

# Mousetrap Vehicles

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**Figure 1: This sample mousetrap-powered vehicle has a large drive wheel and a small axle. The vehicle will move slowly and travel a long distance for each turn of the wheel.**

People are always trying to make work easier. Whether it is moving a heavy crate, traveling to another location, or solving a complex mathematical problem, people have developed complex machines to do most of their work. Nevertheless, people always try to make improvements on their machines in order to make work even easier and faster.

Your challenge will be to design and build a vehicle that is powered by a mousetrap and travels the farthest possible distance. In order to be successful, you must apply your knowledge of how machines work.

Why build a mousetrap-powered car? Well, building a mousetrap vehicle is a very interesting design problem, which is more difficult than it first appears. As you build your car, you will encounter unanticipated problems, and each builder will face different problems. Each person will have to solve his or her problems in different ways. There is never one right answer, but there are many different approaches that need to be tested and verified. Throughout the design and construction of your vehicle, you will have to make trade-offs. Trade-

offs occur because optimizing one variable may prevent optimizing another variable. For example, a car designed to accelerate quickly uses more energy per distance than a slower-accelerating vehicle. When applying the ideas in this book to the design and construction of your vehicle, remember that an extreme exaggeration of an idea will likely have a negative effect on performance. You will have to find a good combination of ideas by repeated experimentation. Pick the idea you think will work best. Work carefully and you will succeed.

One of the most basic designs of a mousetrap vehicle is to attach a string to the mousetrap's lever arm. At the other end of the string, a loop is tied and is placed over a hook mounted on the drive axle. This string is wound around a drive axle with the mousetrap lever arm set. When the mousetrap is triggered, the string is pulled off the drive axle. This causes the drive axle and wheels to rotate and to move the vehicle forward.

# Simple Machines

## Six Simple Machines

- Inclined plane
- Wedge
- Screw
- Lever
- Wheel and axle
- Pulley

Your mousetrap vehicle will have a number of moving parts making it a type of machine. A machine is a device that helps people do work more easily. Every machine works in accordance with scientific laws. Mechanical machines have parts that move. All machines, no matter how complex, are composed of some combination of six simple machines. The six simple machines are: the inclined plane, the wedge, the screw, the lever, the wheel and axle, and the pulley. Understanding the principles of these simple machines will help you design your mousetrap vehicle.

Modern engineers use the laws of physics and mathematics in the design

and construction of the many things you see every day. Machines are designed to ensure that the right amount of force produces the right amount of movement at the right time.

The physical concepts of force, inertia, friction, and mass are explored in this activity. A force is a push or a pull on an object. Inertia is the tendency of an object at rest to stay at rest or a moving object to keep moving. Friction is a force that resists movement between two surfaces. When designing a vehicle for speed and distance, engineers look for ways to decrease friction. Mass is anything that has size and occupies space.

The principles on which the six simple machines work will be discussed in the next few pages. These simple machines have been used since ancient times. You may be able to use one or more simple machines in your mousetrap vehicle.

