MATHEMATICAL APPLICATIONS ON THE AUTOMOBILE -- A UNIT PLAN

An Honors Thesis (HONRS 499)
by
Angela M. Bonner

Thesis Advisors

Dr. Ruth Howes

Ruth H. Howes

Dr. Norman Lee

Norman K. Lee

Ball State University
Muncie, Indiana

April 1992

For Graduation on May 2, 1992
INTRODUCTION

Teachers of every subject must search for ways to motivate students, and they must exert much effort to maintain their students' attention. "The art of motivating students to learn is at the crux of one's concerns when preparing to teach a lesson. For if students can be made to be delightfully receptive learners, then the rest of the teaching process becomes significantly easier and profoundly more effective" (Posamentier, p. 38). This is especially true for teachers of mathematics. In this subject, there already exists a widely-accepted attitude that mathematics is boring, unnecessary, and strongly disliked. Teachers of mathematics must work even harder to overcome this negative attitude.

There are several ways for a teacher to motivate students. Students can be encouraged to learn by the teacher indicating a void in the students' knowledge, showing a sequential achievement, presenting a challenge, indicating the usefulness of a topic, using recreational mathematics, telling a pertinent story, getting students actively involved in justifying mathematical curiosities, or using manipulatives (Posamentier, p. 38-43). These are all activities and concepts that can be included in the teacher's lesson plans. Many can be combined to create a very motivating experience.

The type of motivation may be intrinsic or extrinsic to mathematics. Extrinsic motivation can simply be described as pleasing or avoiding the displeasure of the teacher. In this case, students can perform the
required behavior with little or no understanding, so there is no guarantee that understanding has been achieved (Skemp, p. 96). Intrinsic motivation deals more with pleasing one's self. The learner actually enjoys the material and wants to learn more. The thirst for knowledge for its own sake is the best motivation a student can possess (Skemp, p. 97-8). Intrinsic motivation is the type that a teacher should strive to achieve but is the type that is difficult to accomplish.

One of the best ways to intrinsically motivate students is to relate course work to areas of concern or interest to the students. Such topics include anything about movies, television, sports, or the automobile. This last item is known to be "an interesting and motivating topic of study" (Kwasnoski, p. 776). Demonstrating applications of classroom material using such topics should encourage students to want to learn. Therefore, a unit plan for a high school general mathematics class which revolves around various mathematical applications on the automobile should motivate students to learn more about mathematics.

The students in a general mathematics class can be a hybrid mixture of ability levels and personalities. Some students may have a strong mathematical background yet may not be ready for algebra. Some students are regularly challenged with the required course work. Still others have a poor background in mathematics and continually need remedial help. Most general mathematics students have little or no retention of previously learned material. In addition, students with behavior problems
are commonplace in a general mathematics class. Some only cause trouble in the school, while others may have had confrontations with the law. Indeed, a variety of individuals can be found in the general mathematics classroom.

These students have often been overexposed to the system of repetitive practice or drilling. This leads to rote learning of material. However, rote learning without meaning is relatively unhelpful (Orton, p. 25). Students do not understand the material; they just know how to respond correctly. "Retention and recall are easier if what is learned is meaningful in terms of the network of knowledge already held in the mind of the learner" (Orton, p. 25). This means teachers should use what students already know and are interested in to present new and motivating material. For example, in this unit plan the teacher can use the automobile to teach students about ratio and proportion. Retention of this material should prove to be more significant than when merely using the text's approach.

General mathematics students do have other things in common. They are all in high school, and they are all about fourteen to sixteen years of age. This is the age group in which students begin to learn how to drive. This is the age group in which students start wanting their own cars. This age group is one of the groups most interested in the automobile. For these reasons, mathematical applications on the automobile should also be of interest to students.
Critics of this plan have brought up a very valid point when they have asked, "What about the girls in the class?" The desire to drive and own a car is not limited to the male students. Many female students also gain a keen interest in the automobile. The author of this unit plan is just one example of this.

Although it does contain basic information concerning the engine of the automobile and how it runs, this automotive unit is not a condensed version of auto shop. It does not dwell on the mechanics of the automobile. It is simply a collection of automotive applications of mathematical concepts with which both male and female students may come in contact. The unit plan demonstrates to students "what they will need math for." Finding out how long a road trip will be requires some mathematics. Determining a car's average gas mileage requires some mathematics. These are practical, everyday applications to which students in a general mathematics course can see and, hopefully, relate. Therefore, the gender of the student should not matter.

THE NCTM STANDARDS

In 1989, the National Council of Teachers of Mathematics released a report stating new goals in the education of mathematics. This report, Curriculum and Evaluation Standards for School Mathematics, has since caused a wave of reform throughout mathematics education. Completely new textbooks have been designed. Pre-service teachers have been trained to teach in the ideals of the Standards. Workshops have been held to
inform veteran teachers of these new ideals for their profession. New emphases are being stressed. Old, ineffective ways of teaching are being replaced. New approaches in all areas of mathematics are being developed and presented.

As stated in the *Standards*, new societal goals should include mathematically literate workers, lifelong learning, opportunity for all, and an informed electorate. Although this unit plan can be used to achieve all of these, it particularly pertains to the goal associated with educating the worker. Henry Pollak, a noted industrial mathematician, summarized mathematical expectations for new employees in industry. Among these expectations, he lists the understanding of the underlying mathematical features of a problem (NCTM, p. 4). Elements of this unit plan help demonstrate this type of understanding. Students should realize the mathematical features of such things as gas mileage and scale models.

New goals for students are also presented in the NCTM *Standards*. These goals are that students should learn to value mathematics, become confident in their own abilities, become a mathematical problem solver, learn to communicate mathematically, and learn to reason mathematically (NCTM, p. 5-6). All of these goals can be found and applied using this unit plan on mathematical applications.

First, students can learn to value mathematics when they see its practical use in an everyday situation (finding gas mileage) or in a more advanced problem related to the engine (finding its displacement).
Secondly, students can become more confident in their own mathematical abilities when they realize that they already have been using mathematics and have learned new concepts on the automobile through mathematics. Many students have built models of cars or even planes which, as in the first lesson of this unit, is demonstrating mathematics. Also, "to some extent, everybody is a mathematician and does mathematics consciously. To buy at the market, to measure a strip of wallpaper, or to decorate a ceramic pot with a regular pattern is doing mathematics. School mathematics must endow all students with a realization that doing mathematics is a common human activity" (NCTM, p. 6).

Thirdly, the students should become better problem solvers as a result of material presented in this unit. Students should be able to see new concepts and learn new problem-solving strategies by the unit's end. Next, students will learn to communicate better within mathematics as a result of working with the information contained in these applications. Discussions held in class are just one way students can improve their communication skills. Another way is for teachers to question students on how a problem was solved.

Finally, the goal of learning to reason mathematically can be developed when using this unit. Besides using reasoning skills throughout every lesson, there is one lesson on logic. This material should allow students to see that logical reasoning can help solve a problem whether it is a mathematical problem or a crime to be solved.
TEACHER SUGGESTIONS

This unit plan contains five main sections: ratio and proportion, rates, map reading and planning routes, chart reading, and logic. Within each section, there are worksheets for the students to practice what they are supposed to have learned. The answer keys are included as well. After each of the first four sections, there is a quiz which evaluates the students' understanding of the covered material. There is no quiz over the logic section of this unit. Since logic problems more closely resemble puzzles or games rather than a mathematical concept to be tested, students should not be formally evaluated in this section. The teacher should merely observe students as they work on the problems to sense the students' progress in problem solving.

