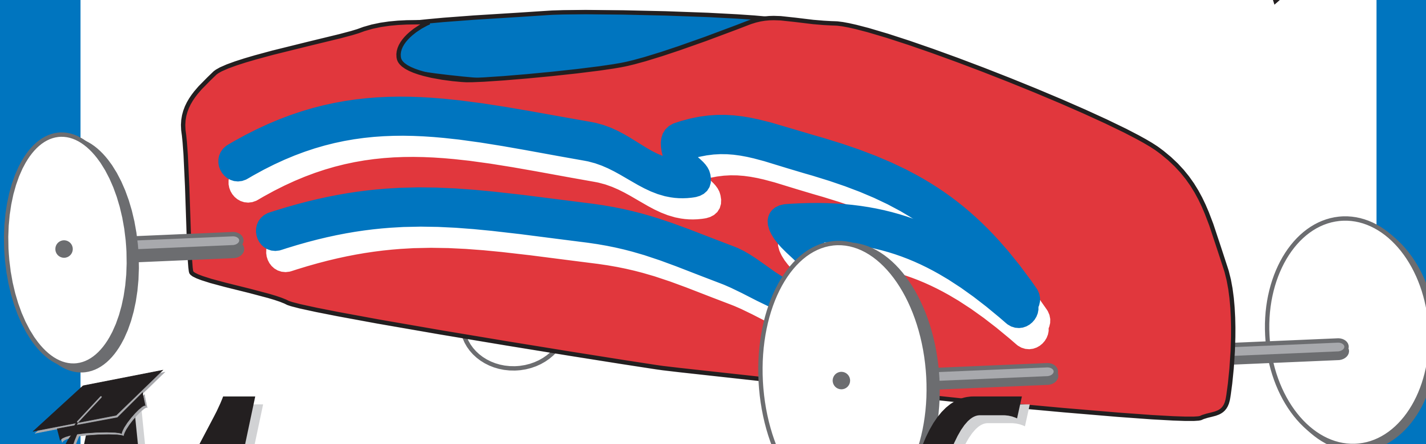

Masters of Gravity

Teacher Guide

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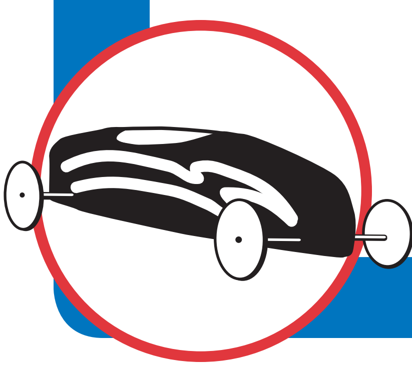

http://www.WesternReservePBS.org/gravity

Masters of Gravity

Table of Contents

The All-American Soap Box Derby

http://AASBD.org

It has been called "The Greatest Amateur Racing Event in the World," "The Gravity Grand Prix" and many other things, but to more than a million youngsters who've participated, it's just the "Soap Box Derby." The Soap Box Derby is a youth racing program that has run nationally since 1934. World Championship finals are held each summer at Derby Downs in Akron, Ohio. Each year, local champions from the Stock, Super Stock and Masters division Soap Box Derby races throughout the world come to Akron to compete for prizes of scholarships and merchandise.

International Soap Box Derby, Inc., an Akron-based non-profit corporation, administers the All-American Soap Box Derby youth program. Local race programs are sponsored by a variety of civic clubs, service organizations and business firms.

For more information, contact the All-American Soap Box Derby online at **http://aasbd.org**.

Masters of Gravity

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This project is funded through a grant from the Ohio Educational Telecommunications Network Commission in support of Ohio SchoolNet.

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Teachers Guide

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Special Thanks To ...

The University of Akron Department of Mechanical Engineering
The All-American Soap Box Derby, Akron, Ohio

Masters of Gravity

This project is designed for the 5th- and 6th-grade classroom. It consists of eight instructional television programs, classroom activities, computer activities, a teachers guide and a Web site. Our goal is to help students learn faster, more in-depth and with better retention.

How the Lessons are Intended to Be Used

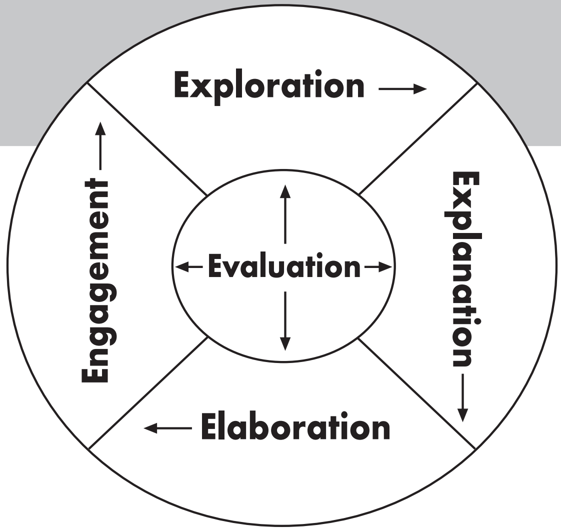
Each lesson starts with an introductory classroom activity. Follow this activity with the first part of the instructional television program. About halfway through the video, a screen tells you to stop the tape. At this point, the students do classroom activities suggested in the teachers guide as well as some on the computer. Next, the class watches the second half of the video lesson, which answers the questions posed in the first half. Finally, students do a culminating activity in which they produce a product that employs the knowledge they have acquired through the lesson.

The Learning Cycle

The **Masters of Gravity** materials use "the learning cycle" as the instructional model for its lesson plans. This learning cycle rests on constructivism as its theoretical foundation, described as "a dynamic and interactive model of how humans learn" (Bybee 1997, 176). A constructivist perspective assumes students must be actively involved in their learning; concepts are not transmitted from teacher to student, but constructed by the student.

In the early 1960s, Robert Karplus and his colleagues proposed and used an instructional model based on the work of Jean Piaget. This model would eventually be called "the learning cycle" (Atkin & Karplus 1962). Numerous studies have shown that the learning cycle as a model of instruction is far superior to transmission models in which students are passive receivers of knowledge from their teacher (Bybee 1997). As an instructional model, the learning cycle provides the active learning experiences recommended by the National Science Education Standards (National Research Council 1996).

The learning cycle used in this curriculum follows Bybee's (1997) five steps of engagement, exploration, explanation, elaboration and evaluation. As in any cycle, there's really no end to the process. After elaboration ends, engagement of the next learning cycle begins. In fact, the elaboration of one learning cycle could be thought of as the pre-assessment that occurs in the engagement of the next lesson. Evaluation is not the last step; rather, it occurs in all four stages of the learning cycle. The description of each part of the learning cycle draws extensively from W. S. Smith's work. (Owens, Smith & Clark-Thomas 2001)



A. Engagement

Engagement is a time when the teacher is on center stage. The teacher poses the problem, pre-assesses the students, helps students make connections and informs students about where they are heading.

The purpose of engagement is to:

- Focus students' attention on the topic.
- Pre-assess what students already know about the topic.
- Inform the students about the lesson's objective(s), so they'll know — at least in general terms — where they're heading.
- Remind students of what they already know that they will need to apply to studying the topic. One of the best ways a teacher can establish a context for the lesson is to ask students questions to refresh their memories.
- Pose a problem for the students to explore in the next phase of the learning cycle.

Evaluation of engagement: Evaluation's role in engagement revolves around the pre-assessment and the discovery of what the students already know about the topic. Frequently, teachers pre-assess students in the elaboration of a previous lesson.

B. Exploration

Now the students take center stage as they collect data to solve the problem. The teacher tries to pique the students' curiosity, making sure the students collect and organize the data needed to solve the problem. The students need to be active and engage in "hands-on" math and science. The purpose of exploration is to have students collect data that they can use to solve the problem before them.

Evaluation of exploration: In this portion of the learning cycle, the evaluation should primarily focus on process, i.e. on the students' data collection, rather than the product of the students' data collection. Teachers ask themselves questions such as the following:

- How well are the students collecting data?
- Are they accurate?
- Are they carrying out the procedures correctly?
- Can they translate a written or spoken problem into a form whereby they can collect data to solve the problem?
- How do they record the data?
- Is it in a logical form or is it haphazard?

C. Explanation

In this phase of the process, students report what they did and try to figure out the answer to the problem that has been presented. The teacher also introduces new words, phrases or sentences to label what the students have already figured out.

The purpose of explanation is to:

- Have students use the data they've collected to solve the problem that is posed.
- Present vocabulary words or phrases to label what the students have learned.

Evaluation of explanation: Since the students are on center stage trying to figure out what's going on, evaluation here focuses on the process the students are using. Remembering that the teacher's purpose is to help students to think for themselves, the evaluation at this point focuses on that — how well can students use the information they've collected and combine it with what they already know to come up with new ideas?

Notice that so far we have passed through three of the learning cycle's stages: engagement, exploration and explanation. To this point we have been acting like a discovery or inquiry teacher, that is, a teacher who focuses on students learning things for themselves. Now we are going to shift gears to some extent in elaboration.

D. Elaboration

The teacher gives students new information that extends what they have been learning in the earlier stages of the learning cycle. In **Masters of Gravity**, this information is usually presented in the second half of each video and on the CD-ROM. At this stage the teacher also poses problems that students will solve by applying what they have learned. The problems include both Soap Box Derby and other examples.

Evaluation of elaboration: The evaluation that occurs during elaboration is what teachers usually think of as evaluation. Sometimes teachers equate evaluation with "the test at the end of the chapter." When teachers have the students do the application problems as part of elaboration, these application problems are "the test."

E. Final Assessment

Most of the final assessment is done in the elaboration phase. The students are preparing products to be shared with the teacher and class. However, since paper-and-pencil tests can provide an efficient means of testing many students, test questions are provided for those who wish to use them.

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Masters of Gravity

Program 1

Collection and Analysis

http://www.WesternReservePBS.org/gravity

Program 1:

Collection and Analysis

Author

Joan Gecina, West Branch Local Schools, Beloit, Ohio

Target Audience

5th- & 6th-Grade Mathematics

Concept

This **Masters of Gravity** instructional television program, **Collection & Analysis**, shows how to use statistics from past Soap Box Derby events and display the data to enable students to learn from the history of the Derby. Students will use Soap Box Derby data to apply mathematical concepts reviewed/used in the lessons.

Learning Objectives

The students will:

1. Compute with whole numbers, fractions and decimals.
2. Change freely between fractions and decimals.
3. Use ratios, decimals and percents in a variety of applications.
4. Collect data and create a bar graph.
5. Use the data and bar graph to express information verbally and/or in writing.
6. Read, interpret and use a graph to identify patterns and draw conclusions.

Curriculum and Proficiency Standards Addressed

The students will:

1. Use models and pictures to relate concepts of ratio, proportion and percent.
2. Compare, order and convert among fractions, decimals and percents.
3. Select, apply and translate among mathematical representations to solve problems.
4. Determine and use the range, mean, median and mode to analyze and compare data and explain what each indicates about the data.
5. Collect, organize, display and interpret data for a specific purpose or need.

How Technology is Integrated in This Lesson:

The students will:

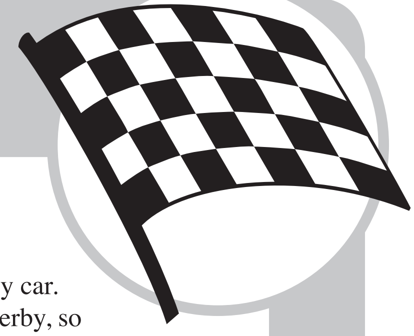
1. Access data from the **Masters of Gravity** CD-ROM and use it to apply their knowledge of using data and performing different mathematical skills.
2. Develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits and productivity.
3. Use technology to locate, evaluate and collect information from a variety of sources.
4. Use technology tools to process data and to report results.

Lesson Overview

To learn from the history of the Soap Box Derby, students will use data from the **Masters of Gravity** CD-ROM. Students will use this information and engage in classroom activities to explain and to calculate ratios, proportions and percentages; to compare numbers; to order numbers; to find mean, median and mode; and to graph information. This lesson, however, will focus mostly on ratios, and ordering, comparing and converting fractions, decimals and percents.

Program 1:

Collection and Analysis



Video Synopsis

Austin is building his first Soap Box Derby race car. His sister, Bridget, is being a pest and wants to know everything because next year she's going to build and race a Soap Box Derby car. Austin says that's ridiculous and, besides, there are more guys than girls in the Soap Box Derby, so she couldn't hope to win. She had better leave him alone since he's the family's only hope of glory.

Bridget wanders next door where Alex, a college student studying engineering, is working on his old car (as usual). She explains the situation, and Alex invites her into the garage to see his Soap Box Derby race car. Alex suggests she do some research to find out the number of girls and boys in the competition and the ratio of wins by both.

The ratio of boys to girls cited in this episode is only an example; your students will need to figure out the correct ratio of girls to boys.

CD-ROM Activities

1. Who Has Won the Most?
The students will collect data from the CD-ROM and determine the number of boys and the number of girls who have won the Soap Box Derby since 1934. They will then compare that number to the ratio since 1971, when girls started to compete.

2. Order Up!
In this exercise, students order a set of six numbers from smallest to largest.

3. Mean, Median, Mode
The students will collect age-gender data on the CD-ROM from the 2002 Soap Box Derby and calculate the mean, median and mode of the participants. (Example: What is the mean age of the boys who participate in the Soap Box Derby? What is the median age? What is the mode age?)

Follow-Up Video

Champions Chat: Accuracy
A world champion Soap Box Derby winner reinforces the need for accuracy when working with numbers.

Austin, Bridget and Alex brainstorm other ways in which to apply their knowledge of ratio, percents, comparing and ordering. They figure out how the school cafeteria determines what foods students like and how advertisers find out to whom they should target their commercials. Different types of graphs are also covered.

Champions Chat: Math and Science
A world champion Soap Box Derby winner reinforces how math and science learned now will be useful later in life.

Learning Strategies

A. Engagement

As a brief review of topics previously studied, the students will work together as a class while the teacher initiates and guides the students through the following activities (see Appendix A: Vocabulary).

Collection and Analysis

Activity 1

The students in the classroom act as the participants, as the teacher asks for a show of hands of those who wear glasses, either part-time or full-time (this does not include sunglasses). Next, the students who don't wear glasses are counted. Write this data as a comparison — the number of students with glasses to the number of students without glasses. Show this ratio in three ways:

$^n/_n$ **n:n** **n to n**

Show the equivalent proportion of the ratios. Review the procedure for calculating proportions when X is a missing corresponding number. Example: $^5/_{20}$ of the class wears glasses. If the same ratio applies to a class of 40, how many students would wear glasses?
($^5/_{20} = {}^X/_{40}$ X = 10)

Find the percent of students with glasses and then the percent of students without glasses. First, divide the denominator (the total number in the class) of the ratio (fraction) into the numerator (the number being counted). The quotient will show a decimal. To convert into a percent, move the decimal point over two places to the right. The results will show the percentage of students who wear glasses and the percentage of those without glasses. Extend this by recalculating those who wear glasses all of the time, and then the students who wear glasses only part-time. Again, show the results as ratios, fractions, decimals and percents.

Construct a bar graph with the students to show the following information:

1. Students who wear glasses all of the time.
2. Students who wear glasses part-time.
3. Students who have glasses and never wear them.
4. Students who do not own or wear glasses.

Students should recall the parts of a bar graph and instruct the teacher/student to complete the graph in the correct manner.

Activity 2

Select eight students to report the number of hours they slept the night before. With this information, find the mean (average), median (middle) and mode (number that occurs most often) of the students' length of sleep.

Evaluation of Engagement

After working with the class on the previous activity, have the students use the same procedure to collect data of children with brown eyes to children with all other eye colors. The teacher will help with the initial part of the data collection by posting the count on the board. The students will work in groups of three or four to find the answers. Students will construct a bar graph to show the results of their calculations.

To assess the students' understanding of mean, median and mode, instruct each student in the group to write his/her name on a piece of paper. Count the number of each letter in the names (that is, how many A's, B's, C's and so on) and find the mean, median and mode of this data.

Apply proportion by having the students solve the following problem: A student measured her heart rate after running in gym class. Her heart beat 30 times in 15 seconds. How many times did it beat in one minute?

B. Exploration

Watch the first half of **Collection and Analysis**. The program will arouse interest in the students to learn about the history of the Soap Box Derby.

Who Has Won the Most?

Alex and Bridget got it wrong! There aren't over 600 winners as stated in the video. Students will collect data from the the CD-ROM to use as a basis to practice and perform skills related to data analysis. The first problem students will tackle is to find out how many boys and girls have really won the Derby since it started. They can follow the procedure used in the video to determine the true ratio.

Now that the students know the ratio of boys to girls since 1934, they will compare the total number of girls and boys who have won the Soap Box Derby since 1971, when girls first started competing. With this information, the students will show the ratio of girls to boys; boys to girls; girls to all participants; and boys to all participants. The students will express the ratios in three different ways and then show equivalent ratios (proportions) with the information. (See Appendix B: Rubric for Written Explanations/Paragraphs)

Order Up!

Students will use the CD-ROM activity "Order Up!" to review placing a set of six numbers in order from smallest to largest. Once the students have completed the review, they will convert the data they have collected into decimals and percents. The information will be compared and ordered as calculations are made.

Evaluation of Exploration

The students will share the results of their calculations and compare them with the results of the other students in the class. Collectively, the class will assess each other for the correct response to each problem. They will use the information acquired to make predictions of the ratio of girls to boys participating in the Soap Box Derby in the next ten years. The students will write in their journals to explain their findings and to state their conclusions. (See Appendix B: Rubric for Written Explanations/Paragraphs)

C. Explanation

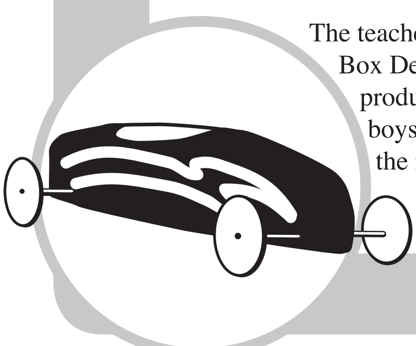
Mean, Median, Mode

The students will collect age-gender information from the CD-ROM activity, "Mean, Median, Mode," using the data for the 2002 Soap Box Derby. They will calculate the mean, median and mode of the participants. (Example: What is the mean age of the boys who participate in the Soap Box Derby? What is the median age? What is the mode age?)

After the students have calculated the data, they will explain the procedure for finding ratio, decimals, percents, mean, median and mode and review how to construct a bar graph. The specific vocabulary associated with data analysis should be reviewed and used. (See Appendix A: Vocabulary)

Evaluation of Explanation

The teacher assigns each student a different segment of the results they have compiled from the Soap Box Derby data. Students will write a paragraph that explains a portion of the data. They will also produce a graph that illustrates the points they make in the paragraph. (Examples: ratio of girls to boys; boys to girls; girls to all participants; boys to all participants; the mean age of the boys/girls; the median age; the mode age.) (See Appendix B: Rubric for Written Explanations/Paragraphs)



D. Elaboration

Watch the second half of **Collection and Analysis**, which covers ratios and proportions and their use in everyday life.

After viewing, have students decide on other ways to apply their knowledge of ratio, percents, comparing and ordering by using these skills in other situations. Examples: What are the ratios/percents of the students who play basketball to those who play soccer? What is the ratio of students who play sports to those who do not? Order and compare the total rainfall each month in the past year (whole numbers, decimals and fractions). Using selected information, the students will work independently to construct a bar graph to show and explain their research. The graph must support the data collected.

Evaluation of Elaboration

The teacher will check the accuracy of the students' calculations and their understanding of the concepts. Students will be assigned a specific problem of the teacher's choice and will complete it as an assessment.

E. Final Assessment

Each student will change fractions to decimals; convert decimals to show percents; order numbers from least to greatest using decimals; show the mean, median and mode of numbers; write an equivalent ratio; and develop a bar graph. (See Appendix C: Collection and Analysis Written Test)

Tools/Resources

Masters of Gravity CD-ROM and **Collection and Analysis** instructional television program
VCR and TV
Computer with Internet access and CD-ROM
Word processing software
Journals

Classroom Management

Suggested time frame for the lesson is eight days:

Review terms, vocabulary and procedures for calculations pertaining to this lesson. *(1 class period)*

Do classroom engagement activity. *(1 class period)*

View **Masters of Gravity** episode and use the Soap Box Derby data for researching specific information posited in the video. *(1 class period)*

Use the data to complete the "Who's Won the Most?" activity *(2 class periods)*

Have students respond in their journals, describing procedures that were used in "Who's Won the Most?" *(1 class period)*

Completion of the "Mean, Median, Mode" activity. *(1 class period)*

Discuss the results and take the post-test. *(1 class period)*

Student Groupings

Whole group review and participation on ratio, percent, decimals and fractions.

Whole group participation in activities.

Whole group instruction and participation on mean, median and mode.

Small group/partner investigations to collect data pertaining to the Soap Box Derby.

Whole group discussion of findings from the collected data.

Whole group discussion of types of graphs appropriate for displaying findings.

Independent/partner development of written description of graph results.

Whole group participation in presenting the results.

Appendix A

Vocabulary

Bar Graph - a graph that uses the height or length of rectangles to compare data.

Data - a set of information.

Decimal - a numeration system based on grouping by tens (it contains a decimal point which separates the ones and tenths place in the number).

Equivalent - having the same value.

Fraction - a way to describe a part of a whole or a part of a group by using equal parts.

Mean - a number found by dividing the sum of two or more numbers by the number of addends (the mean is commonly referred to as the average).

Median - the middle number when numbers are arranged from least to greatest.

Mode - the number that appears most frequently in the set of numbers.

Percent - the ratio of a number to 100.

Proportion - a statement of equality between two ratios.

Ratio - a comparison of two numbers (example: 3 to 5; 3:5; 3/5).

Whole Number - any of the numbers 0, 1, 2, 3, 4, 5 and so on.

Appendix B

Rubric for Written Explanations/Paragraphs

4 points **Has correct answer -** thorough explanation with support

3 points **Has correct answer -** an explanation but lacks support

2 points **Correct answer -** with no or wrong explanation

1 point **Addresses the question -** but wrong answer

0 points **No response**

Collection and Analysis Written Test

Name: ____

Barbara used fractions to plan the size of each serving of food for her picnic, but the serving sizes of the food she bought are shown in decimals. Complete the following activities using Barbara's list.

Hamburger - $\frac{1}{4}$ lb
Potato salad - $\frac{2}{5}$ lb
Fruit salad - $\frac{3}{8}$ lb
Baked beans - $\frac{2}{5}$ lb

1. Change the serving size on the list above to decimals:

Hamburger =
Potato salad =
Fruit salad =
Baked beans =

2. Convert the decimals to show percents of each serving:

Hamburger =
Potato salad =
Fruit salad =
Baked beans =

3. Order the serving sizes from smallest to largest using decimals:

1.
2.
3.
4.

4. Show the mean, median and mode of the serving sizes. (Choose to use fractions, decimals **or** percents):

Mean =
Median =
Mode =

5. Write an equivalent ratio for each item:

6. Develop a bar graph showing the amounts:

Appendix C

Answer Key for Collection and Analysis Written Test

1. Change the serving size on the list above to decimals:

   Hamburger - 0.25 lb

   Potato salad - 0.4 lb

   Fruit salad - 0.375 lb

   Baked beans - 0.4 lb

2. Convert the decimals to show percents of each serving:

   Hamburger - 25% lb

   Potato salad - 40% lb

   Fruit salad - 37.5% lb

   Baked beans - 40% lb

3. Order the serving sizes from smallest to largest using decimals.

   Hamburger - 0.25 lb

   Fruit salad - 0.375 lb

   Potato salad - 0.4 lb

   Baked beans - 0.4 lb

(Baked beans can be listed before potato salad - no specific order)

4. Show the mean, median and mode of the serving sizes. (Choose to use fractions, decimals **or** percents)

   mean - $\frac{57}{160}$; 0.35625; 35.675%

   median - $\frac{31}{40}$; 0.38755; 38.75%

   mode - $\frac{2}{5}$; 0.4; 40%

5. Write an equivalent ratio for each item.

   Any equivalent fraction is acceptable.

6. Develop a bar graph showing the amounts.

   The bar graph can be a vertical or horizontal graph. It should have a vertical and a horizontal axis as well as a title. The numbers being compared should have a reasonable range. It would be best to work with decimals or percents.