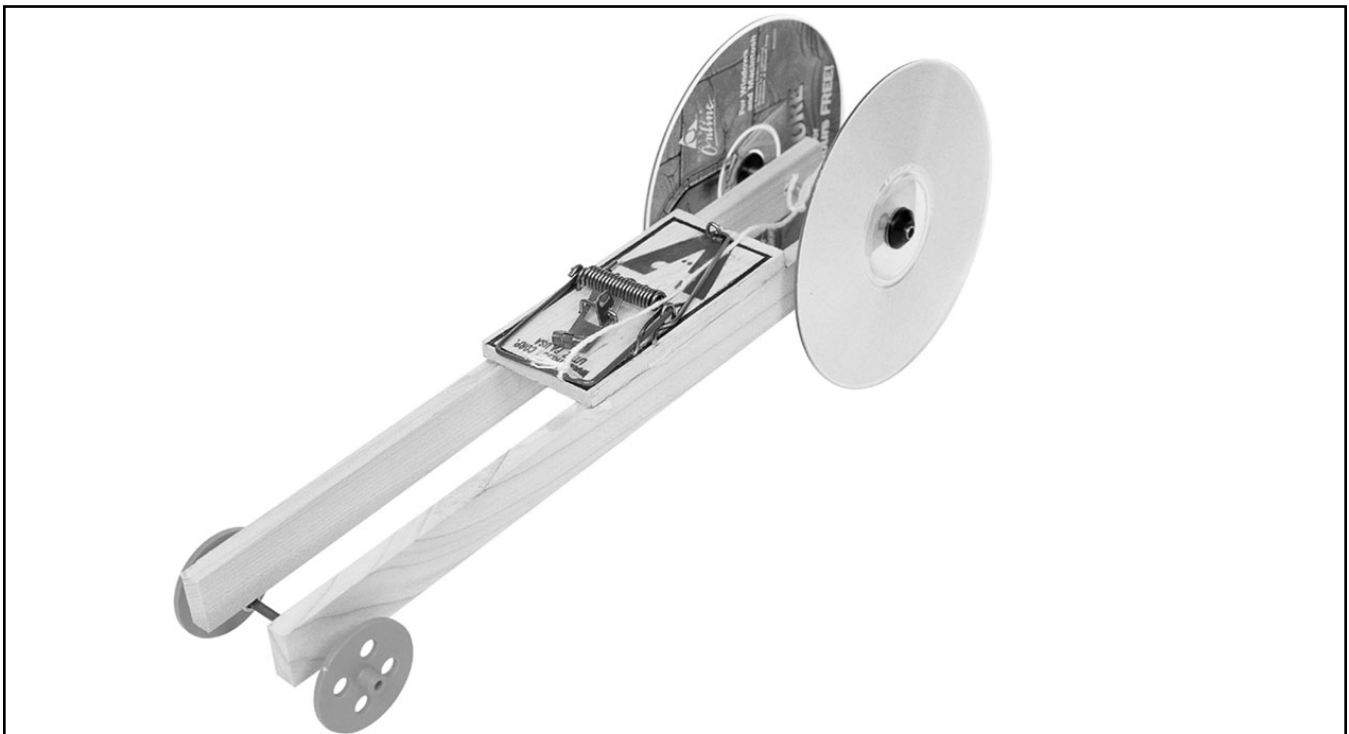


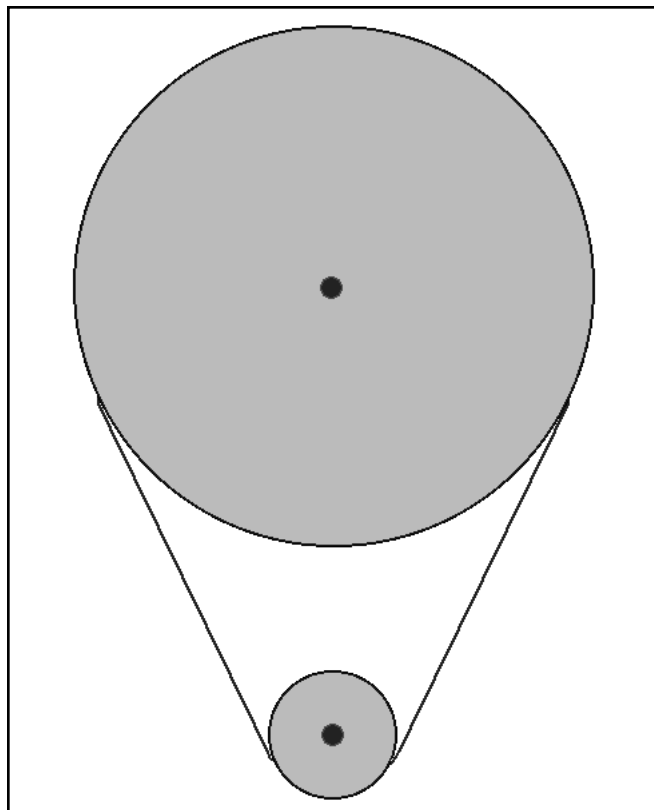
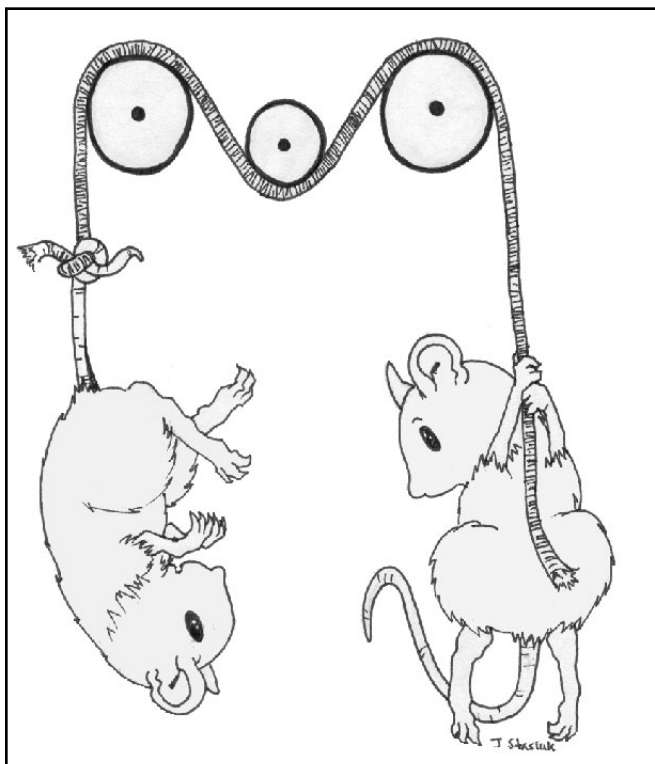
Figure 2: Basic design for a mousetrap vehicle