The main objective behind Mathematical Applications on the Automobile is to motivate students to learn. In order to maintain a level of motivation in the classroom, an individual teacher may choose to modify the plan. This would be quite acceptable, since the objective still remains. Mathematical Applications on the Automobile was created so that it could be taught as a whole unit within a time frame of three to four weeks. Of course, teachers may decide to stretch the material over a complete six- or nine-weeks grading period. Teachers may choose to present the plan altogether with the lessons in consecutive order. Another possibility is that the applications could be distributed over a full school year or a semester. Teachers may choose to present only
certain lessons/topics as enrichment material every few weeks. Some may choose to present a lesson when the classroom text approaches a similar topic. Still others may choose to use only a portion of the entire unit. Whatever the classroom teacher believes is appropriate for the students is an acceptable modification.

This unit was designed with future expansion and modifications in mind. It is possible for the quizzes to be used as tests by themselves or grouped together. The worksheets, as well as the quizzes, can be modified in a variety of ways. A teacher may wish to add or delete problems and complicate or simplify figures in the problems. A teacher may create a worksheet to go along with a prepared one, may create an additional quiz, or may choose not to use the provided quizzes and worksheets at all. The unit plan is actually quite adaptable to an individual teacher's needs.

Classroom presentations of these applications can be an opportunity for the teacher to be creative. Discussions can help improve a student's sense of worthiness by making insightful contributions to the class. One extension activity in the unit is for students to monitor the gas mileage of the family car for a specified amount of time. Perhaps students could share results and discuss which kinds of cars will get better gas mileage. Whenever possible, a teacher should allow students to discuss and share ideas as long as the discussion is educational. "Discussion between peers is a very important ingredient in learning" (Lamon, p. 65). "The interaction of one's own ideas with those of other people (communication)
develops reflective intelligence. ...Intellectual discussion forces on one the necessity to clarify ideas in one's own mind, to state them in terms not likely to be misunderstood, to justify them by revealing their relationships with other ideas; and also, to modify them where weaknesses are found by the other side, ending with a stronger and more cohesive structure than before" (Skemp, p. 43-4). Thus, discussion can play an important role in the classroom experience.

The worksheets following nearly every lesson can be done together as a class or in groups or can be assigned as homework. The day after a lesson has been presented can be spent working on these sheets or reviewing the correct answers. It is suggested that the teacher make transparency copies of each of the worksheets to be covered in class. Then, the teacher, or a student, in front of the whole class can fill in the correct answers showing the proper methodology as well. In this way, students can see the work presented in a clear manner. They may also be able to see good examples of showing the work involved in solving a problem. Many students do not understand the need to show their steps and so do not bother writing them down. Teachers should point out that it would be easier to see where a mistake was made in the problem-solving process and prevent this mistake from happening again if students displayed each step involved. Doing this in class should also improve the students' problem-solving skills.

Another form of modification of this unit plan would be to apply the
subject material in another class level. The students at the junior high/middle school level are close enough in age to the general mathematics students to still be somewhat motivated by the automobile. Moreover, middle school students may be more easily fascinated by the discovery of the mathematical applications that can be found in their world.

These automotive applications can also be implemented in a first- or second-year algebra class. This unit demonstrates many forms of equations and algebraic manipulations that algebra students can comprehend. They will be able to see how equations relate to real situations. An understood objective of this plan is to uncover mathematical applications to show students that mathematics is used in the real world. The NCTM has stated the use of real-world problems to motivate and apply theory should receive more attention from teachers (NCTM, p. 126).

In addition, general mathematics students may be pleasantly surprised to realize that they can do algebra. Their teacher, though, should be wise and keep this information a secret until after the algebraic work is completed. Some students may insist that they cannot do the work if they learn too soon that it is algebra. In other words, the negative attitude about mathematics may rear its ugly head.

One of the goals of the unit is to demonstrate applications of mathematical concepts. Calculators provide ease in this demonstration by
tackling the actual mathematical operations for the students. The use of calculators becomes a crucial part of the unit plan, since many students have consistent trouble with the operations. The NCTM believes that “appropriate calculators should be available to all students at all times” (NCTM, p. 8). The calculators provide a means of by-passing the operational trouble spots in order for students to focus on the broader picture of the applications. On occasion, a teacher may decide not to allow students to use calculators for certain problems. This is one way for a teacher to modify the material for classroom needs. However, this should not be done throughout the unit plan. The complexity of some of the procedures in these applications may be too much for an advanced student to do by hand not just for a general mathematics student to do. Besides, a student must know what to enter into the calculator in order to find the correct answer. The calculator, as with any computer, only does what it is told to do. The NCTM recognizes that “access to technology,” such as the calculator, “is no guarantee that any student will become mathematically literate. Calculators and computers for users of mathematics, like word processors for writers, are tools that simplify, but do not accomplish, the work at hand” (NCTM, p. 8).

Plus, the calculator itself offers excellent motivation. Using the calculator can be considered a technique for using recreational mathematics to motivate students. Students enjoy and prefer to work with a calculator on nearly every kind of problem. Unfortunately, it has
become a "security blanket" for many students. There is nothing wrong with a little confidence-builder, but teachers should beware of students using the calculator as a crutch to do simple, single-digit operations. Students should realize that it is still quicker and just as accurate as a calculator to multiply "3 x 7" in their heads.

The NCTM continues, "Contrary to the fears of many, the availability of calculators and computers has expanded students capability of performing calculations. There is no evidence to suggest that the availability of calculators makes students dependent on them for simple calculations. Students should be able to decide when they need to calculate and whether they require an exact or approximate answer. They should be able to select and use the most appropriate tool. Students should have a balanced approach to calculation, be able to choose appropriate procedures, find answers, and judge the validity of those answers" (NCTM, p. 8).

Even though the NCTM claims to have no evidence, it is common for students to become at least partially dependent upon calculators for simple computations. Veteran teachers can describe their frustration at watching students grab the calculator for just such a type of problem. The author of this unit even confesses to this occasional flaw. As long as teachers discuss with their students about the appropriate and inappropriate times to use a calculator, students should benefit from this tool in the manner that the NCTM describes.
The lesson plans of *Mathematical Applications on the Automobile* were written to educate the teacher as well as the student. Hopefully, the material has been presented clearly enough in the lessons so that instructors unfamiliar with the concepts or terms could learn the important information. It would be impossible for a teacher to adequately teach something when he/she does not understand the material.

Teachers who want to use this unit, whether they understand the material or not, should consider consulting the school's industrial technology department. If the contained material is somewhat confusing to understand, an industrial arts teacher could offer some helpful clarification. More importantly, this consulting teacher, if asked, may be able to provide additional materials to enhance a particular concept in this unit. Working models of automotive parts or colorful diagrams can add to the degree of interest that a student experiences. This, in turn, should foster greater understanding and greater retention of the material that was discussed. Also, students may enjoy having a guest speaker from the industrial technology department. Perhaps an industrial technology teacher may request some assistance from the mathematics department. A "Give-and-Take" relationship between these two departments would not be impossible to achieve. It is even possible that the two teachers might develop an integrated unit based on the automobile. Furthermore, interdepartmental cooperation, besides being beneficial to the students, is something administrators would love to see.
AUTHOR'S PREFACE

In the spring of 1991, I wanted to find mathematical material based on the automobile that I could use in geometry, algebra, analytic geometry, and general mathematics classes. Over the summer, I started my research on the mechanics of the automobile's engine. I learned "the basics" about the internal combustion engine. I learned how the engine operates and "what makes it go." Unfortunately, I did not feel I was finding enough information to use in my project.