Appendix D

Pre-Test Questions

Name: ____

1. Which group of fractions is correctly ordered from the smallest to the largest?

   a. $\frac{1}{10}$ $\frac{1}{8}$ $\frac{1}{6}$

   b. $\frac{1}{4}$ $\frac{1}{9}$ $\frac{1}{3}$

   c. $\frac{1}{2}$ $\frac{1}{3}$ $\frac{1}{5}$

2. Which decimal can be written in the blank to make the statement true? $\frac{1}{5}$ < _________ < $\frac{1}{4}$

   a. 0.150

   b. 0.175

   c. 0.225

   d. 0.265

3. The following brass instruments are in Susan's school orchestra: 2 trumpets, 4 French horns, 3 trombones and 1 tuba. What is the ratio of French horns to all the brass instruments?

   a. 2 to 10

   b. $\frac{3}{10}$

   c. 10 to 4

   d. 4:10

Appendix E

Post-Test Questions

Name: ____

1. Which group of decimals is ordered from greatest to least?

   a. 6.09 7.2 6.60

   b. 6.60 6.09 7.1

   c. 7.1 6.09 6.60

   d. 7.1 6.60 6.09

2. Which fraction can be written in the blank to make the statement true? 0.70 > _________ > 0.42

   a. 1/2

   b. 9/10

   c. 1/10

   d. 2/3

3. In Lauren's handful of jellybeans, there are 3 red beans and 5 yellow beans. She told her brother that he could have all of the red beans. Which expression shows the red jelly beans compared to the whole?

   a. 3:5

   b. 5/8

   c. 3 to 8

   d. 5:8

Answer Key

Appendix D: Pre-Test Answer Key

1. A. $\frac{1}{10}$ $\frac{1}{8}$ $\frac{1}{6}$

2. C. 0.225

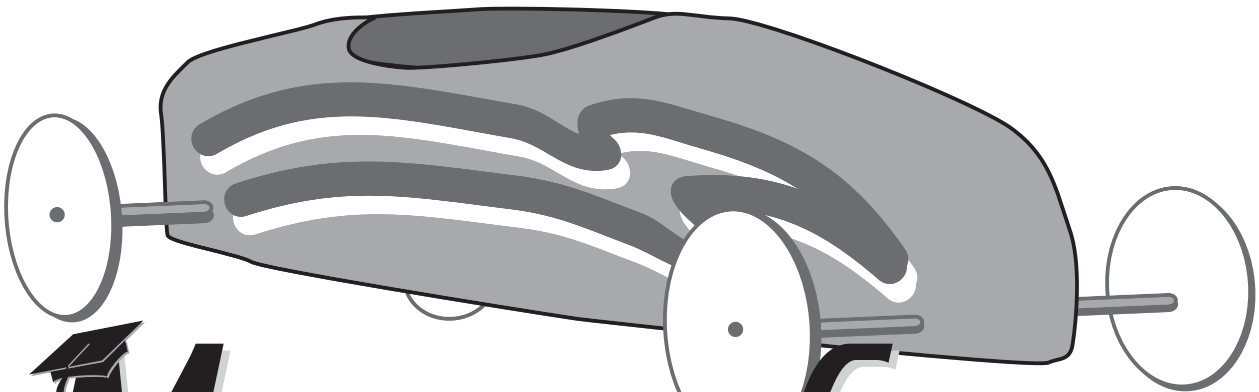
3. D. 4:10

Appendix E: Post-Test Answer Key

1. D. 7.1 6.60 6.09

2. A. $\frac{1}{2}$

3. C. 3 to 8



MASTERS OF GRAVITY

Program 2

Ratio and Proportion

http://www.WesternReservePBS.org/gravity

Program 2:

Ratio and Proportion

Author

Maria Mastromatteo,
Western Reserve PBS,
Kent, Ohio

Target Audience

6th-Grade Mathematics

Concept

In this lesson the students will explore making the drawing of a small car larger by using proportion. The students will study how proportion works in a variety of areas in their lives.

Learning Objectives

The students will:

1. Enlarge a picture placed on a grid using a method of their choosing and explain their procedure.
2. Compute the missing measure using proportion when given three measures in a proportion.
3. Compute the height of a tree using proportion-solving techniques when given the height of a person and his shadow and the length of the shadow of a tree.
4. Apply proportion-solving techniques.

Curriculum and Proficiency Standards Addressed

The students will:

1. Use models and pictures to relate concepts of ratio, proportion and percent.
2. Use variables to create and to solve equations.
3. Use symbolic algebra to represent and to explain mathematical relationships.
4. Convert measures expressed in a given unit to other units in the same measurement system using proportional reasoning and a reference table when appropriate.
5. Select an instrument and measure accurately to a specified level of precision.

How Technology is Integrated in This Lesson

The students will:

1. Gather information from electronic resources.
2. Interact with electronic learning activities.
3. Use the Internet to access practice problems.
4. Use a calculator to do calculations of proportion.
5. Employ technology in the development of strategies for solving problems in the real world.

Lesson Overview

After students watch the first part of **Masters of Gravity, Ratio and Proportion**, they use a worksheet and graph paper to change the proportion of a car drawing. In the second activity they use a worksheet and ruler to chart the proportion of a drawing. After watching the follow-up video, they will apply their knowledge of proportion by determining the ratio of different edible goldfish in a bowl and the number of people in a town. Using the CD-ROM, students will use proportion to determine the height of a tree. Once the method is understood, they will use their knowledge to do the same exercise outside on real trees.

Video Synopsis

Austin is having trouble interpreting the plans for his Soap Box Derby car. The plans use scale drawings and he's having trouble understanding how items on the drawing relate to the actual car. Bridget can't help so they go next door to ask Alex. He shows them a collectors model of a Soap Box Derby car and compares it to the one in his garage. By comparing the two he explains proportion. He pulls out his plans and Austin measures the axle on the car and the plans. Using these two measurements they figure out the proportions of the plans.

Program 2:

Ratio and Proportion

CD-ROM Activities

1. **Length, Height, Wheel Diameter**
   The students determine the value of the dimension in question by using the numbers on the blueprints and the given proportion.

2. **How Tall is the Tree?**
   Students adjust the bear's height, then determine the height of a tree by comparing their shadows.

Follow-Up Video

Champions Chat: Plans
A world champion Soap Box Derby winner reinforces the need to understand and follow plans.

Alex shows Bridget and Austin a project he's working on for one of his college classes. He uses dowel rods to put together model car frames to test their strength. Other examples of ratios and proportions are given.

Learning Strategies

A. Engagement

Watch the first part of the instructional television program, **Masters of Gravity, Ratio and Proportion**.

Break students into groups of two or three. Each group should do the "Length, Height, Wheel Diameter" activity on the CD-ROM.

Groups will be given a drawing of a Derby car on graph paper (Appendix B: Enlarging a Drawing). Their task is to enlarge this same car on a larger piece of paper. They should be provided with a worksheet, larger graph paper, large blank paper squares, markers, etc.

Groups will make a decision as to how they will enlarge the model. (They can then decorate and name their cars.)

Evaluation of Engagement

When the task is completed, students will display their models and explain how they enlarged them. (See Appendix C: Rubric for Enlarging a Drawing and How Tall is the Tree?)

B. Exploration

Students will be put into groups of two or three and use Appendix D: Estimating Size. Groups will measure the front axle, length of the body and the steering cable on a scale drawing and, using proportion, determine what the actual measurement on a full-size car would be. The section that measures one inch on the diagram is actually 13 inches on the real car. This means that the diagram is about 13 times smaller than the actual Derby car. Consequently, they can estimate the size of the various pieces by measuring and multiplying by 13. Using the worksheets provided, students need to measure on their diagram and then estimate what they think the length would be on the actual Derby car.

Students should be asked if there is a way that would make their answers more accurate. Hopefully they'll recall the exploration activity and determine that proportion might help them in this area.

Students should now use proportion to compute the actual measurements on a Derby car and fill in their answer on the worksheet table. Some experience with this will be necessary before the students can complete the task in their groups.

Some students may not operate well at this abstract level. If that is the case, they can determine how much each inch on the diagram is equal to and actually draw that distance on a piece of paper or on the board. They can measure the distance they have drawn and then fill in the proportion (and the table). This process will need to be demonstrated to the students.

Evaluation of Exploration

When the task is completed, use Appendix E: Rubric for Estimating Size to evaluate the work of the students.

C. Explanation

Once the students have filled in their chart, they should share their data and explain how they solved the problem. They can describe what difficulties they encountered and ask questions.

Students will need more practice using proportions. The teacher can go to the **Masters of Gravity** CD-ROM, do work from the textbook or go online to http://www.algebrahelp.com/lessons/proportionbasics/pgw.htm.

The vocabulary words in Appendix A should be discussed after the CD-ROM has been used: ratio, proportion, means, extremes, equal, estimate, measure, inch, variable, variability, sample and population.

Evaluation of Explanation

When the task is completed, use the Appendix E: Rubric for Estimating Size to evaluate the work of the students.

D. Elaboration

Watch the second half of the instructional television program, **Masters of Gravity, Ratio and Proportion**.

Capture-Recapture
Problem to be posed
You have been asked by the game warden of your local lake to determine the number of fish in the lake. The game warden is trying to determine if she needs to restock the lake for fishermen or if there are enough fish in the lake. You will use the process that game wardens use, the capture-recapture method.

(If possible, have a game warden be a guest in the classroom to explain how the process is really carried out.)

Procedure

1. Fill a large bowl with Pepperidge Farm Goldfish. Explain that the bowl is the lake and the goldfish represent the fish in the lake. **(Know prior to class the number of goldfish in the bowl.)**
2. Students will write an estimate of how many fish they think are in the bowl.
3. Introduce the vocabulary words *population* and *sample*.
4. With a cup take out a quantity of the fish (this is the capture) and replace it with the same number of a different kind of fish — for example, you could use cheddar fish or pretzel fish.
5. Mix the fish well. The new fish that have been mixed in are called the "marked" fish because they are marked in some way before being put in the water.
6. Pass the bowl around the room and have the students each take a cup of fish from the bowl (this is the recapture). Students count and record the number of the marked fish in the sample and the total number of fish in the sample. After counting the fish, return them to the bowl. This can be going on while students are performing another activity.
7. After all students have completed this task, they can then use proportion to find the total number of fish in the pond.
8. Data is then collected from each student on the number of marked fish and the total number of fish in the sample. Students should note the marked variability in the samples.
9. The class then determines the mean for the number of marked fish in the sample and the total number in the sample.
10. Using this data, students can use proportion to find the number of fish in the lake. The students will be surprised by how close the class estimate is to the actual number of fish in the population.

Evaluation of Elaboration

How Many People?

1. Distribute worksheet titled "How Many People?" (Appendix F).
2. When students have completed the worksheet, they will write a paragraph explaining:
   a) the answer they got and
   b) how they solved the problem.

   There are a variety of ways that the problem could be solved and any way that is correct is acceptable. Students should show all work.
3. When the task is completed, use Appendix F: Rubric for How Many People? to evaluate the work of the students.

How Tall is the Tree?

Students will be broken into groups of two or three. Each group should do the "How Tall is the Tree?" activity on the **Masters of Gravity** CD-ROM. Student groups then go outside and actually find the height of a tree using the method on the CD-ROM.

Procedure for outside activity:

1. Find a short tree outside (about 8-10 feet). Make sure it's a sunny day so that students can see their shadows.
2. Tell the students it is their job to calculate the height of the tree. Have the students determine what unit of measure they should use. Give them a tape measure and tell them you'll supply other material if they need it (and if you have it) and let them attack the problem. (Have yard sticks, tape measures and other materials available.)

3. After some time, the students should give their solutions to the problem — explaining both what their solution is and how they got it.

4. The proportion is:

$$\frac{\text{Height of the tree (x)}}{\text{Shadow of the tree}} = \frac{\text{Height of the person}}{\text{Shadow of the person}}$$

5. Point out that there are other ways to write this proportion.

Evaluation of How Tall is the Tree?

When the task is completed, use the Appendix C: Rubric for Enlarging a Drawing and How Tall is the Tree? to evaluate the work of the students.

E. Final Assessment

Final assessment is based on the portfolio of activity sheets.
A second assessment can be a paper-and-pencil test (Appendices G and H: Pre- and Post-Test).

Tools/Resources

Masters of Gravity CD-ROM and **Ratio and Proportion** instructional television program
VCR and TV
Computer with Internet access and CD-ROM
Calculators
Graph paper
Glue or tape
Markers
Rulers
Tape measures
Pepperidge Farm Goldfish (two varieties)
Large bowl
Large blank paper
Squares of paper

Classroom Management

Suggested time frame for this lesson is six class periods:

Enlarging a Drawing. *(2 class periods — 1 for work and 1 for analysis of work by the class)*

Estimating Size: Some prior work needs to be done with proportion. *(1 class period)*

Capture-Recapture: Some other activity, such as practicing doing proportion or using the CD-ROM, can be done at the same time as this activity. The culminating activity in which the students collate their data and find the number of fish in the lake takes about 25 minutes. *(1 class period)*

How Many People? *(1 class period)*

How Tall is the Tree? *(1 class period)*

Student Groupings

All activities should be done in groups of two or three.

Appendix A

Vocabulary

Equal - having the same value.

Estimate - an approximate value made by making a “rough” calculation.

Extremes - in the proportion $\frac{1}{6}=\frac{2}{12}$, the extremes are the outer two numbers, 1 and 12.

Inch - a unit of measure equal to $\frac{1}{12}$ of a foot.

Means - in the proportion $\frac{1}{6}=\frac{2}{12}$, the means are the inner two numbers, 6 and 2.

Measure - to determine a distance using a tool.

Population - a total group of people, animals or things that have common characteristics.

Proportion - a statement of equality between two ratios.

Ratio - comparing two numbers.

Sample - a part of the population used to determine qualities of the whole group.

Variability - the spread in a series of data points or numbers (the range from the lowest to the highest).

Variable - a symbol whose value changes.

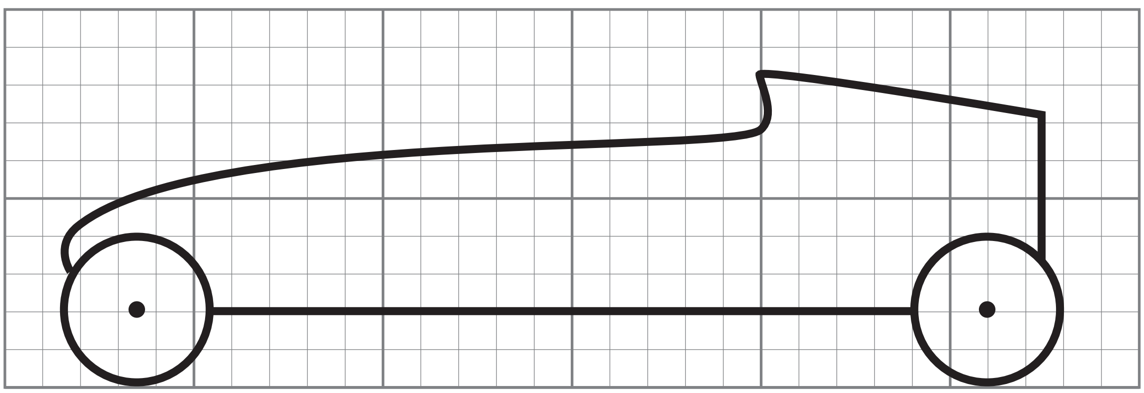
Appendix B

Enlarging a Drawing

Name: ____

Below is a diagram of a Soap Box Derby car imposed on graph paper. Your job is to make the car larger. You must keep the correct proportion. You may use:

- Larger graph paper
- Squares of paper
- A ruler or tape measure
- Markers (to decorate the car you make)



Appendix C

Rubric for Enlarging a Drawing and How Tall is the Tree?

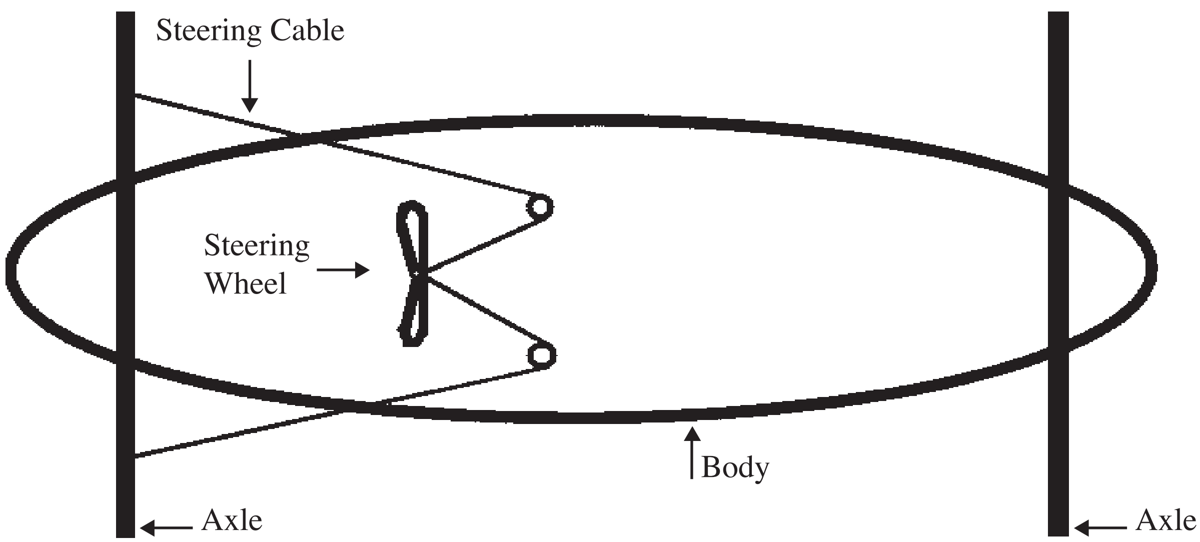
Category	Excellent	Good	Satisfactory	Needs Improvement
Content	Shows a full understanding of the topic.	Shows a good understanding of the topic.	Shows a good understanding of parts of the topic.	Does not seem to understand the topic very well.
Comprehension	Student is able to answer accurately almost all questions posed by classmates about the topic.	Student is able to answer accurately most questions posed by classmates about the topic.	Student is able to answer accurately a few questions posed by classmates about the topic.	Student is unable to answer accurately questions posed by classmates about the topic.
Collaboration With Peers	Almost always listens to, shares with and supports the efforts of others in the group. Tries to keep people working well together.	Usually listens to, shares with and supports the efforts of others in the group. Does not cause "waves" in the group.	Often listens to, shares with and supports the efforts of others in the group but sometimes is not a good team member.	Rarely listens to, shares with and supports the efforts of others in the group. Often is not a good team member.

Appendix D

Estimating Size

Names: ____

Directions: Using a ruler (inches), measure the length of the body, axle and steering cable on the diagram. Estimate the size of the items on an actual race car. The diagram is about 13 times smaller than the actual Soap Box Derby car.



	Length on diagram	Estimate on Derby car
Front Axle		
Body		
Steering Cable		

Appendix D

Estimating Size

Now that you have made an estimate, you need to find the actual measure. Use your calculator to help you.

Example 1: 2 inches on the diagram is equal to 26 inches on the Derby car. How long would a piece that measures 3.5 inches on the diagram be on the Derby car?

The general rule is

$$\frac{\textbf{diagram}}{\text{Derby car}} = \frac{\textbf{diagram}}{\text{Derby car}}$$

$$\frac{\text{2 inch}}{\text{26 inches}} = \frac{\text{3.5 inches}}{\text{N inches}}$$

You would multiply 26 x 3.5, which equals 91. This means that 2N=91. Divide 91 by 2 = 45.5. Therefore the piece on the Derby car would be 45.5 inches.

Example 2: 1 inch on the diagram is equal to 13 inches on the Derby car. How long would a piece be that measures 3½ inches on the diagram be on the Derby car?

The general rule is

$$\frac{\textbf{diagram}}{\text{Derby car}} = \frac{\textbf{diagram}}{\text{Derby car}}$$

$$\frac{\text{2 inch}}{\text{26 inches}} = \frac{3\tfrac{1}{2}\text{ inches}}{\text{N inches}}$$

You would multiply 26 x 3½, which equals 91. This means that 2N=91. Divide 91 by 2 = 45½.
Therefore the Derby car would be 45½ inches.

	Length on diagram	Estimate on Derby car	Actual measure on Derby car
Front Axle			
Body			
Steering Cable			

Are there other ways that this proportion could be set up?

Appendix E

Rubric for Estimating Size

Answer Key for Estimating Size - Page 2

Front Axle: 35.75”
Body: 78”
Steering Cable: 52”

Category	Excellent	Good	Satisfactory	Needs Improvement
Mathematical Errors	90-100% of the steps and solutions have no mathematical errors.	Almost all (85-89%) of the steps and solutions have no mathematical errors.	Most (75-84%) of the steps and solutions have no mathematical errors.	More than 25% of the steps and solutions have mathematical errors.
Explanation	Explanation is written completely and explained well.	Explanation is written completely but explanation needs improvement.	Both the written work and the explanation need improvement, but procedure is correct.	Explanation is difficult to understand and several components of written explanation are not included.

Appendix F

How Many People?

Names: ____

Suppose a high school in a town has 500 students. A random survey of 200 people in the town finds 40 high school students. What is the estimate for the number of people in the town?

Population: Total group you are studying
Sample: Representative part of the group

Let N = # of people in the town

$$\frac{\text{TOTAL \# of high school students in the } \textit{population}}{\text{TOTAL \# of people in town}} = \frac{\text{\# of high school students in the } \textit{sample}}{\text{TOTAL \# of people in } \textit{sample} \text{ population}}$$

$$\frac{\_\_\_\_\_\_}{\mathbf{N}} = \frac{\_\_\_\_\_\_}{\_\_\_\_\_\_}$$

N = _________ people in the town

Procedure:

1. Make an estimate.
2. Solve the problem and write your answer.
3. Write a paragraph about how your group solved the problem.

Appendix F

Answer Key for How Many People?

$$\frac{500}{N} = \frac{40}{200}$$

N = 2,500 people in the town

Rubric for How Many People?

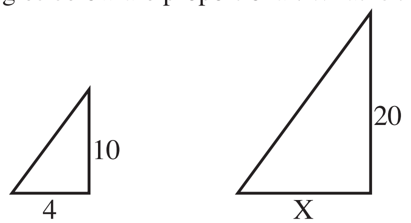
1. Students will solve the problem showing all work.
2. Students will write a description of how they solved the problem.
3. Students will be evaluated using the following rubric:

Category	Excellent	Good	Satisfactory	Needs Improvement
Mathematical Concepts	Explanation shows complete understanding of the mathematical concepts used to solve the problem.	Explanation shows substantial understanding of the mathematical concepts used to solve the problem.	Explanation shows some understanding of the mathematical concepts needed to solve the problem.	Explanation shows very limited understanding of the underlying concepts needed to solve the problem OR is not written.
Explanation	Explanation is detailed and clear.	Explanation is clear.	Explanation is a little difficult to understand, but includes critical components.	Explanation is difficult to understand and is missing several components OR was not included.
Mathematical Terminology and Notation	Correct terminology and notation are always used, making it easy to understand what was done.	Correct terminology and notation are usually used, making it fairly easy to understand what was done.	Correct terminology and notation are used, but it is sometimes not easy to understand what was done.	There is little use, or a lot of inappropriate use, of terminology and notation.

Pre-Test: Ratio and Proportion

Name: ____

1. The triangles below are proportional. What is the length of the base of the large triangle?



a. 14
b. 30
c. 8
d. 40

2. Three out of four children in Mark's school buy their lunch at school. There are 120 children in Mark's school. How many buy their lunch?

$$\frac{3}{4} = \frac{X}{120}$$

a. 20
b. 30
c. 90
d. 100

3. Mr. Bault, our gym teacher, averages 5 foul shots out of every 7 attempts. If he shoots the ball 21 times, how many foul shots should he make?

____

What type of mathematical process is needed to solve this problem?

____

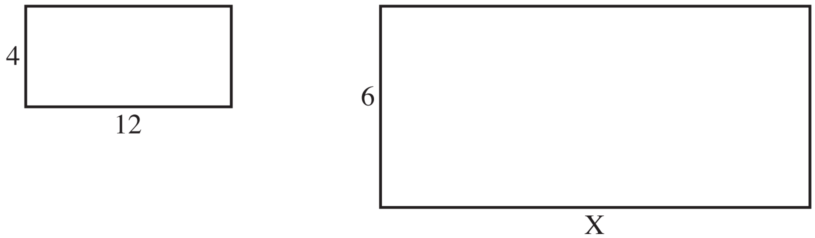
____

____

Post-Test: Ratio and Proportion

Name: ____

1. The rectangles below are proportional. What is the length of the missing side?



2. There are 12 doughnuts in one dozen. How many are there in 5 dozen? Complete the proportion.

$$\frac{1}{12} = \frac{5}{X}$$

a. 17

b. 60

c. 18

d. 24

3. It costs $75.00 per night to stay at the hotel at Six Flags. How much will it cost to stay for a week?

____

Explain how you solved this problem:

____

____

____

____

Answer Key

Appendix G: Pre-Test

1. c. 8
2. c. 90
3. He made 15 foul shots

   Set up a proportion $\frac{5}{7} = \frac{X}{21}$ $\frac{\text{\# made}}{\text{\# tried}}$

Appendix H: Post-Test

1. 18
2. b. 60
3. $\frac{1}{75} = \frac{7}{X} = \frac{\text{nights}}{\text{costs}}$

   X = $525

MASTERS OF GRAVITY

Program 3

Geometry

http://www.WesternReservePBS.org/gravity

Program 3:

Geometry

Author

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Target Audience

5th-Grade Mathematics

Concept

This **Masters of Gravity** instructional television program demonstrates the geometric concept of "the shortest distance between two points is a straight line" and the importance of measurement of angles and segments in making sure that the car travels in a straight path.

Recognition of geometric concepts of points, lines and planes is also included.

Learning Objectives

The students will:

1. Identify examples of points, line segments, planes, circles and triangles.
2. Measure marked distances between two points using string and rulers.
3. Classify types of triangles such as scalene, equilateral, isosceles, acute, right, obtuse or equiangular by measuring angles and/or sides of various triangles using protractors and/or rulers.

Curriculum and Proficiency Standards Addressed

The students will:

1. Apply appropriate techniques and tools to determine measurements.
2. Identify paths between points and compare lengths of paths (e.g., shortest path, paths of equal length).
3. Analyze characteristics and properties of geometric shapes and develop mathematical arguments about geometric relationships.
4. Use multiple classification criteria to classify triangles (e.g. scalene, obtuse).

How Technology is Integrated in This Lesson

The students will:

1. Use technology resources for solving problems and making informed decisions.
2. Use technology tools to enhance learning, increase productivity and promote creativity.
3. Use technology tools to process data and report results.

Lesson Overview

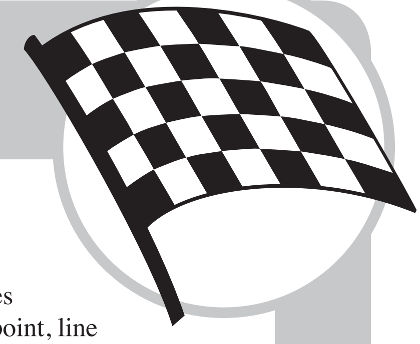
Students will view the introductory video in which Austin's Soap Box Derby car is veering off to the side rather than going straight. The video poses a problem for students to think about and eventually solve.