## Mechanical Advantage in Gear and Pulley Systems

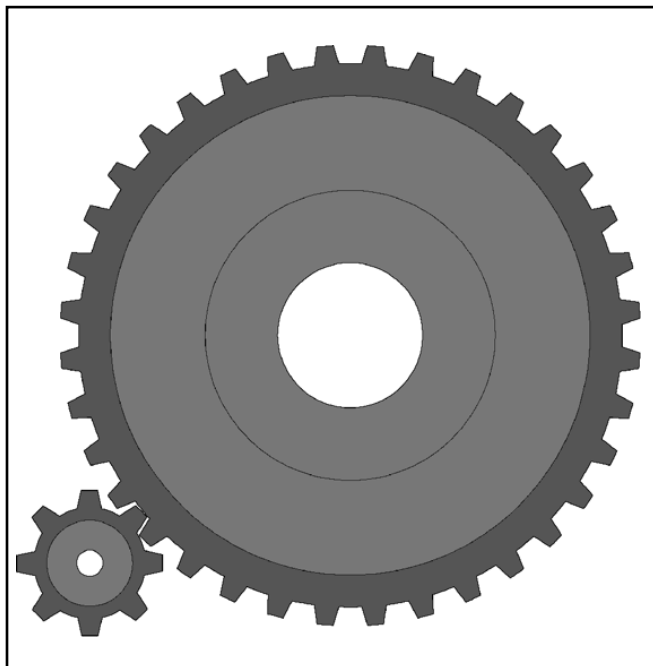
You can use gears or pulleys to control a mousetrap car's speed and distance traveled. Gears are wheels with teeth, and pulleys are wheels with a groove that holds a connecting belt.

Gears and pulleys may be arranged to gain or lose mechanical advantage. An increase in mechanical advantage will increase torque but will decrease speed and distance. A decrease in mechanical advantage will decrease torque but will increase speed and distance. You need enough torque to get the vehicle moving, but you need enough speed and distance to make the vehicle travel far.

By applying the force from the mousetrap to a large pulley on the drive axle, a large amount of torque (or turning force) will be applied, but the axle will rotate at a slow speed. If the force from the mousetrap is applied to a smaller pulley on the drive axle, then the torque will be less, but the speed will be greater than with the large pulley.



**Figure 24:** The big pulley has four times the circumference of the small pulley. It rotates with four times the force and one quarter the speed, but in the same direction.



