.nasa.gov/

The Nine Planets
http://seds.lpl.arizona.edu/nineplanets/nineplanets/nineplanets.html

Solar System Simulator
http://space.jpl.nasa.gov/

How Much Would You Weigh on Another Planet?
http://kids.msfc.nasa.gov/Puzzles/Weight.asp

National Geographic Society: Virtual Solar System
http://www.nationalgeographic.com/solarsystem/

NASA Earth Observatory
http://earthobservatory.nasa.gov/

Astrobiology at NASA
http://astrobiology.arc.nasa.gov/

Robonaut
http://vesuvius.jsc.nasa.gov/er_er/html/robonaut/robonaut.html

Activity 8
Chattanooga Ducks

Adam Wright
December 2001

Description of Module

Chattanooga Ducks provides tours of downtown Chattanooga *in* the Tennessee River. Amphibious vehicles drive on land then plunge into the water at Ross' Landing for a 60-minute adventure on the river and around Maclellan Island. In this module, the student will calculate moment and center of balance. Location: 201 W. 5th St. (5th and Broad Sts.), Chattanooga, TN 37402.

Standards

Measurement, grades 6-8
Problem Solving, grades 6-8

Standards Documents

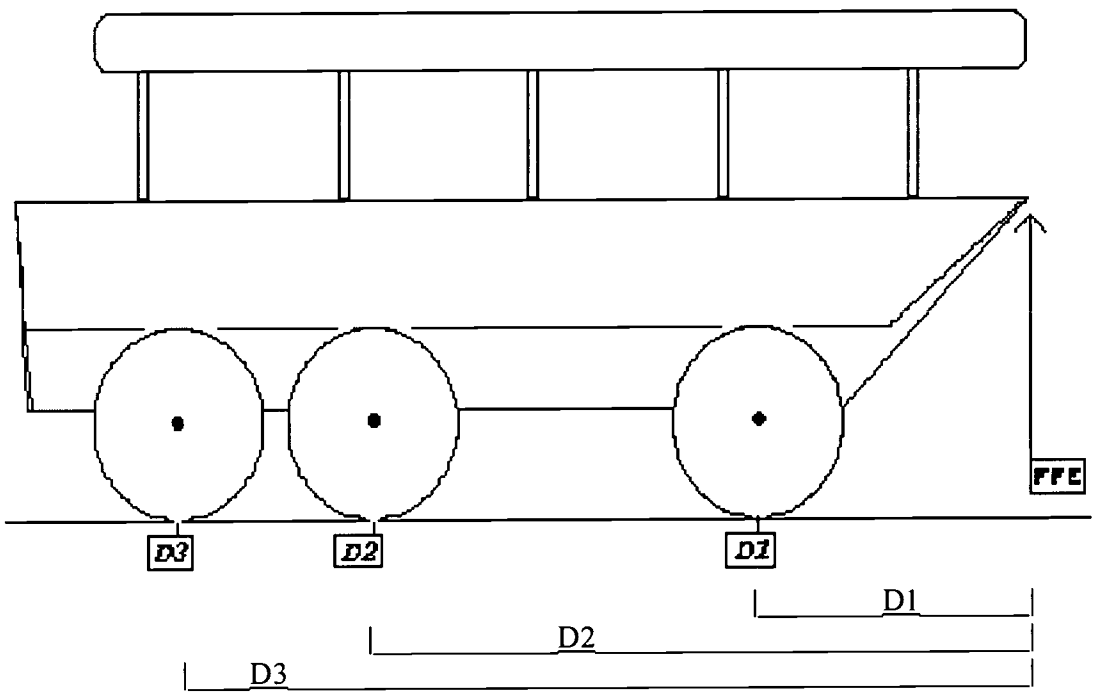
National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems



All distances are measured FFE (From Front End) - the most forward point of reference.

Arm = Distance (FFE)
Weight x Arm = Moment

$$\text{Center of Balance} = \frac{\text{Total Moment}}{\text{Total Weight}}$$

1. If D1 = 74" with a weight of 3,100 lb, D2 = 192" with a weight of 1,100 lb, and D3 = 235" with a weight of 1,400 lb, what is each individual moment? What are the total moment and weight?

2. What is the center of balance for the vehicle?

3. If you found the midpoint of D2 and D3, and combined the weights of both axles, would the center of balance be the same as that found in question 2?

4. What is the center of balance for a two-axle vehicle with D1 = 24" with a weight of 1,700 lb and D2 = 77" with a weight of 1,250 lb?

5. Using the weights from question 1, find the percentage of weight on each axle.

Solutions

1. If D1 = 74" with a weight of 3,100 lb, D2 = 192" with a weight of 1,100 lb, and D3 = 235" with a weight of 1,400 lb, what is each individual moment? What are the total moment and weight?

74 in.	x	3,100 lb	=	229,400 in.-lb
192 in.	x	1,100 lb	=	211,200 in.-lb
235 in.	x	1,400 lb	=	329,000 in.-lb
Total Moment			=	769,600 in.-lb
Total Weight			=	5,600 lb

2. What is the center of balance for the vehicle?

CB = 769,600 in.-lb ÷ 5,600 lb ≈ 137 in. FFE

3. If you found the midpoint of D2 and D3, and combined the weights of both axles, would the center of balance be the same as that found in question 2?

No, but it would be very close.

74 in.	x	3,100 lb	=	229,400 in.-lb
213.5 in.	x	2,500 lb	=	533,750 in.-lb
Total Moment			=	763,150 in.-lb
Total Weight			=	5,600 lb

CB = 763,150 in.-lb ÷ 5,600 lb ≈ 136 in. FFE

4. What is the center of balance for a two-axle vehicle with D1 = 24" with a weight of 1,700 lb and D2 = 77" with a weight of 1,250 lb?

24 in.	x	1,700 lb	=	40,800 in.-lb
77 in.	x	1,250 lb	=	96,250 in.-lb
Total Moment			=	137,050 in.-lb
Total Weight			=	2,950 lb

CB = 137,050 in.-lb ÷ 2,950 lb ≈ 46 in. FFE

5. Using the weights from question 1, find the percentage of weight on each axle.

Axle 1 = 3,100 lb / 5,600 lb x 100% = 55%
Axle 2 = 1,100 lb / 5,600 lb x 100% = 20%
Axle 3 = 25%

Web Sites for Further Exploration

Chattanooga Ducks
http://www.chattanoogaducks.com/

Chattanooga Audubon Society
http://www.audubonchattanooga.org/island.html

Metroducks - Amphibious Vehicle Duck Tours
http://www.metroducks.com/

NASA Glenn Research Center: Torque (Moment)
http://www.grc.nasa.gov/WWW/K-12/airplane/torque.html

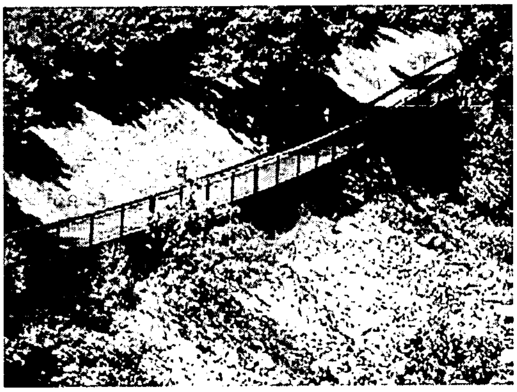
NASA Dryden Flight Research Center: Summary and Review
http://www.dfrc.nasa.gov/Education/OnlineEd/NewtonsLaws/pdf/instructor/instsummary.pdf

See-Saw Torque
http://www.explorescience.com/activities/Activity_page.cfm?ActivityID=21

Chattanooga Audubon Society
http://www.audubonchattanooga.org/

Activity 9
Chattanooga Riverwalk

Rachel Rogers
October 24, 2001



Description of Module

The Riverwalk is a planned, 22-mile pathway along the Tennessee River. In this module, the student will examine the section of the path that begins at the Tennessee Aquarium and goes toward the Walnut Street Bridge. At the bridge, one is given the option of walking up the stairway to the bridge, and across to Coolidge Park; or taking the path through the amphitheater toward the Bluff View Art District. The latter path ends at the Rowing Center; this section of the Riverwalk is about 8 miles in length.

Standards

Measurement, grades 6-8 and 9-12
Data Analysis and Probability, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

Section A

1. As with most sidewalks, the Riverwalk is formed using concrete slabs. Select three of these slabs along the path on which to take measurements. Describe in words or in a drawing the general location of the slabs that you have chosen.

2. What are the length and width measurements for each of these sections of concrete?

3. Calculate the average length and width of these three slabs.

4. Find the area of one of these slabs in square feet? What is the area in square inches?

5. Find the average area for the three slabs in both square feet and square inches.

6. How many of these sections are needed to construct 1 mile of a perfectly straight linear pathway? (1 mile = 5,280 ft.)

Section B

1. Begin anywhere on this section of the Riverwalk. Walk this section at your natural pace for 5 minutes. Draw a map of the section that you walked.

2. Look at your map and think about the distance you have walked from where you started.

3. How many miles in length would you estimate this section of the Riverwalk to be? How many meters in length would you estimate this section of the Riverwalk to be? Describe your process for each estimation.

4. Given this estimate (in miles), calculate your rate of speed for walking this section of the Riverwalk

5. How many slabs would be needed to cover the section walked, according to your estimate of its length?

Section C

1. If you were walking this 8-mile section of the Riverwalk at a pace of 3 miles per hour, how long would it take to walk the entire pathway?

2. At what average pace would you have to travel to complete the path in 45 minutes?

Section D

1. Along this 8-mile section of the Riverwalk, you would pass through the amphitheater.

2. Go to the amphitheater, sit down, and observe your surroundings.

3. Without taking any measurements, estimate the seating capacity of the amphitheater.

4. Take a measurement of the width of your hips; use feet or inches. Estimate the number of people of your size that would fit in the seats of the amphitheater, leaving about 5 inches between each person.

5. Measure the seating areas of the amphitheater; use feet or inches. Based on this measurement, what is your estimate of the seating capacity?

Section E

1. You will notice on your trip through this 8-mile pathway that you pass by several other landmarks. The Hunter Museum, the Bluff View Art District, the tennis center, Citico Creek, and the Tennessee-American Water Company are all located on this route. Select one of these landmarks and write five math problems related to that landmark.

Web Sites for Further Exploration

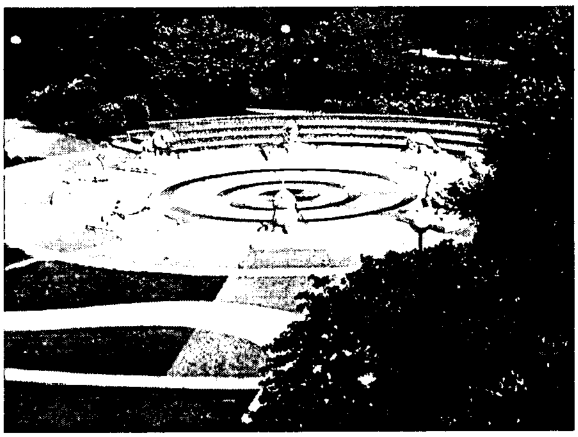
The Chattanooga RiverWalk Tour
http://excursions.home.mindspring.com/riverwalkpics.htm

Southwest Educational Development Laboratory: Using Mathematics in Fossil Reconstruction
http://www.sedl.org/scimath/compass/v03n01/usingmath.html

American University of Beirut: Where Can Your Feet Take You?
http://webfaculty.aub.edu.lb/~websmec/article_3.htm

Activity 10
Coolidge Park

Stephanie Woods
October 23, 2002



Description of Module

Coolidge Park, named after Charles Coolidge, a World War II Medal of Honor recipient, is a 7-acre public park on the north side of the Tennessee River in downtown Chattanooga. It features a variety of recreational activities, including a carousel, an interactive fountain, and a climbing wall, as well as shopping and restaurants. In this module, the student will apply knowledge of algebra to solve problems related to events and landmarks in the park. Location: North of the Tennessee River, between the Market Street Bridge and Walnut Street Bridge.

Standards

Algebra, grades 9-12
Measurement, grades 9-12
Problem Solving, grades 9-12
Connections, grades 9-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. Coolidge Park requires a lot of maintenance to keep it looking nice. Every 6 days, workers cut the grass, and every 5 days, a clean up crew picks up trash. Assuming a new year has begun, and the days of the year are numbered consecutively, (1, 2, 3, ..., 365), when, if ever, will the lawn and the clean up crews be there on the same day?

2. Five brothers were playing in the park. The youngest brother, Jake, is 5 years old. The oldest brother, Jonathan, is three times Jake's age, while the next to the oldest, Joshua, is 3 years younger than Jonathan. Jason's age is two-thirds of Jonathan's age. Justin is 5 years younger than Joshua. How old is each of the brothers?

3. Four boats in the downtown Chattanooga area have a daily average of 150 riders. The first boat has 200 riders, the second boat has only 75 riders, and the fourth boat has 105 riders. How many riders are on the third boat?

4. Jackie and Jeremy went to Coolidge Park on Saturday to climb Walnut Wall. Jackie's climbing times were 3 minutes 15 seconds, 3 minutes 55 seconds, and 3 minutes 35 seconds. What was the average time, in seconds, it took Jackie to climb Walnut Wall? Jeremy's climbing times were 3 minutes 45 seconds, 3 minutes 24 seconds, and 3 minutes. What was the average time, in seconds, it took Jeremy to climb Walnut Wall? Which climber has the faster average? By how many seconds is one climber faster than the other?

5. The Chattanooga Star seats 200 passengers and the Riverboat Barge & Grill seats 250 passengers. If the Chattanooga Star charges $12.55 per person and the Riverboat Barge & Grill charges $10.75 per person, what is the most revenue each company can make per cruise?

6. The Smith family went to the park for their annual family reunion. There were 132 people in attendance. There were four more men than women; 24% of the men wore blue shirts. Estimate the number of men who did not wear a blue shirt.

7. There is a big circle in Coolidge Park that has a game in the center. The diameter of the circle is 188.75 in. Find the circumference of the circle.

8. What is the area of the circle with a diameter of 188.75 in.?

9. Of the various shapes that you can find in Coolidge Park, there are several triangles. A certain triangle has a base of 239 in. and sides that are 267 in. and 184 in. in length. What is the perimeter of this triangle?

Solutions

1. Coolidge Park requires a lot of maintenance to keep it looking nice. Every 6 days, workers cut the grass, and every 5 days, a clean up crew picks up trash. Assuming a new year has begun, and the days of the year are numbered consecutively, (1, 2, 3, ..., 365), when, if ever, will the lawn and the clean up crews be there on the same day?

   Both crews will be there on days numbered as common multiples of 5 and 6: days 30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330, and 360.

2. Five brothers were playing in the park. The youngest brother, Jake, is 5 years old. The oldest brother, Jonathan, is three times Jake's age, while the next to the oldest, Joshua, is 3 years younger than Jonathan. Jason's age is two-thirds of Jonathan's age. Justin is 5 years younger than Joshua. How old is each of the brothers?

Let x = Jake's age	Jake is 5 years old.
3x = Jonathan's age	Jonathan is 15 years old.
3x - 3 = Joshua's age	Joshua is 12 years old.
(2/3)(3x) = Jason's age	Jason is 10 years old.
(3x - 3) - 5 = Justin's age	Justin is 7 years old.

3. Four boats in the downtown Chattanooga area have a daily average of 150 riders. The first boat has 200 riders, the second boat has only 75 riders, and the fourth boat has 105 riders. How many riders are on the third boat?

   $(200 + 75 + x + 105) / 4 = 150$
   $200 + 75 + x + 105 = 600$
   $x + 380 = 600$
   $x = 220$

4. Jackie and Jeremy went to Coolidge Park on Saturday to climb Walnut Wall. Jackie's climbing times were 3 minutes 15 seconds, 3 minutes 55 seconds, and 3 minutes 35 seconds. What was the average time, in seconds, it took Jackie to climb Walnut Wall? Jeremy's climbing times were 3 minutes 45 seconds, 3 minutes 24 seconds, and 3 minutes. What was the average time, in seconds, it took Jeremy to climb Walnut Wall? Which climber has the faster average? By how many seconds is one climber faster than the other?

   Jackie's times: 195 s, 235 s, and 215 s. Jeremy's times: 225 s, 204 s, and 180 s. Jackie's average was 215 s. Jeremy's average was 203 s. Jeremy had the faster average. Jeremy was faster by 12 s.

5. The Chattanooga Star seats 200 passengers and the Riverboat Barge & Grill seats 250 passengers. If the Chattanooga Star charges $12.55 per person and the Riverboat Barge & Grill charges $10.75 per person, what is the most revenue each company can make per cruise?

   The Chattanooga Star's revenue can be no greater than $2,510 (200 x $12.55). The Riverboat Barge & Grill's revenue can be no greater than $2,687.50 (250 x $10.75).

6. The Smith family went to the park for their annual family reunion. There were 132 people in attendance. There were four more men than women; 24% of the men wore blue shirts. Estimate the number of men who did not wear a blue shirt.

   Let x = the number of women
   Let x + 4 = the number of men
   $x + (x + 4) = 132$
   $2x = 128$
   $x = 64$
   $x + 4 = 68$

   24% of the men wore blue shirts
   76% of the men did not wear blue shirts
   $0.76 \times 68 = 51.68$
   Approximately 52 men did not wear a blue shirt.

7. There is a big circle in Coolidge Park that has a game in the center. The diameter of the circle is 188.75 in. Find the circumference of the circle.

   $C = 2\pi r = \pi d = (3.1416)(188.75 \text{ in.}) \approx 592.98 \text{ in.}$

8. What is the area of the circle with a diameter of 188.75 in.?

   $A = \pi r^2 = (3.1416)(94.375 \text{ in.})^2 \approx 27{,}981 \text{ in.}^2$

9. Of the various shapes that you can find in Coolidge Park, there are several triangles. A certain triangle has a base of 239 in. and sides that are 267 in. and 184 in. in length. What is the perimeter of this triangle?

   P = side 1 + side 2 + side 3 = 239 in. + 267 in. + 184 in. = 690 in.

Web Sites for Further Exploration

Coolidge Park
http://www.chattanooga.gov/cpr/parks/coolidgepark.htm

Coolidge Park, Chattanooga, Tennessee Riverfront
http://www.ronlowery.com/gallerypages/a026.html

Word Problems For Kids
http://www.stfx.ca/special/mathproblems/welcome.html

Math Goodies
http://www.mathgoodies.com/

Activity 11
Ducks Unlimited Conservation Benefit at Mary McGuire's Restaurant

Tracie Manypenny
November 11, 2002

Description of Module

Ducks Unlimited is an international nonprofit conservation foundation that works to preserve the wetlands as a natural habitat for migratory birds. It relies on donations to accomplish the foundation's goals. This module asks the student to calculate ratio and area, and work with large numbers. One or more of the problems requires the student to use a multi-step process to solve the problem. Location: 138 Market St., Chattanooga, TN 37402.

Standards

Number and Operations, grades 6-8
Geometry, grades 6-8
Measurement, grades 6-8
Data Analysis and Probability, grades 6-8
Algebra, grades 6-8
Problem Solving, grades 6-8
Reasoning and Proof, grades 6-8
Connections, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. There are about 75 people who have entered a raffle. Each person has 10 tickets. There are 50 prizes that are going to be given away. What is the probability of a given person winning a prize? (A person may win more than one prize.)

2. There is a square table that is 2 feet long and 2 feet wide, and a circular coaster that has a diameter of 2.5 inches. How many coasters will fit side by side on the table top?

3. Each ticket to the Ducks Unlimited banquet costs $40. Four percent of the ticket money went to the restaurant and 96% of the ticket money went to the Ducks Unlimited Wetland Conservation. How much money per ticket did Ducks Unlimited raise?

4. Suppose that 102 people bought tickets to the banquet at $40 per ticket. How much of the proceeds went to the restaurant and how much went to the Ducks Unlimited Wetland Conservation?

5. It costs $250 for a person to sponsor 1 acre of land for 1 year. This prevents the land that is sponsored from being developed (conservation). If you sponsor 4 acres of land for 1 year, how much does that cost per day?

6. If you decided to sponsor the same 4 acres of land for the next year, plus an additional 3 acres of land for the next year, how much would the total cost be for both years? How much would it cost per week?

7. In another raffle, only one prize will be given away. There are 75 people entered for the raffle, and each person has two tickets. What is the probability that one of a given person's tickets will be drawn?

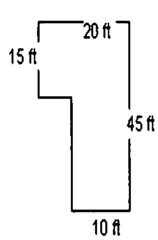
8. Ducks Unlimited has raised $1.587 billion since 1937. What is the average amount that Ducks Unlimited has raised each year from 1937 to 2002 (inclusive)?

9. Ducks Unlimited has a 6-year fundraising effort called "Habitat 2000: Campaign for a Continent." The goal Ducks Unlimited has for this fundraising effort is $600 million. If they exceed this expectation by $302 million, how much money will Ducks Unlimited raise?

10. The total number of acres that Ducks Unlimited has conserved in Canada, the United States, and Mexico is 9,865,373. Suppose that the land is divided equally among the three countries. How many acres has Ducks Unlimited conserved in each country?

11. The United States has lost more than half of its original wetlands due mainly to humans developing the land so that they can live and work there. The United States continues to lose 100,000 acres of wetlands every year. Suppose there are 2,454,065 acres left. How many years will it be until the United States has lost all of its wetlands?

12. The dining area of the restaurant is in an "L" shape. Each table is a square that is 2.5 ft by 2.5 ft. What is the maximum number of tables that will fit into the dining area? Estimate the number of tables that might be used.



Solutions

1. There are about 75 people who have entered a raffle. Each person has 10 tickets. There are 50 prizes that are going to be given away. What is the probability of a given person winning a prize? (A person may win more than one prize.)

   75 people x 10 tickets/person = 750 tickets
   50 prizes ÷ 750 tickets = 1 prize/15 tickets
   1/15 chance of winning a prize = 0.067

2. There is a square table that is 2 feet long and 2 feet wide, and a circular coaster that has a diameter of 2.5 inches. How many coasters will fit side by side on the table top?

   2 ft x 12 in./ft = 24 in.
   24 in. ÷ 2.5 in./coaster = 9.6 coasters = 9 complete coasters
   Nine rows of 9 coasters each, or 81 coasters, will fit on the square table.

3. Each ticket to the Ducks Unlimited banquet costs $40. Four percent of the ticket money went to the restaurant and 96% of the ticket money went to the Ducks Unlimited Wetland Conservation. How much money per ticket did Ducks Unlimited raise?

   $40/ticket x 0.96 = $38.40/ticket

4. Suppose that 102 people bought tickets to the banquet at $40 per ticket. How much of the proceeds went to the restaurant and how much went to the Ducks Unlimited Wetland Conservation?

   102 tickets x $40/ticket = $4,080
   Ducks Unlimited: $4,080 x 0.96 = $3,916.80
   Restaurant: $4,080 x 0.04 = $163.20

5. It costs $250 for a person to sponsor 1 acre of land for 1 year. This prevents the land that is sponsored from being developed (conservation). If you sponsor 4 acres of land for 1 year, how much does that cost per day?

   $250/acre-year x 4 acres = $1,000/year
   $1,000/year ÷ 365 days/year = $2.74/day

6. If you decided to sponsor the same 4 acres of land for the next year, plus an additional 3 acres of land for the next year, how much would the total cost be for both years? How much would it cost per week?

   \$250/acre-year x 7 acres = \$1,750/year for 2nd year.
   From problem 5, the 1st year cost for 4 acres is \$1,000.
   For both years, the total cost would be \$2,750.
   \$2,750 ÷ (52 weeks/year x 2 years) = \$26.44/week

7. In another raffle, only one prize will be given away. There are 75 people entered for the raffle, and each person has two tickets. What is the probability that one of a given person's tickets will be drawn?