The solution will involve making connections among the three parts of the lesson:

1. Recognition of geometric shapes.
2. Determination that a straight line is the shortest distance between two points.
3. Identification of types of triangles and which type is necessary in the alignment of the Soap Box Derby car.

Video Synopsis

Austin test-drives his partially completed car (it has no body yet) and it doesn't go very straight. He can't figure out why. Bridget has been studying shapes in school and notices the triangles on the plans and the ones on the car made by the axles aren't the same. Austin says, "Close enough!" They argue about the importance of Bridget's observation and go to Alex to settle the argument. He's working on his old car and shows them the tires, one of which has a wear pattern that suggests it's out of alignment. Their discussion revolves around what that would mean. Finally Austin has an "aha!" moment and runs off to fix his racer.



CD-ROM Activities

1. **Identify**
   The students will move their cursor over the Soap Box Derby car until an area changes color. When an area changes color, students click on it and four choices will appear: point, line segment, plane and angle. Students choose the one that matches.
2. **Wheel Alignment**
   The students choose from the wheel alignments to determine which will make the car go straight.

Follow-Up Video

Champions Chat: Geometry
A world champion Soap Box Derby winner reinforces how geometry is used in everyday activities.

Alex is putting braces into his model wooden frame (from the last episode) to strengthen it. He shows Austin and Bridget how the braces and the frame form geometric patterns. They talk about the super mileage car Alex is working on in his studies and how important it is for the wheels to be lined up properly. They also talk about geometry in real-life situations — in playground equipment, on a running track (and why it has different starting points but the same finish line), at the miniature golf course, and in hockey, football and soccer.

Champions Chat: Plans
A world champion Soap Box Derby winner reinforces the need to understand and follow plans.

Learning Strategies

A. Engagement

Identify
This exercise teaches students to recognize points, line segments, circles, triangles and planes. The class will use the **Masters of Gravity** CD-ROM activity, "Identify," to get an idea of where this knowledge is applied in the everyday world. A discussion will follow about the various geometric shapes that can be found on the plans for a Soap Box Derby race car — points, line segments and planes (circles and triangles can also be included).

Evaluation of Engagement

1. Students will find examples of points, line segments, angles and planes in the CD-ROM activity.
2. A print-out of a Soap Box Derby car (Appendix A: Geometric Shapes) will be distributed to the students. They will circle all points in red, all line segments in blue, all planes in green, all angles in yellow, all circles in orange and all triangles in pink.

A. Engagement

Recognition of Various Types of Triangles
Distribute worksheets Appendix B: Scalene, Isosceles and Equilateral Triangles and Appendix C: Acute, Right, Obtuse and Equiangular Triangles. The students within each group will measure the angles and sides using protractors and rulers to determine if the triangles are isosceles, equilateral, scalene, acute, right, obtuse or equiangular. At the end of the exercise the students will compare their answers.

Teacher notes: Definitions

Isosceles triangle - a triangle with at least two sides that are the same.
Equilateral triangle - a triangle in which all three sides are the same.
Scalene triangle - a triangle with no sides the same.
Acute triangle - a triangle with all angles less than 90°.
Right triangle - a triangle with one 90° angle.
Obtuse triangle - a triangle with one angle more than 90°.
Equiangular triangle - a triangle in which all angles are equal.

Evaluation of Engagement

1. Math Journal: Ask the students to compare and contrast the seven types of triangles by drawing a picture of each and explaining the differences in writing.

2. Rubric: Students will redo drawings and explanations until mastery is achieved.
   Mastery - Students will draw and label the seven types of triangles according to the definitions of each and identify at least two similarities and two differences.

B. Exploration

Show the students the first segement of **Geometry** from the **Masters of Gravity** series. In this episode, Austin's Soap Box Derby car is driving to the side rather than straight. Tell students that they will do an activity that might explain why.

Shortest Distance

The class will be divided into five racing teams of four or five members each. The classroom will be divided into five racing lanes, labeled A, B, C, D and E, all of which are the same length. The teacher will draw chalk lines or lines made with shoe polish on the floor in each of the five lanes connecting the "starting line" to the "finish line" (some should be curvy, some zig-zagged and one straight). The teacher will explain that the lines represent the path of a race car from the start to the finish line.

Students within each group will be responsible for using string to measure the length of the line from start to finish. Two measurements should be taken and recorded. The string will be laid along each path and then cut. The string will then be straightened and measured with a ruler. The results will be recorded on a data sheet decided on by the collaboration of the students and the teacher. Groups will begin at various lanes. Once finished with lane A that group will move on to lane B, etc., so that each group measures all paths and comparisons can be made. For verification purposes, two measurements of each track by each group should be taken and recorded. The teacher should walk around from group to group to see that everything is going smoothly and to answer any questions that may come up.

Students will work together to collect data and check each other's work. The students can post the lengths they get for each lane and the class should calculate a mean length.

Evaluation of Exploration

Have students report their findings of lengths of line segments and account for any differences in lengths from group to group. (For example, group A may have a slightly different measurement than group B.) Questions: What techniques were used? Why did the results vary?

Given a drawing (Appendix D: Shortest Distance) with three paths, students will use string, scissors, ruler and a pencil to measure different path lengths. Students will place a string on each path, then cut the string at the finish line, straighten it, measure it with a ruler and record their findings. Range of Accuracy: +/- .25 inch.

C. Explanation

The teacher should ask the following leading questions: Suppose you are riding in a Soap Box Derby car and the lines in the classroom activity represent the path your car will travel. Which path do you think the winning car will travel? How do you know? Which path is the shortest? The longest?

Discuss the concept that the shortest distance between two points is a straight line segment.

Discuss the meaning of “as the crow flies” and how roads go around obstacles such as lakes and ponds, etc. This discussion leads to the introduction of Appendix E: Taxi Cab Geometry.

Evaluation of Explanation

Students will summarize their “discovery” from the Taxi Cab Geometry activity (shortest distance between two points is a straight line segment) in their math journals.

D. Elaboration

Students will do an activity on the CD-ROM in which they make adjustments to the wheel alignment of the car to determine how the changes affect the path the car will take down a hill. Use Appendix F: Wheel Alignment to test students’ mastery of the types of triangles.

The student should recognize that:

1. There are various types of triangles.
2. The use of geometry in the construction of the Soap Box Derby car is important to its performance.
3. The type (shape) of the triangle used to line up the frame is significant.
4. The frame must be in the shape of an isosceles triangle for it to travel in a straight path.

Once the above activity is completed, show the second half of the **Geometry** video. The students should keep track of all the ways that geometry is used in daily life as they are named in the video. A class discussion should be held to insure everyone caught all the examples. Ask students to name other examples.

Evaluation of Elaboration

Once the students have analyzed the test runs of virtual Soap Box Derby race cars, they will develop a presentation that includes a short paragraph and explanation of the best way to do the wheel alignment. Through class discussion, decide on the best sentences to use for a paragraph.

Elaboration Rubric

Thinking and problem-solving

No evidence	Some evidence	Evidence	Strong evidence
Does no testing	Testing but no analysis	Partial testing and analysis strategy and data analysis	Uses appropriate testing,

Uses technology appropriately

No evidence	Some evidence	Evidence	Strong evidence
Inappropriate use	Runs car tests	Runs tests, collects data records data	Runs tests, collects and

Connecting and Integrating Knowledge

No evidence	Some evidence	Evidence	Strong evidence
Does not communicate	Writing or graph missing demonstrates results	Writing *or* graph demonstrate results	Writing *and* graph

Applying basic science and math skills

No evidence	Some evidence	Evidence	Strong evidence
Draws no conclusions	Draws conclusions	Conclusions based on data	Conclusions supported by data

E. Final Assessment

Given a test (Appendix G: Pre-Test or Appendix H: Post-Test) with a diagram of Soap Box Derby car wheel and axle layouts, a protractor and a ruler, the students will measure the sides and angles to determine which angles will produce the best results and explain why. They will also determine shapes and demonstrate an understanding of the shortest distance between two points is a straight line.

Tools and Resources

Masters of Gravity CD-ROM and **Geometry** instructional television program
VCR and TV
Computer with Internet access and CD-ROM
Word processing and spreadsheet software
Non-stretch string (fishing line)
Protractors
Scissors
Rulers
Yardsticks
Paper
Colored pencils

Classroom Management

Suggested time frame for the lesson is six days:

Worksheets. *(1 class period each)*

CD-ROM activities. *(1 class period each)*

Shortest Distance Activity — can be done in the gym or on the playground or on large sheets of paper rather than in the classroom. Caution students to be careful when using scissors. *(1 class period)*

Student Groupings

Small group: experiments with measurement activity involving shortest distance between two points.

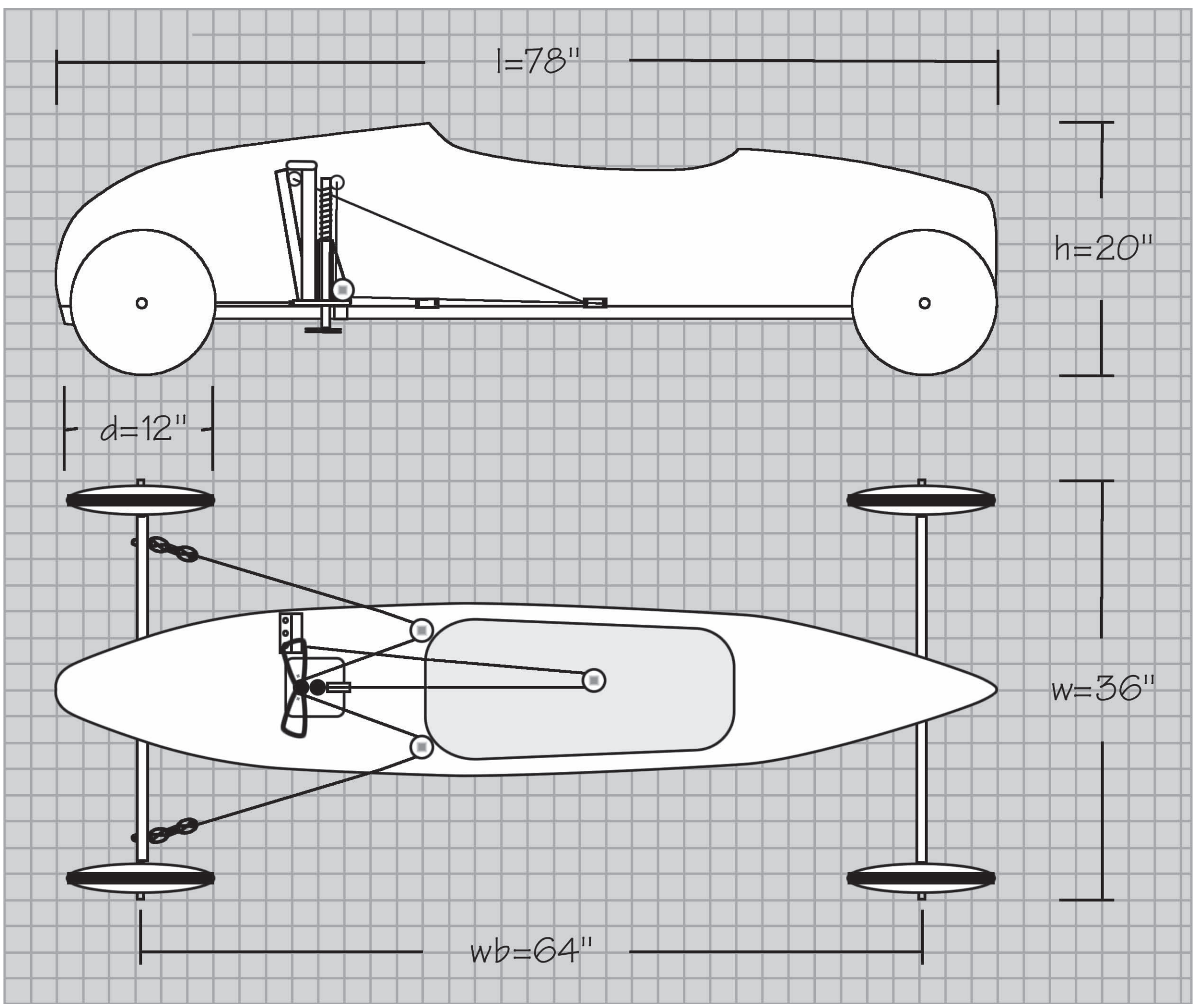
Individuals: development of written description of results.

Whole group: discussion and brainstorming of results of measurements and conclusions.

Geometric Shapes

Name: ____

Circle: Points in red
Line segments in blue
Planes in green
Angles in yellow
Circles in orange
Triangles in pink

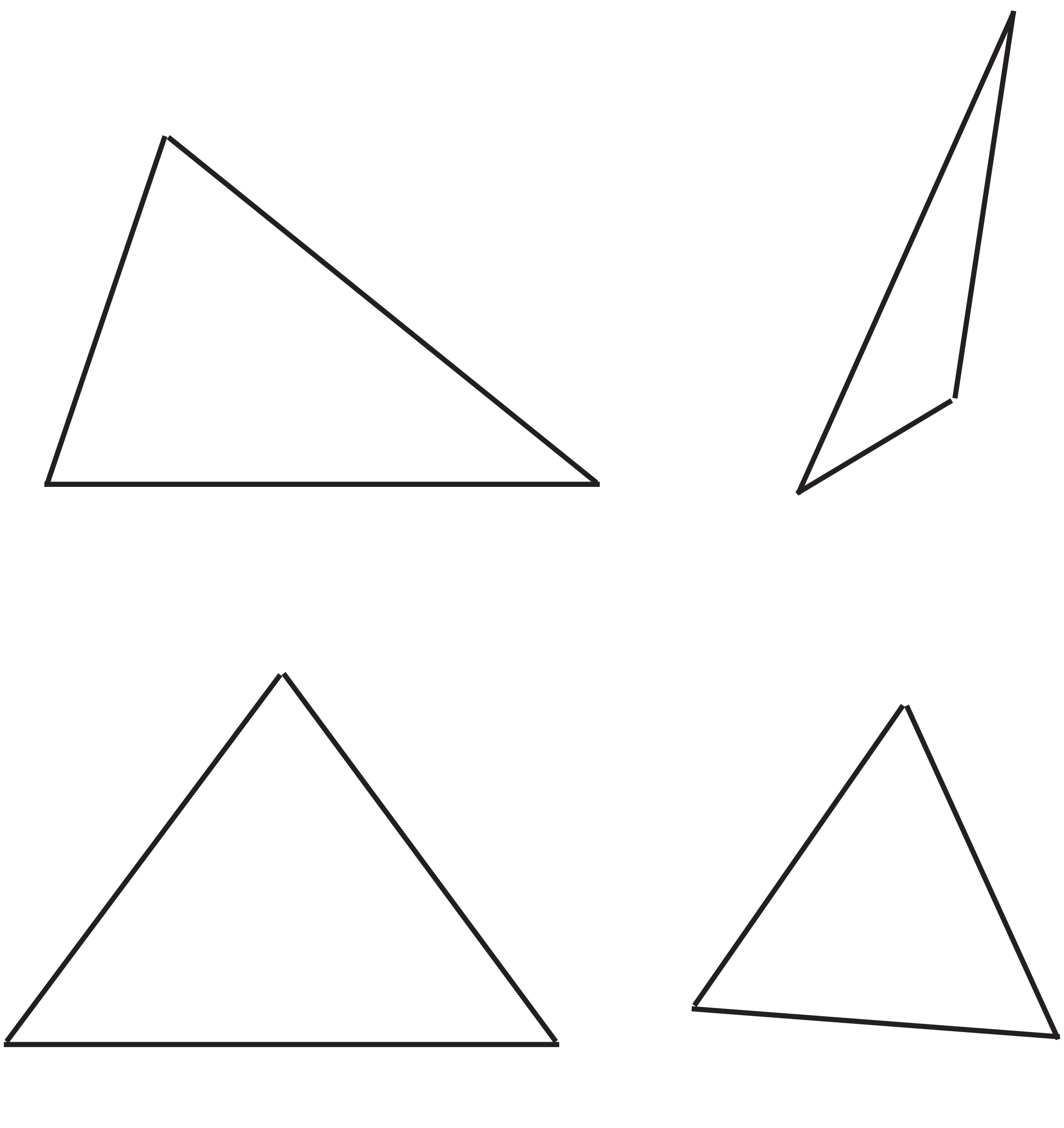


Scalene, Isosceles and Equilateral Triangles

Name: ____

Measure the sides of each triangle and label the measurements.

Identify each type of triangle based on your measurements.

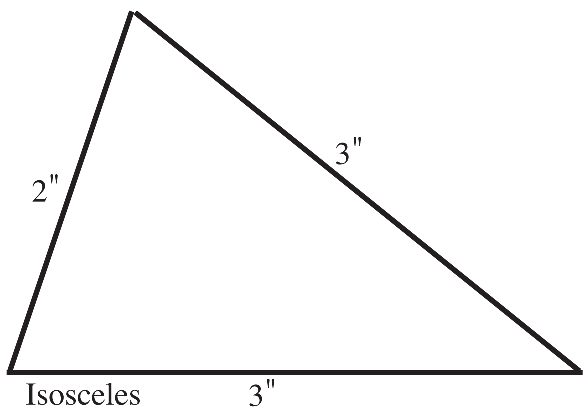


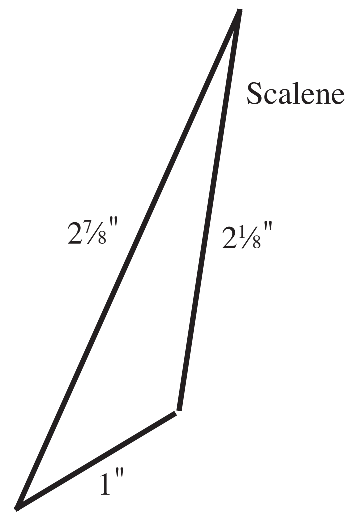
Appendix B

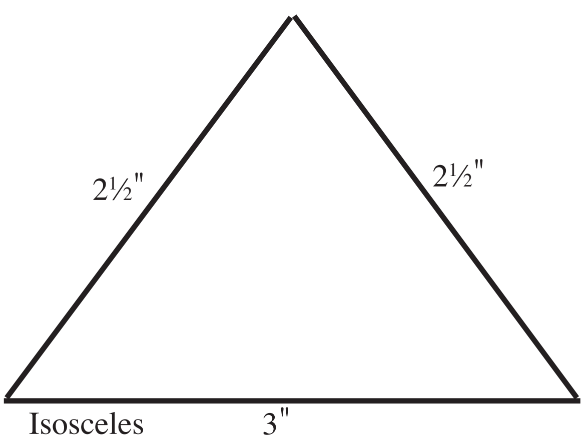
Answer Key: Scalene, Isosceles and Equilateral Triangles

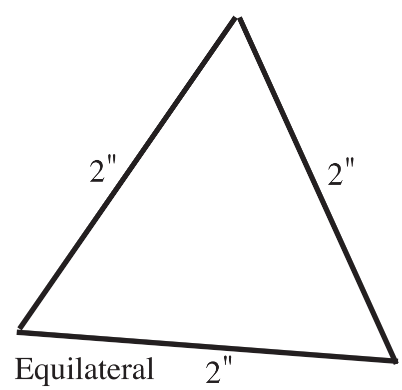
Measure the sides of each triangle and label the measurements.

Identify each type of triangle based on your measurements.









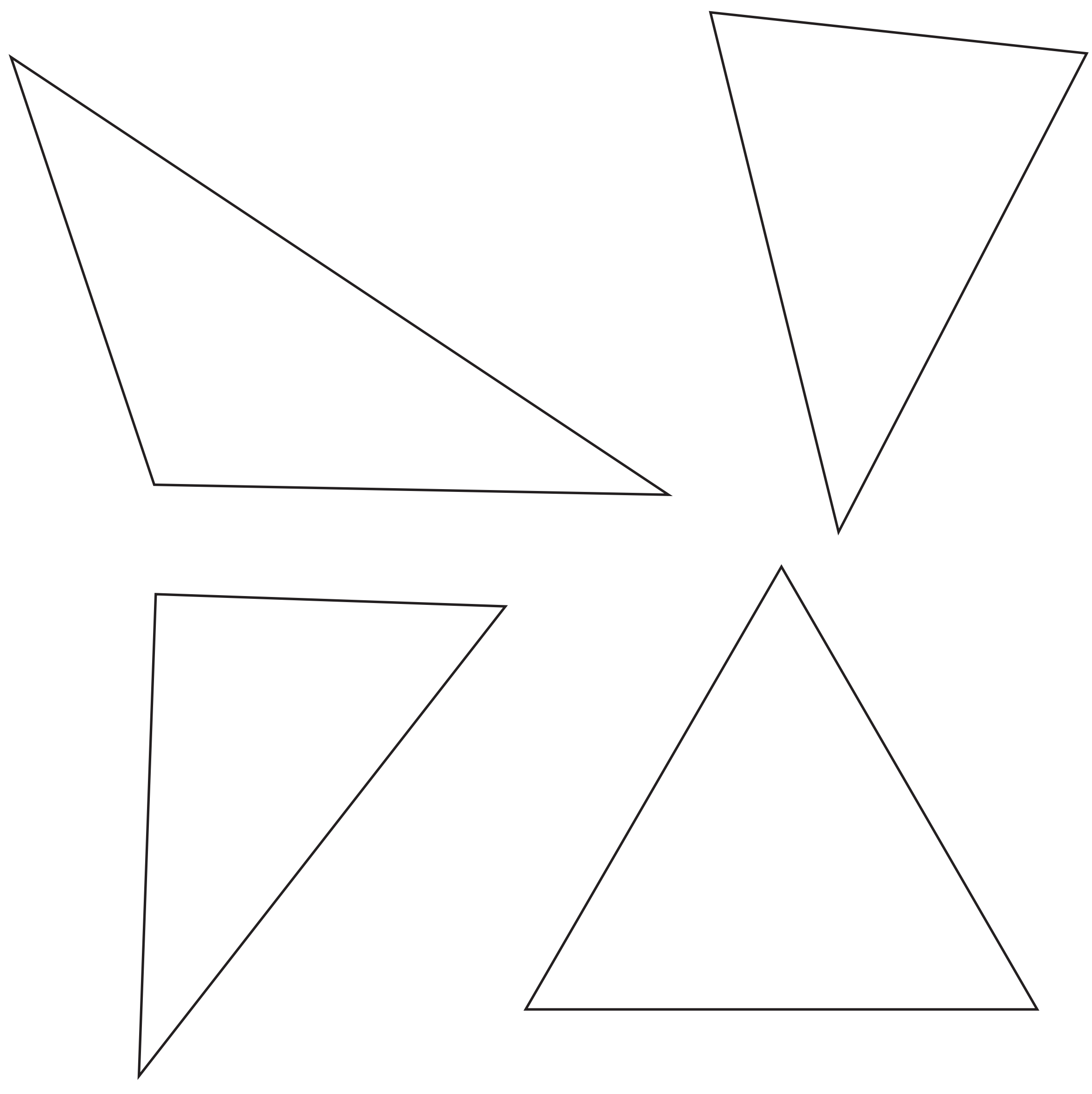
Appendix C

Acute, Right, Obtuse and Equiangular Triangles

Name: ____

Measure each angle in the triangle and label the measurements.

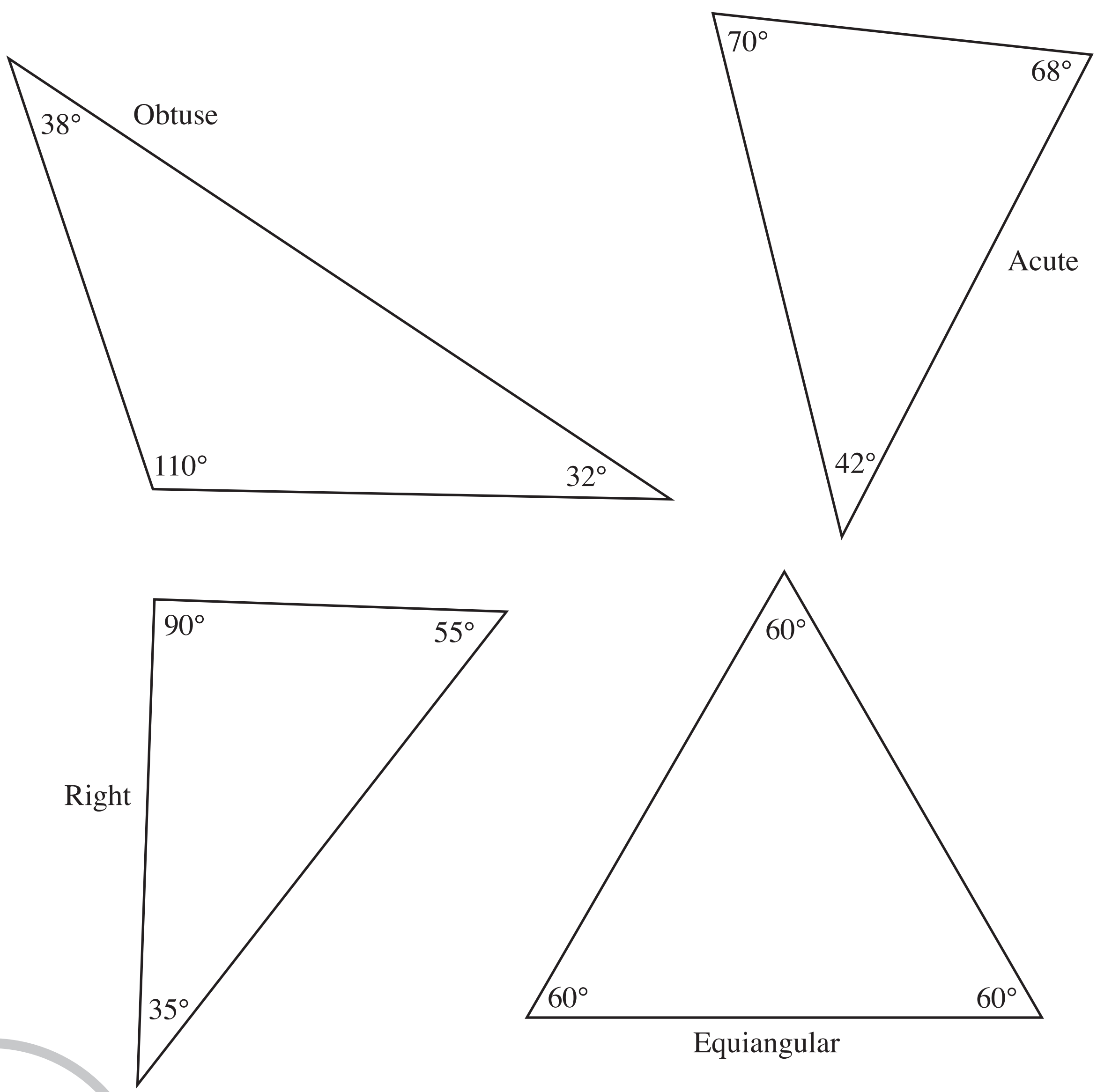
Identify each type of triangle based on your measurements.