I repeatedly came across ratios. Compression ratio, power-to-weight ratio, gear ratios, and axle ratios are but a few examples. I did not want my project to be just about ratios. That would have limited the versatility of my unit plan. These automotive ratios should be examples in just a part of the whole unit.

In addition, other mathematics that I found was too advanced for use in a high school classroom. There was an abundance of information detailing the physics of the automobile. Unfortunately, these physics applications and equations were just too advanced for general mathematics and first-year algebra students to comprehend. (I had trouble understanding the material.)

During the fall of 1991, I completed my student teaching experience. The classes I taught included three geometry classes, a second-year algebra class, and a general mathematics class. The latter of the three was the class that showed me toward which ability level I needed to focus
my unit plan. These students are the ones that could be most motivated by automotive applications of mathematics.

The more advanced mathematics classes in high school contain students highly motivated to do well. Most of the students want to be in the class. Most do not have serious trouble with the subject matter. Most want to go to college. These advanced students are in calculus, analytic geometry or pre-calculus, trigonometry, and, in some cases, second-year algebra.

My student teaching experience showed me that the classes that need some kind of motivation would be the lower level classes. General mathematics especially, but also first year algebra, consumer mathematics, and regular geometry classes are those that need some additional excitement. These students do not enjoy anything about the material.

For these reasons, I turned my attention from finding mathematical concepts about the car that I can teach high school students to gathering mathematical applications on the car with which I can interest students and motivate them to learn in mathematics class. I have, of course, included ratios in this unit plan, but I have also included miles per gallon, speed in miles per hour, proportions, scale models of cars, the distance-rate-time formula, and logic problems.

Whenever I am asked to describe my philosophy of education, I am always sure to include that students should have fun in class. Students
should enjoy learning. It should not be some horrible punishment for students to have to go to school and to have to learn mathematics. Using the car to apply mathematical concepts would be one way in which I could bring fun and excitement to learning mathematics in my classroom. As one of my friends stated, I would be "bringing America's fetish with the car in contact with America's aversion to mathematics." This idea is similar to a "spoonful of sugar helps the medicine go down" lyric sung by Mary Poppins.

When the spring semester of 1992 rolled around, I knew towards which group of students to aim my project. The general mathematics class is difficult to motivate. This kind of class is comprised of students ranging in age from fourteen to sixteen years and ranging in ability from ready for pre-algebra or even algebra to ready to study division and multiplication again. Some students can retain the material, but most have very little retention at all.

I hope that with the use of this unit, I can reach out to these unmotivated students and excite them enough to learn. I understand this will take more than just well-planned teaching materials. The teacher must be excited about the subject as well. The teacher's attitude affects the students' attitudes. If the teacher displays little or no interest in the subject material, regardless of what kind of material it is, students will reflect this lack of interest. However, this unit is a beginning. With this unit plan as part of my personal resources and my own excited interest in
the automobile, I should be able to motivate a class of mathematics students to learn by demonstrating mathematical applications on the automobile.
GENERAL MATHEMATICS - AUTOMOTIVE UNIT PLAN

PURPOSE: Students should become motivated to learn mathematics from studying automotive applications.

TARGET AUDIENCE: This unit is directed towards students in the first and second year of high school in a general mathematics course, a pre-algebra course, or any other basic mathematics course. The age of the student should be 14 -16 years. Possible applications do include the junior high/middle school level courses.

PREREQUISITE SKILLS: Students should be able to add, subtract, multiply, and divide (with or without a calculator) whole numbers, decimals, and fractions. Students should have knowledge of the metric system and other units of measurement.

MATERIALS: Calculators, an overhead projector, transparency pens, maps, a scale car model, an eggbeater, a 10-speed bicycle, and other items listed in the lessons plans.

TIME PERIOD: 16 - 20 Days

CONTENT:
I. Ratios and Proportion
   A. Scale Models (1-2 Days)
      1. Ratios and Scales
      2. Proportions and Scales
      3. Two Worksheets
   B. Gear Ratios (3 Days)
      1. Gears
         a. An Eggbeater
         b. Introduce Bicycle Gears
      2. Gear Ratios
         a. A 10-speed Bicycle
            (1) Covering Distance
            (2) Comparing Gears
            (3) Comparing Speed
         b. Automotive Transmission
            (1) Demonstrate Gear Usage with Arcade Game
(2) Gear Ratios

3. Two Worksheets

C. Other Examples of Ratios on a Car (1 Day)
   1. Compression Ratio
   2. Weight/Power Ratio
   3. Two Worksheets

D. Evaluation - Quiz I

II. Rates

A. Speed (1 Day)
   1. Rates of Speed
   2. Finding Rate of Speed
   3. One Worksheet

B. Gas Mileage (1 Day)
   1. City/Highway Mileage
   2. Finding Gas Mileage
      a. Reading an Odometer
      b. Procedure
   3. Discussion - Fuel Economy
   4. One Worksheet

C. Distance - Rate - Time Formula (1 Day)
   1. Using Proportions to Find Distance
   2. Determining Driving Time
   3. Finding Rate of Speed
   4. One Worksheet

D. Evaluation - Quiz II

III. Map Reading and Planning Routes

A. Planning the Best Route - Small Scale Situations (1 Day)
   1. Going to the Playground/Mall
   2. Comparing Route Distances
   3. One Worksheet

B. Planning the Best Route - Real Map Situations (1 Day)
   1. Discussion - Benefits/Drawbacks of Highway System
   2. Map Legends
   3. Group Activity - One Worksheet

C. Evaluation - Quiz III

IV. Chart Reading

A. Estimated Range (1/2 Day)
   1. Fuel Capacity
   2. Gas Mileage

B. Finding Engine Displacement (1/2 Day)
1. Description
2. Necessary Information
3. Cylinder Volume Formula
4. One Worksheet (Est. Range and Displacement)

C. Evaluation - Quiz IV

V. Logic (1 Day)
A. Introduce Logical Reasoning
B. Logic Problems
   1. Discuss Problem Solving Strategies
   2. Discuss Deductions, Reasonings, and Solutions
RATIO AND PROPORTION
Scale Models

PURPOSE: Students should experience the use of car models to demonstrate scale, ratio, and proportion. Students should learn how to understand and write a ratio, to "translate" sizes with the use of a scale, and to learn about proportions.