   1 prize ÷ (75 people x 2 tickets / person) = 1 prize/150 tickets = 0.0067

8. Ducks Unlimited has raised \$1.587 billion since 1937. What is the average amount that Ducks Unlimited has raised each year from 1937 through 2002 (inclusive)?

   2002 – 1937 + 1 = 66 years
   \$1.587 x 10^9 ÷ 66 years = \$2.40 x 10^7/year, or \$24,045,454/year

9. Ducks Unlimited has a 6-year fundraising effort called "Habitat 2000: Campaign for a Continent." The goal Ducks Unlimited has for this fundraising effort is \$600 million. If they exceed this expectation by \$302 million, how much money will Ducks Unlimited raise?

   \$600 million + \$302 million = \$902 million

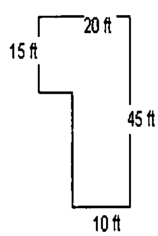
10. The total number of acres that Ducks Unlimited has conserved in Canada, the United States, and Mexico is 9,865,373. Suppose that the land is divided equally among the three countries. How many acres has Ducks Unlimited conserved in each country?

    9,865,373 ÷ 3 countries = 3,288,457.67 acres/country

11. The United States has lost more than half of its original wetlands due mainly to humans developing the land so that they can live and work there. The United States continues to lose 100,000 acres of wetlands every year. Suppose there are 2,454,065 acres left. How many years will it be until the United States has lost all of its wetlands?

    2,454,065 acres ÷ 100,000 acres/year = 24.54 years

12. The dining area of the restaurant is in an "L" shape. Each table is a square that is 2.5 ft by 2.5 ft. What is the maximum number of tables that will fit into the dining area? Estimate the number of tables that might be used.



Area of the right side of the room = 10 ft x 45 ft = 450 ft^2
Area of the left side of the room = 10 ft x 15 ft = 150 ft^2
Total area = 450 ft^2 + 150 ft^2 = 600 ft^2
Area of each table = 2.5 ft x 2.5 ft = 6.25 ft^2
Maximum number of tables = 600 ft^2/ 6.25 ft^2 = 96
This does not leave room for chairs or aisles. Chairs and aisles might each require 1/3 of the floor space, leaving room for 1/3 of the maximum number of tables, or 32 tables.

Web Sites for Further Exploration

Ducks Unlimited
http://www.ducks.org/

Nonprofit Fundraising and Grantwriting
http://www.mapnp.org/library/fndrsng/np_raise/np_raise.htm

Restaurant Math
http://www.umkc.edu/kcrpdc/kcaap/pdf/math/restaurant_math.pdf

Math Project – Graphing – Name That Restaurant!
http://www.highlandtech.us/Sharks2001/GraphingProjectTeam3.htm

Arc and Circles Math Projects
http://www.jug.net/wt/rrh.htm

Activity 12
Fall Creek Falls State Resort Park

Lindsey Carlton
November 6, 2002

Description of Module

In this module, the student will explore area and volume in a state park. Materials needed include a map of the park (available at the park entrance), a pencil, paper, and a measuring tape. Location: Route 3 Box 300, Pikeville, TN 37367.

Standards

Measurement, grades 6-8
Number and Operation, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards.* Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks.* Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. Find the slope of the slide at the playground next to the nature center.

2. Find the area of the playground.

3. Assume the park is planning to fill the playground with sand to a depth of 4 inches. What volume of sand would be needed to fill the playground to this depth?

4. Find the slope of the rail leading down to the cascades.

5. At the swimming hole, measure one section of the bridge to calculate the surface area of the swinging bridge.

6. Find the perimeter of a stop sign.

7. Find the surface area of a stop sign.

8. Find the perimeter of the green painted areas of the basketball court.

9. Find the surface area of the green areas of the basketball court.

10. Find the area, in inches, of each of the 10 parts of the in-bounds area of a tennis court.

11. Find the area of the in-bounds area of a tennis court by measuring the outside perimeter of a tennis court.

12. Find the sum of the calculations in problem 10 and compare with the answer to problem 11. Briefly describe the comparison.

Solutions

1. Find the slope of the slide at the playground next to the nature center.

   51/80

2. Find the area of the playground.

   34 ft 9 in. x 44 ft 10 in. = 34.75 ft x 44.83 ft $\approx$ 1,558 ft^2

3. Assume the park is planning to fill the playground with sand to a depth of 4 inches. What volume of sand would be needed to fill the playground to this depth?

   34 ft 9 in. x 44 ft 10 in. x 4 in. = 34.75 ft x 44.83 ft x 0.33 ft $\approx$ 514 ft^3

4. Find the slope of the rail leading down to the cascades.

   27/34.5

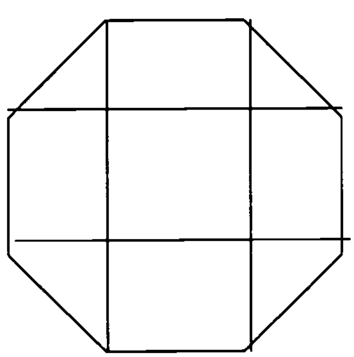
5. At the swimming hole, measure one section of the bridge to calculate the surface area of the swinging bridge.

   One section: 24.8 ft^2
   There are 23 sections.
   Total surface area : 24.8 ft^2 x 23 $\approx$ 570 ft^2

6. Find the perimeter of a stop sign.

   102 in.

7. Find the surface area of a stop sign.



102 in./8 sides = 12.75 in./side
Interior angle = (8 - 2)(180°) / 8 = 135° = 90° + 45°
To find small segment: $x^2 + x^2 = 12.75^2$
$x \approx 9$
Middle: 1 x 12.75 in. x 12.75 in. = 162.5625 $in.^2$
Sides: 4 x 12.75 in. x 9 in. = 459 $in.^2$
Corners: 4 x 1/2 x 9 in. x 9 in. = 162 $in.^2$
Surface area $\approx$ 784 $in.^2$

8. Find the perimeter of the green painted areas of the basketball court.

   178' 10''

9. Find the surface area of the green areas of the basketball court.

   703 ft^2

10. Find the area, in inches, of each of the 10 parts of the in-bounds area of a tennis court.

25,542 $in.^2$	40,986 $in.^2$	71,280 $in.^2$	40,986 $in.^2$
71,280 $in.^2$	25,542 $in.^2$	40,986 $in.^2$	25,542 $in.^2$
40,986 $in.^2$	25,542 $in.^2$		

11. Find the area of the in-bounds area of a tennis court by measuring the outside perimeter of a tennis court.

    $408{,}672\ in.^2 \div 144\ in^2/ft^2 = 2{,}838\ ft^2$

12. Find the sum of the calculations in problem 10 and compare with the answer to problem 11. Briefly describe the comparison.

    Answers will vary. The areas are the same.

Web Sites for Further Exploration

Fall Creek Falls
http://www.state.tn.us/environment/parks/fallcrek

Project Interactive: Shape Explorer
http://www.shodor.org/interactivate/activities/perimeter/

Project Interactive: Activities for Middle School Mathematics
http://www.shodor.org/interactivate/activities/index.html

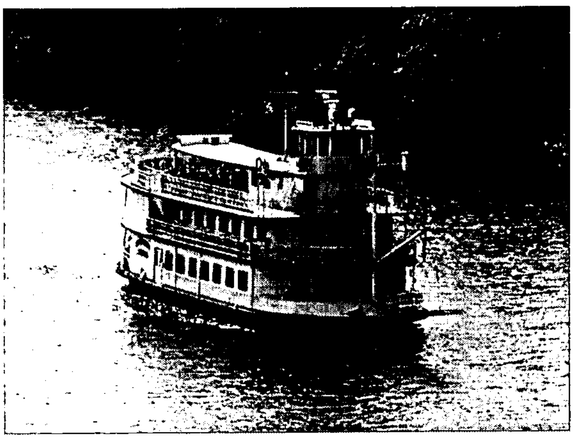
Calculate the Measures of the Rectangle
http://www.mathepower.com/english/rechteck.php

Constant Perimeter and Constant Area Rectangles
http://www.edc.org/MLT/ConnGeo/CP.html

Area and Perimeter
http://www.mathleague.com/help/geometry/area.htm

Activity 13
Family Vacation in Chattanooga

Deanna Rice and Candice Riddle
December 2001



Description of Module

In this module, the student will simulate a 5-day vacation in Chattanooga, tracking all expenses, including travel, lodging, food, and entertainment. Information on pricing will be gathered via Internet research. The student will adhere to a budget and record all expenditures. To complete the assignment, the student will total all expenditures to determine the categories on which they spent the most money and create a graph to model the percent of money spent on each category. This activity will allow the student to work through and solve real-life problems related to budget and finance. This activity is designed for use in a sixth grade classroom. With minor modifications, it would be appropriate for use at other levels. The student will enjoy this real-life application of mathematics, and will gain a greater appreciation for the money spent on a vacation.

Standards

Connections, grades 6-8	Problem Solving, grades 6-8
Data Analysis and Probability, grades 6-8	Representation, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Project Information

For this activity, you will be vacationing with your family in Chattanooga, Tennessee. You will begin your vacation with a predetermined amount of money that you and your family have saved for the vacation. You must report how many people are traveling with you on this family vacation. You will need to specify the number of adults and children (state ages).

During this vacation, it is your responsibility to budget the family's expenses. You will decide how the money will be spent. This will include means of travel, lodging, food, entertainment, etc. You must account for every penny you and your family members spend. An expense sheet will be used to track your expenditures as they occur.

The first step is to decide from what city you and your family will travel. You will then decide how you and your family will arrive in Chattanooga. Are you arriving by plane, car, bus, etc? After making these decisions, if you plan to arrive by car, choose an Internet site to use to calculate the number of miles you must travel to arrive at your destination. You will need to keep track of all your mileage from this point in order to calculate amount and cost of fuel for your travels. If traveling by car, you will need to use a mapping utility on an Internet site.

If you plan to arrive by air, bus, or any other means of travel, you will need to check Internet sites to find airfares, etc. for each family member. Remember to include discounts, if available, for children under certain ages. Record this information on the expense sheet.

If your family requires a rental car, you will need to go to the Internet to find rates for this. You must consider the model of car and the number of days you will need the rental car. Record this information on your expense sheet. You will need to keep track of your mileage from this point in order to calculate your fuel expenses. For this section, you will need to use a mapping utility on an Internet site.

You will need to select a place to stay in Chattanooga. There are Internet sites provided for you to find this information. You will have to calculate how much of your budget you wish to spend on lodging. Include a sales tax of 8.25% for lodging, if the Internet site does not include information on the tax rate.

You will need to track the cost of meals for your family. Also record any meals that may have been eaten while traveling to Chattanooga. There are many restaurants listed on the Internet. You may use the Internet sites provided to select each meal, or you may select others. Some preprinted menus may be available on the Internet. When recording your meal on the expense sheet, use the price of the meal from the menu. After you record your meal, calculate the tax (8.25%) and the tip (15%) on the meal, and enter these figures on the expense sheet. There may be days when you may not eat three meals but you need to record at least two meals per day.

Decide on choices for family entertainment. You may use an Internet site to gather information on the available attractions. Record this information on the expense sheet.

Record any items and tax not covered in the above categories: souvenirs, snacks and drinks, maps, and other supplies for your trip.

After you have completed your vacation and collected all the data, calculate the total for each row and each column on the expense sheet. Find the total of all rows and all columns. These figures should agree in the bottom right-hand corner. If these figures are not identical, you will need to check each row until you find the error.

After you have completed your expense sheet, find the percentages for each category and create a graph of your choice to represent your results.

Notes to the Teacher
Reading can be integrated with this lesson through the student writing a short story to describe their vacation or explaining why particular places, attractions, etc. were selected. The teacher may want to set an amount of money for all students or allow students to determine their own amount of money. The teacher may supply the current price per gallon for gas. The student may wish to share information found on the Internet, such as sites with good deals, special places, etc., with peers. Technology can further be integrated through student use of a spreadsheet or other graphing software to complete the graphing portion of the lesson.

Vacation Expense Record Sheet

	Day 1	Day 2	Day 3	Day 4	Day 5	Total
Travel Airfare/Bus						
Rental Car						
Gas/Fuel						
Lodging						
Food Breakfast						
Lunch						
Dinner						
Tips						
Entertainment Movie						
Attraction						
Miscellaneous						
Total						

Web Sites for Further Exploration

Chattanooga.com
http://www.chattanooga.com/

Expedia
http://www.expedia.com/

Hunter Museum of American Art
http://www.huntermuseum.org/

Lookout Mountain Attractions
http://www.lookoutmtnattractions.com/

Mapquest.com
http://www.mapquest.com/

Ruby Falls
http://www.rubyfalls.com/

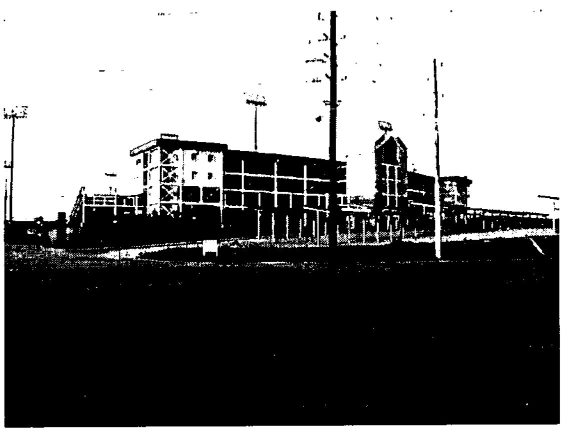
Tennessee Aquarium
http://www.tnaqua.org/

Travelocity
http://www.travelocity.com/

Travel Wizard
http://www.unitedstatesvacationguide.com/Tennessee_Overview.html

Activity 14
Fun Facts at Finley Stadium

Cara Tate and Jennifer Wilson
Fall 2002



Description of Module

In this module, the student will use algebraic operations while working with sample data. Extensive work with unit conversions is required. Location: Intersection of Carter and Main Sts., Chattanooga, TN.

Standards

Number and Operations, grades 6-8
Algebra, grades 6-8
Geometry, grades 6-8
Measurement, grades 6-8
Problem Solving, grades 6-8
Communication, grades 6-8
Connections, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. How many available seats are there in the following sections at Finley Stadium?
   a. In section 101, there are 9 bleacher rows of 19 seats, 11 rows of 18 seats, and 1 row of 17 seats.
   b. In section 102, there are 6 bleachers rows of 37, 8 rows of 36, 7 rows of 35, 2 rows of 34, and 1 row of 33.
   c. In section 103, there are 5 bleacher rows of 16, 11 rows of 17, 7 rows of 18, and 1 row of 19.

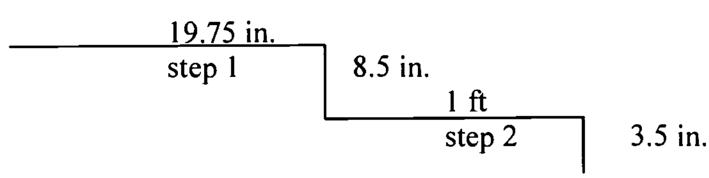
2. Finley Stadium seats 20,688 persons. What percentage of the seats are in the following sections?
   a. Section 101
   b. Section 102
   c. Section 103
   d. Sections 101, 102, and 103 combined

3. For the National Championship football game held at Finley Stadium each year, the admission is $20 per seat. How much money would be collected at the gate for sections 101, 102, and 103, given the following conditions?
   a. 100% of these seats were full?
   b. 50% of these seats were full?
   c. Sections 101 and 102 were full and section 103 was 75 % full?

4. If sections 101, 102, and 103 are representative of the stadium, what is the average number of seats per stadium section?

5. Sections 102 and 103 each have 24 rows. The aisle between these two sections contains 2 steps per row plus an additional 2 steps at the top. How many steps are in this aisle?

6. In this aisle between sections 102 and 103, each row contains two steps. Both steps have a different slope. What are the slopes?



7. The aisle between sections 102 and 103 contains 7 long rail units and 1 short rail unit. The long rail units are 5 ft 8 in. in length. The short rail unit is 2 ft 9 in. in length. If you slid down every rail, how much railing would you have covered?
   a. in inches
   b. in feet
   c. in yards

8. Each bleacher seat has the dimensions of 11.3 inches by 18 inches.
   a. What is the area of each seat in square feet?
   b. What is the total bleacher area available in sections 101, 102, and 103 combined in square yards?

9. There are 8 sets of stadium lights that illuminate the field. Each set has 4 rows of 8 light bulbs. How many light bulbs would need to be purchased in order to replace each bulb?

10. On the south side concourse (the area where the concession stands are located), there are 15 trash cans. Each trash can holds up to 45 gallons of trash. At a UTC Mocs football game, all of the trash cans on this concourse are emptied once. Assuming all the cans are full, how much trash is emptied?
    a. in gallons
    b. in quarts
    c. in pints
    d. in cups

11. The football field, including the end zones, is 120 yards in length by 53 1/3 yards in width. What is the area of the field?
    a. in square yards
    b. in square feet
    c. in square inches
    d. in square miles

12. How many football fields would equal the area of 1 square mile?

Solutions

1. How many available seats are there in the following sections at Finley Stadium?
   a. In section 101, there are 9 bleacher rows of 19 seats, 11 rows of 18 seats, and 1 row of 17 seats.

      (9 x 19) + (11 x 18) + (1 x 17) = 386 seats

   b. In section 102, there are 6 bleachers rows of 37, 8 rows of 36, 7 rows of 35, 2 rows of 34, and 1 row of 33.

      (6 x 37) + (8 x 36) + (7 x 35) + (2 x 34) + (1 x 33) = 856

   c. In section 103, there are 5 bleacher rows of 16, 11 rows of 17, 7 rows of 18, and 1 row of 19.

      (5 x 16) + (11 x 17) + (7 x 18) + (1 x 19) = 412

2. Finley Stadium seats 20,688 persons. What percentage of the seats are in the following sections?
   a. Section 101

      386 / 20,688 x 100% = 1.87%

   b. Section 102

      856 / 20,688 x 100% = 4.14%

   c. Section 103

      412 / 20,688 x 100% = 1.99%

   d. Sections 101, 102, and 103 combined

      (386 + 856 + 412) / 20,688 x 100% = 7.99% ≈ 8%
      or 1.87% + 4.14% + 1.99% ≈ 8%

3. For the National Championship football game held at Finley Stadium each year, the admission is $20 per seat. How much money would be collected at the gate for sections 101, 102, and 103, given the following conditions?
   a. 100% of these seats were full

      (386 + 856 + 412) x $20 = $33,080

b. 50% of these seats were full

1,654 x 0.50 x $20 = $16,540
or
$33,080 / 2 = $16,540

c. Sections 101 and 102 were full and section 103 was 75 % full

[(386 + 856) + (412 x 0.75)] x $20 = $31,020

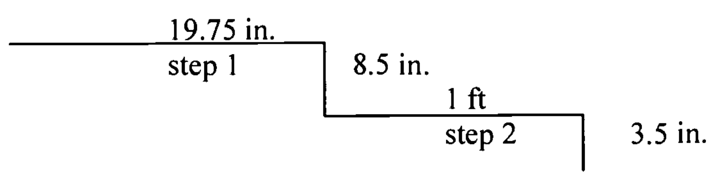
4. If sections 101, 102, and 103 are representative of the stadium, what is the average number of seats per stadium section?

   1,654 seats / 3 ≈ 551 seats

5. Sections 102 and 103 each have 24 rows. The aisle between these two sections contains 2 steps per row plus an additional 2 steps at the top. How many steps are in this aisle?

   24 rows x 2 steps/row + 2 steps = 50 steps

6. In this aisle between sections 102 and 103, each row contains two steps. Both steps have a different slope. What are the slopes?



   slope (m) = rise/run
   m1 = 8.5 in. / 19.75 in. = 0.43
   m2 = 3.5 in. / 12 in. = 0.29

7. The aisle between sections 102 and 103 contains 7 long rail units and 1 short rail unit. The long rail units are 5 ft 8 in. in length. The short rail unit is 2 ft 9 in. in length. If you slid down every rail, how much railing would you have covered?

   a. in inches

      7 [(5 ft x 12 in. / ft) + 8 in.] + (2 ft x 12 in. / ft) + 9 in. = 509 in.

   b. in feet

      7 [5 ft + (8 in. ÷ 12 in. / ft)] + [2 ft + (9 in. ÷ 12 in. / ft)] = 42.42 ft

c. in yards

from a, above: (509 in ÷ 36 in. / yd) = 14.14 yd

8. Each bleacher seat has the dimensions of 11.3 inches by 18 inches.
   a. What is the area of each seat in square feet?

   A = L x W = 18 in. x 11.3 in. = 203.4 in.^{2}
   203.4 in.^{2} ÷ 144 in.^{2} / ft^2 = 1.41 ft^2

   b. What is the total bleacher area available in sections 101, 102, and 103 combined in square yards?

   From problem 1, sections 101 - 103 contain 1,654 seats.
   (1,654 seats x 203.4 in.^{2}/seat) ÷ 1,296 in.^{2} / yd^2 = 259.6 yd^2

9. There are 8 sets of stadium lights that illuminate the field. Each set has 4 rows of 8 light bulbs. How many light bulbs would need to be purchased in order to replace each bulb?

   8 sets x 4 rows / set x 8 bulbs / row = 256 bulbs

10. On the south side concourse (the area where the concession stands are located), there are 15 trash cans. Each trash can holds up to 45 gallons of trash. At a UTC Mocs football game, all of the trash cans on this concourse are emptied once. Assuming all the cans are full, how much trash is emptied?
    a. in gallons

    15 cans/concourse x 45 gal/can = 675 gal

    b. in quarts

    675 gal x 4 qt / gal = 2,700 qt

    c. in pints

    2,700 qt x 2 pt / qt = 5,400 pt

    d. in cups

    5,400 pt x 2 cup / pt = 10,800 cup

11. The football field, including the end zones, is 120 yards in length by 53 1/3 yards in width. What is the area of the field?
    a. in square yards

       $A = L \times W = 120 \text{ yd} \times 53.33 \text{ yd} \approx 6{,}400 \text{ yd}^2$

    b. in square feet
       $1 \text{ yd}^2 = 3 \text{ ft} \times 3 \text{ ft} = 9 \text{ ft}^2$
       $6{,}400 \text{ yd}^2 \times 9 \text{ ft}^2 / \text{yd}^2 = 57{,}600 \text{ ft}^2$

    c. in square inches

       $1 \text{ ft}^2 = 12 \text{ in.} \times 12 \text{ in.} = 144 \text{ in.}^2$
       $57{,}600 \text{ ft}^2 \times 144 \text{ in.}^2 / \text{ft}^2 = 8{,}294{,}400 \text{ in.}^2$

    d. in square miles

       $1 \text{ mi}^2 = 5{,}280 \text{ ft} \times 5{,}280 \text{ ft} = 27878400 \text{ ft}^2 = 2.78784 \times 10^7 \text{ ft}^2$
       $57{,}600 \text{ ft}^2 \div 2.78784 \times 10^7 \text{ ft}^2 / \text{mi}^2 = 0.00207 \text{ mi}^2 = 2.07 \times 10^{-3} \text{ mi}^2$

12. How many football fields would equal the area of 1 square mile?

    $2.78784 \times 10^7 \text{ ft}^2 \div 57{,}600 \text{ ft}^2 / \text{field} = 484 \text{ fields}$

Web Sites for Further Exploration

Chattanooga Mocs
  http://www.gomocs.com/

Math.com
  http://www.math.com/

Eric Weisstein's World of Mathematics
  http://mathworld.wolfram.com/

Ask Dr. Math
  http://www.mathforum.org/dr.math/

Finley Stadium - Davenport Field
  http://gomocs.com/article.asp?articleid=2465

Activity 15
Geometry is Everywhere!
Especially at the Chattanooga Zoo!