Appendix C

Answer Key: Acute, Right, Obtuse and Equiangular Triangles

Measure each angle in the triangle and label the measurements. Tell what type of triangle it is based on your measurements.

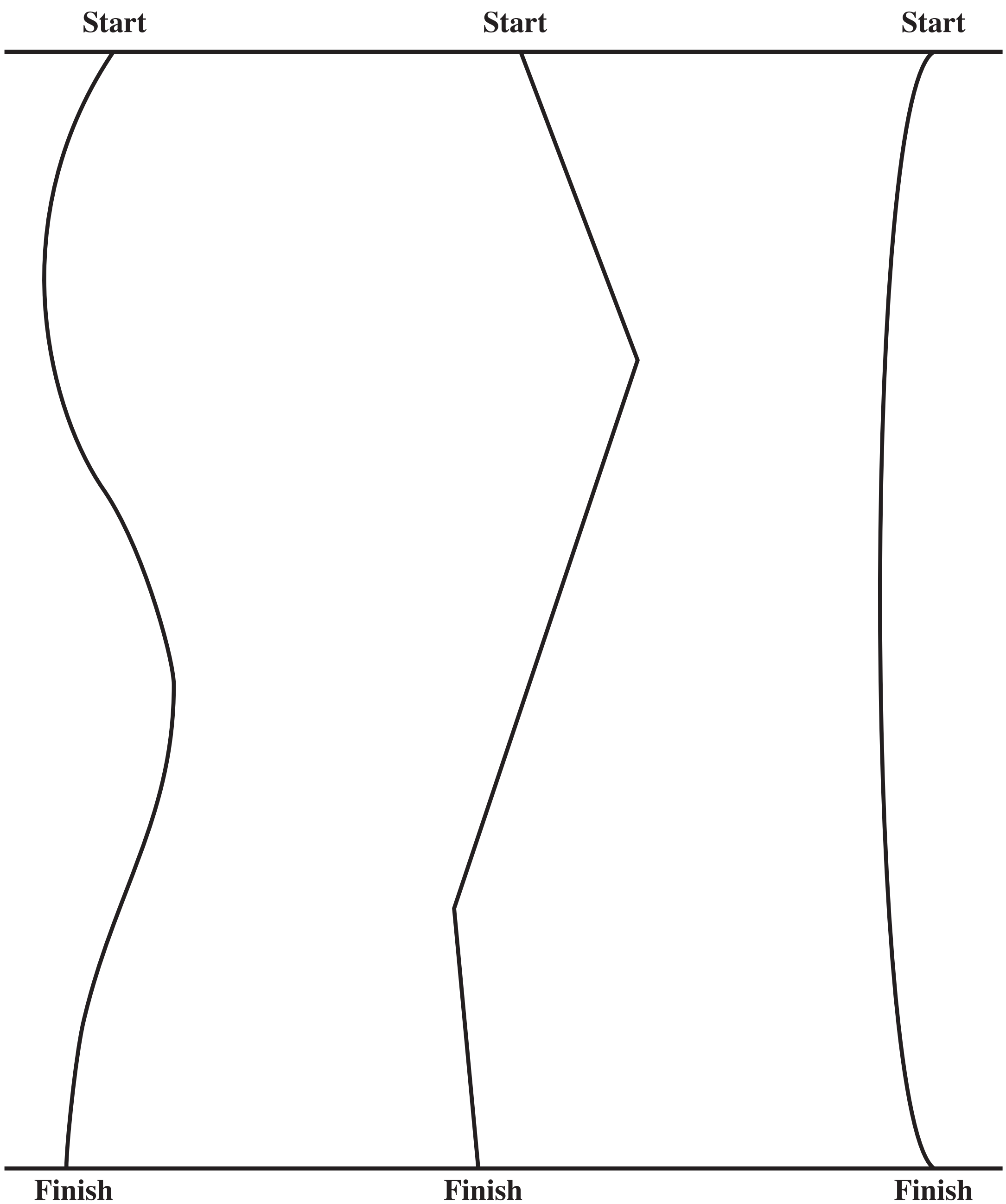


Appendix D

Shortest Distance

Name: ____

Use string, a ruler and scissors to measure each distance from start to finish. Record your answers and compare.



Appendix E

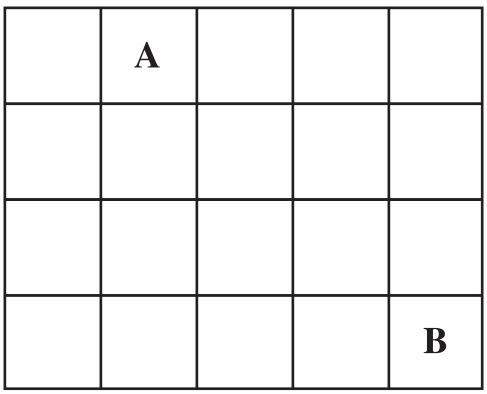
Taxi Cab Geometry

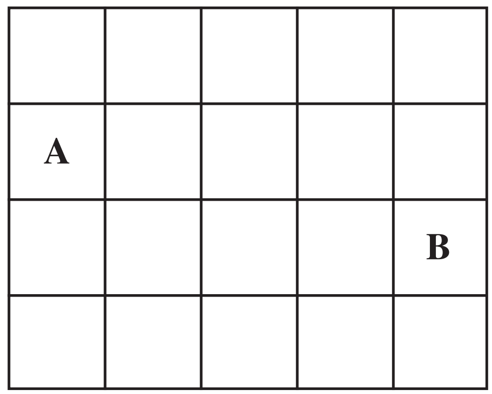
Name: ____

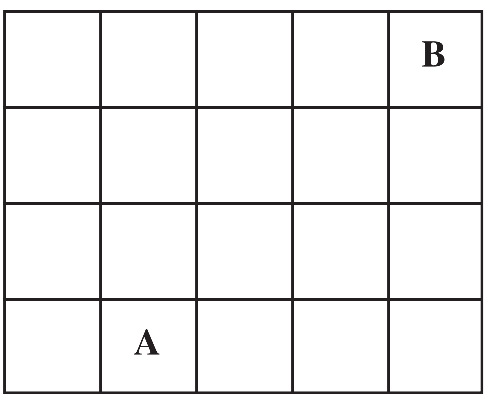
You're a taxi cab driver and you need to know the shortest distance between where you pick people up and where you drop them off. Using this graph paper as your map, figure out the fewest number of squares it takes to travel between points A and B.

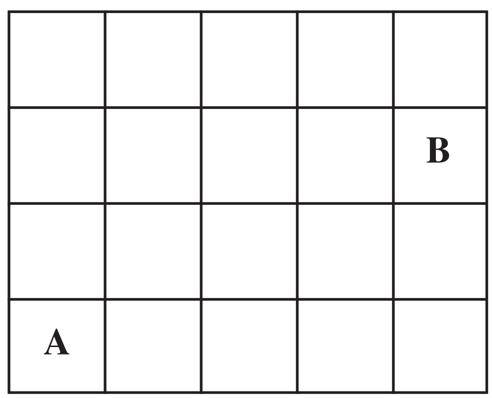
Here are the rules:

1. You may not connect diagonal squares.
2. You can only connect horizontal and vertical squares.
3. How many squares will it take to go from point A to point B?









Each square = .5 inch. Count the number of squares between point A and point B.

Multiply the number of squares you traveled by .5 to find out how far it is from point A to B. Now, draw a straight line between points A and B and measure it. Compare the distances.

Which is the shortest distance?

Appendix F

Wheel Alignment

Name: ____

While adjusting the rear wheels of the Soap Box Derby car, identify the types of triangles each alignment set-up shows.

Types of triangles: Scalene, Isosceles, Equilateral, Acute, Right, Obtuse, Equiangular

Set-up A: ____ .

Set-up B: ____ .

Set-up C: ____ .

Set-up D: ____ .

Set-up E: ____ .

Set-up F: ____ .

Set-up G: ____ .

Draw and label the type of triangle that makes the car go straight.

Appendix F

Answer Key: Wheel Alignment

Set-up A: Obtuse, Scalene

Set-up B: Acute, Scalene

Set-up C: Acute, Scalene

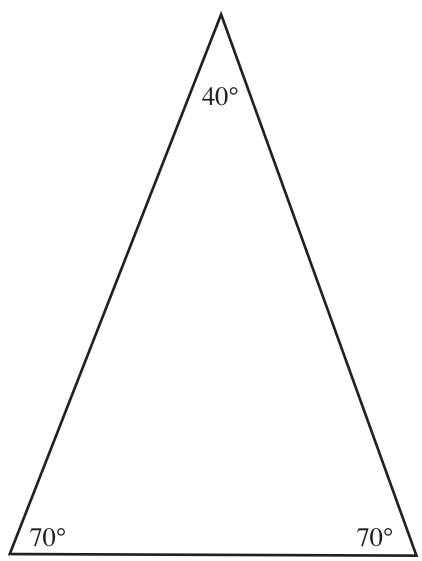
Set-up D: Acute, Isosceles

Set-up E: Acute, Scalene

Set-up F: Right, Isosceles

Set-up G: Obtuse, Isosceles

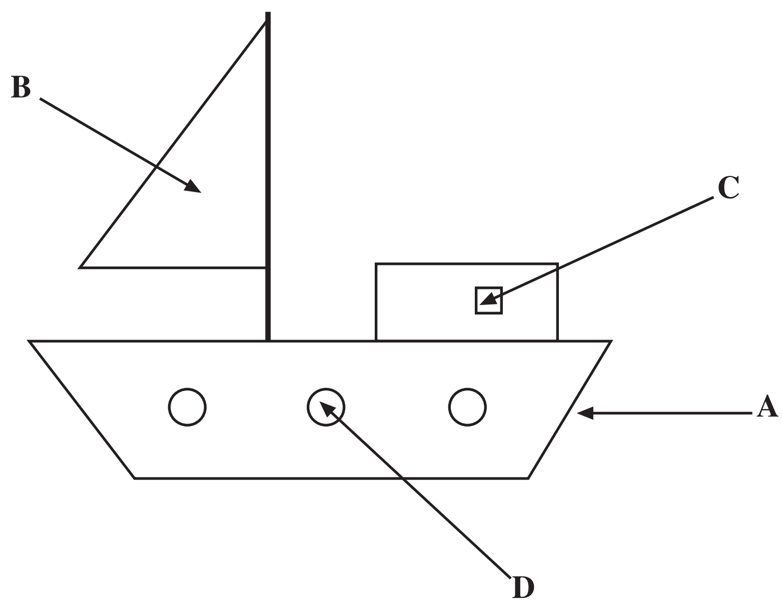
Draw and label the type of triangle that makes the car go straight.



Acute, Isosceles

Pre-Test: Geometry

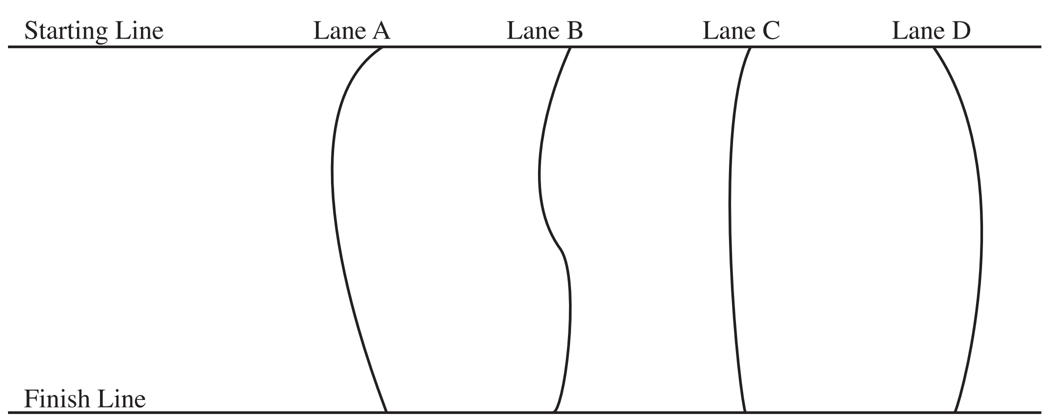
Name: ____

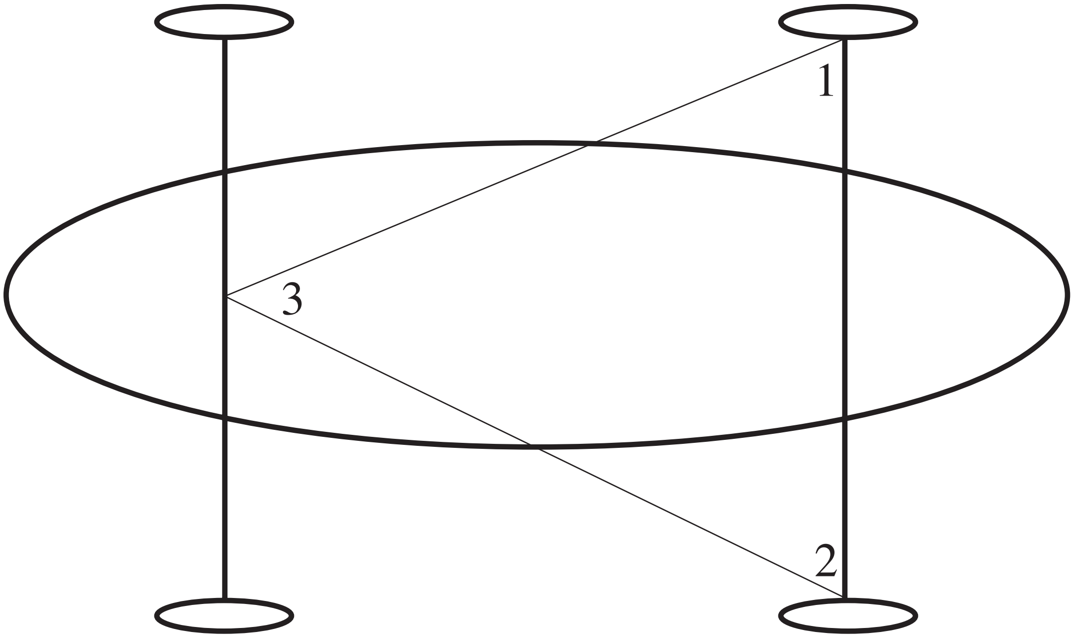


Using the diagram above, circle the letter that corresponds to the correct shape.

1. Triangle	A	B	C	D
2. Line Segment	A	B	C	D
3. Circle	A	B	C	D
4. Square	A	B	C	D

5. The diagram below represents paths of Soap Box Derby race cars during a race. If you want to win the race, which path would you choose? Circle your answer.





6. What angles would make the race car travel in a straight line?

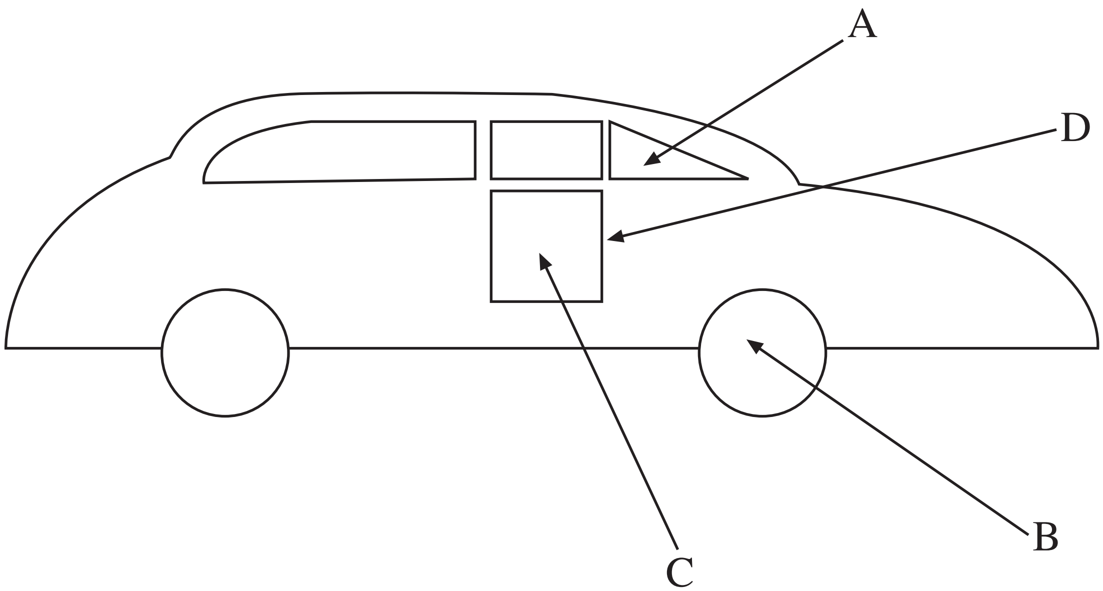
A. angle 1, 50 degrees	angle 2, 60 degrees	angle 3, 70 degrees
B. angle 1, 50 degrees	angle 2, 50 degrees	angle 3, 80 degrees
C. angle 1, 45 degrees	angle 2, 55 degrees	angle 3, 80 degrees
D. angle 1, 45 degrees	angle 2, 65 degrees	angle 3, 70 degrees

7. Explain why the answer you chose in question 6 will cause the car to go straight.

8. What type of triangle is shown in the diagram for question 6?

Post-Test: Geometry

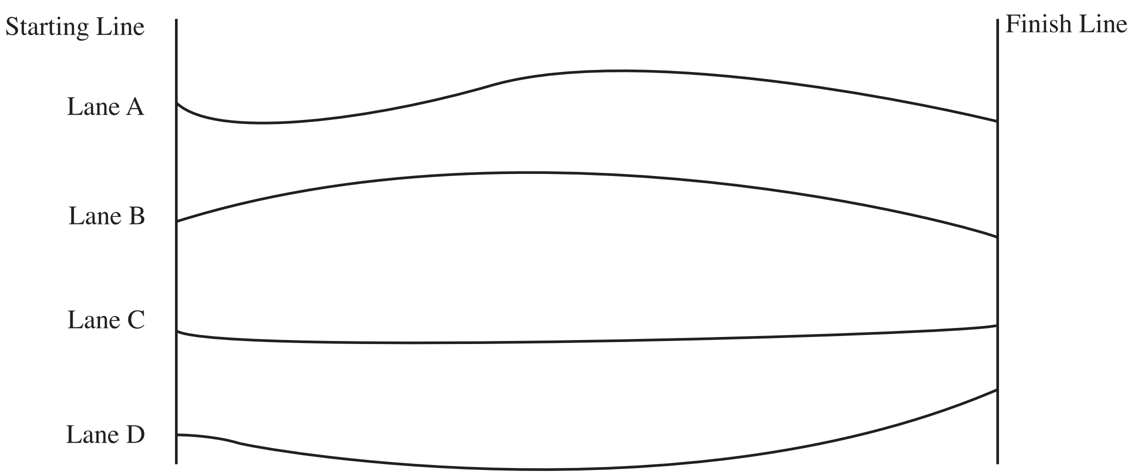
Name: ____

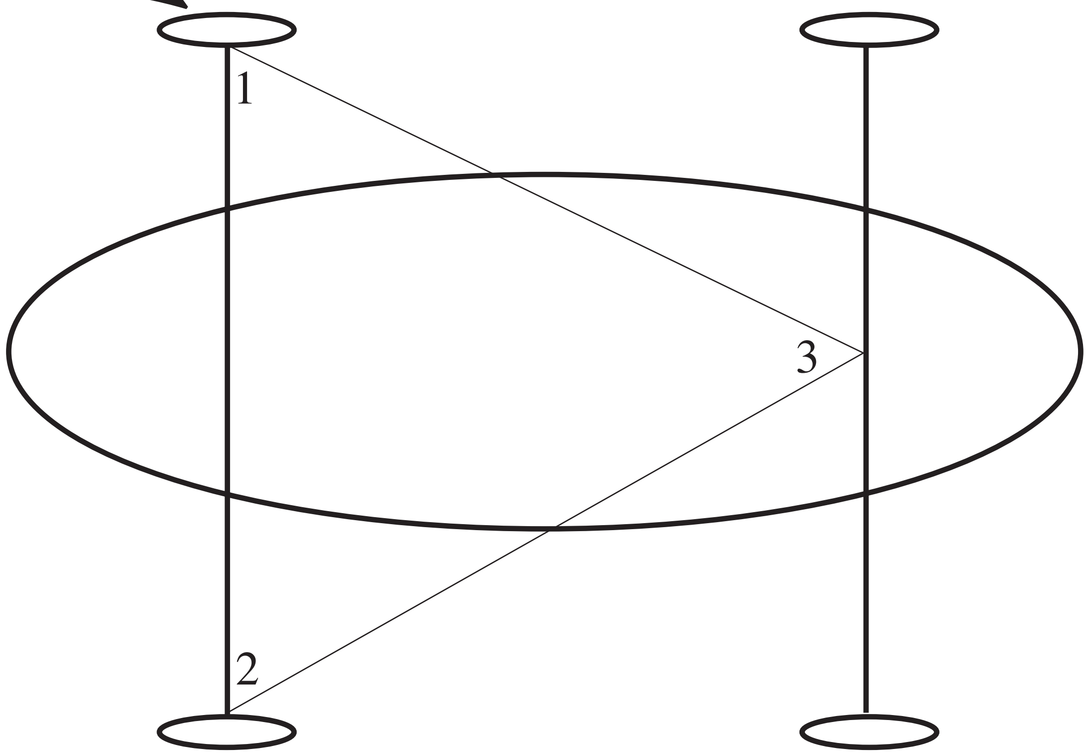


Using the diagram above, choose the letter that corresponds to the correct shape.

1. Square	A	B	C	D
2. Circle	A	B	C	D
3. Line Segment	A	B	C	D
4. Triangle	A	B	C	D

5. The diagram below represents the paths of race cars in a Soap Box Derby race. If you want to win the race, which path would you choose? Circle your answer.





6. In the diagram above, what angle measurements would make the car travel in a straight line?

A. angle 1, 60 degrees	angle 2, 50 degrees	angle 3, 70 degrees
B. angle 1, 65 degrees	angle 2, 70 degrees	angle 3, 45 degrees
C. angle 1, 70 degrees	angle 2, 70 degrees	angle 3, 40 degrees
D. angle 1, 65 degrees	angle 2, 45 degrees	angle 3, 70 degrees

7. Explain why the answer you chose for question 6 will cause the car to go straight.

8. What type of triangle is shown in the diagram for question 6?

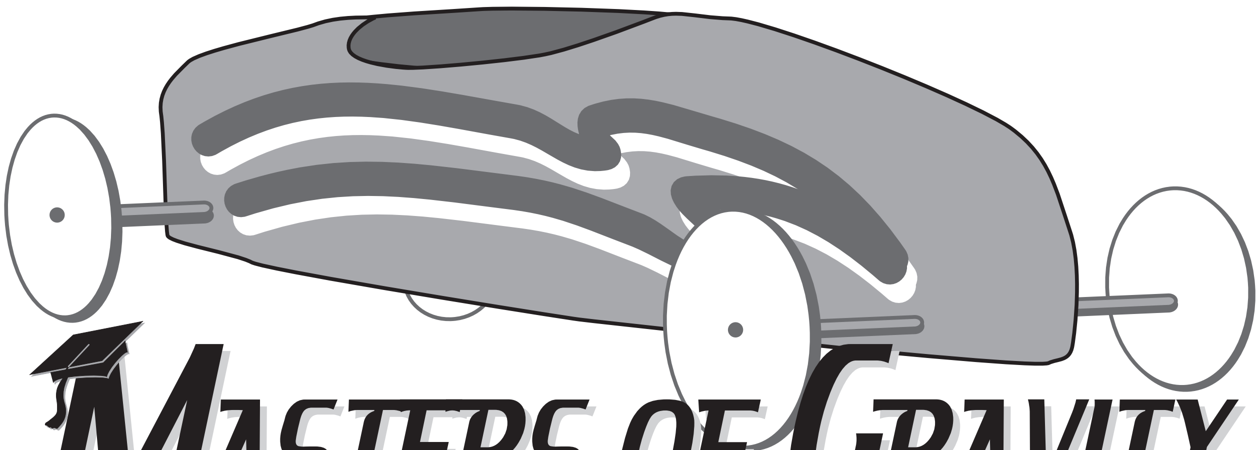
Answer Key

Appendix G: Pre-Test

1. b
2. a
3. d
4. c
5. c
6. b
7. Answers will vary
8. Acute, Isosceles

Appendix H: Post-Test

1. c
2. b
3. d
4. a
5. c
6. c
7. Answers will vary
8. Acute, Isosceles



Masters of Gravity

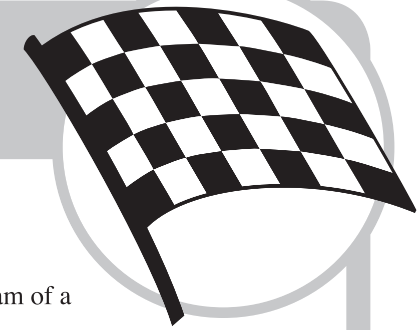
Program 4

Simple Machines

http://www.WesternReservePBS.org/gravity

Program 4:

Simple Machines



Learning Objectives

The students will:

1. Label the simple machines that are present when given a diagram of a mechanism that contains multiple simple machines.
2. Determine what (if any) simple machines are present when given examples of devices.
3. Construct a device consisting of two or more simple machines to accomplish a given task. Student can use K'Nex, Legos or other building blocks, or they can draw and label a prototype design to do this.

