Name: ______________________________ Date: __________

CONTENT 9.2

9.2 Gear Ratios

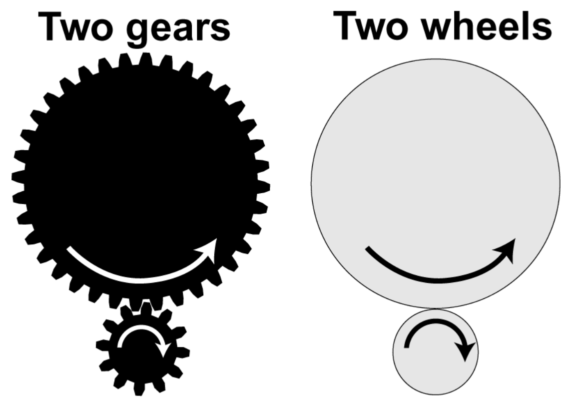
READ

A gear ratio is used to figure out the number of turns each gear in a pair will make based on the number of teeth each gear has.

To calculate the gear ratio for a pair of gears that are working together, you need to know the number of teeth on each gear. The formula below demonstrates how to calculate a gear ratio.

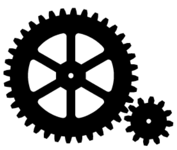
Notice that knowing the number of teeth on each gear allows you to figure out how many turns each gear will take.

Why would this be important in figuring out how to design a clock that has a minute and hour hand?



Gears act like touching wheels, but gears have teeth to keep them from slipping as they turn togeher.

Gear ratio



$$\frac{T_o}{T_i} = \frac{N_i}{N_o}$$

- T_o: Turns of output gear
- T_i: Turns of input gear
- N_i: Number of teeth on input gear
- N_o: Number of teeth on output gear

EXAMPLE

A gear with 48 teeth is connected to a gear with 12 teeth. If the 48-tooth gear makes one complete turn, how many times will the 12-tooth gear turn?

$$\frac{\text{Turns of output gear?}}{\text{One turn for the input gear}} = \frac{\text{48 input teeth}}{\text{12 output teeth}}$$

$$\text{Turns of output gear?} = \frac{\text{48 teeth} \times \text{1 turn}}{\text{12 teeth}} = \text{4 turns}$$

PRACTICE

1. A 36-tooth gear turns three times. It is connected to a 12-tooth gear. How many times does the 12-tooth gear turn?
2. A 12-tooth gear is turned two times. How many times will the 24-tooth gear to which it is connected turn?
3. A 60-tooth gear is connected to a 24-tooth gear. If the smaller gear turns ten times, how many turns does the larger gear make?
4. A 60-tooth gear is connected to a 72-tooth gear. If the smaller gear turns twelve times, how many turns does the larger gear make?
5. A 72-tooth gear is connected to a 12-tooth gear. If the large gear makes one complete turn, how many turns does the small gear make?

6. Use the gear ratio formula to help you fill in the table below.

Table 1: Using the gear ratio to calculate number of turns

Input Gear (# of teeth)	Output Gear (# of teeth)	Gear ratio (Input Gear: Output Gear)	How many turns does the output gear make if the input gear turns 3 times?	How many turns does the input gear make if the output gear turns 2 times?
24	24			
36	12			
24	36			
48	36			
24	48			

7. The problems in this section involve three gears stacked on top of each other. Once you have filled in Table 2, answer the question that follow. Use the gear ratio formula to help. Remember, knowing the gear ratios allows you to figure out the number of turns for a pair of gears.

Table 2: Set up for three gears

Setup	Gears	Number of teeth	Ratio (top gear: middle gear)	Ratio 2 (middle gear: bottom gear)	Total gear ratio (Ratio 1 x Ratio 2)
1	Top gear	12			
	Middle gear	24			
	Bottom gear	36			
2	Top gear	24			
	Middle gear	36			
	Bottom gear	12			
3	Top gear	12			
	Middle gear	48			
	Bottom gear	24			
4	Top gear	24			
	Middle gear	48			
	Bottom gear	36			

8. As you turn the top gear to the right, what direction does the middle gear turn? What direction will the bottom gear turn?

9. How many times will you need to turn the top gear (input) in setup 1 to get the bottom gear (output) to turn once?

10. If you turn the top gear (input) in setup 2 two times, how many times will the bottom gear (output) turn?

11. How many times will the middle gear (output) in setup 3 turn if you turn the top gear (input) two times?

12. How many times will you need to turn the top gear (input) in setup 4 to get the bottom gear (output) to turn 4 times?