Lon Eilders, II and Patrick Shay
October 5, 2002

Description of Module

In this module, the student will use a park map, to follow the path to the numbered exhibit for each set of problems. Required materials include a tape measure (one that is flexible and at least 100 feet in length) and a stopwatch. If it is not feasible to travel to Warner Park Zoo, the teacher could supply the exhibit dimensions for the student to solve the remaining problems. Location: Warner Park, off from McCallie Ave. (at Holtzclaw Ave.).

Standards

Geometry, grades 9-12
Measurement, grades 9-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

Worksheet for a Field Trip to the Chattanooga Zoo

Directions: Using a map of the zoo, follow the path to the numbered exhibit for each set of questions. You will need a tape measure (one that is flexible and at least 100 feet long) and a stopwatch to perform the required measurements and complete the required computations.

Exhibit 7: Turtles

1. Find the turtles' tank, and determine the measurements of length, width, and depth of water.

2. Calculate the volume of water in the turtles' tank.

3. Is this an accurate volume for the tank? Why or why not?

4. How many turtles are there? Determine volume per turtle.

Exhibit 10: Capuchin Monkeys (Organ Grinder Monkeys)

1. Measure the circumference of the cage. (Watch out: Cheetah likes to throw his food bowl.)

2. Determine the diameter of the cage.

3. Determine the radius of the cage.

4. Determine the area of the cage.

5. How many monkeys are there? Determine the ground area per monkey.

Exhibit 14: Petting Zoo

1. Measure the length, width, and depth of the animal food dispenser.

2. What is the total volume of the dispenser?

3. What is the approximate volume it dispenses (size of one serving)?

4. How many times will the machine dispense food as the level changes from full to empty?

5. Assume that the food pellets are free to the zoo. How much money does the zoo earn each time the dispenser is emptied by patrons?

Exhibit 18-20: Train Tracks

1. Measure the length from the start to the end of the tracks (measure at an equal distance between the tracks).

2. Find the rate at which you walk this distance.

3. The path on the map is 1,345 feet. How much time is needed to walk through the zoo if you do not take time to look at anything?

Solutions

Exhibit 7: Turtles

1. Find the turtles' tank, and determine the measurements of length, width, and depth of water.

   66 in. x 40 in. x 25 in.

2. Calculate the volume of water in the turtles' tank.

   $V = lwh = 66{,}000\ \text{in.}^3$

3. Is this an accurate volume for the tank? Why or why not?

   No. The tank narrows as you approach the bottom of the tank. The volume determined is larger than the actual value.

4. How many turtles are there? Determine volume per turtle.

   There are two turtles. $V/\text{turtle} = 33{,}000\ \text{in.}^3/\text{turtle}$

Exhibit 10: Capuchin Monkeys (Organ Grinder Monkeys)

1. Measure the circumference of the cage. (Watch out: Cheetah likes to throw his food bowl.)

   $C = 50.25$ ft

2. Determine the diameter of the cage.

   $d = C/\pi = 16$ ft

3. Determine the radius of the cage.

   $r = d/2 = 8$ ft

4. Determine the area of the cage.

   $A = \pi r^2 = 201\ \text{ft}^2$

5. How many monkeys are there? Determine the ground area per monkey.

   There are two monkeys. $A/\text{monkey} = 100.5\ \text{ft}^2$

Exhibit 14: Petting Zoo

1. Measure the length, width, and depth of the animal food dispenser.

   8.5 in. x 7 in. x 7 in.

2. What is the total volume of the dispenser?

   $V = lwh = 416.5 \text{ in.}^3$

3. What is the approximate volume it dispenses (size of one serving)?

   $V = lwh = 1.5 \text{ in.} \times 1.5 \text{ in.} \times 1.5 \text{ in.} = 3.375 \text{ in.}^3$

4. How many times will the machine dispense food as the level changes from full to empty?

   $n = V_{\text{dispenser}} / V_{\text{dispensed}} = 416.5 \text{ in.}^3 / 3.375 \text{ in.}^3 \approx 123$

5. Assume that the food pellets are free to the zoo. How much money does the zoo earn each time the dispenser is emptied by patrons?

   m = 123 servings x $0.25/serving = $30.75

Exhibit 18-20: Train Tracks

1. Measure the length from the start to the end of the tracks (measure at an equal distance between the tracks).

   94 ft

2. Find the rate at which you walk this distance.

   Answers will vary. Example: 30 s to walk 94 ft = 3.13 ft/s

3. The path on the map is 1,345 feet. How much time is needed to walk through the zoo if you do not take time to look at anything?

   Answers will vary. Example: 1,345 ft / 3.13 ft/s = 429.7 s or 7.16 min (about 7 min 10 s).

Worksheet for a Rainy Day (No Field Trip)

Directions: You will need a tape measure (one that is flexible and at least 100 feet long) and a stopwatch to perform the required measurements and complete the required computations.

Exhibit 7: Turtles

1. Find the turtles' tank, and determine the measurements of length, width, and depth of water. (66 in. x 40 in. x 25 in.)

2. Calculate the volume of water in the turtles' tank.

3. Assume the tank narrows toward the bottom. Is this an accurate volume for the tank? Why or why not?

4. There are two turtles. Determine volume per turtle.

Exhibit 10: Capuchin Monkeys (Organ Grinder Monkeys)

1. Measure the circumference of the cage. (Watch out: Cheetah likes to throw his food bowl.) (C = 50.25 ft)

2. Determine the diameter of the cage.

3. Determine the radius of the cage.

4. Determine the area of the cage.

5. There are two monkeys. Determine the ground area per monkey.

Exhibit 14: Petting Zoo

1. Measure the length, width, and depth of the animal food dispenser. (8.5 in. x 7 in. x 7 in.)

2. What is the total volume of the dispenser?

3. Assume the dimensions of a food pellet serving are 1.5 in. x 1.5 in. x 1.5 in. What is the approximate volume it dispenses (size of one serving)?

4. How many times will the machine dispense food as the level changes from full to empty?

5. Assume that the food pellets are free to the zoo. How much money does the zoo earn each time the dispenser is emptied by patrons? The cost for food is $0.25.

Exhibit 18-20: Train Tracks

1. Measure the length from the start to the end of the tracks (measure at an equal distance between the tracks). (94 ft)

2. Find the rate at which you walk this distance.

3. The path on the map is 1,345 feet. How much time is needed to walk through the zoo if you do not take time to look at anything?

Web Sites for Further Exploration

The Chattanooga Zoo
http://zoo.chattanooga.org/

Parks, Recreation, Arts & Culture
http://www.chattanooga.gov/cpr/

Conversion and Calculation Center
http://www.convertit.com/Go/ConvertIt/

A Dictionary of Units
http://www.ex.ac.uk/cimt/dictunit/dictunit.htm

Interactive Units Converter
http://www.convert-me.com/en

Online Conversion
http://www.onlineconversion.com/

Activity 16
Hamilton County High Schools' Chattanooga Road Rally

Bill Floyd
Fall 2002

Description of Module

In this venture traversing nearly 100 miles, students in 9th through 12th grades will visit all Hamilton County high schools and be engaged with mathematically intriguing questions and problems along the way. Stage times throughout the course provide approximate driving times. Location: Hamilton County, TN.

Standards

Number and Operations, grades 9-12
Algebra, grades 9-12
Geometry, grades 9-12
Measurement, grades 9-12
Problem Solving, grades 9-12
Connections, grades 9-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

Follow directions for each stage and solve mathematics problems either along the way or at the staged site to which you're heading. Approximate stage times for completion of this course have been based on consistent keeping of the posted speed limits. Careful observations of signs and items of interest ("LOOK") along the way are crucial in some solutions to your math questions. Be observant!

Let's begin!

Stage 1
Pre-timed: 5.62 minutes

We begin at the Hamilton County Department of Education (HCDE) Headquarters, located at the corner of Bonny Oaks Drive and Hickory Valley Road.

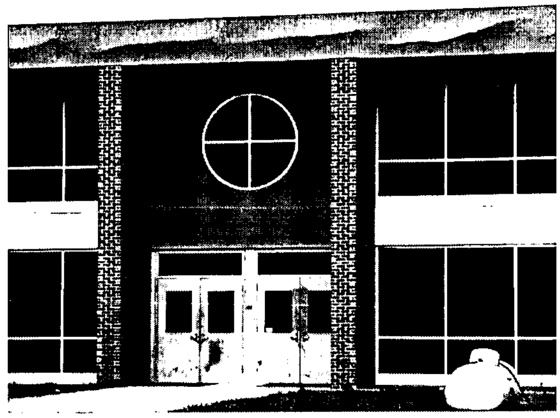
Exit from HCDE
Turn right onto Hickory Valley Road
Forward 2.3 miles
"LOOK" to 9:00
Forward 0.4 mile
Right onto Hwy. 58
Forward 1.4 miles
Enter Central High School

?
What is the quotient when the dividend equals the first half of the school year Central earned the National School of Excellence and the divisor is the number of flag poles found at Building 232 on the Volunteer Army Ammunition Plant site?

Answer: 1986 ÷ 3 = 662

Stage 2
Pre-timed: 13.8 minutes

Exit Central High School
Turn left onto Hwy. 58
Forward 4.4 miles
Right onto Hwy. 153
Forward 4.0 miles
"LOOK" to 1:00
Right onto Hixson Pike
Forward 2.0 miles
Left onto Middle Valley
Forward 0.1 mile
Left onto Old Mission
Forward 0.1 mile
Enter Hixson High School



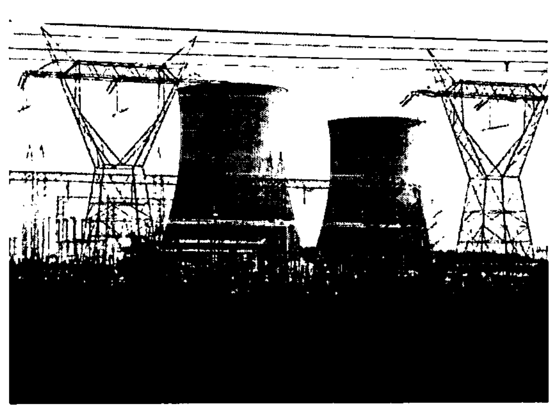
Note the circular windows above the door entrances of the school building.

?
If they each represented a Cartesian coordinate plane, label all quadrants on the picture. How many radians would each arc represent in a quadrant?

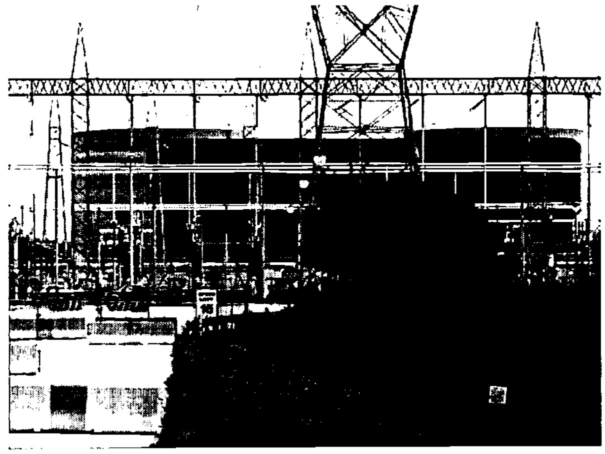
Answer: The radian measure of a circle is 2π, therefore, one quadrant measures $\frac{1}{2}\pi$.

Stage 3
Pre-timed: 17.75 minutes

Exit Hixson High School
Left onto Old Mission
Forward 0.1 mile
Right onto Middle Valley
Forward 0.1 mile
Left onto Hixson Pike
Forward 7.5 miles
Right onto Sequoyah Access Road
Forward 1.0 mile
Right onto Igou Ferry Road
"LOOK" to 10:00



?
The two tallest concrete structures are called cooling towers. What is their geometric solid's name?

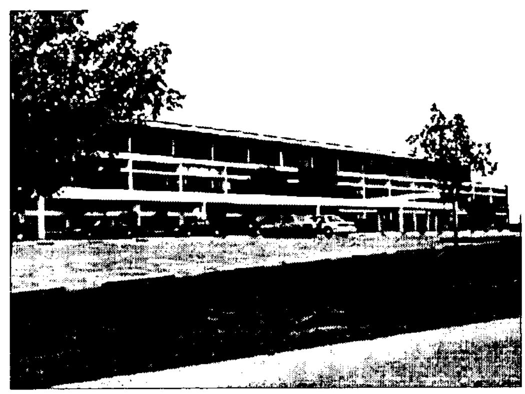


Answer: hyperboloid

?
The reactor buildings are behind the rectangular building on the other side of the electrical switchyard by which you are parked. What geometrical solid do the reactor buildings represent to you?

Answer: cylinder

Return to Sequoyah Access Road
Turn left
Forward 3.2 miles
Left to Soddy Daisy High School



Note:

Standard distances between brick mortar joints at the school are 4 inches in height and 11 7/8 inches in width.

?
Knowing this, compute the following, given the number of bricks:

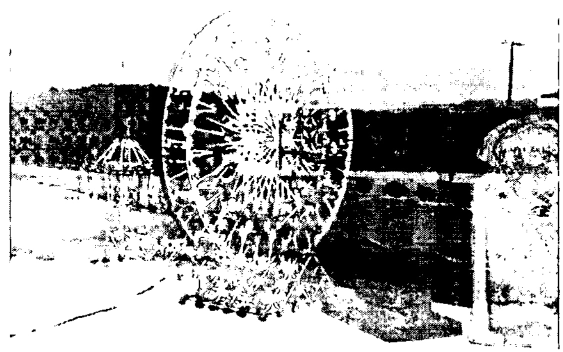
a. Slope of slanted roof on main building (40 high, 18 across).
b. Area of one window pane 1/3 x (10 high, 21.5 across).
c. Area of entire 3-pane window (10 high, 21.5 across).

Answer:

a. (40 x 4 in.) ÷ (18 x 11.875 in.) = 0.75
b. (1/3)(10 x 4 in.)(21.5 x 11.875 in.) = 3,404.2 in.^{2}
c. (10 x 4 in.)(21.5 x 11.875 in.) = 10,212.5 in.^{2}

Note:

On the northeast end of the main school building sits a K'nex Ferris wheel, completely assembled and displayed in the window.

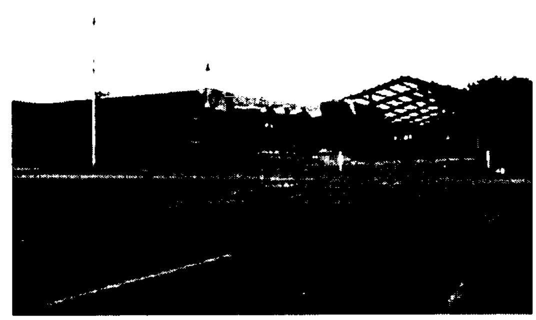


?
What is the angular measurement (in degrees) between each of the 32 spokes?

Answer: 360° ÷ 32 = 11.25°

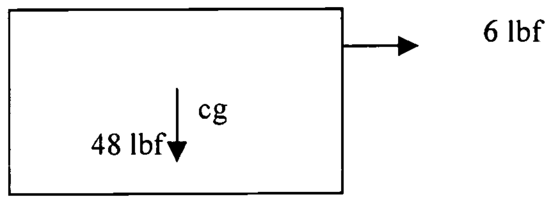
Stage 4
Pre-timed: 15.927 minutes

Exit Soddy Daisy High School
Left onto Sequoyah Access Road
Forward 1.3 miles
Right onto Hwy. 27N
Forward 10.3 miles
Right onto Patterson
Forward 0.25 mile
Enter Sale Creek High School



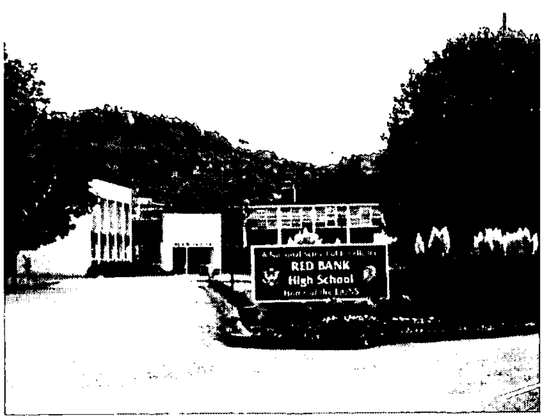
?

Notice that much of the school has new construction going on. Engineers draw free body diagrams at times to determine what forces must be placed on the body to keep it stable/balanced/static. Suppose you have a free body diagram shown below (7 ft wide x 6 ft high) with the applied forces. Show where, and what value, additional force(s) should be to balance the free body diagram.

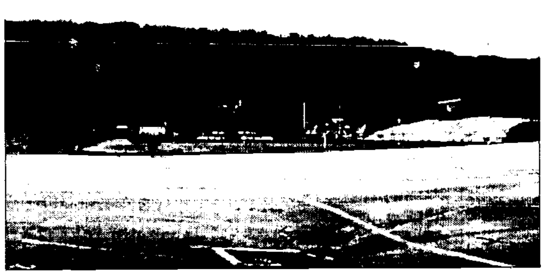


Answer: Forces must be applied such that $\Sigma F(x) = 0$, $\Sigma F(y) = 0$, and the $\Sigma M(cg) = 0$.

Stage 5
Pre-timed: 17.3 minutes



Exit Sale Creek High School
Right onto Patterson
Forward 0.25 mile
Left onto Hwy 27S
Forward 16.6 miles
Right onto Morrison Springs Road
Forward 0.8 miles
Enter left to Red Bank High School

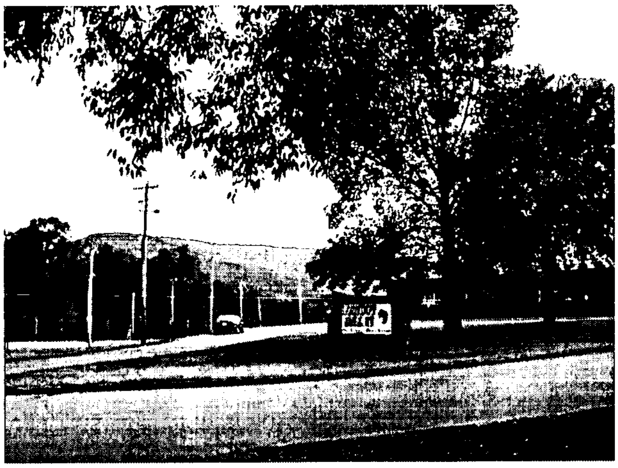


?

You have the responsibility to mark off the lines on their football field. There is great pride always taken in the way it looks. You must make sure the field is "square." That means the sidelines should be the same distance apart end-to-end, and likewise, the goal lines, etc. Suggest how you would ensure this by using properties regarding the corners of the field.

Answer: Rectangular diagonals should measure the same distance or a 3-4-5 proportional triangle could be used to verify square.

Stage 6
Pre-timed: 12.622 minutes



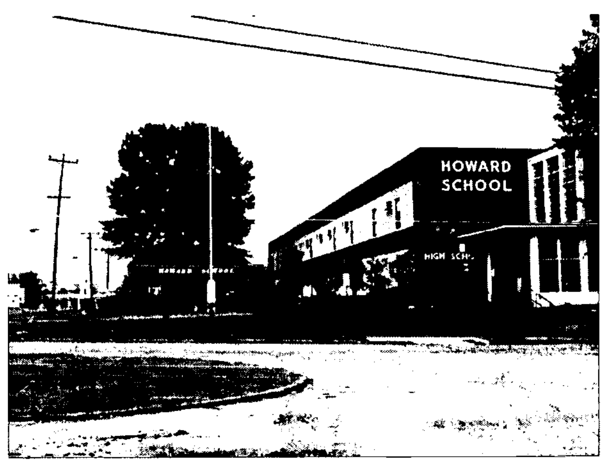
Exit Red Bank High School
Right onto Morrison Springs Road
Forward 0.5 mile
Right onto Hwy. 27S
Forward 6.9 miles
Merge right onto I-24W
Forward 3.3 miles
Right onto Browns Ferry Road
Forward 0.4 mile
Left onto Adkins
Forward 0.3 mile
Left onto Lookout High
Forward 0.1 mile

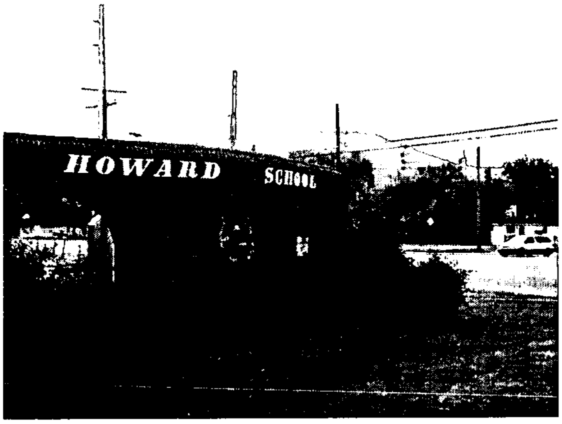
?
If the distance you traveled on Browns Ferry Road minus the distance you traveled on Lookout High was one side of a right triangle, and the distance you traveled on Adkins was the other side of the right triangle, determine the exact distance the school is away from the interstate.

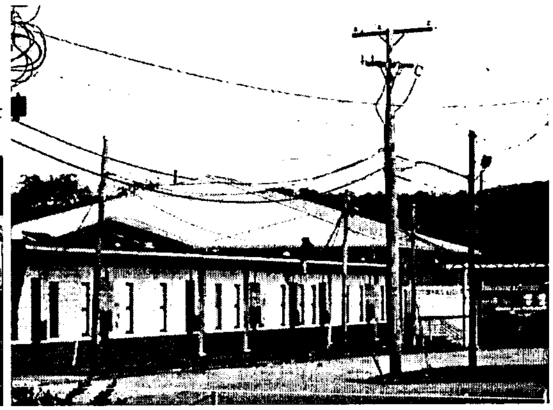
Answer: $= c^2 = (0.4 \text{ mi} - 0.1 \text{ mi})^2 + (0.3)^2$
$c = 0.42$ mi

Stage 7
Pre-timed: 6.129 minutes

Exit Lookout Valley High
Forward 0.1 mile
Right onto Adkins
Forward 0.3 mile
Right onto Browns Ferry Road
Forward 0.5 mile
Left onto I-24E
Forward 3.3 miles
Right onto Broad Street
Forward 0.6 mile
Left onto W. 25^{th}
Forward 0.1 mile
Right onto Market Street
Forward 0.1 mile
Enter left to Howard High School







?
If the roof is symmetrical, how many faces, edges, and vertices does it have?

Answer: 8,13, and 14 respectively

Stage 8
Pre-timed: 8.446 minutes

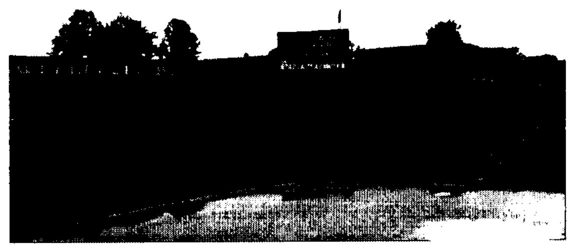
Exit Howard High School
Right onto Market Street
Forward 0.2 mile
Right onto I-24 E
Forward 2.4 miles
Right onto Westside Drive
Forward 0.4 mile
Left onto Ringgold Road
Forward 1.4 miles
Right onto Kingwood, then immediately left onto Greens Lake Road
Forward 0.6 mile
Left onto Bennett
Forward 0.4 mile to East Ridge High School

?
Take the square root of the number of available lines of text on the marquee in front of the school and multiply it by the highway number of Hixson Pike that had a "LOOK" instruction earlier in the trip.