PREREQUISITE SKILLS: Division, multiplication, ability to find equivalent measurements in both standard and metric units (for instance, change from cm to mm)

MATERIALS: Miniature toy cars (like Matchbox or Hot Wheels), model kit cars, rulers, actual measurements of life-size car (dealer catalogs)

DEVELOPMENT AND METHODS:
A. Introduce with Toys - Discussion.
   1. Have students estimate size of toy scale (...what to multiply by to get actual model).
   2. Question toy makers decision to make these sizes; Question the realisticability of toys; Why they are, Why they are not; Question...
   3. Discover what scale means.
      a. Measure a model's width, length, tire size, etc. and compare to same car's actual measurements. Students could discover the relationship between the measurements. (Actual ratios may be approximate.)
      b. The scale (1:16, 1:24, 1:64) is a ratio.
      c. A Ratio is a comparison between two quantities. A ratio is a relationship.
   4. Writing ratios
      a. Model example (1991 Pontiac Firebird)
         (1) 8 in. model length to 195 in. car length
         (2) 8:195  or  8/195
         (3) Simplify to (approx.) 1:24 or 1/24
      b. If 15 cars are in a lot and 4 of them are red, then what would the ratio of red cars to all the cars be?
         (1) red cars : all cars
         (2) 4:15  or 4/15
      c. Using previous car lot, what is the ratio between red
cars and non-red cars?
(1) red cars : non-red cars
(2) 4:11 or 4/11
d. Order of numbers is important. For example, 1:30 is
different from 30:1. Why?
(1) 1:30 "zooms" out and away, makes object smaller
(2) 30:1 "zooms" in, makes object larger

B. Proportions
1. Define proportion noting previous examples.
a. A proportion states that two ratios are equal.
b. \( \frac{8}{192} = \frac{1}{24} \)
   (195 in. was approx. scale, 192 is exact)
c. Demonstrate with other measurements from the cars.

2. Explore properties of proportions.
a. First ratio is multiplied or divided by some number ("top
   and bottom") to get second ratio.
   \( \frac{8}{192} \div 8 = \frac{1}{24} \)
b. Cross products are equal (cross multiplication).
   \( 8 \times 24 = 192 \times 1 \)
   \( 192 = 192 \)

3. Practice writing proportions.
a. For a proportion to be true, the two ratios must use the
   same relationship and must be equal:
   \( \frac{1}{2} = \frac{3}{6} = \frac{4}{8} ; \frac{7}{8} = \frac{14}{15} \)
b. Sample - "If 5 cars out of 500 at the mall have cracked
   windshields, and 2 out of 250 at the movie theater do
   also, are the ratios the same? In other words, do we
   have a proportion?"
   (1) \( \frac{5}{500} ? \frac{2}{250} \)
   (2) Are cross products equal?
   \( 5 \times 250 =?= 500 \times 2 \)
   \( 1250 \neq 1000 \)
   => No

4. Solving Proportions
a. Explore how to find missing terms in a proportion with
   these examples.
   (1) \( \frac{3}{6} = \frac{?}{8} ; \frac{1}{4} = \frac{?}{12} \)
(2) Using 1:16 scale, a model's door is 3 in. wide. What is the life-size width of the door? 1/16 = 3/?

(3) If a model's tail light is 1/2 in. (.5 in.) wide and the real one is 10 in. wide, find the model's scale.

b. Demonstrate cross-multiply-and-divide.
   (1) Cross multiply known numbers then divide by lonely number.
      (2) If \( \frac{8}{192} = \frac{3}{?} \), then \( 192 \times 3 = 8 \times ? \) [cross products]
      \[ => 576 = 8 \times ? \]
      \[ => 576 \div 8 = ? \] [divide]
      \[ => 72 = ? \]

(3) After successful applications, mention that this is algebra!

C. Concluding Discussion and Review
   1. Worksheet I can be done in class.
   2. Review previous examples and terms.

ASSIGNMENT: Worksheets I and II

RATIO AND PROPORTION

Scale Models
Worksheet I - Ratios

Using the scale given for the relationship between the toy model and the life-size model, find the missing measurement.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Model</th>
<th>Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:20</td>
<td>8 in. long</td>
<td>54 in. tall</td>
</tr>
<tr>
<td>1:6</td>
<td>3/4 in. diameter wheels</td>
<td></td>
</tr>
<tr>
<td>1:24</td>
<td>110.7 in. wheelbase</td>
<td></td>
</tr>
<tr>
<td>1:30</td>
<td>183 cm wide</td>
<td>30 cm length license plate</td>
</tr>
<tr>
<td>1:19</td>
<td>1 cm wide headlight</td>
<td></td>
</tr>
<tr>
<td>1:15</td>
<td>1 cm wide headlight</td>
<td></td>
</tr>
</tbody>
</table>

9. Which is bigger, a model of 1:12 scale or of 1:15 scale? __________
   Be able to explain why?

Write a ratio for the relationship given in each problem.

10. Number of red cars to blue vehicles ________
11. Number of sedans to number of trucks ________
12. Number of hatchbacks to total number of vehicles ________
13. Number of red coupes to total number of vehicles ________

Find the scale used on these models.

14. The model door is 5 in. wide and the car door is 45 in. wide ________
15. The model's spoiler is 12 mm high but the car's spoiler is 168 mm high. ________
16. The car's wheelbase is 256 cm but the model's wheelbase is 4 cm.

17. How tall would you be at 1/2 scale (1:2)?
   ...at 1/4 scale (1:4)?

18. How long would your hand be at 1/2 scale?
   ...at 1/4 scale?
Using the scale given for the relationship between the toy model and the life-size model, find the missing measurement.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Model</th>
<th>Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:20</td>
<td>8 in. long</td>
<td>160 in. long</td>
</tr>
<tr>
<td>1:6</td>
<td>9 in. tall</td>
<td>54 in. tall</td>
</tr>
<tr>
<td>1:24</td>
<td>3/4 in. diameter</td>
<td>18 in. diameter</td>
</tr>
<tr>
<td></td>
<td>wheels</td>
<td></td>
</tr>
<tr>
<td>1:9</td>
<td>12.3 in.</td>
<td>110.7 in. wheelbase</td>
</tr>
<tr>
<td>1:24</td>
<td>6 mm clearance</td>
<td>144 mm clearance</td>
</tr>
<tr>
<td>1:30</td>
<td>6.1 cm</td>
<td>183 cm wide</td>
</tr>
<tr>
<td>1:19</td>
<td>1 cm wide headlight</td>
<td>19 cm wide</td>
</tr>
<tr>
<td>1:15</td>
<td>2 cm</td>
<td>30 cm length license plate</td>
</tr>
</tbody>
</table>

9. Which is bigger, a model of 1:12 scale or of 1:15 scale? **1:12 scale**
Be able to explain why?

Write a ratio for the relationship given in each problem.

10. Number of red cars to blue vehicles **4:2**
11. Number of sedans to number of trucks **2:1**
12. Number of hatchbacks to total number of vehicles **2:8**
13. Number of red coupes to total number of vehicles **2:8**

Find the scale used on these models.

14. The model door is 5 in. wide and the car door is 45 in. wide. **1:9**
15. The model's spoiler is 12 mm high but the car's spoiler is 168 mm high. **1:14**
16. The car’s wheelbase is 256 cm but the model’s wheelbase is 4 cm.

1:64

17. How tall would you be at 1/2 scale (1:2)?
...at 1/4 scale (1:4)?

18. How long would your hand be at 1/2 scale?
...at 1/4 scale?
RATIO AND PROPORTION
Scale Models
Worksheet II - Proportions

Write in the missing terms.

1. \[ \frac{4}{7} = \frac{12}{21} = \_ \_ \_ \_ \] \[ \frac{28}{21} \]

2. \[ \frac{6}{9} = \frac{2}{3} = \_ \_ \_ \_ \] \[ \frac{12}{12} \]

3. \[ \frac{8}{5} = \frac{24}{15} = \_ \_ \_ \_ \] \[ \frac{10}{10} \]

4. \[ \frac{13}{39} = \frac{2}{6} = \_ \_ \_ \_ \] \[ \frac{21}{21} \]

Decide whether the following sets of ratios are proportions (= or ≠).