Author

Cathy Suess, Campbell City Schools, Campbell, Ohio

Target Audience

5th-Grade Science

Concept

This **Masters of Gravity** program demonstrates the presence, placement and use of simple machines.

Curriculum and Proficiency Standards Addressed

The students will:

1. Use a simple key to classify objects and/or phenomena.
2. Identify and/or explain the operation of a simple mechanical device, and/or the advantages or disadvantages to the user in its operation.

How Technology is Integrated in This Lesson

The students will:

1. Locate, evaluate and collect information from a variety of sources.
2. Use technology tools to process data and report results.
3. Employ technology in the development of strategies for solving problems in the real world.

Lesson Overview

Students will view the introduction to the video, **Masters of Gravity, Simple Machines,** which talks about how simple machines are used at the Soap Box Derby track — but not which simple machines are at work in the cars. That's for students to figure out when they are given the task of identifying the simple machines in a Soap Box Derby car. The students will be able to recognize the presence of simple machines in common devices. Students will also be given the job of assembling two or more simple machines to perform a given task. The simple machines are wheel and axle, inclined plane, pulley, wedge, lever and screw. Students should be familiar with these machines before experiencing this program.

Video Synopsis

Bridget and Austin are on their way home from school when they see their new neighbor getting out of a vehicle in a wheelchair. As she prepares to go into her house, Bridget and Austin offer to help. "Why thank you," she says, "but that's OK because I have wheels and an axle, and a ramp on the front of my house to give myself a mechanical advantage." The kids look puzzled and the person explains how these simple machines make her life easier. Bridget and Austin stop off at Alex's garage and try to impress him with their limited knowledge of simple machines. Alex asks if they know how many simple machines are in the Soap Box Derby racer Austin is building. The kids run home to check it out.

CD-ROM Activities

1. **Identify**
   Students are asked to identify the simple machines in a Soap Box Derby car.
2. **Memory Game** (timed)
   Students have 60 seconds to match the simple machine illustrations.

Follow-Up Video

Champions Chat: Mechanics
A world champion Soap Box Derby winner explains how simple machines work together to form everyday devices.

Bridget, Austin and Alex discuss all the simple machines that are used in Soap Box Derby cars. Students also see a montage of simple machines used in everyday life.

Champions Chat: Dedication
A world champion Soap Box Derby winner explains that follow-through is an important life lesson.

Learning Strategies

A. Engagement

Review simple machines by conducting a classroom activity in which students classify random objects as one of the six simple machines. (Refer to Appendix A: Prior Knowledge for definitions of the six simple machines.) The teacher should point out a few simple machines in the classroom to get things started, and then the class breaks out into small groups to find other simple machines in the classroom. After compiling a list of all the objects they can find, the students should classify them into each category of simple machines. After all objects are classified as an example of one or more of the six simple machines, each group should share their findings with the whole class.

Evaluation of Engagement

Each group is given Post-It Notes to label simple machines found in the classroom. As the lesson progresses additional classroom examples of simple machines should become apparent to the students. Every time a student discovers a new example, have him/her put up a new Post-It Note.

B. Exploration

The students will view the first segment of **Masters of Gravity, Simple Machines**, which explains how simple machines are used at the Soap Box Derby — but not which simple machines are found in the cars. The students are then given the task of identifying the simple machines in a Soap Box Derby car.

The students view a virtual race car on the **Masters of Gravity** CD-ROM and are asked to identify the simple machines found in the virtual car. (CD-ROM Activity: "Identify")

Evaluation of Exploration

Given a drawing of the Soap Box Derby car, determine and label each simple machine present. Students will then present their answers to the class. (Appendix C: Simple Machines)

C. Explanation

Students will use the CD-ROM activity, “Memory Game.” They have 60 seconds to match simple machine illustrations.

Students brainstorm how simple machines are used in other forms of transportation, for example, any other cars, bikes or riding devices used by students. Students can choose one of these devices and attempt to explain where simple machines are used and locate them. Students can refer to simple machines Web sites for ideas.

The class will watch the second half of **Simple Machines** to discover which simple machines can be found in a Soap Box Derby car as well as other uses of simple machines.

Evaluation of Explanation

Each student should write a paragraph about which simple machines they located, where they were located and what job they play in making transportation machines work. (See Appendix B for Rubric.)

D. Elaboration

Students should investigate Rube Goldberg in preparation for the school’s Invention Convention. Using some building parts, such as K’Nex, they should construct two or more simple machines that can complete a task. For example, students can combine a pulley with a wheel and axle in order to move a marble across the table without the marble touching the surface of the table. Or, use a pulley and some other simple machine to lift a brick without bending over and exerting their own force on it.

Evaluation of Elaboration

Students should display their inventions or prototype designs to determine if the task is completed and specific directions were followed.

E. Final Assessment

1. Students will write a paragraph detailing one of the simple machines located in the classroom. Post the students’ work next to each simple machine located around the room.
2. Students will identify the parts of a bicycle and categorize each part as one of the six simple machines (Appendix D: What Makes a Bicycle Go?).
3. Students will develop a short presentation about the compound machines they constructed for the elaboration phase of the lesson, be able to explain each simple machine they used and describe the job it accomplishes.

Program 4:

SIMPLE MACHINES

Tools/Resources

Masters of Gravity CD-ROM and **Simple Machines** instructional television program
VCR and TV
Computer with Internet access and CD-ROM
Array of items to be classified
K'Nex
Post-It Notes

Classroom Management

Suggested time frame for this lesson is seven to nine class periods:

Review and identify simple machines. *(1 class period)*

Video and CD-ROM activity. *(1 class period)*

Second CD-ROM activity, brainstorming, bicycle exercise, second half of the video. *(1 class period)*

Student designs and displays. *(2 to 3 class periods)*

Final Assessment: Write a paragraph, list simple machines in a bicycle and make presentations. *(2 to 3 class periods)*

Student Groupings

Whole group discussion for review of simple machines.

Small groups for classifying devices into categories of simple machines.

Partners to complete computer CD-ROM activities.

Individual/small group reports on inventions.

Appendix A
Prior Knowledge

Six Simple Machines:

Screw - an inclined plane wrapped around a cylinder to form a spiral.

Pulley - a rope, belt or chain wrapped around a grooved wheel.

Inclined Plane - a ramp.

Wheel and Axle - made of two circular objects, the wheel is the larger one, which turns about the smaller axle.

Wedge - an inclined plane that moves, made up of two inclined planes.

Lever - a rigid bar that is free to move about a fixed point.

Appendix B
Rubric

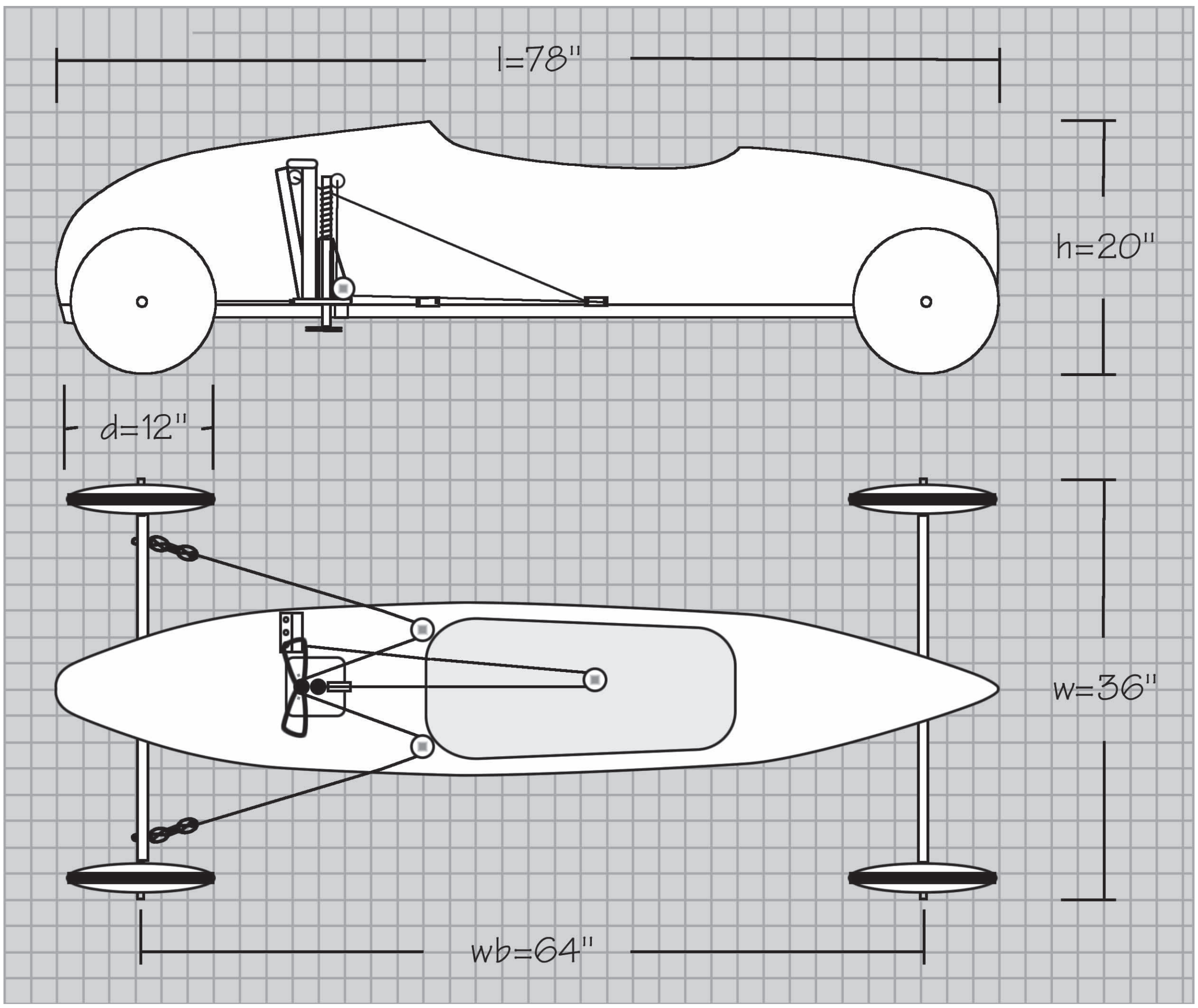
RUBRIC for the engagement, exploration, explanation, elaboration and final assessment:

3 POINTS	The student named the simple machine, identified its location and described the job it performs.
2 POINTS	The student accomplished only two of the three listed paragraph objectives.
1 POINT	The student accomplished only one of the three listed paragraph objectives.

Simple Machines

Name: ____

Circle: Screws in red
Pulleys in blue
Inclined planes in green
Wheel and axles in yellow
Wedges in orange
Levers in pink



Appendix D

What Makes a Bicycle Go?

Name: ____

Label any examples of the following six simple machines found on a bicycle:

Screw - an inclined plane wrapped around a cylinder to form a spiral.

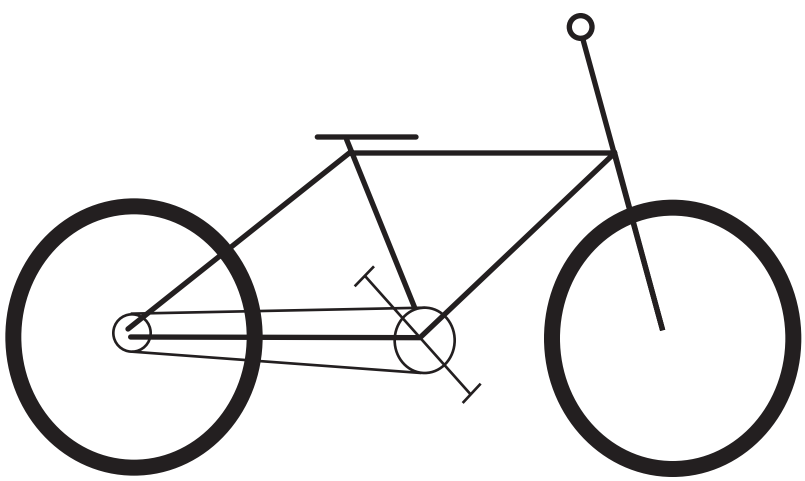
Pulley - a rope, belt or chain wrapped around a grooved wheel.

Inclined Plane - a ramp.

Wheel and Axle - made of two circular objects, the wheel is the larger one, which turns about the smaller axle.

Wedge - an inclined plane that moves, made up of two inclined planes.

Lever - a rigid bar that is free to move about a fixed point.



Appendix D

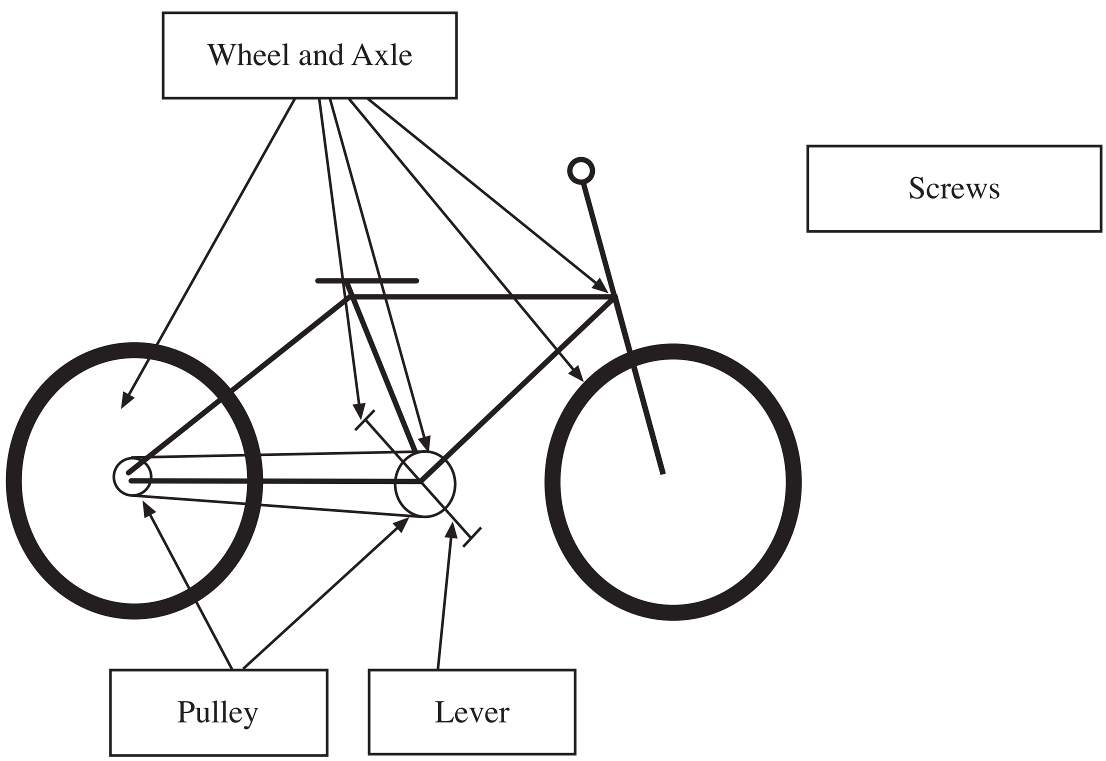
Answer Key: What Makes a Bicycle Go?

Screw - any screw used to fasten the bike together.

Pulley - the chain, front and back sprockets.

Wheel and Axle - front and rear wheels, front sprocket, pedals and where the handlebars rotate in the frame.

Lever - bar that attaches the pedals to the front sprocket.



Appendix E

Pre-Test: Simple Machines

Name: ____

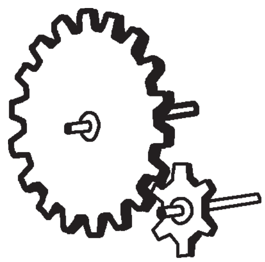
1. The simple machine in this diagram is:

   A. a lever

   B. an inclined plane

   C. a screw

   D. a wheel and axle



2. Observing a pencil sharpener, which of the simple machines is used in making it work?

   A. wheel and axle

   B. inclined plane

   C. wedge

   D. pulley

3. List 3 different things in the classroom that use simple machines and explain how those simple machines are used in them.

Appendix F

Post-Test: Simple Machines

Name: ____

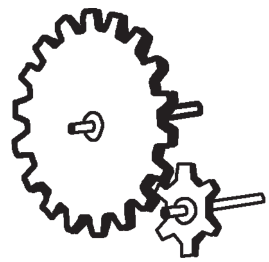
1. What part of the car uses this simple machine?

   A. frame

   B. brake

   C. weight plate

   D. steering wheel



2. A screwdriver is a common tool used in most homes. What three simple machines are at work in a screwdriver?

   A. Group 1: lever, wheel and axle, wedge

   B. Group 2: pulley, inclined plane, wedge

   C. Group 3: inclined plane, wedge, screw

3. List 3 different things in the classroom that use simple machines and explain how those simple machines are used in them.

Answer Key

Appendix E: Pre-Test

1. d
2. c
3. Answers will vary

Appendix F: Post-Test

1. d
2. a
3. Answers will vary

Masters of Gravity

Program 5

Gravity

http://www.WesternReservePBS.org/gravity

Program 5:

GRAVITY

Author

Amy Bennedetti, West Branch Local Schools, Beloit, Ohio

Target Audience

5th-Grade Science

Concept

This **Masters of Gravity** instructional television program demonstrates the effects of gravity on a Soap Box Derby car. Students will expand their knowledge of the concept of gravity and test simulated Soap Box cars to see how changing the weight of the driver will impact the movement of the car.

Learning Objectives

The students will:

1. Identify gravity as a source for getting objects to move.
2. Compare examples of gravitational potential energy (GPE) and conclude how kinetic energy changes as a result of a change in GPE.
3. Identify examples of how gravity makes things move in everyday examples.
4. Construct graphs to share group findings.

Curriculum and Proficiency Standards Addressed

The students will:

1. Investigate conditions that affect the motion of objects.
2. Use written representation to communicate work.
3. Read and interpret simple tables and graphs produced by self and others.
4. Use evidence and observations to explain and communicate the results of investigations.
5. Be able to formulate or identify questions that can be answered through scientific investigations.
6. Formulate and identify questions to guide scientific investigations that connect to science concepts.
7. Gather, record and organize data.
8. Interpret data and use the interpretation to generate explanations.
9. Construct hypotheses and test their validity based on collected evidence.
10. Explain how scientific procedures were used to obtain results.

How Technology is Integrated in This Lesson

The students will:

1. Develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits and productivity.
2. Use technology tools to enhance learning, increase productivity and promote creativity.

Lesson Overview

Students will be introduced to the idea that gravity makes things move. They will learn the term “gravitational potential energy” (GPE) and see how gravity makes objects like the Soap Box Derby cars move from one point to another. They will determine how changing the GPE of the car affects the movement of the car by testing variables with toy cars and ramps. The **Masters of Gravity** CD-ROM will be used to allow the students to virtually test the effects of various weights of drivers in the Soap Box Derby car. The students will use the data collected in the toy car tests and the CD-ROM activities to construct a graph and develop a presentation to share their findings with the class.

Program 5:

Gravity

Video Synopsis

Bridget, Austin and Kevin are playing in the back yard. As Bridget goes down a sliding board she asks why she can't slide up the slide. Austin thinks that's a silly question; it's gravity, of course! Bridget asks for an explanation of gravity, which Austin and Kevin can't supply. Kevin does remember that the Soap Box Derby is called the "Gravity Grand Prix." With that they decide Alex should know the answer. Alex is working on his old car and the kids ask him why the Soap Box Derby is called the Gravity Grand Prix. He has them get into the car, which is facing downhill, and shows them the emergency brake. When the brake is released the car coasts forward. He gives a brief explanation of gravity.

CD-ROM Activities

1. **Height of the Hill**
   Soap Box Derby cars are started from three different heights on the same hill. Discover if the starting height affects the speed of the car at the finish line.
2. **Large or Small?**
   Place a large animal or a small animal in the Soap Box Derby car to change the weight.
3. **Roller Coaster**
   After selecting a hill height, students see how the height of the hill affects the speed of the car. How high must the car be so that it makes it over the second hill?

Follow-Up Video

Champions Chat: Math and Science
A world champion Soap Box Derby winner reinforces how math and science learned now will be useful later in life.

Gravity in real life is explored. Alex explains how the driver of a super mileage car takes advantage of gravity during a driving competition. They use hills to shut off the engine and coast. Other examples of gravity in action include the movement of rivers (flowing downhill or over a waterfall), skydiving, scuba diving, rockslides, avalanches, trampolines and space (weightlessness).

Champions Chat: The Best Part of Racing
A world champion Soap Box Derby winner reinforces how families and other groups can pull together for a common cause.

Learning Strategies

A. Engagement

Gravity Makes Things Move!

Review with the students the importance of "fair tests" when doing any kind of experiment. Also review the scientific method (see Appendix A: Vocabulary) and post a list of the steps involved to allow students to refer to the method as they complete their activities.

Program 5:

Gravity

Introduce the idea that gravity makes things move by doing a classroom demonstration. Holding a softball and a golf ball at the same height from the floor, ask the students which ball they think will hit the floor first when they are let go at the same time. Discuss what makes the balls fall to the floor when released (gravity). Review that gravity is a force of attraction that exists between the earth and each ball. Explain that in this lesson the students will complete activities to explore how gravity is a factor in getting a Soap Box Derby car from the starting line to the finish line.

Evaluation of Engagement

Using various objects of different masses (such as a golf ball and a baseball), hold them at various equal heights and ask the students to predict which object will hit the floor first. The objects will always hit the floor at the same time unless air resistance is a factor.

B. Exploration

Toy Car Testing

Watch the introductory video segment of **Gravity**. After viewing, have the students work in groups to experiment (Appendix B: Does Height Matter?) using small toy cars and wooden ramps to see how changing the height of the starting point affects the distance that the car will travel. (The higher the starting point, the farther the car will travel before it stops if all factors are equal.) The groups will complete at least two tests at each height and find the average distance traveled.

To assure accurate results, each group should use the same car for all tests. Ramps can be made from 12-inch-wide pine plywood boards. Begin tests with ramps 4 cm from the floor and increase the height of the ramp 4 cm for each test.

Each group will then test the effects of weight on the movement of the car by taping metal washers to the top of the car and sending it down the track (Appendix C: Does Weight Matter?). After doing each test twice and recording the average distance that the car traveled, the groups will increase the number of washers and repeat the experiment.

Using the data they have collected from their experiments, have the students predict the results of the **Masters of Gravity** CD-ROM activities, “Height of the Hill” and “Large and Small.” The CD-ROM will allow the students to compare the effects of the movement of the car if the weight or height of the starting point changes. Depending on the ability level of the students, have them develop graphs for these activities.

Evaluation of Exploration

The students will write a brief explanation of the graphs and a summary of the results. For assessment, use the checklist included in Appendix D: Rubric for Group Graphs and Presentations.

C. Explanation

Sharing Data

Once the students have collected their data, made the graphs and summarized their findings, they will plan a short oral presentation to share with the class. During this presentation, the group graphs will be presented to the class and the students will explain what they have discovered. (The higher the starting point, the farther the car will travel. The heavier the car, the farther the car will travel.) Show the second half of the **Gravity** video. This video shows everyday examples of how gravity affects the movement of objects on Earth. Increasing gravity will increase the energy of whatever is moving. Introduce the phrase "gravitational potential energy," which is the amount of potential energy an object holds because of the pull of gravity on that object. The greater the gravitational pull, the more potential energy the object will have.

Evaluation of Explanation

The presentations and follow-up video should demonstrate that increasing the gravitational potential energy (GPE) of an object will increase the energy of the moving object. Use the rubrics in Appendix D to assess student performance.

D. Elaboration

Roller Coaster

Students brainstorm ways in which changing the gravitational potential energy of an object affects its movement.

The students will use the CD-ROM "Roller Coaster" activity to discover how raising the first hill of the ride increases the potential energy available.

Evaluation of Elaboration

Summarize in a journal entry how gravitational potential energy is demonstrated in the CD-ROM "Roller Coaster" activity.

E. Final Assessment

GPE Posters

Each student will create two posters showing what results as an object's gravitational potential energy changes. The posters should show an understanding of how changing the height and weight of an object will affect its motion. (Refer to the worksheet in Appendix E: GPE Posters for instructions.)

Program 5:

Gravity

Tools/Resources

Masters of Gravity CD-ROM and **Gravity** instructional television program
VCR and TV
Computer with Internet access and CD-ROM
Small toy cars (such as Hot Wheels)
Wooden ramps (one for each group)
Washers
Tape
Meter Stick

Classroom Management

Suggested time frame for this lesson is six class periods:

Gravity Makes Things Move! *(1 class period)*

Toy Car Testing. *(1 class period)*

Sharing Data. *(2 class periods)*

Roller Coaster. *(1 class period)*

GPE Posters. *(1 class period)*

Student Groupings

Small group for experiments with toy cars.

Whole group discussion of results from experiments and conclusions about gravitational potential energy.

Partners to conduct virtual experiments and record data.

Small group development of graphs and oral presentations.

Whole group participation in presentations of results.

Appendix A
Vocabulary

Air resistance - the upward force on an object as it falls. The greater the surface area, the greater the air resistance.

Free fall - the motion of an object when the only force acting on it is gravity.

Gravitational potential energy (GPE) - potential energy that is dependent on the height of an object.

Gravity - a force that pulls objects toward the earth.