Answer: SQRT(4)x 319 =638

Stage 9
Pre-timed: 5.2 minutes

Continue on Bennett
Forward 0.3 mile
Left onto McBrien
Forward 0.7 mile
Left onto Ringgold Road
Forward 0.1 mile
Right onto South Moore
Forward 1.5 miles
Right to Brainerd High School



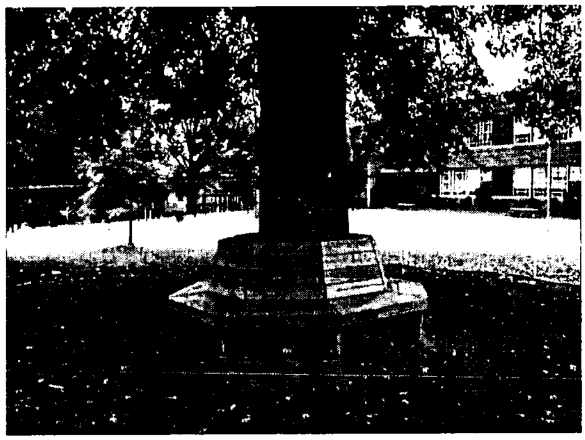
?
How is the supposed time from one point to another calculated given the distance traveled and the speed limit?

Answer: distance(mi) / [speed limit(mi/hr) / 60(min/hr)] = time(min)

Stage 10
Pre-timed: 10.992 minutes

Exit Brainerd High School
Right on North Moore
Forward 1.1 miles
Right onto Shallowford Road
Forward 3.0 miles
Left onto Standifer Gap
Forward 1.3 miles
Left onto Hickory Valley
Forward 0.5 mile
Right onto Tyner Road
Forward 0.2 mile to Tyner Academy

?
If the circumference of the tree around which you want to build a park bench is 127 inches, could the back measurement of one of the eight straight-edged sections be 23 inches and work, given that the eight sections must fit together with no gaps in-between them?



Answer: Yes. Although the bench-back sections would form an octagon rather than a circle, the perimeter of the octagon would be 184 inches.

Stage 11
Pre-timed: 8.732 minutes

Continue on Tyner Road
Forward 0.9 mile
Left onto Lee Hwy.
Forward 0.4 mile
Right onto Hwy. 317
Forward 0.4 mile
Left onto I-75N
Forward 4.0 miles
Right then left onto Hwy. 11
Forward 0.3 mile
Right onto Mountain View Road
Forward 0.7 mile
Left to Ooltewah High School

?
Using string and one of the squaring tricks you might have used at Red Bank High School, explain how the diameter of one of the pod buildings could be determined.

Answer: Double the radius found by measuring the length of one tangent line between a tangent point and the perpendicular intersection with another tangent line to the building.

FINISH LINE

Reference

Hamilton County Department of Education. (2002). *School zone maps*. Retrieved October 19, 2002, from http://www.hcde.org/schools/default.htm

Web Sites for Further Exploration

HCDE High School Info
http://www.hcde.org/schools/highschools/default.htm

Sports Car Club of America: Road Rally
http://www.scca.org/amateur/roadrally/

MathWorld: Hyperboloid
http://mathworld.wolfram.com/Hyperboloid.html

Purplemath: Slope of a Straight Line
http://www.purplemath.com/modules/slope.htm

MathComplete Tutorial: The Slope of a Line
http://www.mathcomplete.com/tutorial/slope.asp

Department of Mathematics at MIT: Slope of a Line (interactive)
http://www-math.mit.edu/18.013A/tools/tools03.html

Radian Measure (interactive)
http://colalg.math.csusb.edu/~devel/precalcdemo/circtrig/src/radiandef.html

Degree/Radian Circle
http://math.rice.edu/~pcmi/sphere/drg_txt.html

More Mathematics than Science
http://id.mind.net/~zona/mmts/mmts.html

The Radian Walk
http://www.pen.k12.va.us/Div/Winchester/jhhs/math/lessons/trig/radwalk.html

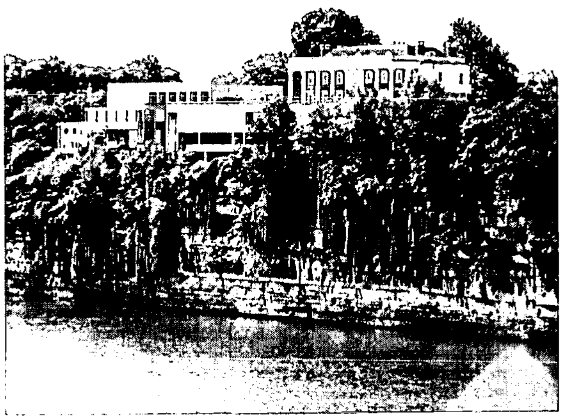
Pythagorean Theorem
http://www.cut-the-knot.org/pythagoras/index.shtml

Animated Proof of the Pythagorean Theorem
http://www.usna.edu/MathDept/mdm/pyth.html

Pythagorean Theorem (interactive)
http://www.frontiernet.net/~imaging/pythagorean.html

Activity 17
Hunter Museum of American Art

Laurie Mamo, Loriann Millwood, and Laura Norman
October 23, 2002



Description of Module

This module requires the student to use visual perception and reasoning to solve mathematics problems involving the geometry of paintings, sculptures, and other works of art. Location: 10 Bluff View, Chattanooga, TN 37403

Standards

Geometry, grades 6-8
Reasoning and Proof, grades 6-8
Representation, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Background Information

The Hunter Museum of American Art combines traditional and modern art collections within a building that is itself a mixture of old and new. The art collection was originally housed only in the 1904 Hunter mansion, owned by one of the founders of the first Coca-Cola bottling company. In 1975, a modern addition was built onto the classic revival mansion, and now contains the contemporary art section. Notice how the two buildings are integrated, and that from many angles, it is possible to see only one of the two structures, without a hint that the two are connected. From the main entrance, the museum seems to be devoted only to modern art; however, as visitors make their way to the upper floors, they suddenly find themselves stepping into a totally different world of curving staircases, ornate fireplaces, classic moldings, and woodwork. It is here, within the original Hunter mansion, that the 19^{th} century paintings are displayed.

Although the Hunter Museum is devoted to art, it is a wonderful place for the middle school student to explore from the point of view of mathematics, especially geometry. Polygons are everywhere, and the sculptures and artwork provide examples for the student to recognize and apply geometric relationships outside the classroom. Many of the sculptures are whimsical, and will capture and hold the attention of the middle school student. Perhaps because the Hunter Museum is thought of more for the arts than for science, the fact of finding such rich mathematical relationships there makes it an effective tool for showing the student how mathematics truly is an aspect of life in every setting.

Problems

1. The museum building itself is filled with many possible math problems regarding perimeter and area. Because the floor is made of parquet, for example, it is easy to ask students to calculate lengths and widths, and therefore area, within the different rooms. The ceiling in the hallway to the left of the entrance desk has ceiling squares that are 4 feet by 4 feet. Counting the number of ceiling squares, how long is the hallway? What is the perimeter of the hallway? What is the area of the hallway?

2. On the first floor, there is a sculpture called *Mirror V*, by James Seawright, a technological artist. The sculpture is composed of several 6 inches by 6 inches mirrors. Notice how this sculpture was made, with a central row of flat mirrors, and sides made of angled mirrors. Why do you think the artist angled the side mirrors? How many small mirrors are there altogether? How far from it do you need to stand in order to see your face in every mirror? How close do you need to stand in order to see only one image of your face?

3. Further along on the first floor, there is a sculpture called *Transducer*, which is composed of mylar and transparent plastic, which is a wonderful, interactive optical illusion. Each student should take turns standing in the middle of this umbrella-shaped reflecting structure, and observe the boundaries, which change appearance according to the artist. Looking down at the floor, how does the reflection of the dome appear? Is it still rounded or is it flat? Why do you think that is?

4. Find the sculpture called *Square*. At every centimeter there is a cut in the wood. If the length of the sculpture is 6 ft, how many cuts are in the wood? There are 12 inches per foot and 2.54 centimeters per inch.

5. On the second floor, there is a sculpture by Sol LeWitt called *13/4*, composed of strips of wood which form 2 inch x 2 inch squares, 13 across on all four sides by 7 high, and then decreasing in a pyramid until there is only 1 square on top. Notice that the pyramid decreases by odd numbers. How many cubic squares are there altogether?

6. At the entrance, study the *Modular Wall Relief in Eight Colors*, by Doris Leeper. How many squares are there? Notice the angles of the pieces that make up each square. Is this a painting or a puzzle? What shapes can you see in this painting, perhaps combining more than one square? Look at the placement of each color. This was completed between 1972 and 1974. Why do you think it took so long?

7. Near the entrance is a piece of furniture, *Triangular Buffet*, by Wendell Castle, made from birdseye maple veneer. If it has a base of 4 feet and a height of 30 inches, what is the total surface area of the triangular front face of the furniture (in square feet)?

8. When you arrive on the third floor, notice that the style of the museum has changed completely. You are now in the original Hunter mansion. Find the fireplace in the southwest room. The footprint forms a trapezoid with bases of 21 inches and 40 inches, and sides of 24 inches. What is the depth of the fireplace? What is the area of the footprint? If the firebox is 32 inches high, what is its volume?

9. Notice the beautiful columns in the front and back of the mansion. How many are there altogether? If the diameter of a column is 36 inches, what are the circumference and cross-sectional area of a column (radius = circumference/2)?

10. The curving staircase has two different patterns of balusters. How many balusters are contained in 20 feet of railing? How many balusters are of each design?

11. Outside of the museum, there is a sculpture composed of a square 4 inch pole with a 6 inch block partially embedded into one corner. Only three full sides of the block are visible. Three sides of 36 in.^{2} each can be seen fully. On the fourth, fifth, and sixth sides, 35.10 in.^{2}; 30.45 in.^{2}, and 26.06 in.^{2}, respectively, can be seen. What surface area of the block is embedded in the pole?

12. Down the street from the Hunter Museum is the River Gallery. Displayed outside is a collection of multicolored glass plates. Some are made up of a colored outer disc and a smaller inner disc. If the diameter of one of the plates is 16 inches, and its inner disc is 4 inches in diameter, what is the area of the outer disc (radius = circumference/2)?

Solutions

1. Hallway is 20' long
   $A = 20 \text{ ft} \times 4 \text{ ft} = 80 \text{ ft}^2$
   $P = (2 \times 20 \text{ ft}) + (2 \times 4 \text{ ft}) = 40 \text{ ft} + 8 \text{ ft} = 48 \text{ ft}$

2. Answers will vary.
   11 mirrors x 11 mirrors = 121 mirrors
   Stand 11 ft away to see multiple images.
   Stand 6 in. away to see only one image.

3. Students need to experience this personally.

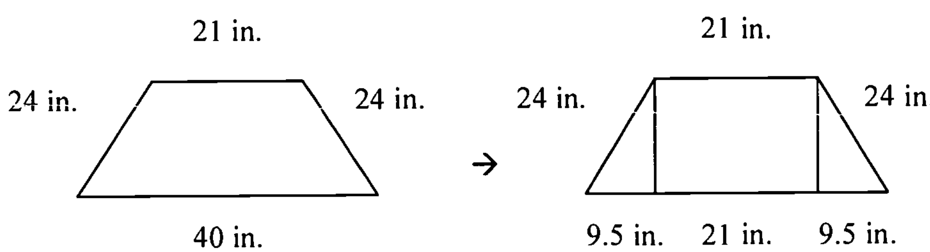
4. 6 ft x 12 in./ft x 2.54 cm/in. = 182.88 cm
   There are 182 cuts from 1 cm to 182 cm in 1 cm units.

5. Base: 13 units x 13 units x 7 units = 1,183 cubic units
   Top: (11 units x 11 units x 1 unit) + (9 units x 9 units x 1 unit) + (7 units x 7 units x 1 unit) + (5 units x 5 units x 1 unit) + (3 units x 3 units x 1 unit) + (1 unit x 1 unit x 1 unit) = 121 cubic units + 81 cubic units + 49 cubic units + 25 cubic units + 9 cubic units + 1 cubic unit = 286 cubic units
   Total: 1,183 cubic units + 286 cubic units = 1,469 cubic units

6. There are 160 squares.
   Answers will vary.

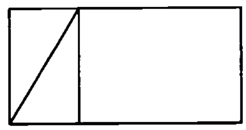
7. Area of triangle = ½ x base x height
   Area = ½ x 4 ft x 30 in. x 1 ft/12 in. = 5 ft^2

8. The height of the trapezoid (depth of the fireplace) can be found by splitting the trapezoid into one rectangle and two triangles:



   Apply the Pythagorean theorem to a right triangle to determine height:
   $h^2 = (24 \text{ in.})^2 - (9.5 \text{ in.})^2 = 576 \text{ in.}^2 - 90.25 \text{ in.}^2 = 485.75 \text{ in.}^2$
   $h \approx 22 \text{ in.}$

To find the area of the footprint, move the rightmost triangle to the left side of the diagram to form one rectangle:



22 in.

30.5 in.

Area = length x width = 30.5 in. x 22 in. = 671 in.^2

To find the volume of the firebox, multiply the area of the footprint by the height of the firebox:
Volume = 671 in.^2 x 32 in. = 21,472 in.^3

9. There are nine columns.
   Circumference = Πd = 3.14 x 36 in. ≈ 113 in.
   Area = $\Pi r^2 = (3.14)(36 \text{ in.}/2)^2 \approx 1{,}017 \text{ in.}^2$

10. There are two balusters every foot, plus the beginning baluster, so 20 feet of railing contains (20 x 2) + 1, or 41, balusters.

11. To solve for the imbedded area, subtract the visible areas from the total surface area of the cube:
    $216 \text{ in.}^2 - [(3)(36 \text{ in.}^2) + 35.10 \text{ in.}^2 + 30.45 \text{ in.}^2 + 26.06 \text{ in.}^2] = 16.39 \text{ in.}^2$

12. Subtract the area of the inner plate (4-inch diameter) from the area of the outer plate (16-inch diameter):
    Outer area = $\Pi r^2 = 3.14 \times (16 \text{ in.}/2)^2 = 200.96 \text{ in.}^2$
    Inner area = $\Pi r^2 = 3.14 \times (4 \text{ in.}/2)^2 = 12.56 \text{ in.}^2$
    Area = $\Pi r^2 = 200.96 \text{ in.}^2 - 12.56 \text{ in.}^2 = 188.4 \text{ in.}^2$

Web Sites for Further Exploration

Hunter Museum
http://www.huntermuseum.org/

Geometric Sculpture of George W. Hart
http://www.georgehart.com/sculpture/sculpture.html

Pablo Picasso, Three Musicians
http://www.usc.edu/schools/annenberg/asc/projects/comm544/library/images/265.htm
l

Pablo Picasso – Three Musicians Coloring Page
http://arthistory.about.com/library/blp_picassomusicians.htm

Activity 18
Lookout Mountain Incline Railway – Into the Clouds

Kelly Eller and Leah Stein
October 17, 2001

Description

The target grade level for this module is sixth through eighth. A field trip relates classroom activities with the real world. There are a variety of problems at varying levels of difficulty within this module. Some problems may be somewhat difficult for sixth graders, while eighth graders may find some problems less challenging. Problems that seem less difficult will be useful as review material. Location: 3917 St. Elmo Ave., Chattanooga, TN, or 827 East Brow Rd., Lookout Mountain, TN 37350.

Standards

Geometry, grades 6-8
Number and Operations, grades 6-8
Measurement, grades 6-8
Problem Solving, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Background Information

(current at the time of the course)

The Incline's slope is roughly 72.7%, which is approximately ¾.

The Incline is open every day of the year except Christmas Day.

Hours for the year are as follows:

- Summer (Memorial Day weekend through Labor Day) – 8:30 a.m. to 9:30 p.m.
- Spring and Fall (April, May, September, and October) – 9:00 a.m. to 6:00 p.m.
- Winter (November through March) – 10:00 a.m. to 6:00 p.m.

General Rates are as follows*:

- Adult - $9.00 round trip or $8.00 one way
- Child (3 – 12) - $4.50 round trip or $3.50 one way
- Seniors - $4.50 round trip or $3.50 one way
  * Children under 2 ride free with paying passenger

Group Rates are as follows**:

- Adults - $7.20 round trip or $6.40 one way
- Students (3 - 17) - $3.60 round trip or $2.80 one way
  ** Minimum of 20 paying passengers with one person paying entire group

Time required for one trip: 45 minutes one way and 1 1/2 hours round trip.

The Incline first opened on November 16, 1895.

Problems

1. At the Incline, pizza is sold in small, medium, and large slices. You bought a medium pizza for lunch. A medium pizza has six slices. If you ate two slices, how much of the pizza would be left? Express this in fraction, percent, and decimal form.

2. The Incline bus is 42 ft long. Convert the length of the bus to inches.

3. If the Incline bus is 60 inches in height, 504 inches in length, and 84 inches in width, what is the surface area of the bus?

4. The Incline is 1.6 km in length. One section of the Incline is 480 cm long. In each section there are nine railroad ties. Estimate the number of ties on the track.

5. At lunch time, one student wanted to buy a Coke that cost $1.49 and a slice of pizza that cost $2.00. He had $5.00 that he could spend on food. Sales tax is at a rate of 8.25%. Did the student have enough money to cover his purchase? If so, how much money did he have left? If not, by how much money was he short?

6. The Incline is 1.6 km in length. For every 20 railroad ties there is 1 pulley. Given 3,000 ties along the track, what is the number of pulleys on the track?

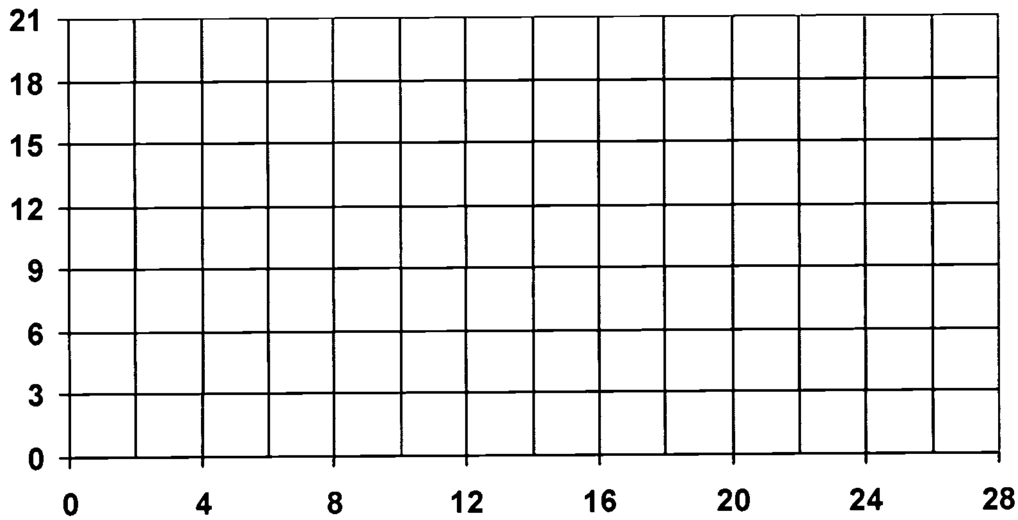
7. If a round trip ride takes 1 1/2 hours, how many complete times can you ride in an 8-hour time period?

8. If you have a family of five – two adults, a 13-year-old, a 10-year-old, and a 2-year-old – how much will it cost the family to take a one way trip? How much more is it to take a round trip?

9. If 88 people ride the Incline approximately every 2 hours, and the Incline is open for 8 hours per day, except Christmas day, how many people have ridden the Incline since its opening in 1895? Omit the extra day for leap years and any closings for maintenance.

10. Given the hours of operation, estimate the number of hours the Incline is open each year?
    Summer total hours: 14 weeks, 13 hours/day
    Spring/Fall total hours: 16 weeks, 9 hours/day
    Winter total hours: 22 weeks, 8 hours/day
    Total = Summer hours + Spring/Fall hours + Winter hours

11. Given that the slope of the Incline, at one point, is roughly 72.7% (about 3/4), graph this line beginning with the point (0,0).



12. If there are 22 fifth-grade students and 2 teachers taking an Incline trip on Lookout Mountain, how much money do they save buying the group rate prices (round trip and one way trip)?

13. If the Incline track is 1 mile long, and the Incline cars pass one another at the half way point, how many feet has each car traveled when they pass?

Solutions

1. At the Incline, pizza is sold in small, medium, and large slices. You bought a medium pizza for lunch. A medium pizza has six slices. If you ate two slices, how much of the pizza would be left? Express this in fraction, percent, and decimal form.

   4 slices out of 6 remain
   Fraction: 4/6, or 2/3, of the pizza is left
   Percent: 67% of the pizza is left
   Decimal: 0.67 of the pizza is left

2. The Incline bus is 42 ft long. Convert the length of the bus to inches.

   42 ft = _______ in.
   There are 12 inches in 1 foot so the bus is 504 inches long.

3. If the Incline bus is 60 inches in height, 504 inches in length, and 84 inches in width, what is the surface area of the bus?

   $$\begin{aligned} SA &= 2(60 \text{ in.} * 504 \text{ in.}) + 2(504 \text{ in.} * 84 \text{ in.}) + 2(60 \text{ in.} * 84 \text{ in.}) \\ &= 2(30{,}240 \text{ in.}^2) + 2(42{,}336 \text{ in.}^2) + 2(5{,}040 \text{ in.}^2) \\ &= 60{,}480 \text{ in.}^2 + 84{,}672 \text{ in.}^2 + 10{,}080 \text{ in.}^2 \\ &= 155{,}232 \text{ in.}^2 \end{aligned}$$

   $$\begin{aligned} &= 155{,}232 \text{ in.}^2 / 144 \text{ in.}^2 / \text{ft}^2 \\ &= 1{,}078 \text{ ft}^2 \end{aligned}$$

4. The Incline is 1.6 km in length. One section of the Incline is 480 cm long. In each section there are nine railroad ties. Estimate the number of ties on the track.

   1.6 km = 1,600 m = 160,000 cm
   160,000 cm ÷ 480 cm/section = 333.33 sections (or 333 1/3 sections)
   333 1/3 sections * 9 ties/section = 3,000 ties on the track.

5. At lunch time, one student wanted to buy a Coke that cost $1.49 and a slice of pizza that cost $2.00. He had $5.00 that he could spend on food. Sales tax is at a rate of 8.25%. Did the student have enough money to cover his purchase? If so, how much money did he have left? If not, by how much money was he short?

   ($2.00 + $1.49)(1.0825) = $3.78
   $5.00 – $3.78 = $1.22
   Yes. He has $1.22 left.

6. The Incline is 1.6 km in length. For every 20 railroad ties there is 1 pulley. Given 3,000 ties along the track, what is the number of pulleys on the track?

   $$\frac{20 \text{ ties}}{1 \text{ pulley}} = \frac{3{,}000 \text{ ties}}{X}$$

   X(20 ties) = (1 pulley)(3,000 ties)
   X = 150 pulleys
   or
   3,000 ties ÷ 20 ties/pulley = 150 pulleys

7. If a round trip ride takes 1 1/2 hours, how many complete times can you ride in an 8-hour time period?

   8 hr / 1.5 hr/trip = 5.33 trips (5 complete trips)

8. If you have a family of five – two adults, a 13-year-old, a 10-year-old, and a 2-year-old – how much will it cost the family to take a one way trip? How much more is it to take a round trip?

