

# Teaching Suggestions

## Science and Mathematics Lab

(Course 3 Lesson 4-1)

### *The Bicycle: A Well-Engineered Machine*

#### OVERVIEW

In this activity, students will use proportions to explain the relationship between force and speed in a bicycle with multiple gears. They will determine the mechanical advantage of a standard ten-speed bicycle and describe the functions of gears.

#### RECOMMENDED TIME

1 class period

#### MATERIALS

- ten-speed bicycle
- block of wood

#### PREPARATION

No special preparation is needed.

#### TEACHING THE LAB

1. Have students work in pairs.
2. Warn students that bicycle gears and chains are greasy.
3. Use the diagram below to show students how to set up and hold the bicycle.



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### *The Bicycle: A Well-Engineered Machine (continued)*

#### DATA AND OBSERVATIONS

Data will vary according to number of gear teeth.

Teeth on Front Gear	Teeth on Rear Gear	Mechanical Advantage (MA)
52	34	0.65
52	29	0.56
52	24	0.46
52	19	0.37
52	14	0.27
42	34	0.81
42	29	0.69
42	24	0.57
42	19	0.45
42	14	0.33

#### **Answers and Conclusions**

- Each combination of gears produces a different mechanical advantage. If a bike has 2 large gears and 5 small gears, then the possible number of combinations is  $2 \times 5$  or 10. The bike will have a maximum of 10 different mechanical advantages.
- Front gear: gear with least number of teeth (smaller gear); Rear gear: gear with greatest number of teeth (largest gear)
- The gear combination with the greatest mechanical advantage (smaller front gear, largest rear gear).
- The gear combination with the least mechanical advantage (larger front gear, smallest rear gear).

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## The Bicycle: A Well-Engineered Machine

### INTRODUCTION

When you ride a bicycle on level ground, the gears increase or decrease the force that you need to exert on the pedals to keep the bike moving. This change of force results in faster or slower speeds. The *mechanical advantage* (MA) is the number of times the effort force (the force from your legs) is multiplied by the machine. Mechanical advantage decreases or increases with the changing of the gears. The *speed advantage* (SA) is the number of times that the machine multiplies the speed at which the effort force is applied. If a bicycle multiplies the force of your legs by two, the speed is reduced by one-half.

### OBJECTIVES

In this lab, you will:

- determine the mechanical and speed advantages of a ten-speed bicycle.
- describe the functions of the gears on a ten-speed bicycle.

### MATERIALS

- ten-speed bicycle
- block of wood

### PROCEDURE

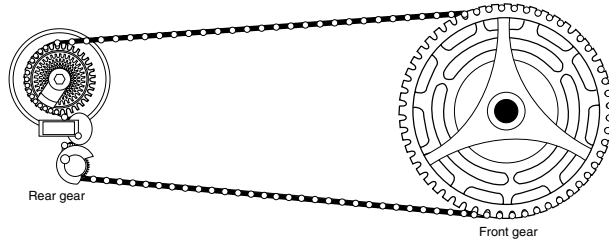
1. Place the block of wood under the bottom bracket of the frame. Have your lab partner steady the bicycle by holding the seat and the handle bars. Now the rear wheel can turn freely when the pedals are turned.
2. Turn the pedals with one of your hands to make the rear wheel turn. While the wheel is turning, shift the gears so that the bicycle is in first gear. While turning the pedal at a constant rate, slowly shift through the ten gears. CAUTION: Do not shift gears when the rear wheel is not turning. Avoid placing your hand near the rear wheel, drive chain, or gears. Observe the speed of the rear wheel as you shift through the gears. Observe how the chain moves across the gears when you shift.
3. Remove the bicycle from the block of wood and lay it on its side.
4. Count the number of teeth on the front gear and rear gear for each combination of gears. Record these values in the table.

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## The Bicycle: A Well-Engineered Machine (continued)

Look at the bicycle gears shown in the diagram. If you count the number of teeth in the two gears, you will find that the front gear has 52 teeth and the rear gear has 34. The mechanical advantage of this combination of gears can be calculated by using the following equation.



$$MA = \frac{\text{number of teeth on rear gear}}{\text{number of teeth on front gear}}$$

For the gears shown, the mechanical advantage is  $\frac{34}{52}$  or 0.65. Calculate the mechanical advantage for each combination of your gears listed in the table. Record these values in the Data Table.

### DATA AND OBSERVATIONS

Teeth on Front Gear	Teeth on Rear Gear	Mechanical Advantage (MA)

### Questions and Conclusions

1. Explain how the use of 2 large gears and 5 small gears produces 10 different mechanical advantages.
2. What gear combination produced the greatest mechanical advantage?
3. Which gear combination do you think is the best for hill-climbing?
4. Which gear combination do you think is the best for racing on a level track?