Kinetic energy - energy that an object has due to its motion.

Laws of motion:

1. An object at rest will remain at rest. An object that is moving at a constant speed will remain moving at that speed unless acted upon by an outside force.
2. The net force of an object is equal to the product of its acceleration and its mass.
3. For every action there is an equal and opposite reaction.

Meter - basic international standard unit of length.

Potential energy - energy that is stored and waiting to be used.

Scientific Method: Seven Steps

1. State the question or problem.
2. Collect information.
3. Form a hypothesis (prediction).
4. Test the hypothesis (experiment).
5. Observe what happens.
6. Record and study the data collected.
7. Form a conclusion.

Sir Isaac Newton - English mathematician in the 1600s who stated the three laws of motion.

Terminal velocity - the greatest velocity an object can reach when it is falling.

Weight - the force of gravity on an object at the surface of the earth.

Appendix B

Does Height Matter?

Name: ____

Question: How does the height of the starting point affect the distance that the toy car will travel?

Hypothesis:

Materials needed (for each group): toy car, meter stick, masking tape, flat plywood board to be used as a ramp, supports to prop up ramps such as books or boxes.

Procedures:

1. Use masking tape to make a starting line on the ramp.
2. Prop the ramp up so the starting point is some distance from the floor. Measure this distance in centimeters and put it into the data table under Height of Starting Point.
3. Place the toy car at the starting point and release it. Allow the car to roll as far as possible. Measure the distance that the car travels in centimeters.
4. Record the distance on the data table under Trial 1.
5. Repeat the test from the same height and record this under Trial 2.
6. Find the average of the distances traveled and record on the data table.
7. Repeat steps 2 through 6, increasing the height of the ramp for each test.

Data Table

Height of Starting Point	Distance Traveled (Trial 1)	Distance Traveled (Trial 2)	Average

Does Height Matter?

Questions:

1. What variable did you change and which variable responded to that change? Explain.

2. On a graph, plot the average distance the car traveled (on the x-axis) against the height of the starting point (on the y-axis). Connect the points.

3. What does the shape of your graph show about the relationship between the height of the ramp and the average distance the car traveled?

4. Did your findings support your hypothesis? Explain.

Appendix C

Does Weight Matter?

Name: ____

Question: How does the weight of the toy car affect the distance it will travel?

Hypothesis:

Materials needed: Toy car, meter stick, masking tape, metal washers, plywood ramp, prop for ramp such as a box or books.

Procedures:

1. Use the masking tape to mark the starting point on the ramp.
2. Prop the ramp up so the starting point is some distance from the floor. Record the height of the starting point in centimeters in the space provided below.
3. The first trial should be conducted without any washers added to the car, so the first trial weight will be 0. Enter this under Weight of the Car Measured in # of Washers Added. Then, place the toy car at the starting line and release it. Allow the car to roll as far as possible. Measure the distance that the car traveled in centimeters.
4. Record this distance on the data table under Trial 1.
5. Repeat the test with the same weight and record this distance data under Trial 2.
6. Find the average distance that the car traveled. Record this distance on the data table.
7. Repeat steps 3 through 6, increasing the weight by taping additional washers on the car for each test.

Data Table

Height of the ramp _____________ (cm)

Weight of the Car Measured in # of Washers Added	Distance Traveled Trial 1 (cm)	Distance Traveled Trial 2 (cm)	Average

Does Weight Matter?

Questions:

1. Which variable did you change and which variable responded to that change? Explain.

2. On a line graph, plot the average distance the car traveled (on the x-axis) against the weight of the car for each trial (on the y-axis). Connect the points.

3. What does the shape of your graph show about the relationship between weight of the car and the average distance traveled?

4. Did your findings support your hypothesis? Explain.

Answer Key

Appendix B: Does Height Matter? (30 points)

Hypothesis: The higher the starting point the farther the car will go. (1 point)

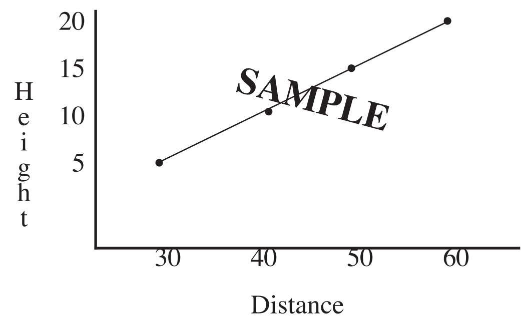
Data Table: Correctly filled out. (16 points)

Questions:

1. Variable changed: height. Variable responded: distance. Explain: more GPE. (3 points)

2. Line graph: (graphs will vary)
   - Title (1 point)
   - y-axis (1 point)
   - x-axis (1 point)
   - Plot points (4 points)
   - Lines (1 point)

Title: Height Changes Distance



3. As height increases so does distance. (1 point)

4. Answers will vary. (1 point)

Answer Key

Appendix C: Does Weight Matter? (23 Points)

Hypothesis: As weight increases the distance traveled will increase. (1 point)

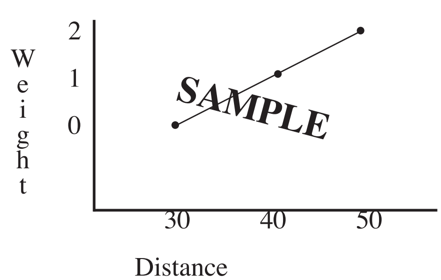
Data Table: Correctly filled out. (9 points)

Questions:

1. Variable changed: weight. Variable responded: distance. Explain: more GPE. (3 points)

2. Line graph: (graphs will vary)
   - Title (1 point)
   - y-axis (1 point)
   - x-axis (1 point)
   - Plot points (3 points)
   - Lines (1 point)

Title: Weight Changes Distance



3. As the weight increases so does the distance. (2 points)

4. Answers will vary. (1 point)

Appendix D

Rubric for Group Graphs and Presentations

Place a checkmark beside each of the following items that is evident from the group graphs and presentations.

	Yes (2 points)	**Somewhat** (1 point)	**No** (0 points)
The graph is constructed properly.			
The graph is neat and easy to read.			
The results of the tests are shown clearly on the graph.			
The group clearly communicates its findings to the class.			
Each group member is involved in the presentation.			
The group shows an understanding of the scientific concepts.			

Appendix E
GPE Posters

Assignment:

Each student will make two posters. One poster will show the results as gravitational potential energy changes for a toy car, and the second poster will show the results as weight increases on a toy car.

Materials Needed

(For each student) Two pieces of poster board, pencil, colored pencils, markers or crayons.

Procedures

1. Design a poster that shows what happens to the distance a toy car travels when the height of a starting ramp increases.
2. Design a poster that shows what happens to the distance a toy car travels when the weight of the car increases.
3. Use the materials provided to draw and color the two posters.
4. Write a summarizing paragraph at the bottom of each poster that explains what has been learned as a result of the lesson.

Poster Rubric

4 points	Each poster clearly shows correct conclusions drawn from the experiments in both the drawings and the summarizing paragraphs. The posters are neatly drawn and colored.
3 points	Each poster shows correct conclusions drawn from the experiments in both the drawings and the summarizing paragraphs. The posters are colored.
2 points	A conclusion is made but not complete. There are drawings, but they are not neatly done and/or colored.
1 point	Shows an incorrect conclusion or the assignment is incomplete.
0 points	Student did not complete project.

Appendix F

Pre-Test: Gravity

Name: ____

1. Dana and Jack are hiking when they come to a river. As they follow the bank of the river, they see that there is a waterfall. The river's water spills over the rocks in a rush. Which of the following causes the water to spill over the rocks?

   a. magnetism

   b. gravity

   c. elasticity

   d. static electricity

2. The 5th-grade class at Henderson Elementary School is doing an experiment with gravitational potential energy. The class is rolling a ball down a 10-centimeter-high ramp and timing how long it takes for the ball to reach the end of the ramp. After testing the ball with the ramp at a height of 10 centimeters, the class changes the height of the ramp to 20 centimeters. The gravitational potential energy at the 20-centimeter height will:

   a. increase

   b. decrease

   c. stay the same

3. In the space below, describe three objects you might see in the park that are moving because of gravity.

   1.

   2.

   3.

4. Using the data collected in the table below, construct a line graph showing the results of the experiment that was completed.

Height of Ramp	Distance Object Traveled
3 cm	10 cm
5 cm	16 cm
7 cm	22 cm

Appendix G

Post-Test: Gravity

Name: ____

1. Max is playing with the new toy car he got for his birthday. He is trying to make the car stay at the top of a ramp in his back yard, but every time he takes his hand off of the car it rolls down the ramp. What is causing the car to roll down the ramp?

   a. the ground

   b. magnetism

   c. gravity

   d. weight

2. Two students each have a golf ball and a ramp of the same length. Jon props up his ramp with books making the ramp 10 centimeters high. Jasmine props up her ramp with books making her ramp 12 centimeters high. When the students roll the golf balls down the ramps at the same time, whose golf ball will roll the farthest?

   a. Jon's

   b. Jasmine's

   c. they will both roll the same distance

3. You and a friend are enjoying a day at the amusement park. In the space below, describe three things that you might see at the amusement park that are moving because of gravity.

   1.

   2.

   3.

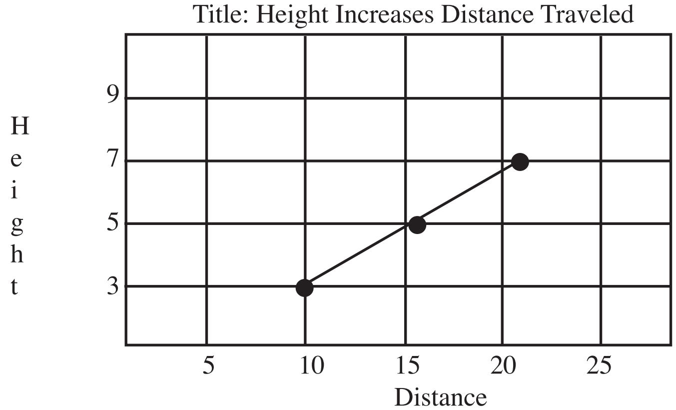
4. Mrs. Jackson's 5th-grade class completed an experiment with toy cars and wooden ramps. They changed the height of the ramp for each test to see if that would change the distance that the car would travel. The data they collected is recorded in the table below. Use the data to create a line graph showing the results of the experiment.

Height of ramp	distance car traveled
6 cm	14 cm
9 cm	22 cm
12 cm	31 cm

Appendix F: Pre-Test Answer Key

1. b
2. a
3. Answers will vary
4.

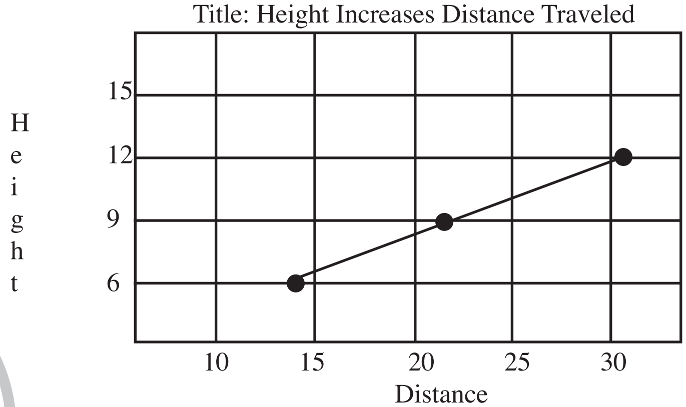
Title: Height Increases Distance Traveled



Appendix G: Post-Test Answer Key

1. c
2. b
3. Answers will vary
4.

Title: Height Increases Distance Traveled



Masters of Gravity

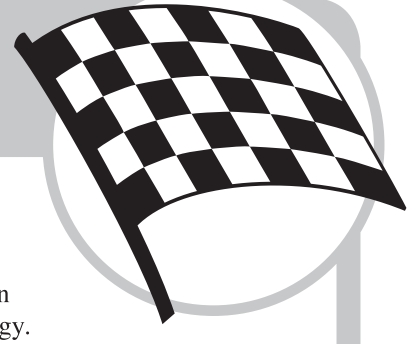
Program 6

Energy

http://www.WesternReservePBS.org/gravity

Program 6:

Energy



Author

Amy Bennedetti, West Branch Local Schools, Beloit, Ohio

Target Audience

5th-Grade Science

Concept

Masters of Gravity, Energy demonstrates how potential energy determines kinetic energy and how this relationship relates to the movement of a car in the Soap Box Derby. Also included in the video is an explanation of Newton's first law of motion.

Learning Objectives

The students will:

1. Label examples as being potential energy or kinetic energy when given a drawing showing examples of potential and kinetic energy.
2. Describe the relationship between potential and kinetic energy.
3. Recognize how Newton's first law of motion applies to various situations.
4. Describe investigative findings and support the findings with evidence.

Curriculum and Proficiency Standards Addressed

The students will:

1. Investigate the factors that influence the motion of objects.
2. Use written representation to communicate work.
3. Read and interpret simple tables and graphs produced by self/others.
4. Use evidence and observations to explain and communicate the results of investigations.
5. Be able to formulate or identify questions that can be answered through scientific investigations.
6. Formulate and identify questions to guide scientific investigations that connect to science concepts.
7. Gather, record and organize data.
8. Interpret data and use the interpretation to generate explanations.
9. Construct hypotheses and test their validity based on collected evidence.
10. Explain how scientific procedures were used to obtain results.

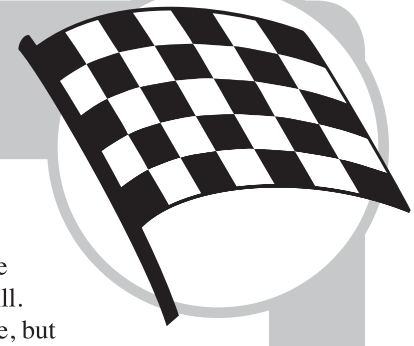
How Technology is Integrated in This Lesson

The students will:

1. Employ technology in the development of strategies for solving problems in the real world.
2. Use productivity tools to collaborate in constructing technology-enhanced models, preparing publications and producing other creative works.

Lesson Overview

Students will be introduced to the idea that the amount of potential energy of an object directly relates to the amount of kinetic energy the object will have. They will review the meanings of the terms "potential" and "kinetic" and discover the importance of the fact that the Soap Box Derby participants all start the race with the same potential. They will determine how changing the potential energy of an object will affect the kinetic energy of the object. Also, the students will review Newton's first law of motion and experiment with the idea behind this law. The **Masters of Gravity** CD-ROM will be used for the students to test the relationship between potential and kinetic energy. The students will use the information collected in the classroom activities and the CD-ROM activities to create a presentation for the class.



Video Synopsis

Bridget and Austin are on their skateboards when Austin announces that, in school today, he learned he has more potential than Bridget does so he'll go farther in this world than she will. To demonstrate his point, he challenges her to a skateboard race. They start at the same time, but Austin crosses the finish line ahead of Bridget. He says this proves he'll always go farther in anything that he does. Bridget is skeptical and thinks something is fishy. They go to Alex's and explain what happened. Alex introduces the concepts of potential and kinetic energy. Alex tells the viewers that Bridget and Austin's race contained too many variables to be valid. Your students are then invited to do some experiments to determine the difference between potential and kinetic energy.

CD-ROM Activities

1. **Throw the Ball**
   In this potential and kinetic energy demonstration, Bridget needs help throwing a ball.
2. **Matching**
   Students demonstrate knowledge of potential and kinetic energy.

Follow-Up Video

Champions Chat: Gravity Can Hurt!
A world champion Soap Box Derby winner reinforces how a sudden stop invokes Newton's first law of motion.

Alex explains Newton's first law of motion: An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless it's acted upon by an outside force. In other words, objects keep on doing what they're doing.

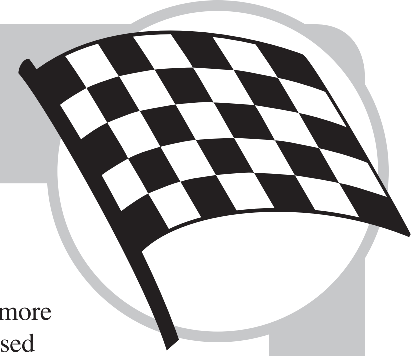
Learning Strategies

A. Engagement

Bouncing Ball
Divide the students into several small groups and provide each group with a tennis ball and a meterstick. Instruct one student in the group to hold the tennis ball next to the meterstick at 15 cm from the floor and let it go. The group should note the height at which the ball bounces after it hits the floor. Next, instruct another student in the group to hold the tennis ball at 25 cm from the floor and the group will note the height at which that ball bounces after it hits the floor. Discuss what causes the ball to reach different heights when dropped from different heights. (The ball has more potential energy as it is held higher; increased gravitational pull is what gives it more potential.)

Evaluation of Engagement

Using the tennis balls, have students make attempts at getting the ball to bounce to certain heights that are given by the instructor. Listen for "reasonable" explanations of what accounts for the different heights reached by the bouncing balls.



B. Exploration

What If?

Show the introductory video segment of **Energy**. The program shows that if one object has more potential energy than another, then that object will be able to move farther because of increased kinetic energy. After viewing the video, have the students review the terms potential and kinetic energy.

Evaluation of Exploration

During class discussion, observe the students for participation. Ask questions of specific students, using “what if” situations involving potential and kinetic energy.

C. Explanation

Throw the Ball* and *Matching

The students will complete the **Masters of Gravity** CD-ROM activities “Throw the Ball” and “Matching” in which they learn about potential and kinetic energy.

Evaluation of Explanation

The students will work in groups to come up with at least three examples of everyday situations that involve potential and kinetic energy. The groups’ examples will be shared with the class.

D. Elaboration

Energy in a Slingshot

The students will work in groups with a plastic toy slingshot and a small Nerf ball as well as a spring scale to test how changing the potential of the Nerf ball by increasing the pull on the slingshot will increase the kinetic energy of the ball and cause it to go farther. The groups should pull the spring scale to certain given measurements and record the distance that the ball travels. Then students can choose targets, estimate the amount of potential energy that will be needed to get the Nerf ball to that target and test their guesses. (See Appendix A: Energy in a Slingshot)

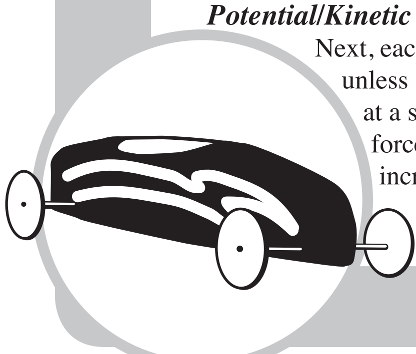
Evaluation of Energy in a Slingshot

The students will write a summary of what they have learned about potential and kinetic energy and how they are related. The summaries should include at least one real-life example of each idea. (See Appendix C: Instructions and Rubric)

Show the follow-up video segment of **Energy**. The video explains Sir Isaac Newton’s first law of motion: an object at rest tends to stay at rest and an object in motion tends to stay in motion at the same speed and in the same direction unless it’s acted upon by an outside force.

Potential/Kinetic

Next, each group will experiment with Newton’s first law of motion (an object at rest tends to stay at rest unless acted upon by an outside force) by rolling a water-filled two-liter bottle down a ramp aimed at a stationary softball. The groups will note that the ball will not move until the bottle (an outside force) hits it. Then test the results if the height of the ramp is increased or decreased, thereby increasing or decreasing the potential of the rolling bottle. How does this affect the motion of the softball? (Increased potential of the rolling bottle increases the kinetic energy of the softball.) (See Appendix B: Potential/Kinetic)



Evaluation of Potential/Kinetic

The students will write a summary of what they have learned about Newton's first law of motion. The summaries should include at least one real-life example of each idea. (See Appendix C: Instructions and Rubric)

E. Final Assessment

Energy Pamphlet
Each student will design and make a pamphlet in which all of the ideas presented in the lesson are summarized by written and drawn explanations. (See Appendix D: Energy Pamphlet for instruction sheet and rubric.)

Tools/Resources

Masters of Gravity CD-ROM and **Energy** instructional television program
VCR and television
Computer with Internet access and CD-ROM
Plastic toy slingshots (one per group)
Small Nerf ball (one per group)
Spring scales (one per group)
Two-liter bottles filled with water (one per group)
Softball (one per group)
Wooden ramps
Meter sticks

Classroom Management

Suggested time frame for this lesson is six class periods:

"Bouncing the Ball" and "What If?" *(1 class period)*

"Throw the Ball" and "Matching." *(1 class period)*

"Energy in a Sling Shot." *(1 class period)*

"Potential/Kinetic." *(1 class period)*

"Energy Pamphlet." *(2 class periods)*

Student Groupings

Small groups for "Bouncing Ball," "Energy in a Slingshot" and "Potential/Kinetic."

Whole class for "What If?" discussion.

Individual for CD-ROM activities and "Energy Pamphlet."

Appendix A

Energy in a Slingshot

Name: ____

Question: How does changing the potential energy of a toy slingshot change the kinetic energy of an object being launched from the slingshot?

Hypothesis:

Materials needed: Toy slingshot, spring scale, small Nerf ball, meter stick

Procedures:

1. Connect the spring scale to the band of the slingshot and pull the band back with the spring scale to the desired measurement. Hold the band at the same point as the spring scale is removed. Hold the Nerf ball in the band and release.
2. Using the meter stick, measure the distance the ball travels.
3. Record this distance on the data table.
4. Repeat the test at the same measurement on the spring scale and record this distance on the data table.
5. Calculate the average distance that the Nerf ball traveled. Record this distance on the data table.
6. Repeat steps 3 through 5, increasing the amount of pull on the slingshot band for each test.
7. Choose various targets around the room and estimate how much pull will be required to shoot the Nerf ball to each target.

Data Table

Measurement on Spring Scale	Distance Traveled (Trial 1)	Distance Traveled (Trial 2)	Average

Energy in a Slingshot

1. What variable did you change and which variable responded to that change? Explain.

2. On a graph, plot the average distance the Nerf ball traveled (on the x-axis) against the measurement on the spring scale (on the y-axis). Connect the points.

3. What does the shape of your graph show about the relationship between the measurement on the spring scale and the average distance the Nerf ball traveled?

4. Did your findings support your hypothesis? Explain.

Potential/Kinetic

Name: ____

Question: How does changing the potential energy of one object affect the kinetic energy of another object?

Hypothesis:

Materials needed (per group): two-liter bottle filled with water, wooden ramp, softball, meter stick or measuring tape, masking tape, boxes or books

Procedures:

1. Place a strip of masking tape near the top of the ramp to mark a starting line.
2. Measure 30 cm out from the bottom of the ramp and place a piece of masking tape there to mark the spot for the softball.
3. Place the softball on the tape on the floor.
4. Prop the ramp to the desired height using the boxes or books.
5. Hold the two-liter bottle at the starting point on the ramp and release (without pushing).
6. After the bottle hits the softball and the ball quits rolling, measure the distance that the softball travels and record on the data table.
7. Repeat the test with the ramp at the same height. Record the distance that the softball travels. Calculate an average of the two distances and record on the data table.
8. Repeat steps 6 and 7 for each increased height of the ramp.
9. Discuss with your group the conclusion that can be made about how the increased height of the ramp (increased potential energy of the bottle) affects the movement (kinetic energy) of the softball.

Data Table

Height of Ramp	Distance Traveled (Trial 1)	Distance Traveled (Trial 2)	Average

Potential/Kinetic

1. What variable did you change and which variable responded to that change? Explain.

2. On a graph, plot the average distance the softball traveled (on the x-axis) against height of the ramp (on the y-axis). Connect the points.

3. What does the shape of your graph show about the relationship between height of the ramp and the average distance the softball traveled?

4. Did your findings support your hypothesis? Explain.

Answer Key:

Appendix A: Energy in a Sling Shot (26 points)

Hypothesis: The farther back the slingshot is drawn, the farther the Nerf ball will go. (1 point)

Data Table: Correctly filled out. (12 points)

Questions:

1. Variable changed: pull back length. Variable responded: distance. Explain: more potential energy. (3 points)
2. Line graph: (graphs will vary)

Title: Potential Increases Kinetic Energy

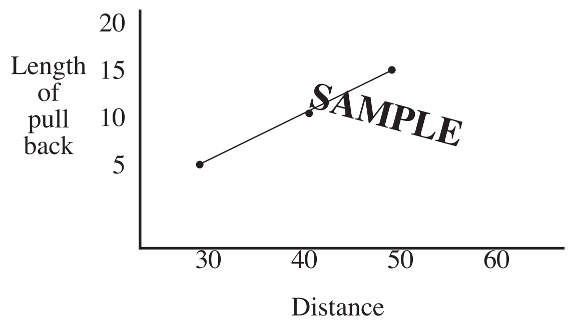
Title (1 point)

y-axis (1 point)

x-axis (1 point)

Plot points (3 points)

Lines (1 point)



3. As pull back increases so does distance. (1 point)
4. Answers will vary. (2 points)

Answer Key

Appendix B: Potential/Kinetic (26 Points)

Hypothesis: As you increase the potential energy of the pop bottle, the kinetic energy released in the softball will increase. (1 point)

Data Table: Correctly filled out. (12 points)

Questions:

1. Variable changed: height. Variable responded: distance. Explain: more potenial energy. (3 points)
2. Line graph: (graphs will vary)

Title (1 point)

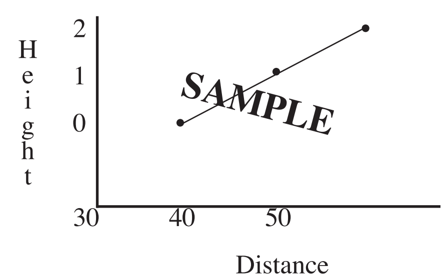
y-axis (1 point)

x-axis (1 point)

Plot points (3 points)

Lines (1 point)

Title: Potential Increases Kinetic Energy



3. As the height increases so does the distance. (1 point)
4. Answers will vary. (2 points)

Appendix C
Instructions and Rubric for Elaboration Evaluation Assignments

Energy in a Slingshot

Each student will write a summary that includes an explanation of how the potential energy of an object affects the kinetic energy of that object. A real-life example of each idea should also be included.