   One way – 2($8.00) + ($8.00) + $3.50 + 0 = $27.50
   Round Trip – 2($9.00) + ($9.00) + $4.50 + 0 = $31.50
   $31.50 - $27.50 = $4.00
   It will cost $4.00 more for the family to take a round trip ride.

9. If 88 people ride the Incline approximately every 2 hours, and the Incline is open for 8 hours per day, except Christmas day, how many people have ridden the Incline since its opening in 1895? Omit the extra day for leap years and any closings for maintenance.

   88 people/2 hr x 8 hr/day = 352 people/day
   364 day/yr x 352 people/day = 128,128 people/yr
   2001 – 1895 = 106 years
   106 yr x 128,128 people/yr = 13,581,568 people (over 13 million people)

10. Given the hours of operation, estimate the number of hours the Incline is open each year?

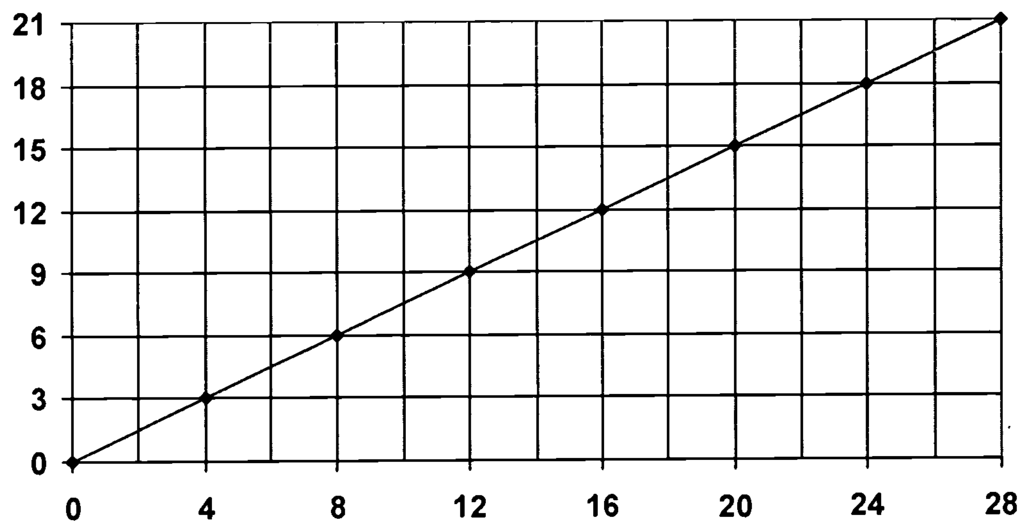
    Summer total hours: 14 weeks, 13 hours/day
    14 wk x 7 days/wk = 98 days
    98 days x 13 hr/day = 1,274 hr

    Spring/Fall total hours: 16 weeks, 9 hours/day
    16 wk x 7 days/wk = 112 days
    112 days x 9 hr/day = 1,008 hr

Winter total hours: 22 weeks, 8 hours/day
22 wk x 7 days/wk = 154 days
154 days x 8 hrs/day = 1,232 hr

Total = Summer hours + Spring/Fall hours + Winter hours
1,274 hr + 1,008 hr + 1,232 hr = 3,514 hr ≈ 3,500 hr

11. Given that the slope of the Incline, at one point, is roughly 72.7% (about 3/4), graph this line beginning with the point (0,0).



12. If there are 22 fifth-grade students and 2 teachers taking an Incline trip on Lookout Mountain, how much money do they save buying the group rate prices (round trip and one way trip)?

Group rates, round trip
22($3.60) + 2($7.20) = $93.60

Nongroup, round trip
22($4.50) + 2($9.00) = $117.00
Money saved = $117.00 - $93.60 = $23.40.

Group rates, one way
22($2.80) + 2($6.40) = $74.40

Nongroup, one way
22($3.50) + 2($8.00) = $93.00
Money saved = $93.00 – $74.40 = $18.60.

13. If the Incline track is 1 mile long, and the Incline cars pass one another at the half way point, how many feet has each car traveled when they pass?

1 mi/trip x 5,280 ft/mi x 0.5 trip = 2,640 ft

Web Sites for Further Exploration

CARTA – Incline Railway
http://www.carta-bus.org/CARTA%20Web%20Site/Incline/Incline%20Home%20Page.html

Engines of Our Ingenuity – No. 409: The Lookout Mountain Incline
http://www.uh.edu/admin/engines/epi409.htm

Southern Highlands Attractions – Lookout Mountain Incline Railway
http://southernhighlands.org/lookmouninra.html

About North Georgia – History of the Incline Railway
http://ngeorgia.com/tenn/theincline.html

Science Conversions – Length
http://www.tcaep.co.uk/science/convert/length/

Equation Sheet – Unit Conversions
http://www.equationsheet.com/units.php?SID=HNRGNSWY&TABLE=Units

Pittsburgh Inclines
http://web.presby.edu/~jtbell/transit/Pittsburgh/Inclines/

Mount Beacon Railway, Hudson Valley (NY)
http://www.pojonews.com/enjoy/stories/mtbeacon.htm

The Prospect Mountain Cable Incline Railway; Lake George, NY
http://www.railroadextra.com/lginclin.Html

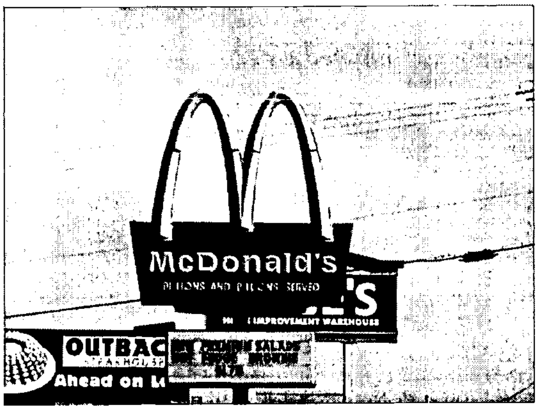
How Stuff Works – What is a funicular railway?
http://www.howstuffworks.com/question512.htm

Funicular
http://www.brantacan.co.uk/funicular.htm

KIDiddles: Song Lyrics – Funiculi, Funicula
http://www.kididdles.com/mouseum/f059.html

Activity 19
McDonald's Math

Stacia Bearden and Ashli Brown
Fall 2002



Description of Module

In this module, the student will plan meals, with respect to monetary and calorific budgets, using McDonald's menu items. Location: Various.

Standards

Number and Operations, grades 6-8
Data Analysis and Probability, grades 6-8
Problem Solving, grades 6-8
Communication, grades 6-8
Connections, grades 6-8
Representation, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

Problem 1

McDonald's claims to serve one billion customers each year. How many pounds of ground beef would they need if they were to serve each customer with only one quarter-pound cheeseburger? Remember to show all work and explain your answer in complete sentences.

Problem 2

Step 1

Use the Internet site listed under the Reference section to create three meals of your choice. While doing this, keep in mind that you are only allowed to spend a total of $20.00 and that you must consume at least 1,200 calories at each meal. (Local pricing may be provided by the teacher. The local tax rate is 8.25%.)

Step 2

a. When you started this assignment, what were your initial plans to meet the standards set in the instructions in Step 1?

b. What was your average spending for every meal? Use complete sentences and be sure to show all of your mathematical work.

c. How many calories did you consume during each meal? You must use complete sentences and show and explain all of your mathematical work.

d. What were some of the problems that you faced while trying to meet these goals?

e. Write a short paragraph containing your results to present to the class. You must include your entire menu plan, as well as your ending budget and ending calorie count.

Problem 3

Use the following information to complete the questions below:

- One case of French fries contains five bags of French fries.
- Each bag of French fries makes the following servings:
  25 small fries or 12.5 large fries or 8 super-sized fries
- 2 small fries = 1 large fry
- 1 large fry + 1 small fry = 1 super-sized fry

a. How many cases/bags would be needed to make 100 small fries?

b. How many cases/bags would be needed to make 15 small fries, 10 large fries, and 2 super-sized fries?

c. How many different fry combinations can you think of if given three cases of fries? Show your work and combinations to justify your answer.

Problem 4

On an average day, a particular restaurant can serve an average of 100 customers in 1 hour. Most of the orders consist of either Happy Meals or Value Meals. Answer the following:

a. If a total of 25 Happy Meals (small fry), 45 Value Meals (large fry), and 40 super-sized Value Meals (super-sized fry) are sold during 1 hour of lunch, how many cases of fries will be needed in order to complete all the orders?

b. How many cases will be needed for a regular Monday through Friday schedule for 4 weeks, with a lunch period of 3 hours each day? Remember to show your work and explain your answers in complete sentences.

c. With the information provided create your own problem to present to the class. You will be graded on how well you prove your answer.

Menu Worksheet

Breakfast

Food Items	Cost	Calories
Beginning Balance	Total Cost	Total Calories
Ending Balance		Unused Calories

Lunch

Food Items	Cost	Calories
Beginning Balance	Total Cost	Total Calories
Ending Balance		Unused Calories

Dinner

Food Items	Cost	Calories
Beginning Balance	Total Cost	Total Calories
Ending Balance		Unused Calories

Solutions

Problem 1

McDonald's claims to serve one billion customers each year. How many pounds of ground beef would they need if they were to serve each customer with only one quarter-pound cheeseburger? Remember to show all work and explain your answer in complete sentences.

1,000,000,000 burgers ÷ 4 burgers/lb = 250,000,000 lb

The number of pounds of ground beef needed is equal to the number of burgers served (1,000,000,000) divided by the number of burgers per pound of ground beef (4), or 250,000,000 pounds of ground beef.

Problem 2

Answers will vary for all steps and parts.

Problem 3

a. How many cases/bags would be needed to make 100 small fries?

   100 small fries ÷ 25 small fries/bag = 4 bags (less than 1 case).
   The student must use complete sentences to explain this answer.

b. How many cases/bags would be needed to make 15 small fries, 10 large fries, and 2 super-sized fries?

   10 large fries = 20 small fries
   2 super-sized fries = 2 large fries + 2 small fries = 6 small fries
   15 small fries + 20 small fries + 6 small fries = 41 small fries
   41 small fries ÷ 25 small fries/bag = 1.64 bags (less than 1 case)
   The student must use complete sentences to explain this answer.

c. Answers will vary.

Problem 4

a. If a total of 25 Happy Meals (small fry), 45 Value Meals (large fry), and 40 super-sized Value Meals (super-sized fry) are sold during 1 hour of lunch, how many cases of fries will be needed in order to complete all the orders?

   25 small fries + 45 large fries + 40 super-sized fries
   = 25 small fries + 90 small fries + 120 small fries
   = 235 small fries
   235 small fries ÷ 25 small fries/bag = 9.4 bags (more than 1 case)
   9.4 bags ÷ 5 bags/case = 1.88 cases

b. How many cases will be needed for a regular Monday through Friday schedule for 4 weeks, with a lunch period of 3 hours each day? Remember to show your work and explain your answers in complete sentences.

   1.88 cases/hr x 3 hr/day x 5 days/week x 4 weeks = 112.8 cases (564 bags)

c. Answers will vary.

Reference

McDonald's USA. (2003). *McDonald's USA nutrition facts for popular menu items.* Retrieved July 12, 2003, from http://www.mcdonalds.com/countries/usa/food/nutrition/categories/nutrition/index.html

Web Site for Further Exploration

McDonald's USA Food & Nutrition
http://www.mcdonalds.com/countries/usa/food/

Food and Nutrition Information Center
http://www.nal.usda.gov/fnic/

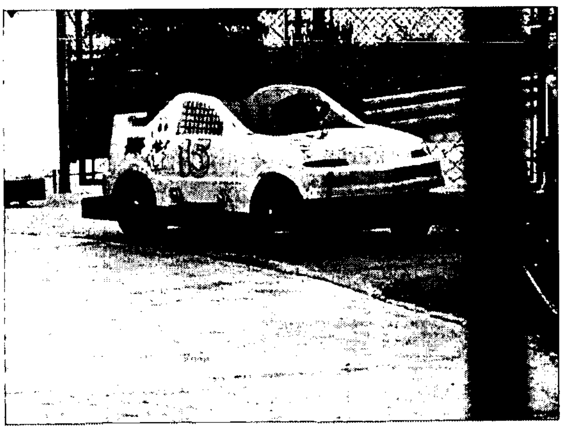
MathWorld – Large Number
http://mathworld.wolfram.com/LargeNumber.html

Miami Museum of Science – Estimating Large Numbers
http://www.miamisci.org/ph/lpextend2.html

Examples of Large Numbers
http://phyun5.ucr.edu/~wudka/Physics7/Notes_www/node15.html

Activity 20
Miniature Golf in Chattanooga – Sir Goony's Family Fun Center

Emily Smith
November 2001



Description of Module

Sir Goony's Family Fun Center contains the nation's first miniature golf course. In this module, the student will apply mathematics to activities such as miniature golf, bumper boats, and go-carts. Location: 5918 Brainerd Rd., Chattanooga, TN 37421.

Standards

Measurement, grades 6-8
Problem Solving, grades 6-8
Number and Operations, grades 6-8
Data Analysis and Probability, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Background Information

(current at the time of the course)

Cost of Goony Golf

Adults (12 and over)	$5.00
Children	$4.00
Children under age 2	Free

2 golf courses with 18 holes each
Golf ball colors: pink, green, red, blue, light blue, orange, yellow, purple (156 total)
Length of golf clubs:
  Tall (heights of 5'5" and taller): 2.8 ft.
  Medium (heights of 4'5" - 5'5"): 2.0 ft
  Short (heights of 4'5" and shorter): 1.5 ft

Cost of Bumper Boat Ride

Adults	$5.00
Children	$5.00

1 course
Length of ride: 5 minutes
12 bumper boats

Cost of Go-Cart Ride

Adults	$5.00
Children	$5.00

1 course
Length of ride: 5 minutes
Average laps per ride: 8
15 single-rider carts
5 double-rider carts (when two are riding the total cost is $6)

Hours of Operation

Monday - Thursday: 4:00 p.m. - 10:00 p.m.
Friday: 4:00 p.m. - 12:00 a.m.
Saturday: 10:00 a.m. - 12:00 a.m.
Sunday: 12:00 p.m. - 10:00 p.m.

Problems

1. A group of eight girls and seven boys that are ages 9 through 11 are going to play goony golf. They have three adult chaperones: two want to play golf and one does not want to play golf. They have five coupons for buy-one-get-one-free games that can only be used by one adult and one child and they must pay for the more expensive price. How much will the total charge be for the group to play?

2. Bobby and John are going to ride the go-carts. Sir Goony's is offering a special for a ride that lasts 9 minutes for the cost of $10.50. Are the boys getting a good deal with the discounted ride? Calculate the actual cost of both rides to make a comparison.

3. Two boys and their father are trying to figure out what size golf club each will need to play goony golf. The first boy is approximately 55 inches tall, the second boy is approximately 145 centimeters tall, and the father is 72 inches tall. Convert their heights to feet and inches to determine which golf club is best for each to use.

4. At Sir Goony's, there are 156 golf balls in eight different colors, including 25 pink, 18 green, 23 red, 11 blue, 10 light blue, 31 yellow, and 19 orange.

   How many purple golf balls are there?
   What is the ratio of pink to light blue golf balls?
   What is the ratio of orange to purple golf balls?
   What are your chances of getting a yellow or a pink golf ball?

5. Look on the Internet to find the city in which miniature golf originated. What was the year that miniature golf was invented? (Hint: Use the Web sites listed.)

6. Sir Goony's is offering a "back-to-school" special for middle school students, grades 6-8, or ages 11-14, that includes one bumper boat ride, two go-cart rides, and one game of goony golf for $15.95. How much did the students save if their ages classified them as children? How much did the students save if their ages classified them as adults? What percentage was saved on each pricing (round answers)?

7. A group of 23 customers that are all over the age of 12 want to play a game of goony golf. What is the time required to play one game of golf, using both courses, with each hole taking approximately 2 minutes to play? How much would it cost the group to play if a sales tax of 8.25% is added?

8. A family of four wants to spend an evening at Sir Goony's playing goony golf and riding the bumper boats. There are two adults, and two children between the ages of 9 and 11. They have $43.00 to spend. Will each member of the family be able to ride the bumper boats and play a game of golf if a sales tax of 8.25% is added?

9. A family of eight wants to have a go-cart race. They have $100 to spend. How many times can the entire family ride the go-carts if a sales tax of 8.25% is added?

10. If every golf ball, every bumper boat, and every go-cart (single and double) were in use, how many people would be in the park? How much would the activities cost if the people were adults? How much would the activities cost if the people were children?

Solutions

1. A group of eight girls and seven boys that are ages 9 through 11 are going to play goony golf. They have three adult chaperones: two want to play golf and one does not want to play golf. They have five coupons for buy-one-get-one-free games that can only be used by one adult and one child and they must pay for the more expensive price. How much will the total charge be for the group to play?

   Use two buy-one-get-one-free coupons for adults: 2 x \$5.00 = \$10.00
   2 children golf at no cost on the two buy-one-get-one-free coupons
   13 children: 13 x \$4.00 = \$52.00
   Total = \$10.00 + \$52.00 = \$62.00

2. Bobby and John are going to ride the go-carts. Sir Goony's is offering a special for a ride that lasts 9 minutes for the cost of \$10.50. Are the boys getting a good deal with the discounted ride? Calculate the actual cost of both rides to make a comparison.

   8 laps ÷ 5 min = 1.6 laps/min
   \$5.00 ÷ 8 laps = \$0.625/lap

   9 min x 1.6 laps/min = 14.4 laps
   14 laps x \$0.625 per lap at regular price = \$8.75
   \$10.50 ÷ 14.4 laps = \$0.73/lap

   No. The special ride is not a good deal.

3. Two boys and their father are trying to figure out what size golf club each will need to play goony golf. The first boy is approximately 55 inches tall, the second boy is approximately 145 centimeters tall, and the father is 72 inches tall. Convert their heights to feet and inches to determine which golf club is best for each to use.

1^{st} boy: 55 in. ÷ 12 in./ft = 4 remainder 7 = 4 ft 7 in.	Use a medium club.
2^{nd} boy: 145 cm ÷ 2.54 cm/in. ÷ 12 in./ft = 4.76 in. ≈ 4 ft 9 in.	Use a medium club.
Father: 72 in. ÷ 12 in./ft = 6 ft	Use a tall club.

4. At Sir Goony's, there are 156 golf balls in eight different colors, including 25 pink, 18 green, 23 red, 11 blue, 10 light blue, 31 yellow, and 19 orange.

   How many purple golf balls are there?
   156 – (25 + 18 + 23 + 11 + 10 + 31 + 19) = 19

   What is the ratio of pink to light blue golf balls?
   25:10 or 5:2

What is the ratio of orange to purple golf balls?
19:19 or 1:1

What are your chances of getting a yellow or a pink golf ball?
(yellow + pink) / total = (31 + 25) / 156 = 56/156 = 14/39 chance (approximately 1/3)

5. Look on the Internet to find the city in which miniature golf originated. What was the year that miniature golf was invented? (Hint: Use the Web sites listed.)

   Chattanooga (Lookout Mountain)
   1927

6. Sir Goony's is offering a "back-to-school" special for middle school students, grades 6-8, or ages 11-14, that includes one bumper boat ride, two go-cart rides, and one game of goony golf for $15.95. How much did the students save if their ages classified them as children? How much did the students save if their ages classified them as adults? What percentage was saved on each pricing (round answers)?

   Children:
   $\$5.00 + (2 \times \$5.00) + \$4.00 = \$19.00$
   $\$19.00 - \$15.95 = \$3.05$
   $\$3.05 \div \$19.00 \times 100\% \approx 16\%$

   Adults:
   $\$5.00 + (2 \times \$5.00) + \$5.00 = \$20.00$
   $\$20.00 - \$15.95 = \$4.05$
   $\$4.05 \div \$20.00 \times 100 \approx 20\%$

7. A group of 23 customers that are all over the age of 12 want to play a game of goony golf. What is the time required to play one game of golf, using both courses, with each hole taking approximately 2 minutes to play? How much would it cost the group to play if a sales tax of 8.25% is added?

   Assume the group splits with approximately half of the customers going to one course and half of the customers going to the second course. This would place 12 people on one course and 11 people on the other course. If all customers require the same amount of time, on average, then the length of time needed for 23 people to complete the game is dependent on when the last person in the larger group finishes. The 12th person in the larger group must wait for each person in front of him to complete the first hole before he can begin; therefore, the time for him, and thus the group, to complete the course is:
   (11 people x 2 min/person) + (18 holes x 2 min/hole) = 58 min
   $5.00/person x 23 people x 1.0825 = $124.49

8. A family of four wants to spend an evening at Sir Goony's playing goony golf and riding the bumper boats. There are two adults, and two children between the ages of 9 and 11. They have $43.00 to spend. Will each member of the family be able to ride the bumper boats and play a game of golf if a sales tax of 8.25% is added?

   Bumper boats: 4 x $5.00 = $20.00
   Golf: (2 x $5.00) + (2 x $4.00) = $18.00
   Total: ($20.00 + $18.00) x 1.0825 = $41.14
   Yes. The family can afford to ride the bumper boats and play golf.

9. A family of eight wants to have a go-cart race. They have $100 to spend. How many times can the entire family ride the go-carts if a sales tax of 8.25% is added?

   Cost for one round: (8 people x $5.00/person x 1.0825) = $43.30
   $100 ÷ $43.30/round = 2.31 rounds
   The entire family can ride the go-carts twice.

10. If every golf ball, every bumper boat, and every go-cart (single and double) were in use, how many people would be in the park? How much would the activities cost if the people were adults? How much would the activities cost if the people were children?

    156 people + 12 people + 15 people + (2 x 5) people = 193 people
    Adults: [(156 + 12 + 15) x $5.00] + (5 x $6.00) = $945
    Children: (156 x $4.00) + [(12 + 15) x $5.00] +(5 x $6.00) = $789

Web Sites for Further Exploration

Lomma Miniature Golf
http://www.lommagolf.com/history.html

Coolmath.com - an amusement park of math ... and more!
http://www.coolmath.com/

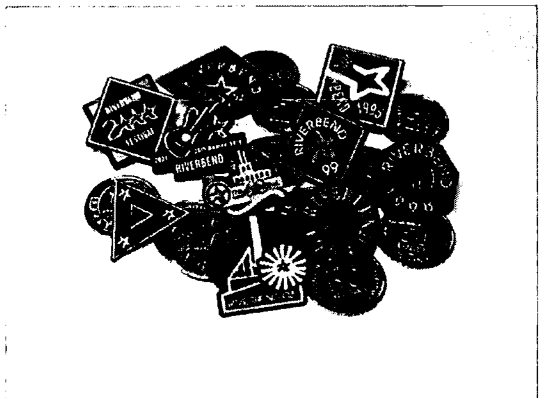
Cedar Point, Sandusky, OH
http://www.cedarpoint.com/

Harris Miniature Golf
http://www.harrisminigolf.com/

Atlantic Miniature Golf Course Design & Construction
http://www.atlanticminigolf.com/

Activity 21
Riverbend Festival

Rebecca Brock
October 23, 2002



Description of Module

Riverbend is a 9-day music festival held each year in June. Artists representing a variety of musical styles perform on six stages. A fireworks display closes the festival on the last evening. In this module, designed for students in grades 6 and 7, the student will solve practical problems related to attendance at the festival. Location: Downtown Chattanooga, along the south bank of the Tennessee River, from the Hunter Museum to Ross' Landing Marina.