Name: ______________________ Date: __________

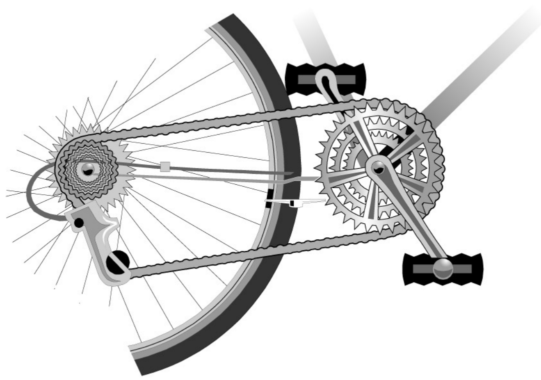
CHALLENGE! 9.2

9.2 Bicycle Gear Ratios Project

READ

How many gears does your bicycle really have?

Bicycle manufacturers describe any bicycle with two gears in the front and five in the back as a ten-speed. But do you really get ten different speeds? In this project, you will determine and record the gear ratio for each speed of your bicycle. You will then write up an explanation of the importance (or lack of, in some cases) of each speed. You will explain what the rider experiences due to the physics of the gear ratio, and in what situation the rider would take advantage of that particular speed.



To complete this project, you will need:

- Multi-speed bicycle
- Simple calculator
- Access to a library or the Internet for research
- Access to a computer for work with a spreadsheet (optional)

PRACTICE

On a multi-speed bicycle, there are two groups of gears: the front group and the rear group. You may want to carefully place your bicycle upside down on the floor to better work with the gears. The seat and handlebars will keep the bicycle balanced.

1. Draw a schematic diagram to show how the gears are set up on your bicycle.

2. Now, count the number of teeth on each gear in each group. Record your data in a table on paper or in a computer spreadsheet. Use these questions to guide you.

   a. How many gears are in the front group?

   b. How many teeth on each gear in the front group?

   c. How many gears are in the rear group?

   d. How many teeth on each gear in the rear group?

3. Now, calculate the gear ratio for each front/rear combination of gears.
   Use the formula: front gear ÷ rear gear.
   Organize the results of your calculations into a new table either on paper on in a computer spreadsheet.
   How many different gear ratios do you actually have?

4. Use your library or the Internet to research the development of the multi-speed bicycle. Take careful notes while you do your research as you will use the information you find to write a report (see step 7). In your research, find the answers to the following questions.
   a. In what circumstances would a low gear ratio be helpful? Why?
   b. In what circumstances would a high gear ratio be helpful? Why?

5. Write up your findings and results according to the guidelines below.

Your final project should include:

- **A brief (one page) report** that discusses the evolution of the bicycle. What was the first bicycle like? How did we end up with the modern bicycle? Why was the multi-speed bicycle an important invention?
- **A schematic diagram** of your bicycle's gears. Include labels.
- **An organized, professional data table** showing the gear ratios of your bicycle.
- **A summary report** (one page) in which you interpret your findings and explain the trade-off between force and distance when pedaling a bicycle in each of the different speeds. Include answers to questions 4(a) and 4(b). In your research, you should make a surprising discovery about the speeds—what is it?
- **Reflection:** Finish the report with one or two paragraphs that express your reflections on this project.

Name: ______________________________ Date: __________

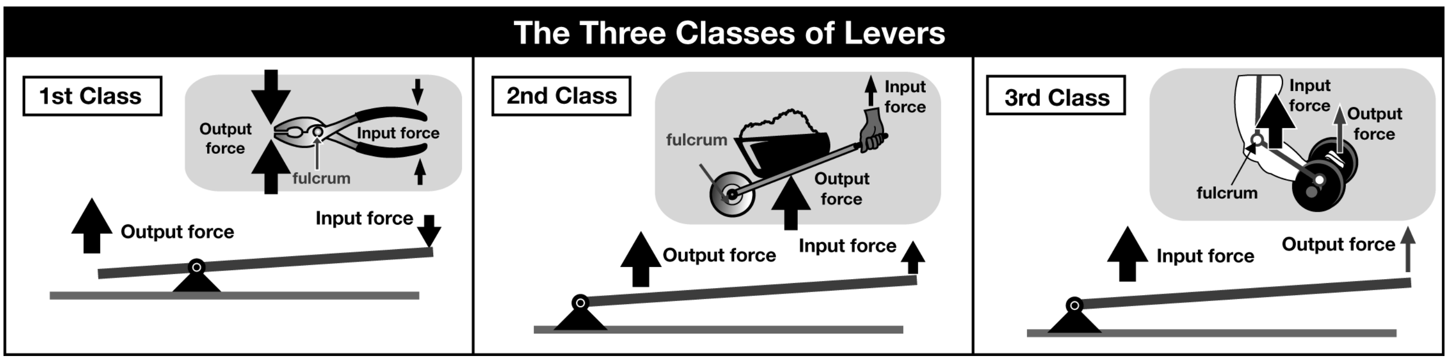
CONTENT 9.3

9.3 Types of Levers

READ

A lever is a simple machine that can be used to multiply force, multiply distance, or change the direction of a force. All levers contain a stiff structure that rotates around a point called the **fulcrum**. The force applied to a lever is called the **input force**. The force applied to a load is called the **output force**.