Rubric

4 points	The summary is neatly written and includes a clear and correct explanation of what was learned about the relationship between potential and kinetic energy.
3 points	The summary is complete and includes correct explanations of the relationship between potential and kinetic energy.
2 points	The summary includes a partial explanation of the relationship between potential and kinetic energy.
1 point	The summary is incomplete or includes incorrect ideas.
0 points	No summary.

Potential/Kinetic

Each student will write a summary that includes an explanation of what the student has learned about Newton's first law of motion. The law should be stated in the summary and the student should explain in his or her own words what he/she has learned regarding this law. A real-life example of each idea should also be included.

Rubric

4 points	The summary is neatly written and includes a clear and correct explanation of Newton's first law of motion. The summary also includes a real-life example of each idea.
3 points	The summary is complete and includes correct explanations of Newton's first law of motion.
2 points	The summary includes a partial explanation of Newton's first law of motion.
1 point	The summary is incomplete or includes incorrect ideas.
0 points	No summary.

Appendix D

Energy Pamphlet

Assignment

Design and make a pamphlet that includes drawn and written explanations of the ideas covered in this lesson.

1. Show and label examples of potential and kinetic energy.
2. Describe the relationship between potential and kinetic energy.
3. Describe how Newton's first law of motion applies to various situations.
4. Describe the findings of your experiments.

Materials

8½ x 11 white paper, stapler, pencils, markers or crayons

Procedures For Pamphlet

1. Use one or two sheets of 8½ x 11 white paper. The papers should be stacked and folded in half.
2. Staple the folded papers at the side to make the pamphlet.
3. Design a cover for the pamphlet.
4. On the pages of the pamphlet summarize the ideas learned in this lesson with words and pictures.

Rubric

4 points	The pamphlet is neatly done and completely and correctly explains the ideas learned in the lesson with pictures and words. The pictures are appropriate examples.
3 points	The pamphlet is complete and includes pictures and words that correctly explain the ideas learned in the lesson.
2 points	The pamphlet includes pictures and/or words and partially explains the ideas learned in the lesson.
1 point	The pamphlet is incomplete and/or contains incorrect explanations.
0 points	No pamphlet.

Appendix E

Pre-Test: Energy

Name: ____

1. A rock sitting at the top of a hill is kicked by a small boy. As the rock rolls down the hill, which form of energy is at work?

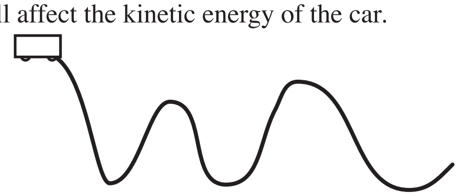
   a. potential

   b. kinetic

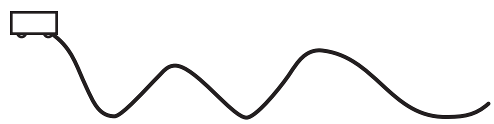
   c. chemical

   d. nuclear

2. Which roller coaster car will have the most potential energy? Circle your answer. Describe how that potential will affect the kinetic energy of the car.



Roller Coaster A



Roller Coaster B

3. Mary is watching a crash test in which dummies are being used to test the safety of different cars. The dummies are thrown forward when the car hits a wall. Which of the following causes the dummies to be thrown forward?

   a. The dummies were traveling at a constant speed until the car hit the wall.

   b. The car moved so fast that it caused the dummies to go into the windshield.

   c. The dummies had more weight on the top so they tended to move forward when the car hit the wall.

   d. The dummies wanted to crash into the windshields.

4. Mrs. Smith's 5th-grade class completed an experiment on potential and kinetic energy. A basketball was dropped from various heights and the return bounce of the ball was measured. They summarized the findings of the investigation on a chart as shown:

Height of basketball before bounced	Height of return bounce
7 cm	5 cm
10 cm	8 cm
18 cm	16 cm

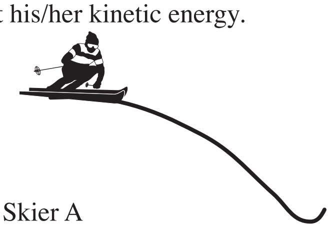
Using the data that the students in Mrs. Smith's class collected, describe how a change in the potential energy of the basketball affects the return bounce of the ball. Support your explanation with evidence from the data in the chart.

Post-Test: Energy

Name: ____

1. A toy car sits at the top of a wooden ramp. A girl passing by taps the car and it rolls down the ramp. Identify the energy as the car sits at the top of the ramp.
   a. potential
   b. kinetic
   c. chemical
   d. nuclear

2. Which skier has more potential energy, skier A or skier B? Circle your answer. Describe how that skier's position will affect his/her kinetic energy.



Skier A

Skier B

3. An egg delivery truck is traveling at a constant speed down a country road. Suddenly, a deer runs in front of the truck and the driver slams on the brakes. The eggs in the back are thrown forward. Which of the following causes the eggs to be thrown forward?
   a. The eggs had less friction when the driver hit the brakes.
   b. The driver threw the eggs forward because he was angry.
   c. The eggs were traveling at a constant speed until the driver hit the brakes to stop the truck.
   d. The truck was on a hill and gravity caused the eggs to move forward.

4. Mr. Brown's 5th-grade class completed an experiment on potential and kinetic energy. For their investigation, the students shot Cheerios with toy slingshots. For each shot, the students measured how far back the slingshot was pulled and then measured how far the Cheerio flew. Their results were recorded in the chart below:

Length slingshot was pulled back	Distance Cheerio flew
3 cm	7 cm
5 cm	12 cm
8 cm	20 cm

Using the data the students collected, describe how a change in the potential energy of the Cheerio in the slingshot affects the kinetic energy of the Cheerio. Support your explanation with evidence from the data in the chart.

Answer Key

Appendix E: Pre-Test

1. b
2. a — Car A will travel faster and farther.
3. a
4. The higher the starting point for the ball, the more potential energy it has. The more potential energy that is available, the higher the ball will bounce (release of kinetic energy). The data shows that the farther up the ball is released, the higher it will bounce.

Appendix F: Post-Test

1. a
2. a — Skier A is on a higher hill. When he starts down the hill, he will release more kinetic energy.
3. c
4. The farther back the slingshot is pulled, the more potential energy there is. When the slingshot is released, the Cheerio has more kinetic energy due to its motion. The data shows that the farther back the slingshot is pulled, the farther the Cheerio travels.

Masters of Gravity

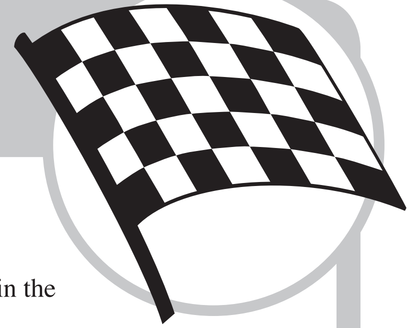
Program 7

Friction

http://www.WesternReservePBS.org/gravity

Program 7:

Friction



Author

Pat McClun, Leetonia Exempted Village Schools, Leetonia, Ohio

Target Audience

5th-Grade Science

Concept

Friction is a force that opposes motion. Rolling, sliding and air resistance are three kinds of friction. Students will explore these concepts in classroom activities and later apply them to the movement of a Soap Box Derby car.

Learning Objectives

The students will:

1. Apply knowledge of variables by identifying a variable present in the description of an experiment.
2. Demonstrate an understanding of aerodynamics by developing, designing and conducting a simple experiment to measure the effect of aerodynamics on speed.
3. Draw a design of a car and describe places where friction has been increased or decreased to enhance the performance of the car.

Curriculum and Proficiency Standards Addressed

The students will:

1. Identify one or two variables in a simple experiment or investigation.
2. Develop, design and conduct simple experiments to answer questions.
3. Evaluate a product or design.

How Technology is Integrated in This Lesson

The students will:

1. Use the **Masters of Gravity** CD-ROM to test the effects of increasing or decreasing friction.
2. Develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits and productivity.
3. Use technology to locate, evaluate and collect information from a variety of sources.

Lesson Overview

Students will participate in activities to engage them in the observation of various types of friction and how they affect movement. Students will collect and record data, then relate the data to the construction of a Soap Box Derby car and real-life situations.

Video Synopsis

Bridget and Austin go with Alex for a visit to the All-American Soap Box Derby headquarters in Akron, Ohio. On the way, Bridget sticks her hand out the window and first holds it against the wind and next turns it to cut the wind. Alex tells her she is experiencing the friction wind causes, just like in the Soap Box Derby. When they get to Derby Downs, they look at some of the old cars and compare their shapes.

CD-ROM Activities

1. **Race**
   Students conduct three races over three different terrains. Each terrain needs a different type of tire to create the friction needed to win the race. An image of the type of tire on the car appears below each of them to help students make their decisions.

2. **Air Resistance**
   Students choose between body styles to determine which will be more aerodynamic, and think about how increasing friction may influence the outcome of the race.

Follow-Up Video

Champions Chat: Aerodynamics
A world champion Soap Box Derby winner reinforces the fact that paying attention to every small detail creates winners.

Alex shows Austin and Bridget the three student-built race cars constructed at The University of Akron. He also explains how their body shapes differ. Each car is designed for a specific task and as a result they look very different. The students build the cars according to how aerodynamic they have to be for each race. Alex also talks about the tires each car uses. The formula car has soft slicks to get a lot of friction on smooth asphalt. The Baja car has a lot of tread to get friction in dirt and mud. The super mileage car has hard narrow tires to cut down friction.

Learning Strategies

A. Engagement

Pre-Assessment /Post-Assessment
Questions to answer: What do I know? What do I want to know? Upon completion of the unit on friction, answer the question, What did I learn? (KWL). Discuss what students already know and what they want to know. (See Appendix B: KWL Worksheet)

Review Vocabulary and the Scientific Method (see Appendix A: Vocabulary).

Introduce friction by class exploration. Students work in small groups and use the materials to move objects across the floor. Use round objects (pencils, marbles, etc.) as lubricants and flat items (wood block, books, etc.) as the objects to move across the floor. Experiment to find which lubricant works best with each object. Ask groups to explain what they observe and what materials work best for moving heavy objects.

Materials: pencils, marbles, drinking straws, tennis balls, blocks of wood, books, etc.

Evaluation of Engagement

Students will write observations in a journal. They should include a paragraph about where they encounter good and bad friction in their everyday lives (e.g., sports, skateboarding, walking on ice, etc.). They could explore this idea: What if there were no friction? Pose this prompt for the class: As you were walking or riding to school today, you looked around and noticed some very strange things going on around you. You suddenly realize that friction is missing. Think like a scientist and describe what you see.

Journals may be evaluated using the following checklist:
___ Observation includes references to the amount of force used to move each object with the various materials.
___ Real-life examples include references to rolling and sliding friction.

B. Exploration

Watch the first half of **Masters of Gravity, Friction**. Record additional observations in a log.

Does the Surface Matter?

Does the surface affect the distance the car will roll? Students work in groups of three or four. They predict which surface will allow the car to travel the farthest. Students roll a car down an inclined plane with different surfaces and measure the distance it travels. (See Appendix C: Does the Surface Matter?)

Evaluation of Does the Surface Matter?

Were the predictions correct? Why do you think there was a difference in the distance the car traveled? Record observations supported by the data in a journal.

Does the Design Matter?

Does the design of the body affect speed? Students work in small groups to design an experiment to test the effect of air resistance on the speed a model car will travel. Each group may use its own design or all the groups can brainstorm to come up with one experiment that the whole class conducts. Introduce the formula S=D/T to determine the speed. This formula will be explored more in the next lesson, **Speed**. Students may make a double bar graph of the data or compute the average speed of the car during the trials. (See Appendix D: Does the Design Matter?)

Evaluation of Does the Design Matter?

Draw conclusions based on the data. Does the design of the body affect the speed? Would the position of the driver be a variable affecting speed? Why or why not? Record observations supported by the data in a journal.

How Lubricants Affect Surface Friction

Are lubricants effective in decreasing surface friction? Students work in small groups. Less time and clean-up will be needed if each group is given a different lubricant to test and the data is shared. (See Appendix E: How Lubricants Affect Surface Friction)

Evaluation of How Lubricants Affect Surface Friction

What was the effect? Which lubricant worked best to improve performance? Reflect on allowing lubricants on the axles of Soap Box Derby cars. Discuss the influence of the variables in all the explorations and relate the explorations to a Soap Box Derby car. Record observations in a journal.

Students do the CD-ROM Activities

1. **Race**
   Select the car that you think is going to win by clicking on the image of the tire. Why will this tire win? Have students write observations in a journal. They should include a paragraph about why each race car's tires makes a difference.
2. **Air Resistance**
   Select the car that you think is going to win by clicking on a car at the bottom of the screen. Have students write observations in a journal. They should include a paragraph about how a car's body style influences friction.

Watch the second half of **Friction**. Record additional observations in a journal.

C. Explanation

Students should share findings from the explorations. This summary may be used to guide the students to an understanding of the lessons. The following points should be brought out in class discussions.

1. Movement creates friction.
2. We tested three types of friction: air resistance, sliding and rolling friction.
3. Friction is a <u>force</u> that always opposes motion.
4. Friction creates heat.
5. Energy is always transferred to heat energy.
6. Friction is a force that occurs when surfaces slide or slip over one another.
7. Friction occurs in liquids and in gases, collectively called fluid friction.
8. The amount of air friction depends on the speed and shape of the moving object.
9. The faster the object moves, the more collisions that occur with particles of the air causing increased friction.
10. Lubricants reduce friction and therefore reduce heat and the amount of energy needed for movement to occur.

Evaluation of Explanation

The journals may be evaluated using the following checklist:

___ All materials, including graphs, are present.

___ Materials are labeled and neatly organized.

___ Science terms are used correctly to answer the questions at the end of each exploration.

___ Concepts pointed out in the explanation should be noted.

After class discussion and review, students should write a paragraph summarizing “What I Learned.” (See Appendix B: KWL Worksheet)

D. Elaboration

Does Shape Matter?

Prepare an oral presentation for the class. Draw a design of your race car. Label places where friction occurs. Describe your design to the class, explaining where you reduced or increased friction and why. Explain why your car will win in a race against all the other designs in the class. (See Appendix F: Does Shape Matter?)

Evaluation of Elaboration

Students should again make a list of the good and bad friction they encounter in their everyday lives.

E. Final Assessment

The students will keep a portfolio. It should include their daily journal, KWL sheet, written predictions, observations, graphs, summaries and drawing.

The final assessment should include the class presentations, pre- and post-tests and the portfolio.

Suggestion

Display the presentation drawings in the class and have the students vote by secret ballot on the car they think will win due to its aerodynamic design.

Tools/Resources

Masters of Gravity CD-ROM and **Friction** instructional TV program
VCR and TV
Computer with Internet access and CD-ROM
Word processing and spreadsheet software (logs/graphs)
Hot Wheels or K'nex cars
Approximately one- to four-meter wooden or plastic ramps
Meter sticks
Stop watch
Drinking straws
Marbles, pencils, wooden blocks, lubricants

Classroom Management

Suggested time frame for the lesson is eight class periods:

Pre-assessment and introduction of friction. *(1 class period)*

Introductory video, **Friction**, and "Does the Surface Matter?" *(1 class period)*

"Does the Design Matter?" *(1 class period)*

"How Lubricants Affect Surface Friction." *(1 class period)*

CD-ROM Activities. *(1 class period)*

Follow-up video and "Does Shape Matter?" *(1 class period)*

Oral presentations (approximately 2 to 3 minutes per student). *(2 class periods)*

Safety Note: Some students may have an allergic reaction to one of the lubricants. Goggles should be worn when working with lubricants to prevent accidental eye contact.

Student Groupings

Small groups for observations and measurements.

Whole group discussion of results, graphs and video.

Independent work on written journal entries, conclusions and oral presentation.

Suggestion: Pair students with special needs for graphing and written work as needed.

Appendix A
Vocabulary

Air resistance - fluid friction experienced by objects that move through the air.

Friction - the force that one surface exerts on another when the two rub against each other. Friction is a force that *always* opposes motion.

The strength of the force of friction depends on two factors:

1. The types of surface involved.
2. How the surfaces are pushed together.

Forms of friction:

1. **Sliding friction -** caused by solid surfaces sliding together.
2. **Rolling friction -** created when an object rolls over a surface.
3. **Fluid friction -** caused when objects move through a fluid.

Lubricant - a substance or an object that decreases the force of friction. Lubricants reduce heat and the amount of energy needed to move an object.

Speed - the distance traveled by a moving object per unit of time (speed = distance / time, or S=D/T).

Scientific Method: Seven Steps

1. State the question or problem.
2. Collect information.
3. Form a hypothesis (prediction).
4. Test the hypothesis (experiment).
5. Observe what happens.
6. Record and study the data collected.
7. Form a conclusion.

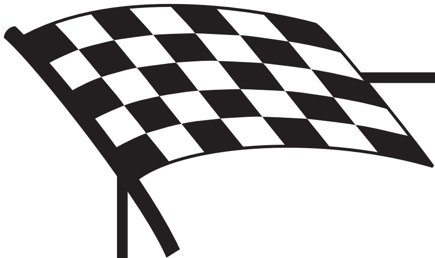
Know - Want to Know - Learn Worksheet

Name: ____

What I **know**.

What I **want to know**.

What I **learned**.



Appendix C

Does the Surface Matter?

Name: ____

Question: Does the surface affect the distance the car will roll?

Hypothesis:

Materials: Various surfaces, ramps, meter sticks and toy cars.

1. Set up the ramp using books to prop it up. Measure and record the height.
2. In the data table write what surface you are testing.
3. Roll a car down the inclined plane and measure the distance the car travels in centimeters.
4. Repeat on the same surface.
5. Write results in the data table.
6. Calculate the average distance traveled.
7. Repeat steps 2 through 6 on four different surfaces.

Data Table

Height of the ramp ____ (cm)

Surface	Distance Traveled (Trial 1)	Distance Traveled (Trial 2)	Average Distance Traveled

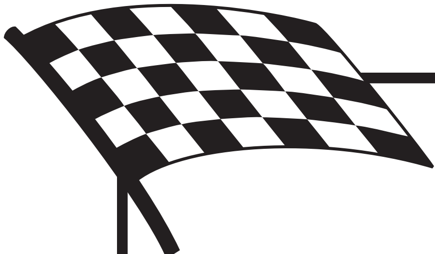
Does the Surface Matter?

1. Which surface allowed the car to travel the longest distance? Explain why.

2. Which surface caused the car to travel the shortest distance? Explain why.

3. Did your findings support your hypothesis? Explain.

4. If you were a contestant in the Soap Box Derby, on what type of surface would you want to race your car? Explain why.



Appendix D

Does the Design Matter?

Name: ____

Question: Does the design of the body affect the speed of the car?

Hypothesis:

Materials: Inclined plane, cars, stopwatch, meter stick, corrugated cardboard square cut to the width of the car, tape.

1. Set up the ramp using books to prop it up.
2. Mark a finish line two to four meters from the starting line.
3. Start the stopwatch when you release the car to run down the ramp.
4. Stop the stopwatch when the car crosses the finish line.
5. Record the time data in the data table.
6. To determine speed, use the formula **Speed = Distance/Time.**
7. Record the speed data in the data table.
8. Repeat the test three times and average the results.
9. Tape the cardboard to the front of the car and repeat steps 3 through 8.

Data Table ***(no cardboard)***

	Trial 1	Trial 2	Trial 3	Average of Trials 1-3
Record Time				
Record Speed				

Data Table ***(with cardboard)***

	Trial 1	Trial 2	Trial 3	Average of Trials 1-3
Record Time				
Record Speed				

Does the Design Matter?

1. Which speeds were faster — the trials with the cardboard or without the cardboard? Explain why.

2. Did your findings support your hypothesis? Explain.

3. If you were a contestant in the Soap Box Derby, what type of car would you want — one with lots of air resistance or one with little air resistance? Explain why.

How Lubricants Affect Surface Friction

Name:____

Question: Are lubricants effective in decreasing surface friction?

Hypothesis:

Materials: Inclined plane, four cars, a meter stick and various lubricants such as oils, petroleum jelly, soap, baby powder.

Determining Baseline Data

To run this experiment you first need to determine how far each car will go without lubricants. This is called gathering baseline data.

1. Set up a ramp
2. Place a piece of tape across the ramp to be your starting line.
3. Release the car at the starting line.
4. Measure the distance the car traveled and record the data.
5. Run three trials for each car.
6. Calculate the average distance traveled for each car.
7. Repeat steps 3 through 6 for each car.

Baseline Data

Car	Distance (Trial 1)	Distance (Trial 2)	Distance (Trial 3)	Average Distance
Car 1				
Car 2				
Car 3				
Car 4				

Testing Lubricants

After establishing your baseline data for all four cars, apply one lubricant to the axles of each car. Each car should have a different lubricant.

1. Release the car at the starting line.
2. Measure the distance traveled and record the data.
3. Run three trials for each lubricant.
4. Calculate the average distance traveled for each lubricant.
5. Repeat steps 1 through 4 for each car.

Lubricant Data

Car	Distance (Trial 1)	Distance (Trial 2)	Distance (Trial 3)	Average Distance
Car 1				
Car 2				
Car 3				
Car 4				

How Lubricants Affect Surface Friction

1. Which lubricant allowed the car to travel the farthest? Explain why.

2. Did your findings support your hypothesis? Explain.

3. In the Soap Box Derby, should racers be allowed to use lubricants on the axles? Explain why.

Answer Keys for Friction Classroom Activities

Appendix C: Does the Surface Matter? (29 points)

Hypothesis

The smoother the surface, the farther the car will roll. (2 points)

Data Table

Measured and recorded the height of the ramp. (1 point)
Recorded the data correctly. (12 points)
Averaged the different trials. (4 points)

Questions

1. Smoothest. Less friction. (2 points)
2. Roughest. Most friction. (2 points)
3. Yes or No – answers will vary. (2 points)
4. Smooth. Less friction equals faster speed. (4 points)

Appendix D: Does the Design Matter? (26 points)

Hypothesis

The design of the body will affect the speed of the car. (2 points)

Data Tables

Recorded data correctly. (6 points)
Calculated the speed correctly. (6 points)
Averaged the trials correctly. (4 points)

Questions

1. Without cardboard, the car was faster. Less friction or air resistance. (2 points)
2. Yes or No – answers will vary. (2 points)
3. Little air resistance. The less air resistance you have the faster you will go. (4 points)

Appendix E: How Lubricants Affect Surface Friction (48 points)

Hypothesis

Lubricants will decrease the surface friction. (2 points)

Data Tables

Recorded data correctly. (32 points)
Averaged the distance correctly. (8 points)

Questions

1. Answers will vary. The lubricant caused less friction, allowing the car to go farther. (2 points)
2. Yes or No – answers will vary. (2 points)
3. Answers will vary. (2 points)

Appendix F

Does Shape Matter?

Name: ____

1. In your own words, define the following terms and give at least one example of each:

   Friction

   Fluid Friction

   Air Resistance

2. From what you know about friction, fluid friction and air resistance, how do you think the shape of a car will affect the speed it will travel?

3. On a separate sheet of drawing paper, design and draw your own Soap Box Derby car. After you draw your car, label the points on your car where friction will occur.

4. On a separate sheet of notebook paper, write a description of your car, including the areas where friction will occur and why friction occurs in those areas. You will be asked to present your drawing and your description in class.

Appendix F

Answer Key: Does Shape Matter?

1. Friction – force that one surface exerts on another when they rub against each other.
   Fluid Friction – friction caused when objects move through a fluid.
   Air Resistance – fluid friction experienced by objects that move through the air.
2. The more aerodynamic, the faster it will go.
3. Drawings will vary.

Rubric for Oral Presentation Assessment

4 Exceptional	The drawing shows many relevant features. The report describes the features using science terms. The speaker shows **strong evidence** of understanding and applies the concepts studied in the lesson.
3 Very good	The drawing shows some relevant features. The report describes the features using some of the science terms. The report shows **evidence** of understanding and applies the concepts studied in the lesson.
2 Limited	The drawing shows a few relevant features. The report describes some features but is limited in its use of science terms. The report shows **some evidence** of understanding and is limited in its application of the concepts.
1 Minimal	The drawing shows little attention to completing the task. The report describes few features and shows **little evidence** of understanding and applying the concepts.
0 Off Task	No attempt was made or the student did not follow directions for completing the task.

Appendix G

Pre-Test: Friction

Name: ____

1. Describe how important friction is in the design and construction of an automobile.

2 Students in class conducted an experiment to see which soil would grow the tallest radish plants. They placed one radish seed in each of three cups filled with three different soils. Cup A was placed on a shelf. Cup B was placed by the door and cup C by the window. Each cup was watered daily. The height of each plant was measured daily for five days. The plant in cup B grew the tallest so the students concluded that soil B was the best.

Does the experiment follow the Scientific Method? Choose the best answer:

a. The experimental design followed the Scientific Method.

b. There are too many variables because they didn't place all the cups in the same location.

c. There are not enough trials to determine which soil is best.

d. B and C are the best answers.

3. Engineers at an automotive plant are designing a car that will get better gas mileage. Is the shape of the body of the car important to their design? Why or why not?

Appendix H

Post-Test: Friction

Name: ____

1. Describe how important friction is in the design and construction of an automobile.

2. Students conducted an experiment to determine the speed two different toy cars would travel. They propped a board up on one end with books to make a ramp and marked a starting line and a finish line. They used the formula S=D/T to calculate the speed. They released the small car and charted the data for ten runs down the ramp. Before they tested the larger car they decided to move the ramp across the room because it was in the path of students walking by. The larger car on average traveled the fastest.

   Does the experiment follow the Scientific Method? Choose the best answer:

   a. The experimental design followed the Scientific Method.

   b. We need to know how they set the ramp up when they moved it.

   c. There are not enough trials to determine which car is fastest.

   d. B and C are the best answers.