5. \[ \frac{1}{4} = \frac{5}{20} \]

6. \[ \frac{1.2}{12} = \frac{4.5}{45} \]

7. \[ \frac{3}{42} = \frac{1.5}{20} \]

8. \[ \frac{4.5}{8} = \frac{9}{16} \]

Complete the following proportions with the missing term.

9. \[ \frac{8}{192} = \_ \_ \_ \_ \] \[ \frac{24}{24} \]

10. \[ \frac{11}{5} = \_ \_ \_ \_ \] \[ \frac{66}{66} \]

11. \[ \frac{3}{11} = \_ \_ \_ \_ \] \[ \frac{33}{33} \]

12. \[ \frac{2}{1} = \_ \_ \_ \_ \] \[ \frac{37}{37} \]

13. \[ \frac{2}{0.3} = \_ \_ \_ \_ \] \[ \frac{6}{6} \]

14. \[ \frac{5}{500} = \_ \_ \_ \_ \] \[ \frac{25}{25} \]

Write a proportion for each of these problems, then find the missing term.

15. 3 trucks out of 5
60 out of what?

16. 4 of every 7 sports cars
How many of every 49?

17. 3 car models for $22.50
1 model for what?

18. 10 cars out of 30
45 out of what?
RATIO AND PROPORTION

Scale Models
Worksheet II - Proportions

Write in the missing terms.

1. \( \frac{4}{7} = \frac{12}{21} = \frac{16}{28} \)

2. \( \frac{6}{9} = \frac{2}{3} = \frac{8}{12} \)

3. \( \frac{8}{5} = \frac{24}{15} = \frac{16}{10} \)

4. \( \frac{13}{39} = \frac{2}{6} = \frac{7}{21} \)

Decide whether the following sets of ratios are proportions (= or ≠).

5. \( \frac{1}{4} = \frac{5}{20} \)

6. \( \frac{1.2}{12} = \frac{4.5}{45} \)

7. \( \frac{3}{42} ≠ \frac{1.5}{20} \)

8. \( \frac{4.5}{8} = \frac{9}{16} \)

Complete the following proportions with the missing term.

9. \( \frac{8}{192} = \frac{1}{24} \)

10. \( \frac{11}{5} = \frac{66}{30} \)

11. \( \frac{3}{11} = \frac{33}{121} \)

12. \( \frac{2}{1} = \frac{74}{37} \)

13. \( \frac{2}{0.3} = \frac{40}{6} \)

14. \( \frac{5}{500} = \frac{25}{25} \)

Write a proportion for each of these problems, then find the missing term.

15. 3 trucks out of 5
60 out of what?
100

16. 4 of every 7 sports cars
How many of every 49?
28

17. 3 car models for $22.50
1 model for what?
$7.50

18. 10 cars out of 30
45 out of what?
135
RATIO AND PROPORTION

Gear Ratios

PURPOSE: Students should observe the mathematics involved in an eggbeater, a 10-speed bicycle, and a car. Students should realize the benefits of gears, gain some understanding of gear ratios, learn how to find a gear ratio on a bicycle, and learn to use gear ratios to find distance traveled by a bicycle.

PREREQUISITE SKILLS: Multiplication and division of decimals; understanding of ratios and proportions

MATERIALS: A whisk, wooden spoon, or blade from an electric mixer; a manual (cranking) eggbeater/mixer, a 10-speed bicycle, a mixing bowl (optional), calculators, tape

DEVELOPMENT AND METHODS:

A. Introduce benefits of gears.
   1. Demonstrate work involved when mixing “by hand” with a whisk, wooden spoon, or even a blade from an electric mixer.
      a. Discuss effort, exhaustion, work done factors (much effort and exhaustion for amount of work).
      b. Discuss an easier way (without electricity!).
   2. Demonstrate work involved when mixing with an eggbeater/mixer.
      a. Discuss effort, exhaustion, work done factors (less effort and less exhaustion for much more work).
      b. Note the gears involved.
         (1) one crank makes blades turn __?__ times
         (2) gears make things easier to do
      c. Find the gear ratio.
         (1) Tape a gear tooth and a blade to count the revolutions and the number of teeth.
         (2) Count the number of teeth on cranking gear.
         (3) Count the number of teeth on blade gear.
         (4) Divide (2) by (3) => gear ratio
   3. Discuss how nearly everything has gears in it.
      a. The first computers and calculators did.
      b. Small toys, big toys, bicycles, cars

B. Demonstrate bicycle gears.
1. Describe 10-speed bicycle gear set-up.

   - Rear wheel has 5 sprockets (gear wheels with teeth).
   - Pedals turn 2 sprocket wheels.
   - A dérailleur (derailer) moves the chain from one sprocket to another (changes the gear and the gear ratio).
   - Gear shifters are by the handle bars.
   - The name "10-speed" comes from the 10 possible combinations of the sprockets.

2. Define gear ratios.

   - The ratio between the number of teeth on the front sprocket to the number of teeth on the rear sprocket in use.
     (1) 40 teeth/20 teeth ⇒ 2/1 or 2
     (2) This example means the rear sprocket turns twice for every one turn of the front sprocket (pedals).
   - The size of the wheel including the tire matters (most 10-speed wheels are 27 in. in diameter).
   - The gear ratio = ratio x wheel diameter
     (1) 2/1 x 27 = 54/1, or just 54, gear ratio.
     (2) This number is used to compare gears.

3. Sample situations

   - If a gear setting uses 46 teeth on the front sprocket, 16 teeth on the rear, and a 27-inch wheel, what is the gear ratio? 46/16 x 27 = 78 (approx.)
   - If a gear setting uses 50 front teeth, 16 rear teeth, and 27-inch wheels, what is the gear ratio? 50/16 x 27 = 84 (approx.)
   - Which would be harder to pedal, the 78 or the 84? Why?
     (1) the 84 gear ratio
     (2) It involves more teeth and it travels farther...

4. Find distance traveled in each gear.

   - Demonstrate with bicycle.
(1) One pedal turn = ? tire turns.
(2) Change gears and repeat.
(3) Discuss what the number of wheel turns has to do with how far the bike travels.

b. Gear ratio \( \times \pi (\pi) \) = Distance traveled forward with each turn of the pedals (each pedal revolution).
(1) 78 gear ratio \( \times \pi = 245 \) in. (rounded)
(2) 84 gear ratio \( \times \pi = 264 \) in. (rounded)
(3) Similar to \( C = \pi \times d \), the circumference of a circle.

c. Higher gear ratios offer greater distance but with greater difficulty in pedaling.

ASSIGNMENT: Worksheet III

RATIO AND PROPORTION

NAME ______________________

Gear Ratios
Worksheet III - Bicycle Ratios

Find the ratios of the bicycle gears with the given numbers of teeth.

1. Front sprocket has 47 teeth
   Rear sprocket has 18 teeth

2. Front has 50 teeth
   Rear has 20 teeth

3. Front has 52 teeth
   Rear has 26 teeth

4. Front has 54 teeth
   Rear has 30 teeth

Find the gear ratios of the bikes and gears indicated. Round answers to the nearest tenth.

5. Front sprocket has 45 teeth
   Rear sprocket has 15 teeth
   Wheel diameter is 27 in.

6. Front sprocket has 49 teeth
   Rear sprocket has 14 teeth
   Wheel diameter is 24 in.

7. 27-inch 10-speed in 3rd gear of 3:1 ratio

8. 24-in. 10-speed in 8th gear of 4.2:1 ratio

9. What information do you need to find the gear ratio on a bicycle?

10. What is the formula used to find these gear ratios?

11. Which would be harder to pedal, a 68 or a 78 gear ratio?

12. Which would make a bike travel farther, a 65 or a 74?
13. What is the formula used to find the distance covered by one revolution of the pedals in a particular gear? 