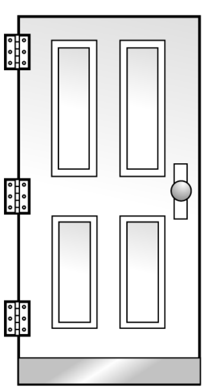
There are three types or classes of levers. The class of a lever depends on the location of the fulcrum and input and output forces. The picture below shows examples of the three classes of levers. Look at each lever carefully, noticing the location of the fulcrum, input force, and output force.



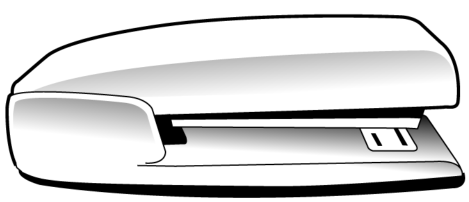
PRACTICE 1

1. In which class of lever is the output force between the fulcrum and input force?
2. In which class of lever is the fulcrum between the input force and output force?
3. In which class of lever is the fulcrum on one end and the output force on the other end?
4. Do the following for each of the levers shown below and at the top of the next page:
    a. Label the fulcrum (F).
    b. Label the location of the input force (I) and output force (O).
    c. Classify the lever as first, second, or third class.

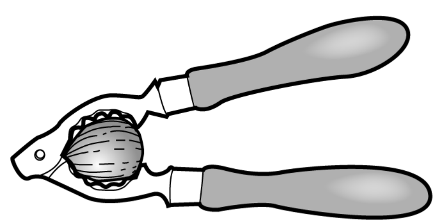
Door



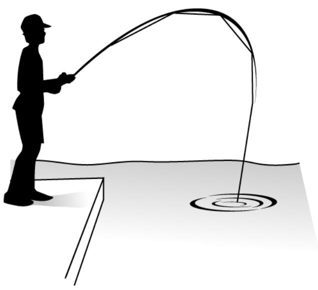
Stapler



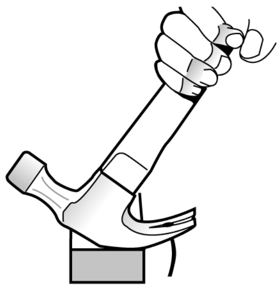
Nutcracker



Fishing Rod

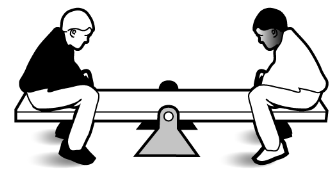


Hammer Claw



Oar

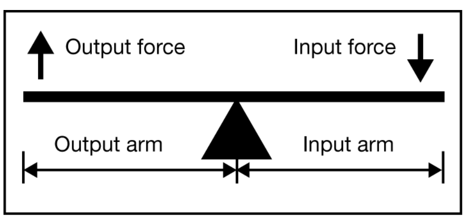
See-saw

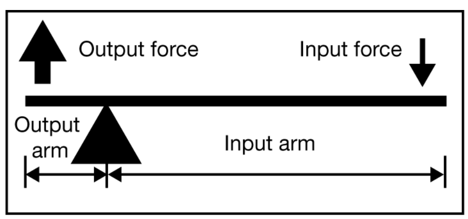


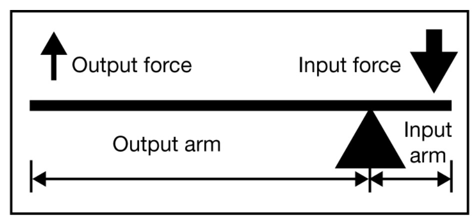
READ

The relationship between a lever's input force and output force depends on the length of the **input arm** and **output arm**. The input arm is the distance between the fulcrum and input force. The output arm is the distance between the fulcrum and output force.

If the input and output arms are the same length, the forces are equal. If the input arm is longer, the input force is less than the output force. If the input arm is shorter, the input force is greater than the output force.







