Lever

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CHAPTER 1 Lever

- Define lever.
- Describe the three classes of levers.
- Outline how each class of lever changes force.

A hammer can be used to pull a nail out of a board. You can see how it's done in this picture. When you push down on the handle of the hammer, the claw end of the hammer pulls up on the nail. A hammer is an example of a machine called a lever.

What Is A Lever?

A **lever** is a simple machine consisting of a bar that rotates around a fixed point. The fixed point of a lever is called the fulcrum. Like other machines, a lever makes work easier by changing the force applied to the machine or the distance over which the force is applied.

How does a hammer make it easier to pull a nail out of a board? First, it changes the direction of the force applied to the hammer—the hand pushes down on the handle while the claw end of the hammer head pulls up. Often, you can push down with more force than you can push up because you can put your own weight behind it. The hammer also increases the strength of the force that is applied to it. It easily pulls the nail out of the board, which you couldn't do with your hands alone. On the other hand, the hammer decreases the distance over which the force is applied. The hand pushing down on the handle moves the handle over a distance of several inches, whereas the hammer pulls up on the nail only an inch or two.

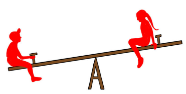
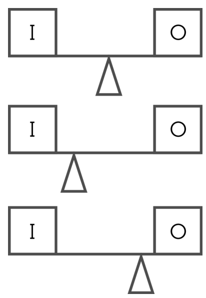
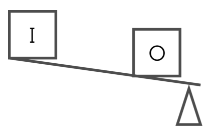
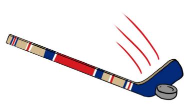
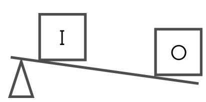
Q: Where is the fulcrum of the hammer when it is used to pull a nail out of a board? In other words, around what point does the hammer rotate?

A: The fulcrum is the point where the head of the hammer rests on the surface of the board.

Classes of Levers

Other levers change force or distance in different ways than a hammer removing a nail. How a lever changes force or distance depends on the location of the input and output forces relative to the fulcrum. The input force is the force applied by the user to the lever. The output force is the force applied by the lever to the object. Based on the location of input and output forces, there are three basic types of levers, called first-class, second-class, and third-class levers. The **Table** 1.1 describes the three classes.

TABLE 1.1: Classes of Levers

Class of Lever	Example of Lever in This Class	Location of Input & Output Forces & Fulcrum*	Ideal Mechanical Advantage	Change in Direction of Force?
First class	Seesaw 		1 <1 >1	yes yes yes
Second class	Wheelbarrow 		>1	no
Third class	Hockey stick 		<1	no

- Δ = fulcrum I = input force O = output force

The **Table** 1.1 includes the ideal mechanical advantage of each class of lever. The mechanical advantage is the factor by which a machine changes the input force. The ideal mechanical advantage is the increase or decrease in force that would occur if there were no friction to overcome in the use of the machine. Because all machines must overcome some friction, the ideal mechanical advantage is always somewhat greater than the actual mechanical advantage of the machine as it is used in the real world.

Q: Which class of lever is a hammer when it is used to pry a nail out of a board? What is its mechanical advantage?

A: To pry a nail out of a board, the fulcrum is located between the input and output forces. Therefore, when a hammer is used in this way it is a first class lever. The fulcrum is closer to the output force than the input force, so the mechanical advantage is >1. In other words, the hammer increases the force applied to it, making it easier to pry the nail out of the board.

Comparing Classes of Levers

All three classes of levers make work easier, but they do so in different ways.

- When the input and output forces are on opposite sides of the fulcrum, the lever changes the direction of the applied force. This occurs only with first-class levers.
- When both the input and output forces are on the same side of the fulcrum, the direction of the applied force does not change. This occurs with both second-class and third-class levers.
- When the input force is applied farther from the fulcrum than the output force is, the output force is greater than the input force, and the ideal mechanical advantage is greater than 1. This always occurs with second-class levers and may occur with first-class levers.
- When the input force is applied closer to the fulcrum than the output force is, the output force is less than the input force, and the ideal mechanical advantage is less than 1. This always occurs with third-class levers and may occur with first-class levers.
- When the input and output forces are the same distance from the fulcrum, the output force equals the input force, and the ideal mechanical advantage is 1. This occurs only with first some first-class levers.

Advantage of Third Class Levers

You may be wondering why you would use a third-class lever when it doesn't change the direction or strength of the applied force. The advantage of a third-class lever is that the output force is applied over a greater distance than the input force. The output end of the lever must move faster than the input end in order to cover the greater distance.

Q: A broom is a third-class lever when it is used to sweep a floor (see the **Figure** 1.1), so the output end of the lever moves faster than the input end. Why is this useful?

A: By moving more quickly over the floor, the broom does the work faster.

FIGURE 1.1

Summary

- A lever is a simple machine consisting of a bar that rotates around a fixed point called the fulcrum.
- Based on the location of the input and output forces relative to the fulcrum, there are three basic types of levers: first-class, second-class, and third-class levers. The classes differ in their mechanical advantage and whether they change the direction of the input force.

Review

1. What is a lever?
2. In the broom pictured in the **Figure** 1.1, where is the fulcrum and where are the input and output forces applied?
3. If you use a screwdriver to pry the lid off a paint can, which class of lever is the screwdriver? How does the screwdriver change the force that is applied to it? What is its ideal mechanical advantage?
4. Give an example of a lever that isn't mentioned in the article. What is its class?

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References

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