Using a calculator, find the distance traveled in inches per revolution of the pedals with the given gear ratios. Round answers to the nearest whole inch.

14. gear ratio 64

15. gear ratio 72

16. gear ratio 81

17. gear ratio 94
RATIO AND PROPORTION

NAME KEY

Gear Ratios
Worksheet III - Bicycle Ratios

Find the ratios of the bicycle gears with the given numbers of teeth.

1. Front sprocket has 47 teeth
   Rear sprocket has 18 teeth
   \[ \frac{47}{18} = 2.6 \]

2. Front has 50 teeth
   Rear has 20 teeth
   \[ \frac{50}{20} = 2.5 \]

3. Front has 52 teeth
   Rear has 26 teeth
   \[ \frac{52}{26} = 2 \]

4. Front has 54 teeth
   Rear has 30 teeth
   \[ \frac{54}{30} = 1.8 \]

Find the gear ratios of the bikes and gears indicated. Round answers to the nearest tenth.

5. Front sprocket has 45 teeth
   Rear sprocket has 15 teeth
   Wheel diameter is 27 in.
   \[ \frac{45}{15} = 3 \]

6. Front sprocket has 49 teeth
   Rear sprocket has 14 teeth
   Wheel diameter is 24 in.
   \[ \frac{49}{14} = 3.571 \]

7. 27-inch 10-speed in 3rd gear
   of 3:1 ratio
   \[ \frac{27}{9} = 3 \]

8. 24-in. 10-speed in 8th gear
   of 4.2:1 ratio
   \[ \frac{24}{9.6} = 2.5 \]

9. What information do you need to find the gear ratio on a bicycle?
   The ratio of the gear and the diameter of the wheel

10. What is the formula used to find these gear ratios?
    Diameter of wheel \( \times \) ratio = gear ratio

11. Which would be harder to pedal, a 68 or a 78 gear ratio?
    78

12. Which would make a bike travel farther, a 65 or a 74?
    74
13. What is the formula used to find the distance covered by one revolution of the pedals in a particular gear? ________________________

\[ \text{gear ratio} \times \pi = \text{distance in inches} / \text{revolution} \]

Using a calculator, find the distance traveled in inches per revolution of the pedals with the given gear ratios. Round answers to the nearest whole inch.

14. gear ratio 64
   201 in/rev

15. gear ratio 72
   226 in/rev

16. gear ratio 81
   254 in/rev

17. gear ratio 94
   295 in/rev
RATIO AND PROPORTION
Gear Ratios - Day 2

PURPOSE: Students should extend their understanding of gear ratios. Students should understand reasons for changing gears. Students should understand revolutions per minute, distance per revolution, and how to find the speed of a bike in terms of distance per minute. Students should also practice some applications of these terms.

PREREQUISITE SKILLS: Understanding of previous lesson on bicycle gear ratios; rounding decimals

MATERIALS: Calculators

DEVELOPMENT AND METHODS:
A. Review previous discoveries involving gear ratios.
   1. Finding gear ratios
   2. Finding distance traveled
   3. Pedaling difficulty
B. Discuss benefits of changing gears.
   1. Suppose Jake was riding comfortably on level ground in a 78 gear ratio and then he came to a rather steep hill. Should he switch to a higher or lower gear ratio? (Should he just get off and walk?)
      a. On level ground, if he switches to a higher gear, what happens? He goes farther but with harder pedaling.
      b. On level ground, if he switches to a lower gear, what happens? Pedaling is easier but he does not go as far.
      c. Going uphill, what happens to the pedaling? It gets more difficult.
      d. Going uphill, should he switch to a higher or lower gear? A lower gear; Pedaling would become easier except the hill increases the difficulty so pedaling actually feels the same.
   2. Jake made a trade-off. His pedaling will feel just as hard (easy) as before, but he will have to pedal more times to go as far.
      a. Most machines offer this trade-off: gears, pulleys, jacks.
         (1) Pulleys make you pull the rope longer not harder.
(2) Jacks make you pump often not harder.
3. Ask students which they would prefer: pedaling harder or pedaling more often.

B. Applications
1. First, define revolutions per minute (rpm's). Emphasize need for proper labeling!!
   a. It is the number of pedal revolutions every minute.
   b. 75 rpm's means 75 pedal turns every minute.
2. Find the distance and speed of a bicyclist.
   a. We found the distance traveled from one pedal revolution.
      Gear ratio \( \times \pi \) = distance per revolution
   b. To find the distance traveled when pedaling so many rpm's (say 65), multiply the distance per revolution by the number of rpm's. This answer will be in terms of distance in inches per time in minutes. This is also the speed of the bicyclist.
      (1) 78 gear ratio \( \times \pi \) = 245 inches/rev.
      (2) 245 in. \( \times \) 65 rpm = 15,925 in./min.
3. Brian can turn a 68 gear ratio at 100 rpm or a 72 gear ratio at 84 rpm. For maximum speed, which should he choose? (These are the very considerations bicycle racers use in determining which to use for the final sprint.)
   a. 68 g.r. \( \times \pi \) = 214 in./rev.
      214 in./rev. \( \times \) 100 rpm = 21,400 in./min.
   b. 72 g.r. \( \times \pi \) = 226 in./rev.
      226 in./rev. \( \times \) 84 rpm = 18,984 in./min.
   c. Since 21,400 in./min. is greater than 18,984 in./min., the maximum speed is used in the 68 gear ratio.

C. Additional Exercises in Class (Optional)
1. Lisa approaches a hill which raises whatever gear she is in by 10. Lisa cannot pedal anything harder than a 62 gear ratio. If her 3-speed bicycle has 48, 58, and 78 gear ratios, which should she use?
   a. Easy to answer, may be difficult to understand situation
   b. the 48 gear
2. How far forward with each revolution of the pedals will a 65 gear ratio move a bicycle whose wheel diameter is 27 inches?
   a. 65 g.r. \( \times \pi \)
   b. about 204 inches
3. Josh can spin a 72 g.r. 80 rpm and a 96 g.r. 48 rpm. Which
gives a greater speed?

a. \( 72 \times \pi = 226 \)
   \[ 226 \times 80 = 18,080 \text{ in./min.} \]

b. \( 96 \times \pi = 302 \)
   \[ 302 \times 48 = 14,496 \text{ in./min.} \]

c. Since 18,080 is greater than 14,496, the 72 gear ratio gives a greater speed.

ASSIGNMENT: Worksheet IV

1. What happens to the pedaling when a person shifts up to a higher gear? Does it get easier or harder?

2. What happens to the pedaling when a person does not change gears but rides uphill?

3. Should a person shift up when riding uphill? Why or why not?

4. Do higher gears or lower gears make a bike go farther?

5. Would a person using a lower gear travel as far as someone using a higher gear if they pedal the same number of times?

6. How can a person using a lower gear keep up with someone using a higher gear?

7. Kari and Mike are riding identical 10-speed bicycles. If Kari is in 3rd gear, Mike is in 5th gear, and they are riding side by side, then who must pedal more often (faster) to keep up with the other?