PRACTICE 2

1. Label the input arm (IA) and output arm (OA) on each of the levers you labeled above and on the previous page.
2. In which of the levers is the input force greater than the output force?
3. In which of the levers is the output force greater than the input force?
4. In which of the levers are the input and output forces equal in strength?
5. Find two other examples of levers. Draw each lever and label the fulcrum, input force, output force, input arm, and output arm. State whether the input or output force is stronger.

Name: ______________________ Date: __________

9.3 Levers in the Human Body

READ

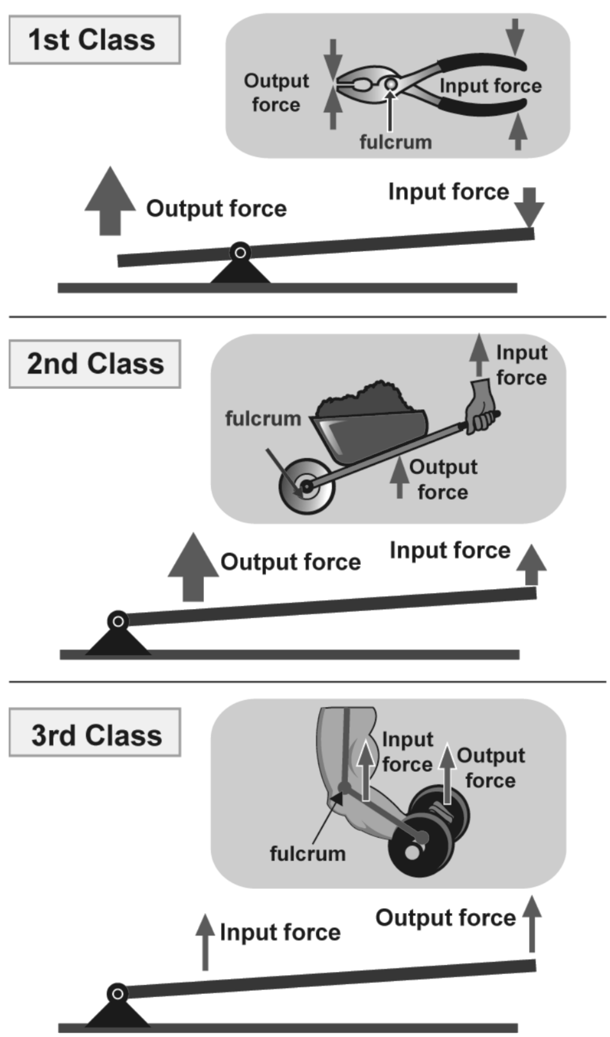
Your skeletal and muscular systems work together to move your body parts. Some of your body parts can be thought of as simple machines or levers.

There are three parts to all levers:

- Fulcrum - the point at which the lever rotates.
- Input force (also called the *effort*) - the force applied to the lever.
- Output force (also called the *load*) - the force applied by the lever to move the load.

There are three types of levers: first class, second class and third class. In a first class lever, the fulcrum is located between the input force and output force. In a second class lever, the output force is between the fulcrum and the input force. In a third class lever, the input force is between the fulcrum and the output force. An example of each type of lever is shown below.

The Three Classes of Levers



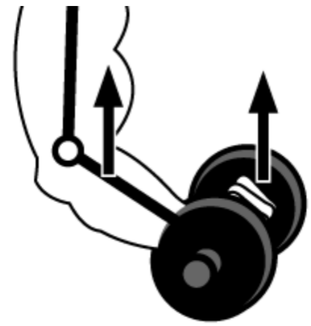
PRACTICE

The three classes of levers can be found in your body. Use diagrams A, B, and C to answer the questions below. Also label the effort (input force), fulcrum and load (output force) on each diagram.

LEVER A

1. Type of Lever: __________

2. How is this lever used in the body?

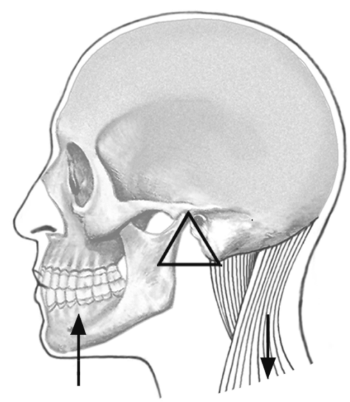


A

LEVER B

3. Type of Lever: __________

4. How is this lever used in the body?

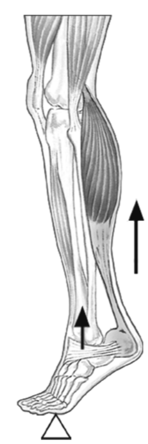


B

LEVER C

5. Type of Lever: __________

6. How is this lever used in the body?



C