3. Engineers at an automotive plant are designing a car that will get better gas mileage. Is the shape of the body of the car important to their design? Why or why not?

Answer Key

Appendix G: Pre-Test

1. Student should be given points for indicating some knowledge of the three types of friction and where they play a role in the movement of an automobile.
2. D. There are too many variables to determine which soil was best. We do not know if the placement of the cups also changed the amount of light the plants received or if the temperatures in the locations were different. Also, planting one seed in one cup does not allow enough trials to make the results valid.
3. The shape is important to cut down on air resistance.

Appendix H: Post-Test

1. (Same as Pre-Test)
2. B. The ramp should have been set up with the exact incline and starting point to make the second part of the experiment the same as the first. Ten trials are probably enough to make the results valid.
3. The shape is important to cut down on air resistance.

Masters of Gravity

Program 8

Speed

http://www.WesternReservePBS.org/gravity

Program 8:

Speed

Author

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Target Audience

6th-Grade Science

Concept

Students are motivated with the **Masters of Gravity, Speed** instructional video to ponder just how the change in the length of the track, as well a change in ramp height, directly affects the speed of the car.

Students will apply the concepts of measurement, distance, time and speed, make predictions and report their findings on their observations.

Learning Objectives

The students will:

1. Identify that if they know the distance an object travels in a certain amount of time, they know the speed of the object.
2. Be able to explain in complete sentences the effect of the incline of the ramp on the average speed of a car.
3. Calculate the speed of a car using the formula Speed = Distance/Time when given distance and time.
4. Be able to interpret a motion graph that shows changes in distance as a function of time.

Curriculum and Proficiency Standards Addressed

The students will:

1. Use written representation to communicate work.
2. Read and interpret simple tables and graphs produced by self/others.
3. Use evidence and observations to explain and communicate the results of investigations.
4. Use a variety of measuring instruments, emphasizing appropriate units.
5. Demonstrate the ability to formulate or identify questions that can be answered through scientific investigations.
6. Formulate and identify questions to guide scientific investigations that connect to science concepts.
7. Gather, record and organize data.
8. Interpret data and use the interpretation to generate explanations.
9. Construct hypotheses and test their validity based on collected evidence.
10. Explain how scientific procedures were used to obtain results.
11. Demonstrate understanding that the motion of an object can be described by its position, direction and speed.

How Technology is Integrated in This Lesson

The students will:

1. Observe the video to encounter concepts as well as encourage ongoing inquiry.
2. Use the **Masters of Gravity** CD-ROM to test their hypotheses about how ramp length and height can affect the speed of a Soap Box Derby car as they race virtually.
3. Use technology tools to enhance learning, increase productivity and promote creativity.

Lesson Overview

Students will be introduced to elements that affect the speed of a Soap Box Derby race car. The students will determine how the length of the hill affects the car's speed through a hands-on classroom activity practicing the skills of measuring time and distance to find the speed of a moving object. Next, the students will apply what they learned to the **Masters of Gravity** CD-ROM activity by using the virtual program to manipulate the height of a zip line. They will do

virtual tests to conclude that the height of the starting point on a zip line will increase the speed attained. The students will create and compare graphs of these results with others. The students will use the information gathered to help them write a persuasive essay either for or against the newer, shorter length of the Soap Box Derby track.

Next, the students will watch a video clip to generate discussion about how the difference in the starting ramp's pitch (angle) could affect the speed of a car. Through another hands-on classroom activity, students will determine that the steeper the ramp, the faster the car goes. They will use the same materials to conduct test runs, this time altering the height of the ramps. The students will continue by using the other **Masters of Gravity** CD-ROM activity in which they get to use the virtual program to manipulate the Soap Box Derby ramp angles to create test runs until they have succeeded in making all three ramps equal in speed outcome. Once again, the students will create graphs to share their findings with the class as a group, as well as write about their findings and tell why all ramps must be of equal speed.

Video Synopsis

Watch the first half of **Speed**. Austin, looking at statistics about the Soap Box Derby, discovers that racers used to start higher up the hill. He wonders why that was changed.

CD-ROM Activity

1. **Zip Line**
   Select the height at which a zip line is attached to a cliff. How does the height affect the speed of the descent?

Middle Video Synopsis

Champions Chat: Driving
A world champion Soap Box Derby winner reinforces how being precise creates winners.

Austin tells Bridget that he has detected an advantage in the center lane of the Soap Box Derby racetrack. Bridget suspects that if her brother can figure out how to get an advantage, there must be something wrong with his logic. To settle the argument they ask Alex. He explains that the Soap Box Derby goes to great lengths to make sure all the lanes are equal.

CD-ROM Activity

2. **Adjusting the Ramps**
   To equalize each lane in the Soap Box Derby race, the starting ramps are adjusted. Can you make all three lanes equal?

Follow-Up Video

Champions Chat: Driving
A world champion Soap Box Derby winner reinforces how planning ahead and doing research can help accomplish goals.

The speed that real cars go must be taken into consideration when engineers design curves in roads. Interstates are compared with neighborhood streets. Students also compare The University of Akron student-built Baja, formula and super mileage cars.

Champions Chat: Math and Science
A world champion Soap Box Derby winner reinforces how the math and science a student learns now will be useful later in life.

Learning Strategies

A. Engagement

Review prior knowledge and vocabulary for this lesson (see Appendix A: Prior Knowledge /Vocabulary).

Questions to answer: What do I know? What do I want to know? Upon the completion of this concept lesson on speed, answer the question: What did I learn? (Use Appendix B: What Do I Know? What Do I Want to Know? What Did I Learn? worksheet.)

Students will watch the short introductory video clip as Austin ponders the Soap Box Derby statistics concerning the starting point of the ramps. Turn the video off and have students work in informal cooperative groups to inquire as to why the starting place on the track has changed over the years. Question to ask: "Why did Soap Box Derby officials change the starting place of the ramp and therefore the length of the track?"

Evaluation of Engagement

Students will respond to the above question in their science journals, forming a hypothesis as to how the length of the track/ramp affects the speed of a car.

B. Exploration

Before going on, be sure to review, through a line of informal questions, the items in Appendix A: Prior Knowledge /Vocabulary to insure students' understanding so that they can apply that knowledge during these activities.

Does Length Matter?
The students will work in cooperative groups to design different length ramps and race toy cars to determine how the length of the track affects the speed of the car. The students will create a graph to organize and display their data using a computer-graphing program. (See Appendix C: Does Length Matter? for specific instructions for this classroom activity.)

Students do the **Masters of Gravity** CD-ROM "Zip Line" activity to inquire how height affects speed to conclude that the longer course produces a faster (more dangerous) finish! This activity lets the students run a virtual zip line down different heights of slides. The students will create a graph of their own design to organize and display their data from this activity. This activity will help students prepare to write a persuasive essay either for or against the changing of the track length.

Evaluation of Exploration: Persuasive Essay

Students will clearly state the conclusion that the longer the track, the faster the car travels. They should back up this conclusion in their essay with evidence from both classroom and CD-ROM activity data. This essay will be created with the help of a computer word processing program (see Appendix E: Rubric For Essays and Paragraphs), observation of student group activity data collection and graphing. The groups will graph their results to share with the class.

C. Explanation

Students share graphs and persuasive essays with the members of their group in an informal teacher-guided discussion. Use this time to summarize the activities and check for understanding and applications of the speed concept (such as definition of speed and how to use the formula).

Evaluation of Explanation

Listen for the specific items required in the rubric for their written assessment. (See Appendix E: Rubric for Essays and Paragraphs)

D. Elaboration

Watch the next segment of **Speed** on different ramp pitches (height). Returning to the video, the students again observe Austin pondering the use of one lane as an advantage over another. His sister, Bridget, intercedes and the two visit Alex to settle their debate. Alex gives them some food for thought, leading them to further investigate the ramps themselves.

Height vs. Speed

After the tape is turned off, the students return to their cooperative groups and toy car racers. This time the students are asked to write a hypothesis in their journals of what effect the angle of the ramp has on the speed of the car. They then conduct trials to determine how the height of the ramp affects the speed of a moving object. The groups will again share their findings in the form of graphs. (See Appendix D: Height vs. Speed)

“Adjusting the Ramps,” another **Masters of Gravity** CD-ROM activity, manipulates the starting ramp pitch, leading students to understand that the adjustments must be made and tests must be done to have three ramps equal in speed. The students can go to the Computer Lab or work in groups in the classroom (if computer stations are available) to do the second CD-ROM activity. This activity takes the students through actual testing runs and ramp adjustments just like at the Soap Box Derby. The students virtually choose the adjustments to the ramps and run trials until all ramps are equal. The students should write a paragraph explaining the starting ramp testing process and why it’s important. (See Appendix E: Rubric for Essays and Paragraphs)

Watch the final part of **Speed**, which gives examples of how speed must be taken into consideration when engineers design our roads and cars.

Evaluation of Elaboration

The students will not only graph their finding, but must also write out their conclusions in paragraph form to share as a group with the rest of the class. The paragraph will be created with the help of a computer word processing program and will respond to the following instructions:

> Each year the Soap Box Derby officials adjust the three starting ramps after running numerous test trials. Apply what you have learned from the classroom and CD-ROM activities to explain why these trials and adjustments need to be done. (See Appendix E: Rubric for Essays and Paragraphs)

E. Final Assessment

Students share graphs and conclusion paragraphs with the members of their group in an informal teacher-guided discussion. Use this time to summarize the activities and check for understanding and applications of the speed concept (such as definition of speed and how to use the formula). Evaluate the students' understanding by listening for the specific items required in the rubric for their written assessment. (See Appendix F: Rubric for Oral Assessment/Evaluation)

Tools/Resources

Masters of Gravity CD-ROM and **Speed** instructional television program
TV and VCR
Computers with CD-ROM port
Word processing and spreadsheet software
Toy cars
Meter stick
Masking tape
Boards
Cardboard
Stopwatch

Classroom Management

Suggested time for this lesson is nine class periods:

Classroom pre-activities. *(1 class period)*

"Does Distance Matter?" *(1 class period)*

"Zip Line." *(1 class period)*

Persuasive Essay (assessment). *(1 class period)*

Class presentations (assessment). *(1 class period)*

"Height vs. Speed." *(1 class period)*

"Adjusting the Ramps." *(1 class period)*

Conclusion paragraph (assessment). *(1 class period)*

Classroom presentations (assessment). *(1 class period)*

Student Groupings

Whole group for classroom pre-activities.

Small groups of four for Classroom Activities 1 & 2. This allows for familiarity in their inquiry discussions, though the teacher must closely monitor and facilitate discussion and activity progress.

Groups of two for CD-ROM activities.

Appendix A

Prior Knowledge

Understand definition of SPEED.

Know how to measure length in meters.

Steps of the Scientific Method process with emphasis on the variables within experiments.

1. State the question or problem.
2. Collect information.
3. Form a hypothesis (prediction).
4. Test the hypothesis (experiment).
5. Observe what happens.
6. Record and study the data collected.
7. Form a conclusion.

Vocabulary

Acceleration - increase in velocity.

Average speed - total distance traveled divided by total time.

Constant speed - speed that does not change.

Deceleration - decrease in velocity.

Mass - amount of matter in an object.

Meter - the basic SI (International System of Units) unit of length.

Momentum - the product of an object's mass and velocity
Equation for momentum: Momentum = Mass x Velocity

Motion - change in position or distance of one object from another.

Speed - the distance traveled by a moving object per unit of time.

Equation for speed: $\text{speed} = \frac{\text{distance}}{\text{time}}$

Velocity - speed in a given direction.

Appendix B

Know - Want to Know - Learn Worksheet

Name: ____

What I **know**.

What I **want to know**.

What I **learned**.

Appendix C

Does Length Matter?

Name: ____

Question: How does the length of a ramp affect the speed of an object?

Hypothesis:

Materials needed: Toy car, meter stick, masking tape, flat boards, small sturdy piece of cardboard, supports to prop up the ramps (books, boxes) and a stopwatch.

Procedure

1. Using two books, prop up one end of the board to make a ramp.
2. Use masking tape to mark a starting line on the board. Start with the line halfway up the board, then move it farther up the incline for each trial.
3. Measure the distance in centimeters from the starting point to the end of the ramp. Put this in the data table.
4. Mark a finish line some distance from the end of the ramp.
5. Working in groups of three, one student holds the vehicle at the starting point. As the holder releases the vehicle, another student starts the stopwatch. When the vehicle crosses the finish line the third student calls out "stop" so that the timer can stop the stopwatch.
6. Record the time on the data table under Trial 1.
7. Repeat the test and record the data in the Trials 2 and 3 columns.
8. Move the starting line tape up the incline so the length of the incline is longer.
9. Repeat steps 2 through 8 for three different lengths of the incline.
10. Find the average time for each length of ramp and record it in the data table.
11. Find the speed for each length of the ramp and record it in the data table.

Data Table

Length of Ramp (cm)	Trial 1 (sec)	Trial 2 (sec)	Trial 3 (sec)	Average Time (sec)	Speed (cm/sec)

Does Length Matter?

1. How did you find the average time of the test runs (from the starting line to the finish line)?

2. How did you find the speed the vehicle traveled down the incline (from the starting line to the finish line)?

3. Which variable did you change and which variable responded to the change? Explain.

4. On a graph, plot the length of the boards (on the x-axis) against the speed of the vehicle (on the y-axis). Connect the points.

5. What does the shape of your graph show about the relationship between the length of the ramp and speed?

6. Did your findings support your hypothesis? Explain.

7. You are once again a contestant in the Soap Box Derby. Would you want the track length to be changed? Why? Give at least two reasons for or against the changing of the length.

Height vs. Speed

Name: ____

Question: How does the angle (height) of a ramp affect how fast an object moves?

Hypothesis:

Materials needed: Vehicle, meter stick, masking tape, flat board, supports to prop up the ramps (books, boxes), a stopwatch.

Procedure:

1. Lay the board flat on the floor. Mark a finish line 2.5m from the beginning of the board (starting point of vehicle).
2. Prop up the starting point end of the board to make an incline using one book. Measure the height. Record this on the data table.
3. Working in groups of three, one student holds the vehicle at the starting point. As the holder releases the vehicle, another student starts the stopwatch. When the vehicle crosses the finish line the third student calls out “stop” so that the timer can stop the stopwatch.
4. Record the time on the data table under Trial Time 1.
5. Repeat steps 3 and 4 and record the times under Trial Times 2 and 3.
6. Change the height of the ramp and repeat steps 2 through 5.
7. Record each change in height on your data table.
8. Find the average speed the vehicle traveled down each different height ramp to the finish line.

Data Table

Distance Traveled _____ (centimeters)

Height of Ramp	Trial Time 1 (sec)	Trial Time 2 (sec)	Trial Time 3 (sec)	Average Time (sec)	Speed (cm/sec)

Height vs. Speed

1. Describe how you found the average time and speed of the different heights of the ramp to the finish line.

2. Which is the manipulated variable and which is the responding variable in this activity? Explain.

3. On a line graph, plot the height of the ramp (on the x-axis) against the average speed of the car (on the y-axis). Connect the points.

4. What does the shape of your graph show about the relationship between speed and the height of the ramp?

5. Each year Soap Box Derby officials adjust the three starting ramps after running numerous test trials. Apply what you have learned from the classroom and CD-ROM activities to explain why these trials and adjustments need to be done.

Answer Key

Appendix C: Does Length Matter? (37 points)

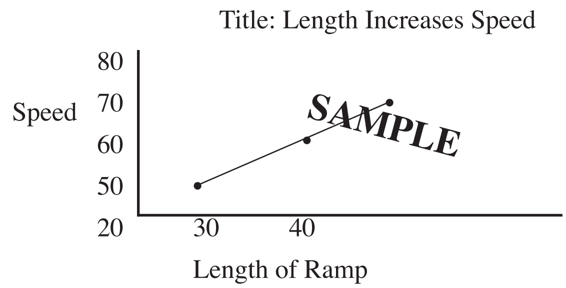
Hypothesis

As the length of the ramp increases, the speed will increase. (1 point)

Data Table (18 points)

Questions

1. Averaged the different trial times. (1 point)
2. Multiplied the distance times the average time. (1 point)
3. Variable changed - length; variable responding - speed. (2 points)
4. Line graph: Graphs will vary according to measurements.
   - Title (1 point)
   - y-axis (1 point)
   - x-axis (1 point)
   - Plot points (3 points)
   - Lines (1 point)



5. As length increases so does the speed. (1 point)
6. Yes or no - answers will vary. (2 points)
7. Answers will vary. (4 points)

Appendix D: Height vs. Speed (38 points)

Hypothesis

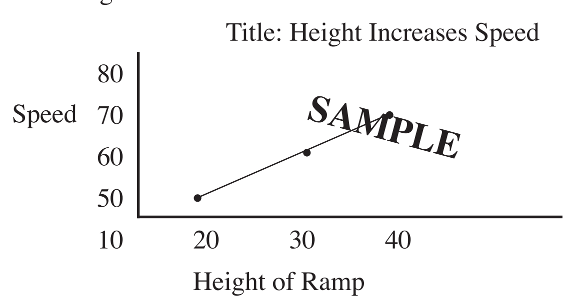
The higher the ramp the faster the object moves. (1 point)

Data Table

Distance traveled. (1 point)
Data fields. (24 points)

Questions

1. Averaged the different trial times. (1 point)
2. Variable changed - height of the ramp; variable responding - speed. (2 points)
3. Line graph: Graphs will vary according to measurements.
   - Title (1 point)
   - y-axis (1 point)
   - x-axis (1 point)
   - Plot points (3 points)
   - Lines (1 point)



4. As the height increases so does the speed. (1 point)
5. The heights of the ramps are adjusted to make all the lanes equal. (1 point)

Appendix E

Rubric for Essays and Paragraphs

Using a 4-point scale:

4 points (Exceptional)	Clearly states correct conclusion and gives at least three reasons verifying their choice. Reasons are backed up with evidence found in their data from the classroom activity as well as the CD-ROM activity.
3 points (Very Good)	Clearly states correct conclusions and choice but gives fewer than three reasons and evidence to back them.
2 points (Limited)	States correct conclusion but does not give any valid reasons or evidence found from the activities.
1 point (Minimal)	States an incorrect conclusion though tries to show evidence to back their choice.
0 points (Off Task)	Chooses not to complete the assignment.

Appendix F

Rubric for Oral Assessment/Evaluation

Using a 4-point scale:

4 points (Exceptional)	The graph shows all relevant features as instructed. The written assignment also follows all instructions. While speaking, the students show **strong evidence** of understanding and apply the concepts focused on in the lesson.
3 points (Very Good)	The graph shows some relevant features. The written assignment describes the features using some science terms surrounding this concept. While speaking, the students show **evidence** of understanding and apply the concepts focused on in the lesson
2 points (Limited)	The graph shows few relevant features. The written assignment describes some features but is very limited in use of specific terms surrounding this concept. While speaking, the students show **some evidence** of understanding and apply the concepts focused on in the lesson
1 point (Minimal)	The graph shows little attention to completing the task. The written assignment describes few features and shows **little evidence** of understanding and applying the concepts.
0 points (Off Task)	No attempt was made or the student did not follow the directions for completing the task.

Appendix G

Pre-Test: Speed

Name: ____

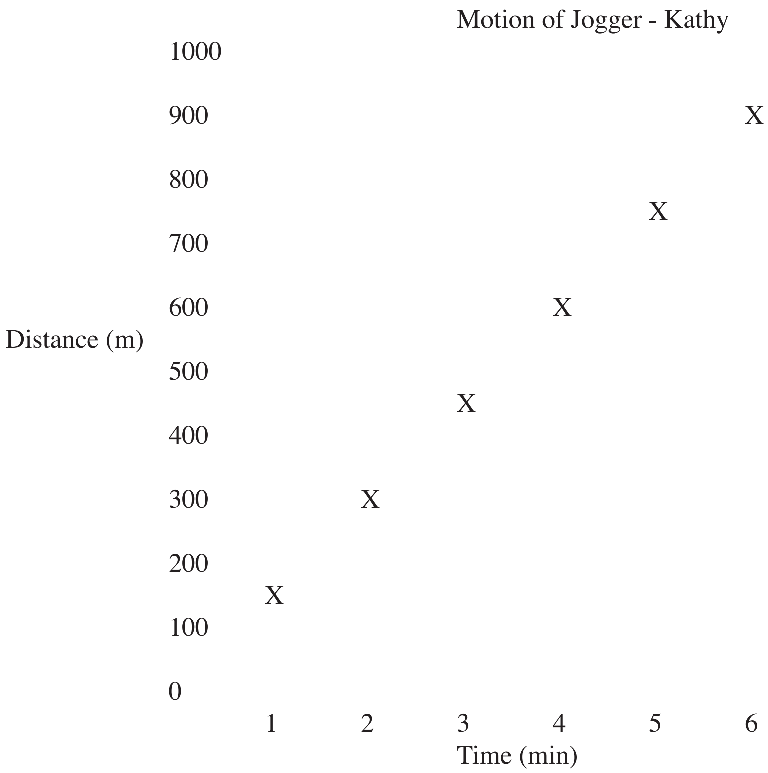
1. Speed equals distance divided by
    a. time
    b. velocity
    c. size
    d. motion

2. If you know the distance an object traveled in a certain amount of time, you can determine
    a. the size of the object
    b. the speed of the object
    c. the location of the object
    d. the velocity of the object

3. A train that travels 100 km in 4 hours is traveling at what average speed?
    a. 50 km/h
    b. 100 km/h
    c. 2 km/h
    d. 25 km/h

4. On a graph showing distance (on the x-axis) versus time (on the y-axis), a horizontal line represents an object that is
    a. moving at a constant speed
    b. increasing its speed
    c. not moving at all
    d. decreasing its speed

Use the graph below to answer the following question:



5. What two variables are plotted on this graph?

6. How far did Kathy jog in the first four minutes?

7. What is Kathy's average speed?

Appendix H

Post-Test: Speed

Name: ____

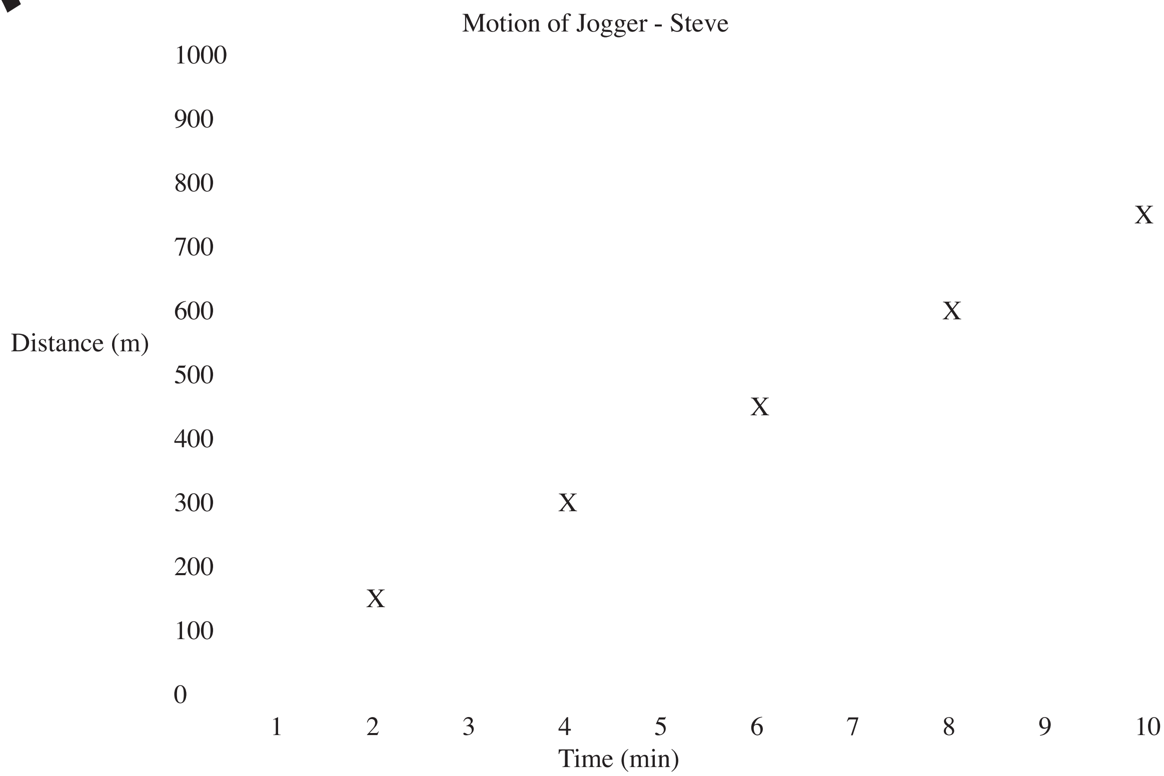
1. If you know a car traveled 300 km in 3 hours, you can find its
    a. acceleration
    b. direction
    c. average speed
    d. velocity

2. If a bicyclist travels 30 km in 2 hours, her average speed would be
    a. 30 km/h
    b. 60 km/h
    c. 15 km/h
    d. 2 km/h

3. You can show the speed of an object on a line graph in which you plot the distance against
    a. velocity
    b. time
    c. speed
    d. direction

4. On a graph showing distance (on the x-axis) versus time (on the y-axis), a horizontal line represents an object that is
    a. moving at a constant speed
    b. increasing its speed
    c. not moving at all
    d. decreasing its speed

Use the graph below to answer the following question:



5. What two variables are plotted on this graph?

6. How far did Steve jog in the first four minutes?

7. What is Steve's average speed?

Answer Key

Appendix G: Pre-Test

1. a. Time
2. b. the speed of an object
3. d. 25 km/h
4. c. not moving at all
5. Distance and time
6. 600 meters
7. 150 meters per minute

Appendix H: Post-Test

1. c. average speed
2. c. 15 km/h
3. b. time
4. c. not moving at all
5. Distance and time
6. 300 meters
7. 75 meters per minute

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