8. How far forward with each revolution of the pedals will an 83 gear ratio move a bicycle with 27-inch wheels?

9. How far forward will a 95 gear ratio move the same bike?

10. Find the speed Michelle rides her bike if she can turn a 58 gear ratio at 110 rpm.
RATIO AND PROPORTION

NAME KEY

Gear Ratios
Worksheet IV - Distance and Speed

1. What happens to the pedaling when a person shifts up to a higher gear? Does it get easier or harder? It gets harder

2. What happens to the pedaling when a person does not change gears but rides uphill? It gets harder

3. Should a person shift up when riding uphill? No Why or why not? The pedaling would get too hard

4. Do higher gears or lower gears make a bike go farther? Higher gears

5. Would a person using a lower gear travel as far as someone using a higher gear if they pedal the same number of times? No

6. How can a person using a lower gear keep up with someone using a higher gear? Pedal more often

7. Kari and Mike are riding identical 10-speed bicycles. If Kari is in 3rd gear, Mike is in 5th gear, and they are riding side by side, then who must pedal more often (faster) to keep up with the other? Kari must pedal faster

8. How far forward with each revolution of the pedals will an 83 gear ratio move a bicycle with 27 inch wheels? 261 inches

9. How far forward will a 95 gear ratio move the same bike? 298 inches

10. Find the speed Michelle rides her bike if she can turn a 58 gear ratio at 110 rpm. 20,020 inches/minute
RATIO AND PROPORTION
Gear Ratios - Day 3

PURPOSE: Students should understand how and why cars use gear ratios.

PREREQUISITE SKILLS: Understanding of previous gear ratio lessons

MATERIALS: A car racing video game such as “Pole Position” or “Super Monaco GP”; a video monitor for all to see; sample gear ratios

DEVELOPMENT AND METHODS:
A. Introduce use of gear ratios on a car.
   1. Find a fair way to pick a student to play the video game.
   2. While student is playing, have class notice relationship between the gear (H/L) and the speed (or rpm).
      a. Notice car will only go so fast in Low gear.
      b. The car must be shifted into High gear to go faster.
   3. If the car has gears, what we know from the bicycle lesson is that it also has gear ratios.
   4. Discuss that a car with a manual transmission (a “stick”) means the driver changes the gears and an automatic transmission shifts itself.

B. Describe effects of gears and gear ratios.
   1. Show examples of a car's gear ratios (taken from a magazine).
      1st........2.78:1	Infiniti Q45
      2nd........1.54:1	4-speed automatic
      3rd........1.00:1	(front drive)
      4th........0.69:1
   2. Explain representations.
      a. These ratios relate the number of turns the crankshaft makes to the number of turns the drive shaft makes in each gear. (The crankshaft is a shaft inside an engine that turns and runs everything. The drive shaft is a shaft from the transmission to the rear drive axle that sends the power to the rear wheels. It is that turning pipe you can see underneath a large box truck.)
      b. These ratios also relate the number of teeth on the “sprocket wheel” on the crankshaft to the number of teeth on the “sprocket wheel” on the drive shaft.
   3. Explain meaning.
a. 1st gear.....2.78:1 => Ratio is the highest because engine must overcome inertia (car doesn't want to move) and friction of standing still to move (turn) the drive axle (the axle that the engine sends power to). The engine is turning faster than the drive shaft.

b. 2nd gear.....1.54:1 => Engine is still turning faster than the drive shaft.

c. 3rd gear.....1.00:1 => The engine (crankshaft) and the drive shaft are turning the same.

d. 4th gear.....0.69:1 => Because the ratio is less than 1:1, the drive shaft is turning faster than the crankshaft. The engine doesn't have to work as hard to keep the car moving. It's like when you're riding a bike and you start pedaling slower but don't actually slow down much.

e. Gears with ratios less than 1:1 might be referred to as overdrive gears.

C. Sample Problems

<table>
<thead>
<tr>
<th></th>
<th>NISSAN 300ZX 2+2</th>
<th>DODGE STEALTH ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>trans.</td>
<td>5-speed manual</td>
<td>5-speed manual</td>
</tr>
<tr>
<td>Gear ratios</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1st)</td>
<td>3.21:1</td>
<td>3.09:1</td>
</tr>
<tr>
<td>(2nd)</td>
<td>1.93:1</td>
<td>1.83:1</td>
</tr>
<tr>
<td>(3rd)</td>
<td>1.30:1</td>
<td>1.22:1</td>
</tr>
<tr>
<td>(4th)</td>
<td>1.00:1</td>
<td>0.89:1</td>
</tr>
<tr>
<td>(5th)</td>
<td>0.75:1</td>
<td>0.74:1</td>
</tr>
</tbody>
</table>

1. How many overdrive gears does each car have? 1 and 2

2. Which car uses a gear that spins the drive shaft just as often as the crankshaft spins? Nissan

D. Use rest of class time playing car game, discussing topic

RATIO AND PROPORTION
More Automotive Applications

PURPOSE: Students should practice finding ratios. Students should learn about compression ratio and weight/power ratio.

PREREQUISITE SKILLS: Understanding of previous ratio material; multiplication and division of decimals; rounding decimals

MATERIALS: Calculators, available auto shop diagrams, charts of technical data from a car magazine

DEVELOPMENT AND METHODS:
A. Discuss previous ratios about cars covered in class.
   1. gear ratios
   2. scale model ratios
   3. proportions
B. Introduce compression ratio.
   1. Discuss the four-stroke engine.
      a. intake stroke - intake of fuel
      b. compression stroke - fuel is compressed
      c. power stroke - spark plug ignites fuel, fuel explodes, explosion pushes piston down which turns crankshaft
      d. exhaust stroke - expulsion of burned gases
   2. Discuss compression stroke.
      a. piston moves up in the fuel-filled cylinder
      b. piston compresses fuel (squeezes together)
   3. The compression ratio compares the volume of fuel in the cylinder before compression with the volume of compressed fuel after compression.
      a. 10:1
      b. 7.5:1

Fig. 4-3. This cylinder has a 4 to 1 compression ratio. When the piston is at TDC (B), the fuel-air mixture is compressed to one-quarter (1/4) the volume that was displaced when the piston was at BDC (A).
4. Discuss what effect different ratios may cause.
   a. Higher ratios mean fuel is compressed more and power stroke is stronger.
   b. Lower ratios mean fuel is not compressed as much and so the power stroke is not as strong.

5. Worksheet V (may choose to assign at end of lesson)

C. Introduce Weight/Power ratio.

1. A way to compare cars or to see if a car needs a bigger engine is to find its Weight to Power ratio.

2. This ratio is found by relating the weight of the car to its horsepower (peak power output).
   a. Find the car's weight in pounds.
   b. Find the car's horsepower in hp @ rpm.
   c. Divide weight by hp.
   d. Round answer to the nearest tenth.
   e. Example using a Mitsubishi 3000GT VR-4.
      (1) 3792 lbs.
      (2) 300 hp @ 6000 rpm
      (3) $3792 \div 300 = 12.64 => 12.6$

3. This ratio is an example of a ratio that is understood to be "something : one".
   a. $\frac{3792}{300} = 12.6$ or 3792:300 and 12.6:1
   b. In Motor Trend, the weight/power ratio in lb./hp is written as just one number, such as 17.4.
   c. Relate this to the fact that any number can be expressed as a fraction by placing it over 1.