Standards

Number and Operations, grades 6-8
Problem Solving, grades 6-8
Reasoning, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. To eat and drink at the Riverbend festival you must buy tokens. Tokens are valued at 50 cents each. You decide to purchase $10.00 in tokens. How many tokens will you receive? If the token value changes so that each token is worth 25 cents, how many tokens would you receive?

2. Riverbend pins sell for $24 each (2003) and allow access to the festival for all 9 days. If you attend the festival each day, how much are you paying per day? If the festival lasts for 6 hours each day and you are there the full time each day, how much are you paying per hour?

3. During 2001, there were 1,200 volunteers at the Riverbend festival. Each year, the number of volunteers needed increases by 2%. How many volunteers were needed in 2002? How many volunteers will be needed in 2005?

4. Six hundred thousand (600,000) people (adults, children 11 years and older) attended Riverbend in 2001. An increase of 1.5% was expected for Riverbend 2002. How many additional people were projected to attend Riverbend in 2002?

5. The Riverbend festival occurs over 9 days. How many weeks is this? The Riverbend festival is active for six hours each day. How many minutes is this?

6. For 8 nights during Riverbend, there is a performer on the Coca-Cola stage from 9:30 p.m. until 11:00 p.m. How many hours is the Coca-Cola stage in use during Riverbend? During the entire festival, what percentage of time is the Coca-Cola stage in use? (Hint: use your answer from problem 5.)

7. The Riverbend festival begins at 5:00 p.m. You live 20 miles from the festival and are able to travel at a speed of 50 miles per hour when driving to the festival. How long will it take you to travel from home to the festival? If it takes 20 minutes to walk from the parking lot to the festival entrance, at what time should you leave your house in order to arrive at the opening time?

8. There were 28 concession stands at Riverbend in 2002: 6 on Chestnut Street, 16 on Concession Row, 2 in the Children's Village, 1 in the Bluff View, and 3 on mobile carts. What percent of the concession stands were located on Concession Row? What percent of the concession stands were not located on Chestnut Street?

9. Nancy's concession stand sells elephant ears for 4 tokens, funnel cakes for 6 tokens, tea for 3 tokens, lemonade for 4 tokens, and Coke for 2 tokens. If you want to buy 2 funnel cakes and one lemonade, how much money will it cost? If you want to buy one set of elephant ears and 2 Cokes, how much money will it cost?

10. Sixty people can fit inside a 110-square-foot area in front of the Coca-Cola stage. There are 600 people attending to hear the Chattanooga Symphony. How much area will be needed?

Solutions

1. To eat and drink at the Riverbend festival you must buy tokens. Tokens are valued at 50 cents each. You decide to purchase \$10.00 in tokens. How many tokens will you receive? If the token value changes so that each token is worth 25 cents, how many tokens would you receive?

   \$10.00 ÷ \$0.50/token = 20 tokens
   \$10.00 ÷ \$0.25/token = 40 tokens
   You will receive 20 tokens when the tokens are valued at 50 cents each.
   You will receive 40 tokens when the tokens are valued at 25 cents each.

2. Riverbend pins sell for \$24 each (2003) and allow access to the festival for all 9 days. If you attend the festival each day, how much are you paying per day? If the festival lasts for 6 hours each day and you are there the full time each day, how much are you paying per hour?

   \$24.00 ÷ 9 days = \$2.67/day
   \$2.67/day ÷ 6 hr/day = \$0.45/hr

3. During 2001, there were 1,200 volunteers at the Riverbend festival. Each year, the number of volunteers needed increases by 2%. How many volunteers were needed in 2002? How many volunteers will be needed in 2005?

   In 2002: 1,200 volunteers x 1.02 = 1,224 volunteers
   $V_n = V_0 (1 + i)^n$, where V_n = future volunteers, V_0 = current volunteers, i = percent increase, and n = number of years
   In 2005: V_n = 1,200 volunteers x $(1+.02)^4$ = 1,299 volunteers

4. Six hundred thousand (600,000) people (adults, children 11 years and older) attended Riverbend in 2001. An increase of 1.5% was expected for Riverbend 2002. How many additional people were projected to attend Riverbend in 2002?

   600,000 people x 0.015 = 9,000 people

5. The Riverbend festival occurs over 9 days. How many weeks is this? The Riverbend festival is active for six hours each day. How many minutes is this?

   9 days ÷ 7 days/wk ≈ 1.29 wk
   9 days x 6 hr/day x 60 min/hr = 3,240 min

6. For 8 nights during Riverbend, there is a performer on the Coca-Cola stage from 9:30 p.m. until 11:00 p.m. How many hours is the Coca-Cola stage in use during Riverbend? During the entire festival, what percentage of time is the Coca-Cola stage in use? (Hint: use your answer from problem 5.)

   8 days x 90 min/day = 720 min
   720 min x 1 hr/60 min = 12 hr
   720 min ÷ 3,240 min x 100% ≈ 22%

7. The Riverbend festival begins at 5:00 p.m. You live 20 miles from the festival and are able to travel at a speed of 50 miles per hour when driving to the festival. How long will it take you to travel from home to the festival? If it takes 20 minutes to walk from the parking lot to the festival entrance, at what time should you leave your house in order to arrive at the opening time?

   driving time = 20 mi ÷ 50 mi/hr x 60 min/hr = 24 min
   driving time + walking time = 24 min + 20 min = 44 min.
   You should leave your house no later than 4:16 p.m. in order to arrive by 5:00 p.m.

8. There were 28 concession stands at Riverbend in 2002: 6 on Chestnut Street, 16 on Concession Row, 2 in the Children's Village, 1 in the Bluff View, and 3 on mobile carts. What percent of the concession stands were located on Concession Row? What percent of the concession stands were not located on Chestnut Street?

   Located on Concession Row: 16 stands ÷ 28 stands x 100% = 57%
   Not located on Chestnut Street: 22 stands ÷ 28 stands x 100% = 79%

9. Nancy's concession stand sells elephant ears for 4 tokens, funnel cakes for 6 tokens, tea for 3 tokens, lemonade for 4 tokens, and Coke for 2 tokens. If you want to buy 2 funnel cakes and one lemonade, how much money will it cost? If you want to buy one set of elephant ears and 2 Cokes, how much money will it cost?

   (2 cakes x 6 tokens/cake) + (1 lemonade x 4 tokens/lemonade) = 16 tokens
   16 tokens x $0.50/token = $8.00
   (1 ears x 4 tokens/ears) + (2 Cokes x 2 tokens/Coke) = 8 tokens
   8 tokens x $0.50/token = $4.00

10. Sixty people can fit inside a 110-square-foot area in front of the Coca-Cola stage. There are 600 people attending to hear the Chattanooga Symphony. How much area will be needed?

Find the square footage required for one person then multiply that requirement by the number of people attending the event, or use a proportion:
$110 \text{ ft}^2 / 60 \text{ people} = 1.833 \text{ ft}^2/\text{person}$
$1.833 \text{ ft}^2/\text{person} \times 600 \text{ people} = 1{,}100 \text{ ft}^2$

or

$$\frac{110 \text{ ft}^2}{60 \text{ people}} = \frac{X}{600 \text{ people}}$$

$(60 \text{ people})(X) = (600 \text{ people})(110 \text{ ft}^2)$
$X = 1{,}100 \text{ ft}^2$

Web Sites for Further Exploration

Riverbend Festival
http://www.riverbendfestival.com/

Education 4 Kids: Money Experience for Kids
http://www.edu4kids.com/money/

Soverign Bank: KidsBank.com
http://www.kidsbank.com/

FirstGov for Kids
http://www.kids.gov/k_money.htm

Money Central Station
http://www.moneyfactory.com/kids/start.html

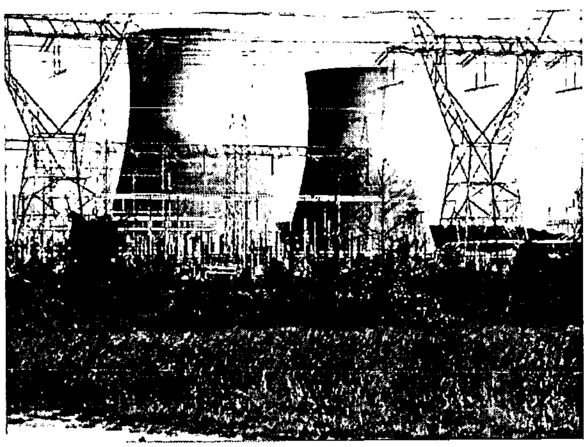
US Mint's Site for Kids
http://www.usmint.gov/kids/

Ratio, Proportion, and a $10 Bill
http://www.mathsolutions.com/mb/content/newsletters/spring_00_nl_4.html

Exploratorium: Science of Cycling – Drives & Gears
http://www.exploratorium.edu/cycling/gears1.html

Activity 22
Sequoyah Nuclear Plant and Training Center

Vince Betro, Russell Morphis, and James Kearney
November 7, 2001



Description of Module

In this module, the student will explore probability and ratio, as applied to nuclear accidents and natural disasters. Location: Igou Ferry Rd., Soddy Daisy, TN 37379.

Standards

Data Analysis and Probability, grades 9-12
Algebra, grades 9-12
Reasoning, grades 9-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Good morning, everybody!

Today we are going to visit the Sequoyah Nuclear Power Plant that is operated by the Tennessee Valley Authority (TVA), outside of Chattanooga, Tennessee. All of your homes receive power from TVA, and some of it likely comes from Sequoyah. Before we get there, we are going to do some mathematics to get warmed up and alleviate some possible fears about going to the nuclear facility.

Did you know?

Did you realizc that the probability of a nuclear accident at this plant is about 1/10,000,000 years? The probability of a tornado is 1/10,000 years. Pretty good odds, don't you think?

To help you see how unlikely these events are in conjunction or in comparison with each other, think about and experiment with the following questions:

1. What is the probability of both a tornado and a nuclear accident happening?

   Solution: When one is curious about two events occurring simultaneously, one must realize the resulting probability must be smaller than either of the two original probabilities. Therefore, one must multiply the probabilities. In this case, 1/10,000,000 x 1/10,000 = 1/100,000,000,000 (which is quite tiny!).

2. What is the probability of either a tornado or a nuclear accident occurring?

   Solution: In the case of an "or" statement, one must realize the resulting probability must be larger than either of the two original probabilities since either event will be a success. Therefore, one must add the probabilities. In this case, 1/10,000,000 + 1/10,000 = 1,001/10,000,000 (which is much larger than the solution to problem 1, but still quite tiny!).

3. What is the probability of two tornadoes occurring simultaneously?

   Solution: As you may recall from problem 1, one must multiply the probabilities. In this case, 1/10,000 x 1/10,000 = 1/100,000,000 (which is quite tiny!).

4. What is the probability of two nuclear accidents occurring simultaneously?

   Solution: As you may recall from problem 1, one must multiply the probabilities. In this case, 1/10,000,000 x 1/10,000,000 = 1/100,000,000,000,000 (which is the smallest of all!).

5. Which of these probabilities is the smallest? Which of these probabilities is the largest? How many times more likely is it to have a nuclear accident occur than to have either a tornado or a nuclear accident occur?

   Solution: The first two answers follow from the answers to the previous four questions. The probability of two nuclear accidents occurring simultaneously is the smallest (problem 4). The probability of either a tornado or a nuclear accident occurring is the largest (problem 2).

   When finding how many times more likely it is for one event to occur than another event to occur, divide the two answers to calculate the number of times one probability will fit into another. In this case, the probability of a nuclear accident is 1/10,000,000; the probability of either a tornado or a nuclear accident occurring is 1,001/10,000,000. Dividing the larger number by the smaller number shows that it is 1,001 times more likely to have a tornado or a nuclear accident occur than to have a nuclear accident occur. This is because the probability of a tornado occurring is much higher than the probability of a nuclear accident occurring. Reasoning such as this allows for many more opportunities for thought than just being curious about one event occurring in isolation. Can you think of anything else that becomes more likely when you are curious about it or another thing happening? (Everything is like this; the more open one is to outcomes, the more likely it is that he or she will get what he or she wants!)

Now, does that not make you feel much safer about nuclear power than you were before? However, the government is very particular that we know a little about safety before we enter the facility. The first place we will visit is the radiation safety area. If you look at all of the protective gear, you might get the false impression that this is the best way to protect yourself from radiation. However, the best way is still the "old-fashioned" way, since some radiation can get through these materials. What is the "old-fashioned" way, you might ask? Get away!

Did you know?

Distance is one of the strongest components in determining how much any force affects you. Some forces, like sound, become exponentially stronger as the distance between the object and the source decreases. Others, like gravity and radiation, get weaker by a factor of the distance between the object and the source squared ($1/d^2$). Exponential forces dissipate faster than "inverse square" forces since they have a greater rate of change; this is much like how the graph of a log function increases faster than that of $y = x^2$.

Radiation density is an inverse square function. That means that the farther away you get from it, you decrease your exposure by a factor of the square of that distance. For example, if my friend is 2 feet away from a nuclear sample and I am 10 feet away, he is five times closer than I am. Recall from our discussions of probability that to find how many times more one thing is than another, we divide them. Thus, we will not actually use the measures of how far away from the source we are when we find out how much less radiation I will receive than my friend will receive. Rather, we will divide 10 by 2, then find the inverse square of the quotient. Therefore, I will receive $1/(10/2)^2$ or 1/25 of the radiation my friend will receive. Let us try some examples!

1. If I am 30 feet from the radiation source and you are 600 feet away from the source, by what factor is your exposure decreased?

   Solution: Since the solution requires an inverse square function, and you are 20 times further from the source, you will receive $1/20^2$ or 1/400 of the radiation I receive (400 times less radiation!).

2. To see why we used the ratio instead of separate steps, we are going to experiment with dividing fractions. How much is $1/600^2 \div 1/30^2$?

   Solution: Remember that when we divide fractions, we invert and multiply the divisor. Thus, $1/600^2 \div 1/30^2 = 1/600^2 \times 30^2/1 = 30^2/600^2 = 900/360{,}000 = 1/400$. The result is the same as in problem 1, but the solution required extra steps. Thus, we use the ratio of 600 to 30 in our calculation of how much more or less radiation is received!

3. If I am 3,000 feet from the radiation source and you are 10 feet from the source, by what factor is your radiation exposure greater than mine?

   Solution: Since the solution requires an inverse square function, and you are 300 (3,000/10) times closer, I will receive $1/300^2$ or 1/90,000 of the radiation you receive! I guess it pays to follow your teacher when on a field trip!

4. Another important point about ratios is that they are reversible. If I am receiving 1/90,000 as much radiation as you are receiving, how many times more radiation are you receiving than I am receiving?

   Solution: The aforementioned ratio means that for every 1 unit of radiation I receive, you receive 90,000 units of radiation. That means that you receive 90,000/1 (or 90,000) times more radiation than I receive. When the object of the proportion changes, you flip the proportion over to change its direction of impact.

Now, for the most exciting part of the trip! Here we are in the exact, working model of the control room! There are numerous safeguards in the system which will not allow a chain reaction without fairly obvious intentions. The computers control all the outputs from the operator to the reactor, and other inner workings of the plant. The computers help to insure that things do not go too awry by a logic concept called the "AND gate." The gate was designed by programmers so that when two specific criteria are both "turned on," the system will work. However, when either or both is "turned off," the system will automatically shut down. This helps to prevent accidents from occurring.

Did you know?

The logic behind an "AND gate" was part of the basis of Aristotelian logic, the system used by the Ancient Greeks in their study of geometry and philosophy. Essentially, Aristotle believed that if a response was based on two different stimuli, without both stimuli occurring simultaneously, the response would not happen. This basic Aristotelian logic is the basis for computer programs, and numerous other technological and philosophical disciplines the world over.

Below is an example of an "AND gate." It assures that, if the proper commands are not given for the use of the steam dump, the water will not be condensed and sent back into the reactor, allowing it to become contaminated in the case of an accident. For the following exercises, you will need the flowchart of the steam dump configuration.

Review the flowchart. It is a fairly complicated schematic, but as we are not here to learn about operating a nuclear plant, have no fear. Do not be concerned with what each switch specifically does, but instead look at the boxes numbered 1-4. These are the diagram's equivalent of "AND gates." The arrows represent commands and the operations from which they came. For example, in order for gate 1, which leads to the actual controls for the steam dump, to operate, the commands from gates 2 and 3 must be executed properly or gate 1 will not have both arrows coming into it. Thus, it would not start the steam dump working.

1. If one does not turn the steam dump on at the circular switch at the very bottom of the page, which gates will not operate?

   Solution: Gates 1 and 2 will not operate because one of the commands gate 2 needs to operate (the steam dump "on" switch) has not been fulfilled. Therefore, since gate 2 is not operational, gate 1 is not receiving its second stimulus, and thus the steam dump (the next piece in the chain) will not turn on.

2. If P12 is not executed, which gate(s) will not turn on and/or be affected?

   Solution: Gates 2 and 4 will not turn on. Since gate 1 is dependent on gate 2, it would be affected, and would not turn on since both of its conditions would not be met.

3. Another important type of gate is the "OR gate" (gate 5 is an example). If either RTB 'A' (a black arrow) or both "Steam Press Mode" and C7 (gray arrows) are activated it will work. This type of switch is used to give the controller more options of where he wants the action to begin, depending on the situation. Would there be any difference in the actions of gates 1-4 if RTB 'A' (a black arrow) or both "Steam Press Mode" and C7 (gray arrows) were executed?

Solution: No. Since this is an "OR gate," as long as one of the sets of commands is executed, the gate will operate, and the chain reaction remains intact!

4. List all of the commands that must be fulfilled in order for gate 4 to open.

   Solution: Gate 4 depends on input from the three components leading to it, symbolized in the flowchart by the arrows from Steam Dump Bypass, P12, and gate 3. In addition to these commands, C9 must be executed for gate 3 to operate; and either RTB 'A' or both C7 and Steam Press Mod" must be executed ("OR gate") for gate 5 to operate. Thus, a total of six or seven commands must be given (depending on which command(s) were executed at gate 5) before the steam dump turns on. This is a safeguard as it is difficult to do that much accidentally!

There you have it! You have just learned some of the principles behind what a nuclear engineer does everyday. Hopefully, you learned about some mathematics in the process. We will see you back at the school!

Web Sites for Further Exploration

Tennessee Valley Authority: Sequoyah Nuclear Plant
http://www.tva.gov/sites/sequoyah.htm

Meltdown at Three Mile Island
http://www.pbs.org/wgbh/amex/three/

Meltdown at Three Mile Island - What Happened: Step-by-Step
http://www.pbs.org/wgbh/amex/three/sfeature/tmiwhattxt.html

World Nuclear Association: Three Mile Island: 1979
http://www.world-nuclear.org/info/inf36.htm

U.S. Nuclear Regulatory Commission
http://www.nrc.gov/

U.S. Nuclear Regulatory Commission: Students' Corner
http://www.nrc.gov/reading-rm/basic-ref/students.html

ThinkQuest: Chernobyl
http://library.thinkquest.org/3426/

World Nuclear Association: Chernobyl
http://www.world-nuclear.org/info/chernobyl/inf07.htm

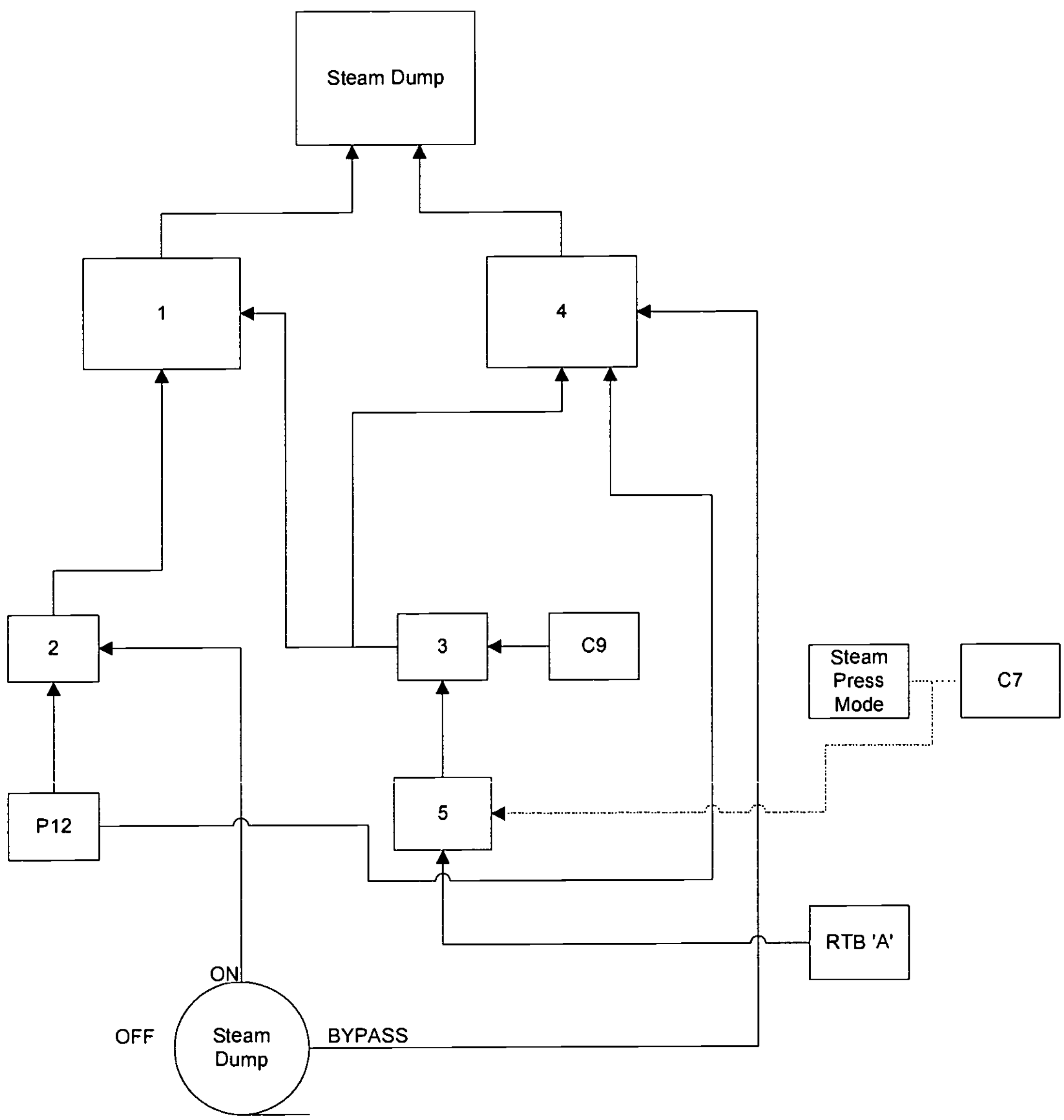
Math Forum: Ask Dr. Math - High School Probability
http://mathforum.org/library/drmath/sets/high_probability.html

Oswego City School District: Regents Exam Prep Center, Mathematics A
http://regentsprep.org/Regents/math/math-a.cfm

Oswego City School District: Regents Exam Prep Center, Mathematics B
http://regentsprep.org/Regents/mathb/mathb.cfm

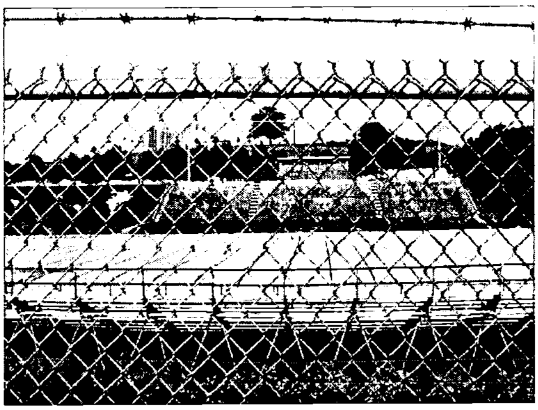
Princeton Plasma Physics Laboratory: Internet Plasma Physics Experience – The Virtual Tokamak
http://ippex.pppl.gov/temp/tokamak/default.htm

Flowchart



Activity 23
Soddy Daisy High School Football Stadium

David Green and Rob Wood
November 11, 2002



Description of Module

This module is geared toward seventh grade mathematics students. It includes facts and figures about the Soddy Daisy High School football stadium. In this module, the student is asked to work with measurements and conversions. Students may work in pairs. Location: 618 Sequoyah Access Road, Soddy Daisy, TN 37379.