4. Discuss the difference between finding power to weight ratio and finding weight to power ratio.
   a. power/weight = $\frac{300}{3792} = 1:12.6$
   b. weight/power = $\frac{3792}{300} = 12.6:1$

5. Discuss meaning of ratios.
   a. A higher ratio means the car is heavy for the amount of work it can do. (21:1)
   b. A lower ratio means the car is light and can go faster, like sports cars. (12:1)
   c. It takes a lot of work to get a car moving and keep it moving. If the car is heavy, it takes even more work. If the car is light it does not take as much work to move, so
it can go faster. It is good to have a low Weight/Power ratio in a performance car.

6. Worksheet VI (Students should use calculators.)

ASSIGNMENT: Worksheets V and VI; can be done in or out of class
(Worksheet VI problems were generated from information provided in the Motor Trend article.)


RATIO AND PROPORTION
More Automotive Applications
Worksheet V - Compression Ratio

Use the following information to find the missing numbers. Write ratios in simplest terms.

1. \[\frac{18}{2}\]
2. \[\frac{15.3}{1.5}\]
3. \[\frac{?}{1.5}\]
4. \[\frac{22}{?}\]

10.6 : 1
8.8 : 1

5. 9.8 to 1
   _____ to 2.7

6. _____ to 1
   35.5 to 5

7. 8.4 : 1
   _____ : 3.3

8. 9.3 : 1
   21.4 : _____

9. \[\frac{7.8}{1} = \frac{48.4}{1}\]

10. \[\frac{10.5}{1} = \frac{_______}{1.8}\]

11. \[\frac{1}{45.1}\]

12. \[\frac{1}{11.1} = \frac{48.8}{_______}\]
RATIO AND PROPORTION
More Automotive Applications
Worksheet V - Compression Ratio

Use the following information to find the missing numbers. Write ratios in simplest terms.

1. \[ \frac{18}{2} = \frac{9}{1} \]
   \[ 10.6 : 1 \]

2. \[ \frac{15.3}{1.5} = \frac{10.2}{1} \]
   \[ 8.8 : 1 \]

3. \[ ? \]
   \[ ? = \frac{15.9}{1.5} \]
   \[ 10.6 : 1 \]

5. \[ 9.8 : 1 \]
   \[ \frac{26.5}{2.7} \]

6. \[ 7.1 \]
   \[ 35.5 : 5 \]

7. \[ 8.4 : 1 \]
   \[ \frac{27.7}{3.3} \]

8. \[ 9.3 : 1 \]
   \[ 21.4 : \frac{2.3}{1} \]

9. \[ \frac{7.8}{1} = \frac{48.4}{6.2} \]

10. \[ \frac{10.5}{1} = \frac{18.9}{1.8} \]

11. \[ \frac{1}{10} = \frac{4.5}{45} \]

12. \[ \frac{1}{11.1} = \frac{4.3}{48.8} \]
Find the missing terms. Round ratios to the nearest tenth, but round horsepower and weights to the nearest whole number.

1. Peak Output...200hp @ 5500rpm  
   Curb Weight........ 3455 lbs.  
   Weight/Power __________  

2. Peak Output...183hp @ 5800rpm  
   Curb Weight........ 3325 lbs.  
   Weight/Power __________  

3. Curb Weight... 2119 lbs.  
   Peak Output... 81hp @ 5500rpm  
   Weight/Power __________  

4. Curb Weight... 2745 lbs.  
   Peak Output...140hp @ 6400rpm  
   Weight/Power __________  

5. Weight/Power... 17.1  
   Curb Weight...... 2732 lbs.  
   Peak Output ______________hp  

6. Weight/Power... 18.2  
   Curb Weight...... 2367 lbs.  
   Peak Output ______________hp  

7. Curb Weight... 2361 lbs.  
   Weight/Power... 17.9  
   Peak Output ______________hp  

8. Curb Weight... 3792 lbs.  
   Weight/Power... 12.6  
   Peak Output ______________hp  

9. Peak Output...140hp @ 6400rpm  
   Weight/Power... 18.0  
   Curb Weight... ____________  

10. Peak Output...110hp @ 4800rpm  
    Weight/Power... 21.4  
    Curb Weight... ____________  

11. Weight/Power... 13.8  
    Peak Output... 200hp @ 6000rpm  
    Curb Weight... ____________  

12. Weight/Power... 14.9  
    Peak Output...190hp @ 6800rpm  
    Curb Weight... ____________  

13. Explain how to find the weight of the vehicle?

14. Explain how to find the horsepower?
RATIO AND PROPORTION
More Automotive Applications
Worksheet VI - Weight/Power Ratio

Find the missing terms. Round ratios to the nearest tenth, but round horsepower and weights to the nearest whole number.

1. Peak Output... 200hp @ 5500rpm
   Curb Weight...... 3455 lbs.
   Weight/Power      17.3

2. Peak Output... 183hp @ 5800rpm
   Curb Weight...... 3325 lbs.
   Weight/Power      18.2

3. Curb Weight... 2119 lbs.
   Peak Output... 81hp @ 5500rpm
   Weight/Power      26.2

4. Curb Weight... 2745 lbs.
   Peak Output... 140hp @ 6400rpm
   Weight/Power      19.6

5. Weight/Power... 17.1
   Curb Weight...... 2732 lbs.
   Peak Output      159.8 hp

6. Weight/Power... 18.2
   Curb Weight...... 2367 lbs.
   Peak Output      130.1 hp

7. Curb Weight... 2361 lbs.
   Weight/Power... 17.9
   Peak Output      131.9 hp

8. Curb Weight... 3792 lbs.
   Weight/Power... 12.6
   Peak Output      301 hp

9. Peak Output... 140hp @ 6400rpm
   Weight/Power... 18.0
   Curb Weight... 2520 lbs.

10. Peak Output... 110hp @ 4800rpm
    Weight/Power... 21.4
    Curb Weight... 2354 lbs.

11. Weight/Power... 13.8
    Peak Output... 200hp @ 6000rpm
    Curb Weight... 2760 lbs.

12. Weight/Power... 14.9
    Peak Output... 190hp @ 6800rpm
    Curb Weight... 2831 lbs.

13. Explain how to find the weight of the vehicle?

    Multiply the peak output by the weight/power ratio.

14. Explain how to find the horsepower?

    Divide the weight by the weight/power ratio.
RATIO AND PROPORTION

Quiz 1

Scale Models
Write a ratio for each. Simplify the answer whenever possible.

1. Wheels
   Model: 3/4 in. diameter
   Car: 18 in. diameter

2. Headlights
   Model: 1 cm wide
   Car: 19 cm wide

Complete the following proportions with the missing terms.

3. \( \frac{7}{8} = \frac{\_}{32} \)
4. \( \frac{11}{10} = \frac{\_}{110} \)
5. \( \frac{74}{37} = \frac{8}{\_} \)
6. \( \frac{0.12}{\_} = \frac{3}{0.6} \)

Write a proportion, then find the missing term.

7. 3 red cars out of 5 cars
   12 red cars out of how many?

8. 3 dented fenders out of 4
   12 dented out of how many?

Gear Ratios
Find the gear ratios of these bikes.

9. Front sprocket has 44 teeth
   Rear sprocket has 18 teeth
   Wheel diameter is 27 inches

10. Front has 49 teeth
    Rear has 18 teeth
    Wheel diameter is 24 inches

11. What is the formula used to find the distance covered by one pedal revolution of a bike in a particular gear?

12. Find the distance traveled (in inches per pedal revolution) of a bike in a gear that has a ratio of 70.