Standards

Measurement, grades 6-8
Problem Solving, grades 6-8
Number and Operations, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1 yard = 3 feet	1 inch = 2.54 centimeters
5,280 feet = 1 mile	slope = rise/run

1. Given that there are 23 steps on the stadium seating, and each step is 28.5 inches wide, what is the total width in feet? What is the total width in centimeters?

2. Given that the total height of the stadium seating is 23.96 feet, and there are 23 steps, how many inches high is each step? How many meters high is each step?

3. Using information from problems 1 and 2, calculate the slope of the stadium seating.

4. In football, the field is 120 yards in length from the back of one end zone to the back of the other. How long is the field in feet? How long is the field in inches?

5. The record for a field goal is 63 yards. How long is the field goal in centimeters? How long is the field goal in meters? Bonus: Name the kicker(s) who performed this feat.

6. If one lap around the track is a length of 1,320 feet, how many laps must be completed to run 1 mile?

7. If you ran 7 laps around the 1,320-foot track, how many miles did you run? How many meters did you run?

8. If 1 lap around the track is a length of 1,320 feet, find the length of 1 lap in inches. Find the length of 1 lap in centimeters?

9. If it takes 6 minutes to run 4 laps, how many seconds would it take to run the same number of laps?

10. If a person can run 1 mile in 6.5 minutes, how many miles could the person run in 52 minutes?

Solutions

1. Given that there are 23 steps on the stadium seating, and each step is 28.5 inches wide, what is the total width in feet? What is the total width in centimeters?

   23 steps x 28.5 in./step = 655.5 in.
   655.5 in. ÷ 12 in./ft = 54.625 ft
   655.5 in. x 2.54 cm/in. = 1,664.97 cm

2. Given that the total height of the stadium seating is 23.96 feet, and there are 23 steps, how many inches high is each step? How many meters high is each step?

   23.96 ft ÷ 23 steps x 12 in./ft = 12.5 in./step. One step is 12.5 in. high.
   12.5 in./step x 2.54 cm/in. x 1 m/100 cm = 0.318 meter/step. One step is 0.318 meter high.

3. Using information from problems 1 and 2, calculate the slope of the stadium seating.

   Slope = rise / run = 23.96 ft ÷ 54.625 ft = 0.439

4. In football, the field is 120 yards in length from the back of one end zone to the back of the other. How long is the field in feet? How long is the field in inches?

   120 yd x 3 ft/yd = 360 ft
   360 ft x 12 in./ft. = 4,320 in.

5. The record for a field goal is 63 yards. How long is the field goal in centimeters? How long is the field goal in meters? Bonus: Name the kicker(s) who performed this feat.

   63 yd x 36 in./yd x 2.54 cm/in. = 5,760.72 cm
   5,760.72 cm x 1 m/100 cm = 57.6072 meters
   Bonus: Elam, Dempsey

6. If one lap around the track is a length of 1,320 feet, how many laps must be completed to run 1 mile?

   5,280 ft/mile ÷ 1,320 ft/lap = 4 laps/mile

7. If you ran 7 laps around the 1,320-foot track, how many miles did you run? How many meters did you run?

   7 laps x 1,320 ft/lap ÷ 5,280 ft/mile = 1.75 miles
   1.75 miles x 5,280 ft/mile x 12 in./ft x 2.54 cm/in. x 1 m/100 cm ≈ 2,816 meters

8. If 1 lap around the track is a length of 1,320 feet, find the length of 1 lap in inches. Find the length of 1 lap in centimeters?

   1,320 ft x 12 in./ft = 15,840 in.
   15,840 in. x 2.54 cm/in. = 40,233.6 cm

9. If it takes 6 minutes to run 4 laps, how many seconds would it take to run the same number of laps?

   6 min x 60 sec/min = 360 sec

10. If a person can run 1 mile in 6.5 minutes, how many miles could the person run in 52 minutes?

    52 min ÷ 6.5 min/mile = 8 miles (assuming no fatigue)

Web Sites for Further Exploration

Science Made Simple
http://sciencemadesimple.com/conversions.html

Funbrain.com - Power Football
http://www.funbrain.com/football/

Myschoolonline.com - Football Math
http://www.myschoolonline.com/content_gallery/0,3138,2507-108666-2-40399,00.html

FreeMathHelp.com - Sports Math
http://www.freemathhelp.com/sports.html

Sports Teams and Math
http://score.kings.k12.ca.us/lessons/football.html

Football
http://oncampus.richmond.edu/academics/as/education/projects/webunits/math/football.html

Mudd Math Fun Facts
http://www.math.hmc.edu/funfacts/ffiles/10010.2.shtml

HowStuffWorks, Inc. – How are the college football rankings determined?
http://entertainment.howstuffworks.com/question535.htm

Activity 24
Swimming and Bicycling at Booker T. Washington State Park

Steven Park
March 28, 2003

Description of Module

Booker T. Washington is a state park along the banks of the Tennessee River. It offers trails for hiking and cycling, and boat ramps for recreational use. This module asks the student to think critically about volume and circumference. Location: 5801 Champion Rd., Chattanooga, TN 37416.

Standards

Measurement, grades 9-12
Problem Solving, grades 9-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

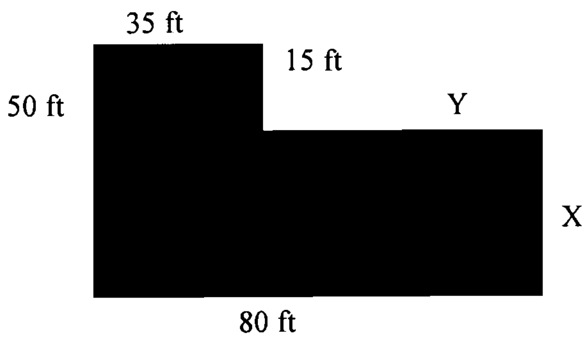
Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. If admission to the park is $3.00 per vehicle, and the part of the operating budget not funded by the state is $25,000, how many vehicles must enter the park each year to meet the budget?

   Answer problems 2-5 based on the following information:
   The average swimming pool depth is 4 feet. The measurement of each side is as follows:



2. What is the value for X?

3. What is the value for Y?

4. If filled, what is the potential volume of water the pool could hold?

5. If the park keeps the water 3 inches from the top lip of the pool, what is the actual volume of water the pool holds?

6. If the average swimmer displaces 2.5 cubic feet of water, how many swimmers would it take to make the water spill over the sides of the pool?

   Answer problems 7-8 using the following information:
   From the office to the boat ramp it is 1,600 feet. Adding the loop to the group campground and picnic area #1, the total distance for a trip to the ramp and back would be 5,200 feet (1 mile = 5,280 feet). The ranger on duty must drive this route four times per day to check the conditions in the park.

7. How many miles per day does the ranger travel?

8. If the ranger rode a bicycle, instead of driving a vehicle, to make the rounds, how many revolutions per trip would be made by one wheel on the ranger's bicycle? How many revolutions per day would be made by one wheel on the ranger's bicycle? The bicycle wheel has a 26-inch diameter.

Solutions

1. If admission to the park is \$3.00 per vehicle, and the part of the operating budget not funded by the state is \$25,000, how many vehicles must enter the park each year to meet the budget?

   \$25,000 ÷ \$3.00/vehicle = 8,334 vehicles

2. What is the value for X?

   From the diagram, the width of X is the total width of the pool minus the known width: 50 ft – 15 ft = 35 ft

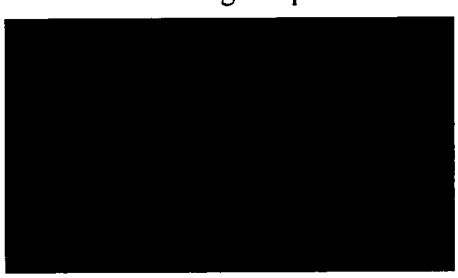
3. What is the value for Y?

   The length of Y is the total length of the pool minus the known length: 80 ft – 35 ft = 45 ft

4. If filled, what is the potential volume of water the pool could hold?

   Volume = Length x Width x Height, or V = L x W x H. There is more than one way to solve this problem. In the first method, find the area of the rectangular pool (50 ft x 80 ft), subtract the cut-out area (15 ft x 45 ft), and multiply by the depth (H) to find the actual volume.
   $V = [(80\text{ ft} \times 50\text{ ft}) - (45\text{ ft} \times 15\text{ ft})] \times 4\text{ ft} = 13{,}300\text{ ft}^3$

Rectangular pool



Pool considered as two parts

In the second method, consider the pool as two separate parts, or left and right rectangles. Find the area of each rectangle (35 ft x 50 ft; 45 ft x 35 ft), add them together to find the total area (3,325 ft^2), and multiply by the depth (4 ft) to find the volume of the pool (13,300 ft^3).

5. If the park keeps the water 3 inches from the top lip of the pool, what is the actual volume of water the pool holds?

   In problem 4, the depth was 4 ft. Filling the pool to a height of 3 in. from the top brings the depth of the pool to 3 9/12 ft, or 3 3/4 ft. Expressed as a decimal, this is equal to 3.75 ft. Multiply the area of the surface of the pool by 3.75 ft to determine the volume of water the pool holds:
   $V = [(80 \text{ ft} \times 50 \text{ ft}) - (45 \text{ ft} \times 15 \text{ ft})] \times 3.75 \text{ ft}$
   $V = 3{,}325 \text{ ft}^2 \times 3.75 \text{ ft}$
   $V = 12{,}468.75 \text{ ft}^3$

6. If the average swimmer displaces 2.5 cubic feet of water, how many swimmers would it take to make the water spill over the sides of the pool?

   The maximum potential volume, found in problem 4, is 13,300 ft^3. The water volume, found in problem 5, is 12,468.75 ft^3. The maximum displacement before water spills over the sides of the pool is the difference of these volumes, or 831.25 ft^3. To calculate the maximum number of swimmers, divide the maximum displacement, 831.25 ft^3, by the volume of water displacement per swimmer, 2.5 ft^3, to yield the maximum number of swimmers, 332.5. The number of swimmers must be a whole number, so the maximum swimmer capacity is 332. Thus, 333 swimmers would cause the water to spill over.

7. How many miles per day does the ranger travel?

   (4 trips/day x 5,200 ft/trip) ÷ 5280 ft/mi = 3.94 mi/day

8. If the ranger rode a bicycle, instead of driving a vehicle, to make the rounds, how many revolutions per trip would be made by one wheel on the ranger's bicycle? How many revolutions per day would be made by one wheel on the ranger's bicycle? The bicycle wheel has a 26-inch diameter.

   Find the circumference of the wheel (or length per revolution), convert from inches to feet, then divide the circumference into the total trip distance:
   Circumference = pi x diameter, or $C = \pi \times d$
   $\pi \approx 3.14$
   C = 3.14 x 26 in./revolution = 81.68 in./revolution
   81.68 in./revolution ÷12 in./ft = 6.807 ft/revolution
   5,200 ft/trip ÷ 6.807 ft/revolution ≈ 764 revolutions/trip
   764 revolutions/trip x 4 trips/day = 3,056 revolutions/day

Web Sites for Further Exploration

Booker T. Washington State Park
http://www.state.tn.us/environment/parks/bookert

Booker T. Washington State Park Map
http://www.state.tn.us/environment/parks/bookert/parkmap.htm

ENC Math Topics: Perimeter/Area/Volume
http://www.enc.org/weblinks/math/0,1544,1-perimeter+area+volume-any-Perimeter-Area-Volume,00.shtm

Math Forum: Geometric Formulas
http://mathforum.org/dr.math/faq/formulas/

University of Illinois at Urbana-Champaign: MSTE Java Activities
http://www.mste.uiuc.edu/java/

Annenberg/CPB: Math in Daily Life—Home Decorating
http://www.learner.org/exhibits/dailymath/decorating.html

Maths Helper
http://homepages.ihug.com.au/~shane007/maths/

Math.com Geometry Formulas
http://www.math.com/tables/geometry/index.htm

AAA Math
http://www.aaamath.com/

AAA Math: Geometry
http://www.aaamath.com/B/geo.htm

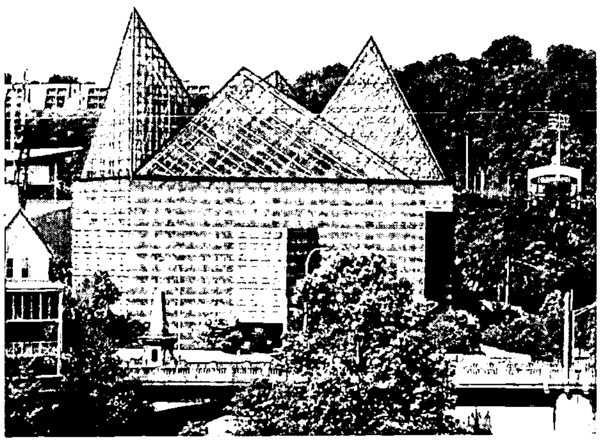
Conversion Formulas
http://www.igus.com/conv.htm

Conversion Factors
http://www.cmsenergy.com/Tools&Terms/T07.asp

Welcome to Tennessee State Parks
http://www.state.tn.us/environment/parks/

Activity 25
Tennessee Aquarium (2001)

Jennifer Dial and Deborah Wilson
November 7, 2001



Description of Module

The Tennessee Aquarium houses a collection of fish and reptiles from around the globe and boasts the largest fresh water aquarium in the world. Tours through the aquarium include everything from crocodiles to sharks to snakes in a recreated natural environment. Location: One Broad St., Chattanooga, TN 37402.

Standards

Number and Operations, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

1. The Nick-a-Jack tank holds 138,000 gallons of water. If it filters 750 gallons of water per minute, how many times each day is the tank filtered?

2. The Gulf tank holds 88,000 gallons of water. To create this salt water, the staff uses 66 pounds of Instant Ocean for every 200 gallons of water. How many pounds of Instant Ocean were used to start the tank?

3. If the Gulf tank filters 300 gallons of water per minute, how many times each day is the tank filtered?

4. If the Gulf tank needs 6,000 gallons of fresh water each week to keep it full, how much Instant Ocean is used each week?

5. The brook trout is 7" long. If, as an adult, he will be approximately 20" in length, what percentage of his adult size is he now?

6. The skin of a snake stretches 20% when it is shed. If the black mamba snakeskin is 9 ft. long, how long is the snake?

7. The rattlesnake rattles its tail 50 times per second. A predator approaches the snake and does not leave for six minutes. If the snake rattled his tail the entire time, how many times did the tail rattle?

8. In 2001, the alligator snapping turtle was 100 years old. In what year was he born?

9. The alligator snapping turtle can stay under water for 50 minutes. What is the minimum number of times he must surface in each 24-hour period if he plans to be submerged the maximum amount of time?

10. The Smith family consists of Mr. and Mrs. Smith and their three children. If the adult and child admission prices are $12.95 and $6.95, respectively, how much will it cost for the family to visit the Aquarium?

11. The Smith family plans to visit the Aquarium at least three times in the next year. If they buy the family membership for $65.00, how much will they have saved by their third visit?

12. In the gift shop, the Smith family members each buy a t-shirt. If the adult-sized t-shirts cost $15.95 each and the child-sized t-shirts cost $12.95 each, what is the total amount of the purchase? (Assume sales tax is included in the price.)

13. Mrs. Johnson's class of 26 students has just had a field trip to the Aquarium. Mrs. Johnson would like to buy a pencil for each student. If each pencil costs $0.60, what will be the total cost? (Assume sales tax is included in the price.)

14. Judy wants to purchase a $7.50 stuffed otter for her brother, a $10.25 large mug for her mother, a $12.25 cap for her father, and a $12.95 t-shirt for herself. If Judy only has $30.00, how much is she short? (Assume sales tax is included in the price.)

15. The timber rattlesnake eats, on average, 14 meals per year. Approximately how often is he fed (in days)?

16. The beluga sturgeon ate 6,500 squid from 1992 to 2001. Approximately how many squid did he eat each week?

17. The beluga sturgeon weighs 126 pounds. If his maximum weight is 2,000 pounds, what percentage of his maximum weight is he now?

18. The Arapaima fish was 12" in length in 1992 and 6' in length in 2001. Approximate his yearly growth.

19. The Aquarium uses 1,200 pounds of seafood each month to feed its many inhabitants. The Aquarium opened in 1992. What is the total number of pounds of seafood have they used since opening (1992-2001)?

20. The Aquarium feeds its reptiles with 600 rats and 1,200 mice each month. If each mouse costs $0.33 and each rat costs $0.56, how much is spent in 1 year on mice and rats?

21. The Wilson family has visited the Aquarium on 11 different occasions. They have seen the otters only three times. What is the probability that they will see the otters on their next visit?

22. The alligator snapping turtle exhibit has the dimensions 4'x 4' x 4' and is visible only on three sides. What is the total viewing area?

23. Mrs. Wilson bought a four-pack of film for $7.59 but forgot to bring it, so she bought one roll of film from the gift shop for $5.95. How much more did the single roll from the gift shop cost than one roll from the pack? (Assume sales tax is included in the price.)

Solutions

1. The Nick-a-Jack tank holds 138,000 gallons of water. If it filters 750 gallons of water per minute, how many times each day is the tank filtered?

   (750 gal/min x 60 min/hr x 24 hr/day) ÷ 138,000 gal = 7.83/day
   The tank is filtered 7.83 times per day.

2. The Gulf tank holds 88,000 gallons of water. To create this salt water, the staff uses 66 pounds of Instant Ocean for every 200 gallons of water. How many pounds of Instant Ocean were used to start the tank?

   (66 lb / 200 gal) (88,000 gal) = 29,040 lb

3. If the Gulf tank filters 300 gallons of water per minute, how many times each day is the tank filtered?

   (300 gal/min x 60 min/hr x 24 hr/day) ÷ 88,000 gal = 4.91/day
   The tank is filtered 4.91 times per day

4. If the Gulf tank needs 6,000 gallons of fresh water each week to keep it full, how much Instant Ocean is used each week?

   (66 lb / 200 gal) (6,000 gal) = 1,980 lb

5. The brook trout is 7" long. If, as an adult, he will be approximately 20" in length, what percentage of his adult size is he now?

   7 in. / 20 in. = 0.35
   0.35 x 100% = 35%

6. The skin of a snake stretches 20% when it is shed. If the black mamba snakeskin is 9 ft long, how long is the snake?

   The length of the snakeskin is 120% of the length of the snake, or 1.2 times as long.
   9 ft ÷ 1.2 = 7.5ft

7. The rattlesnake rattles its tail 50 times per second. A predator approaches the snake and does not leave for six minutes. If the snake rattled his tail the entire time, how many times did the tail rattle?

   50 rattles/s x 60 s/1 min x 6 min = 18,000 rattles

8. In 2001, the alligator snapping turtle was 100 years old. In what year was he born?

   2001 - 100 = 1901

9. The alligator snapping turtle can stay under water for 50 minutes. What is the minimum number of times he must surface in each 24-hour period if he plans to be submerged the maximum amount of time?

   (24 hr x 60 min/hr) ÷ 50 min = 28.8
   He must surface 29 times.

10. The Smith family consists of Mr. and Mrs. Smith and their three children. If the adult and child admission prices are $12.95 and $6.95, respectively, how much will it cost for the family to visit the Aquarium?

    (2 adult x $12.95/adult) + (3 child x $6.95/child) = $46.75

11. The Smith family plans to visit the Aquarium at least three times in the next year. If they buy the family membership for $65.00, how much will they have saved by their third visit?

    From problem 10: (3 visits x $46.75/visit) - $65.00 = $75.25

12. In the gift shop, the Smith family members each buy a t-shirt. If the adult-sized t-shirts cost $15.95 each and the child-sized t-shirts cost $12.95 each, what is the total amount of the purchase? (Assume sales tax is included in the price.)

    2 adult x $15.95/adult + 3 child x $12.95/child = $70.75

13. Mrs. Johnson's class of 26 students has just had a field trip to the Aquarium. Mrs. Johnson would like to buy a pencil for each student. If each pencil costs $0.60, what will be the total cost? (Assume sales tax is included in the price.)

    26 pencils x $0.60/pencil = $15.60

14. Judy wants to purchase a $7.50 stuffed otter for her brother, a $10.25 large mug for her mother, a $12.25 cap for her father, and a $12.95 t-shirt for herself. If Judy only has $30.00, how much is she short? (Assume sales tax is included in the price.)

    $30.00 – ($7.50 + $10.25 + $12.25 + $12.95) = -$12.95
    She is $12.95 short.

15. The timber rattlesnake eats, on average, 14 meals per year. Approximately how often is he fed (in days)?

    365 days / 14 = 26.07 days
    He is fed approximately every 26 days.

16. The beluga sturgeon ate 6,500 squid from 1992 to 2001. Approximately how many squid did he eat each week?

    6,500 squid ÷ (52 wk/yr x 9 yr) = 13 to 14 squid/wk

17. The beluga sturgeon weighs 126 pounds. If his maximum weight is 2,000 pounds, what percentage of his maximum weight is he now?

    126 lb / 2,000 lb = 0.063
    0.063 x 100% = 6.3%

18. The Arapaima fish was 12" in length in 1992 and 6' in length in 2001. Approximate his yearly growth.

    ((6 ft x 12 in./ft) – 12 in.) / 9 yr = 6.67 in./yr

19. The Aquarium uses 1,200 pounds of seafood each month to feed its many inhabitants. The Aquarium opened in 1992. What is the total number of pounds of seafood have they used since opening (1992-2001)?

    1,200 lb/mo x 12 mo/yr x 9 yr = approximately 129,600 lb

20. The Aquarium feeds its reptiles with 600 rats and 1,200 mice each month. If each mouse costs $0.33 and each rat costs $0.56, how much is spent in 1 year on mice and rats?

    12(($0.33 x 600) + ($0.56 x 1,200)) = $10,440

21. The Wilson family has visited the Aquarium on 11 different occasions. They have seen the otters only three times. What is the probability that they will see the otters on their next visit?

    3/11 or approximately 27% chance

22. The alligator snapping turtle exhibit has the dimensions 4 ft x 4 ft x 4 ft and is visible only on three sides. What is the total viewing area?

    3(4 ft x 4 ft) = 48 ft^2

23. Mrs. Wilson bought a four-pack of film for \$7.59 but forgot to bring it, so she bought one roll of film from the gift shop for \$5.95. How much more did the single roll from the gift shop cost than one roll from the pack? (Assume sales tax is included in the price.)

    Cost per roll = \$7.59 ÷ 4) = \$1.90
    Price difference = \$5.95 - \$1.90 = \$4.05

Web Sites for Further Exploration

Tennessee Aquarium
  http://www.tennis.org/

Ripley's Aquarium of the Smokies, Gatlinburg, TN
  http://www.ripleysaquariumofthesmokies.com/

Online Conversion – Volume Conversion
  http://www.onlineconversion.com/volume.htm

Indianapolis Zoo's Drop Dead Gorgeous Snakes – Snake Facts!
  http://www.indyzoo.com/snakes/facts.htm

National Aquarium, Baltimore, MD
  http://www.aqua.org/

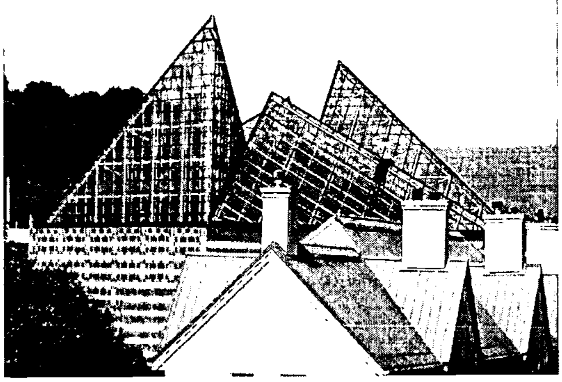
Shedd Aquarium, Chicago, IL
  http://www.shedd.org/

New England Aquarium, Boston, MA
  http://www.neaq.org/index.flash4.html

Monterey Bay Aquarium, Monterey, CA
  http://www.mbayaq.org/

Activity 26
Tennessee Aquarium (2002)

Jill Pisarek
November 2002



Description of Module

The Tennessee Aquarium is home to many different aquatic animals, birds, and reptiles. There is a lot of science, as well as mathematics, contained within the Aquarium. It is not difficult to find simple, as well as complex, problems. In this module, the student will explore problems designed for learning both mathematics and science. Location: One Broad St., Chattanooga, TN 37402.

Standards

Algebra, grades 9-12
Measurement, grades 9-12
Problem Solving, grades 9-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

Seahorses

1. Development has destroyed a large portion of the areas in which seahorses live. Seahorse fisheries result in a worldwide harvest of 20 million animals per year. It is now the year 2002. In 2052, how many seahorses will have been harvested?

2. In Hong Kong, seahorses, by weight, are more valuable than silver, at up to $1,200/kg. If you live in Hong Kong and own 5,000 g of seahorses, how much money would you make if you sold that amount of seahorse weight?

Otters

1. River otters have a top swimming speed underwater of approximately 6-7 miles per hour, and can stay submerged for up to 4 minutes.

   a. How far will an otter travel if swimming at a rate of 6 miles per hour for 4 minutes?

   b. How far will an otter travel if swimming at a rate of 7 miles per hour for 4 minutes?

   c. Approximately how much time is required for an otter to travel 10 miles?

   d. At what velocity must an otter swim to travel 7 miles in 4 minutes?

   e. If an otter swims for 12 minutes while submerged, how far did it travel?

Fish

1. Convert the dimensions to feet and to centimeters (1 in. = 2.54 cm).

Fish	Inches	Feet	Centimeters
Brook Trout	20		
Brown Trout	40		
Northern Hog Sucker	24		
Striped Shiner	7.25		
Bonnethead Shark	60		
Southern Sting Ray	72 (across disc)		
Green Moray Eel	96		

2. In a tank of trout, there are a total of 120 fish. If there are 3 times as many Brook Trout as Brown Trout, how many of each type of trout are in the tank?

Some koi enthusiasts show their prize fish at competitions; champions receive cash prizes. A grand champion koi recognized as best of its variety may sell for as much as $100,000, but a breeder of champions may sell for more than $1,000,000.

3. If you own two grand champion koi and your friend owns a breeder, how much money might these fish be worth to each of you?

4. How many grand champion koi must you have to have fish of the same monetary value as your friend?

Waters of the World

1. Complete the chart.

The World's Water	Percent
Rivers and Streams	0.001
Groundwater, Lakes, Wetlands, and Vapor	0.65
Icecaps and Glaciers	
Oceans	97.20

The Mississippi River

Volume: On average, more than 4 million gallons of water enter the lower Mississippi's channel every second.

1. How many gallons of water enter the Mississippi's channel during the month of June?

2. How many seconds are required for 65 million gallons of water to enter the Mississippi's channel?

The Mighty Amazon

One fifth of the world's river water is carried by South America's primary resource - the mighty Amazon. As much as 8 ft of rain may fall each year in the surrounding forest highlands, and the Amazon drains it away like a powerful water magnet. Fed by 1,000 smaller rivers, the Amazon drains an area the size of the face of the moon.

1. From 1970-2002, how much rain fell in the Amazon's surrounding area?

2. What fraction of the world's river water is **not** carried by the Amazon?

Solutions

Seahorses

1. Development has destroyed a large portion of the areas in which seahorses live. Seahorse fisheries result in a worldwide harvest of 20 million animals per year. It is now the year 2002. In 2052, how many seahorses will have been harvested?

   50 yr x 20,000,000 seahorses/yr = 1,000,000,000 seahorses = 1.0×10^9 seahorses

2. In Hong Kong, seahorses, by weight, are more valuable than silver, at up to $1,200/kg. If you live in Hong Kong and own 5,000 g of seahorses, how much money would you make if you sold that amount of seahorse weight?

   5,000 g x 1 kg/1,000 g x $1,200/kg = $6,000

Otters

1. River otters have a top swimming speed underwater of approximately 6-7 miles per hour, and can stay submerged for up to 4 minutes.

   a. How far will an otter travel if swimming at a rate of 6 miles per hour for 4 minutes?

      d = v x t = (6 mi/hr x 4 min) x 1hr/60 min = 0.4 mi

   b. How far will an otter travel if swimming at a rate of 7 miles per hour for 4 minutes?

      d = v x t = (7 mi/hr x 4 min) x 1hr/60 min = 0.47 mi

   c. Approximately how much time is required for an otter to travel 10 miles?

      Answers may vary, depending on velocity.
      t = d/v = 10 mi ÷ 6 mi/hr = 1.67 hr

   d. At what velocity must an otter swim to travel 7 miles in 4 minutes?

      v = d/t = (7 mi ÷ 4 min) x 60 min/1 hr = 105 mi/hr

   e. If an otter swims for 12 minutes while submerged, how far did it travel?

      Answers may vary, depending on velocity.
      d = v x t = (6 mi/hr x 12 min) x 1hr/60 min = 1.2 mi

Fish

1. Convert the dimensions to feet and to centimeters (1 in. = 2.54 cm).

Fish	Inches	Feet	Centimeters
Brook Trout	20	1.67	50.8
Brown Trout	40	3.33	101.6
Northern Hog Sucker	24	2.0	60.96
Striped Shiner	7.25	0.604	18.415
Bonnethead Shark	60	5.0	152.4
Southern Sting Ray	72 (across disc)	6.0 (across disc)	182.88 (across disc)
Green Moray Eel	96	8.0	243.84

2. In a tank of trout, there are a total of 120 fish. If there are 3 times as many Brook Trout as Brown Trout, how many of each type of trout are in the tank?

   There is a ratio of 3 Brook Trout to 1 Brown Trout, or 3 parts to 1 part out of a total of 4 parts.
   3/4 Brook Trout x 120 = 90 Brook Trout
   1/4 Brown Trout x 120 = 30 Brown Trout

Some koi enthusiasts show their prize fish at competitions; champions receive cash prizes. A grand champion koi recognized as best of its variety may sell for as much as $100,000, but a breeder of champions may sell for more than $1,000,000.

3. If you own two grand champion koi and your friend owns a breeder, how much money might these fish be worth to each of you?

   You: 2 koi x $100,000/koi = $200,000
   Your friend: 1 koi x $1,000,000/koi = $1,000,000

4. How many grand champion koi must you have to have fish of the same monetary value as your friend?

   $1,000,000 ÷ $100,000 = 10

The Waters of the World

1. Complete the chart.

   The percentages must total 100. Add the given values, then subtract the sum from 100 to find the value for Icecaps and Glaciers.

The World's Water	Percent
Rivers and Streams	0.001
Groundwater, Lakes, Wetlands, and Vapor	0.65
Icecaps and Glaciers	2.149
Oceans	97.20

The Mississippi River
Volume: On average, more than 4 million gallons of water enter the lower Mississippi's channel every second.

1. How many gallons of water enter the Mississippi's channel during the month of June?

   4×10^6 gal/s x 3,600 s/hr x 24 hr/day x 30 days = 1.04×10^{13} gal

2. How many seconds are required for 65 million gallons of water to enter the Mississippi's channel?

   65×10^6 gal $\div$ 4×10^6 gal/sec = 16.25 s

The Mighty Amazon
One fifth of the world's river water is carried by South America's primary resource - the mighty Amazon. As much as 8 ft of rain may fall each year in the surrounding forest highlands, and the Amazon drains it away like a powerful water magnet. Fed by 1,000 smaller rivers, the Amazon drains an area the size of the face of the moon.

1. From 1970-2002, how much rain fell in the Amazon's surrounding area?

   32 yr x 8 ft/yr = 256 ft

2. What fraction of the world's river water is **not** carried by the Amazon?

   Since 1/5 of the world's river water is carried by the Amazon, 4/5 of the world's river water is not carried by the Amazon.
   1 – 1/5 = 4/5

Web Sites for Further Exploration

Tennessee Aquarium
http://www.tnaqua.org/

River Crossing
http://www.emsl.pnl.gov:2080/docs/mathexpl/swimwalk.html

The Math Forum – Ask Dr. Math: Farmer Crossing a River
http://mathforum.org/library/drmath/view/57914.html

Mountain Math Denali
http://www.northstar.k12.ak.us/schools/joy/denali/Trumbull/math.html

Relative Velocity
http://physics.bu.edu/~duffy/java/RelV2.html

Relative Velocity and Riverboat Problems
http://www.glenbrook.k12.il.us/gbssci/phys/Class/vectors/u3l1f.html

Mississippi River Facts
http://www.nps.gov/miss/features/factoids/

MIT: Project Amazonia
http://web.mit.edu/12.000/www/m2006/final/index.html

NASA Earth Observatory
http://earthobservatory.nasa.gov/

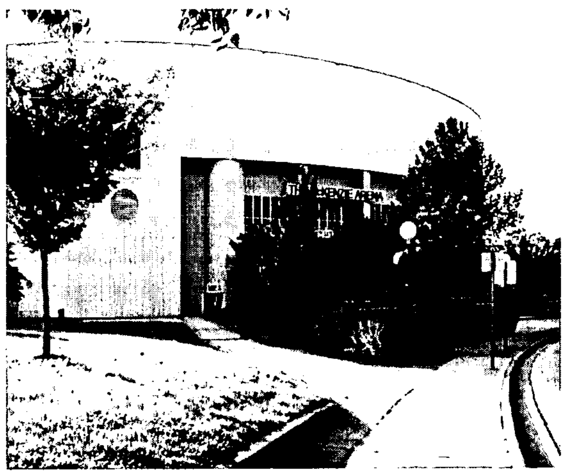
NASA Earth Observatory
http://earthobservatory.nasa.gov/Study/RiverSeasons/

Volvo Ocean Adventure: The Amazing Amazon
http://www.volvooceanadventure.org/article.php/rz_1_rom_05_rl_00100_00100.html

NOAA
http://www.noaa.gov/

Activity 27
The McKenzie Arena

James Beasley and Keith Galloway
December 2001



Description of Module

The McKenzie Area, at The University of Tennessee at Chattanooga, is the site of many campus and community events, including athletics, concerts, and shows. In this module, the student will apply general mathematics, estimation, and geometry skills to count or calculate numbers of stairs, seats, etc. in the arena, as well as surface area and volume of the arena. Location: UTC campus, 720 East 4th St. (4th and Mabel Sts.), Chattanooga, TN 37403.

Standards

Number and Operations, grades 6-8
Geometry, grades 6-8

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems

Formulas for reference

Circumference = $2\pi r$
Area of a circle = πr^2
Surface area of cylinder = $2\pi r^2 + 2\pi rh = (2\pi r)(r + h)$
Volume of a cylinder = $\pi r^2 h$

Answer the following questions about The McKenzie Arena. Solutions to these problems are verifiable on site. You may modify this module for your own gymnasium or stadium, writing and solving problems of your own.

1. What is the total number of stairs walked from the floor to the top row of the upper level?

2. What is the total vertical distance in inches from the floor to the top row of the upper level?

3. How many times must you walk around the arena to have walked the equivalent of 1 mile?

4. Which level of seating has the most leg room? Which level of seating has the least leg room?

5. What is the total number of stairs inside the arena?

6. What is the average number of seats per section in the arena?

7. If every seat in the arena is filled for a basketball game, and one out of every three people is wearing a Mocs shirt, how many people are wearing Mocs shirts? (The "Mocs" is the university's athletics identity.)

8. Find the surface area and the volume of the arena. Assume that the arena is a cylinder.

Solutions

1. There are 86 steps.

2. The total vertical distance is 634 inches.

3. You must walk around the arena approximately 6 1/2 times (6.58 actual) to have walked the equivalent of 1 mile.

4. The middle seating level has the most leg room (12 inches), and the upper level has the least leg room (9 inches).

5. There are 2,072 stairs in the arena.

6. There are 134 seats per section, on average, in the arena.

7. There are 3,739 people wearing Mocs shirts.

8. Surface Area = 186,868.36 ft^2 (approximately 186,000 ft^2)
   Volume = 5,379,240.56 ft^3 (approximately 5 million ft^3)

Web Sites for Further Exploration

UTC McKenzie Arena
http://www.utc.edu/mckenziearena/

The Official Web Site of the University of Tennessee at Chattanooga Mocs
http://gomocs.com/

Surface Area and Volume
http://www.shodor.org/interactivate/activities/sa_volume/index.html

Activity: Volume and Surface Area
http://www.middleweb.com/EDC/EDCimages/4MATH.pdf

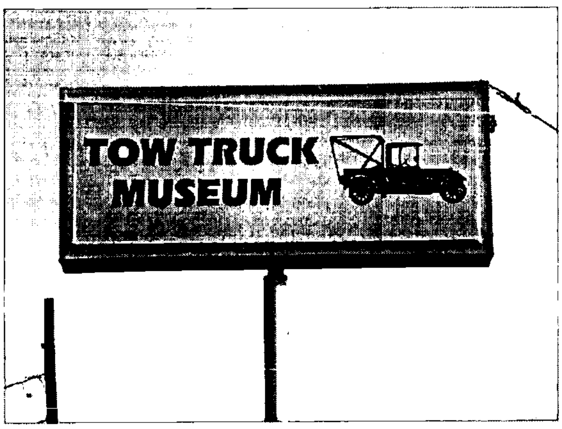
The Sizes of Living Things
http://curriculum.calstatela.edu/courses/builders/lessons/less/les9/area.html

Annenberg/CPB: Hummingbird
http://www.learner.org/jnorth/tm/humm/BodyHeat.html

New York Road Runners: Fleet Empire State Building Run-Up
http://www.nyrrc.org/race/2002/r0205a00.htm

Activity 28
Towing and Recovery Museum

Dru Smith and Jack Swanson
October 30, 2002



Description of Module

This module presents a summary of right triangle trigonometry as applied to the towing industry. The student will collect data and apply formulas. Location: 401 Broad St., Chattanooga, TN 37402.

Standards

Geometry, grades 9-12
Connections, grades 9-12
Reasoning and Proof, grades 9-12

Standards Documents

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved July 7, 2003, from http://standards.nctm.org

National Council of Teachers of Mathematics. (2003). *Illuminations*. Retrieved July 7, 2003, from http://illuminations.nctm.org/

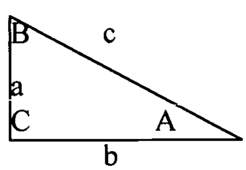
Tennessee Department of Education. (2002). *Mathematics curriculum standards*. Retrieved July 7, 2003, from http://www.state.tn.us/education/ci/cistandards2001/math/cimath.htm

Hamilton County Department of Education. (2002). *HCDE standards & benchmarks*. Retrieved July 7, 2003, from http://www.hcde.org/standards/stindex.html

Problems and Solutions

The site that we chose to visit for our group project was the Towing and Recovery Museum on Broad Street. It was very interesting and it had several examples of right triangle geometry and trigonometry. We could have easily used this in a 10th grade geometry course. Since most tow trucks use booms that create a right triangle with the object being towed and have an angle that could be easily measured, and there are sides of the triangle that are easily measured with a tape measure, we decided that this would be a good place to show concepts involving right triangle geometry. With that in mind, there are several situations that would require different formulas to solve for a missing side or angle. If two angles are known (one of them is always 90°), then you can solve for the other angle knowing that the sum of the three angles will equal 180°. If two sides of the triangle are known, then you can solve for the other side using the Pythagorean theorem. If two angles and one side are known, or two sides and one angle are known, then you can solve for the other unknown sides or angles by using proportions equal to each other in a formula that we will list later. Not only would this be very informative to a 10th grade geometry class, but it could be used as a learning tool for a physics class or a college trigonometry class as a review. Since this module is designed to be used as a field trip for a high school mathematics class, we would plan to give examples of how this would be practical in the student's life. We could describe how right angles are the best choice for designing buildings. That is why most buildings are straight, as opposed to leaning at an angle other than 90°. Usually one would only see that if the foundation was built on soft ground and the building sank on one side, as with the leaning tower of Pisa. We would explain how the tow trucks work and that the boom on them is used to get extra power to pull a person's car out of a ditch if they were to ever have a wreck or a flat tire (with no spare). Using examples like these might help the student to relate to a situation that they have been a part of or that someone they know has endured. If the lesson content is relevant, the student will benefit from the exercise.

We would then proceed by having the student take measurements; we would tell the student which sides or angles to measure before telling them what will be solved. Some of the examples we found looked like the following:



Angle A is 30° and angle B is 60°. We also know that the sum of all three angles is 180°. We measured side a to be 10 ft in length.

Knowing this, and using the Law of Sines formula, the length of side b may be found:

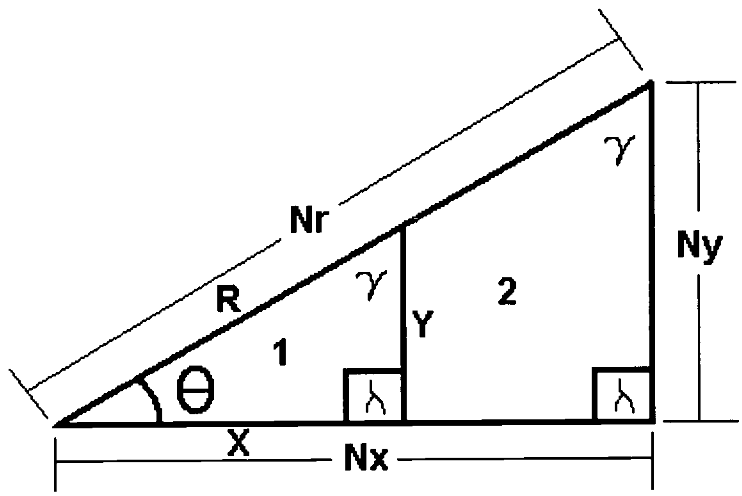
a / sin A = b / sin B = c / sin C
10 / sin 30 = b / sin 60
Solving for side b, we get b= 17.32.

Knowing the lengths of two sides, use the Pythagorean theorem to solve for the third side, side c:

$a^2+b^2 = c^2$
$10^2+17.32^2 = c^2$
$400 = c^2$
$c = 400^{1/2} = 20$

We now have the measurements of all the sides and all the angles of the right triangle.

Proof



Consider triangle 1 (the smaller triangle). The total number of degrees =180; λ=90, Θ=90-γ, γ =90- Θ. There are 3 sides, one of which is the slanted side (R), also known as the hypotenuse. Of the other two sides the one farthest away from Θ (y) is the opposite side. The one closest to Θ (x) is called the adjacent side. We could divide the lengths of 2 sides and get the ratios Y/R, X/R, Y/X and their reciprocals. Now consider triangle 2. Its angles are the same as triangle 1's angles but its sides are longer by a factor of N, such that N is an element of the real numbers and N is greater than zero. If we divide the sides of triangle 2, we get NY/NR, NY/NR, NY/NX, and their reciprocals. But N/N=1, so the ratios of triangle 2 become Y/R, X/R, Y/X, and their reciprocals - this is the same result as triangle 1 yielded. If the angle Θ were a different size in triangle 1, the lengths of the sides would be different, creating triangle 3, and therefore, the ratios would be different. But if a triangle N times bigger than triangle 3 was considered, then the ratios of the sides would be the same as the ratios for triangle 3 since, once again, the N's would cancel. This shows that the ratio of two sides of a right triangle is a number dependent on Θ, not on the length of the sides. Let's give these ratios names: call Y/R sin Θ, X/R cos Θ, and Y/X tan Θ. Their reciprocals will be called secant Θ, cosecant Θ, and cotangent Θ, respectively. Their inverse functions will be called $\sin^{-1}\Theta$, $\cos^{-1}\Theta$, and $\tan^{-1}\Theta$. These yield the value of Θ, given the ratio of the sides. Your calculator has all of these functions in memory so that you can hit a few buttons as described in your owner's manual to yield the ratio desired, given the value of Θ, or the value of Θ given the ratio of 2 sides.

It can also be proved that $X^2+Y^2=R^2$ and $R=\sqrt{(X^2+Y^2)}$, but that proof is beyond the scope of this discussion. If you doubt this is true, measure several right triangles. I guarantee it always holds true. This formula is known as the Pythagorean theorem.

Using the sin Θ, cos Θ, tan Θ, sec Θ, csc Θ, cot Θ, $\sin^{-1}\Theta$, $\cos^{-1}\Theta$, $\tan^{-1}\Theta$, and the Pythagorean theorem, you can algebraically solve any right triangle given two sides or one side and one angle: See summary.

If you are given the dimensions of the triangle in terms of γ instead of Θ, you could simply redraw the triangle flipped and turned so that γ is in the lower left hand corner, λ is in the lower right hand corner, and Θ in the upper right hand corner, then solve as before. With practice, you will be able to solve a triangle given in terms of γ or Θ rotated some way other than in the figure by mentally taking note of the relative position of λ.

Summary of Equations

$\text{Sin}\ \Theta = \text{opp/hyp} = y/r$	$X^2 + Y^2 = R^2$
$\text{Cos}\ \Theta = \text{adj/hyp} = x/r$	$R = \sqrt{(X^2+Y^2)}$ $X = \sqrt{(R^2-Y^2)}$ $Y = \sqrt{(R^2-X^2)}$
$\text{Tan}\ \Theta = \text{opp/adj} = y/x$	$\Theta + \gamma + \lambda = 180$
$\text{Opp} = \sin\Theta(\text{hyp}) = \tan\Theta(\text{adj})$	$\lambda = 90$
$\text{Adj} = \cos\Theta(\text{hyp}) = \text{opp}/\tan\Theta$	$\Theta = 90 - \gamma$
$\text{Hyp} = \text{opp}/\sin\Theta = \text{adj}/\cos\Theta$	$\gamma = 90 - \Theta$

$\Theta = \sin^{-1}(\text{opp/hyp}) = \cos^{-1}(\text{adj/hyp}) = \tan^{-1}(\text{opp/adj})$

Web Sites for Further Exploration

International Towing & Recovery Hall of Fame & Museum
http://www.internationaltowingmuseum.org/

CBS News Sunday Morning: Chattanooga: Tow Truck Town
http://www.cbsnews.com/stories/2003/02/21/sunday/main541562.shtml

Math Forum: Geometry Problems Library
http://mathforum.org/library/problems/geometry.html

Right Triangle Relationships
http://hyperphysics.phy-astr.gsu.edu/hbase/rttri.html

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