**Figure 25:** The big gear has four times the number of teeth and four times the circumference of the small gear. It rotates with four times the force and one quarter the speed, but in the opposite direction.

# Design Considerations

Before you can successfully build a mousetrap car, you must give some time and thought to its design. Consider the following factors.

- Inertia
- Rotational inertia
- Chassis construction
- Lever, pulley, or gear drive system
- Position of the mousetrap
- Type of axle and bearing
- Wheel diameter and width
- Friction between moving parts
- Aerodynamics

## Reduce Inertia by Reducing Weight

It is harder to get a heavy object moving compared to a light object. Build your vehicle using lightweight materials so that the mass of the vehicle will be as low as possible. The weight of your vehicle is a very important design consideration.

Also, weight is a direct multiplier on rolling resistance. Twice the weight means twice the rolling resistance for the same wheels and bearings. However, there must be enough weight on the drive wheels so that they do not spin.

## Reduce Rotational Inertia

Rotational inertia is the resistance that a rotating object has to changes in its state of rotation. Rotational inertia depends on the amount of mass and where the mass is located. A light wheel will not always accelerate faster than a heavy wheel. It is more important to note where the mass is located from the center of the wheel. To achieve fast acceleration from the start line, use the lightest wheels possible. Keep the center of mass close to the center of the wheel, and remove mass from the outside of the wheel.

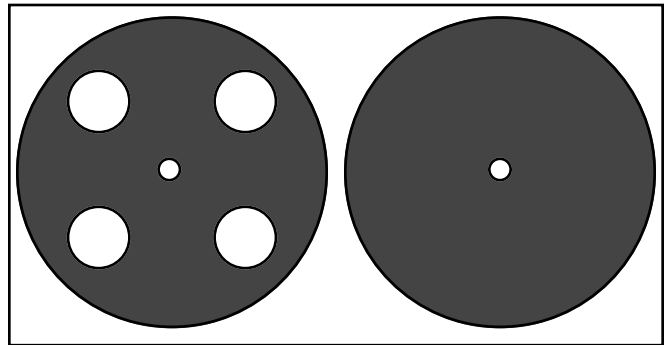
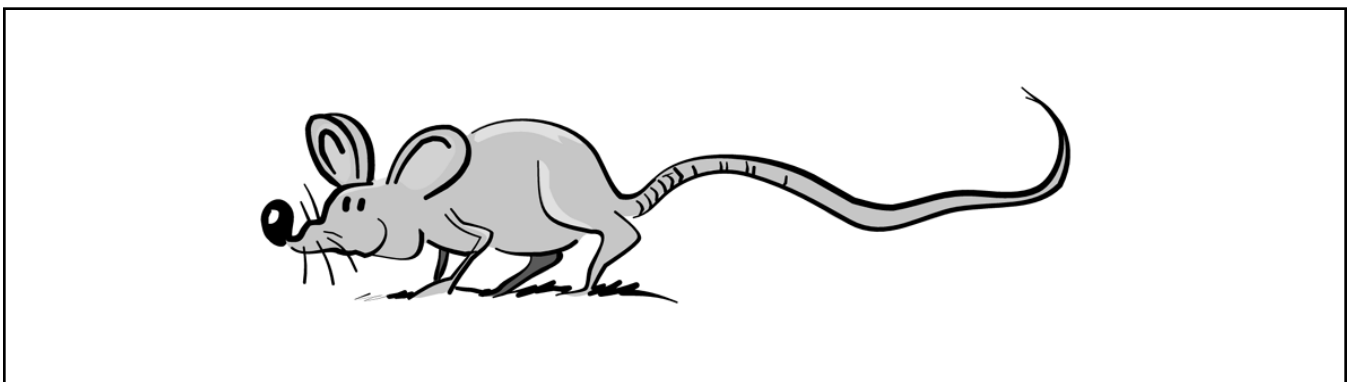


Figure 28: Which wheel has less rotational inertia if they are the same diameter?

## Build a Strong and Stiff Chassis

The vehicle chassis must be strong and stiff. Strong means it will not break easily; stiff means it will not bend easily. Making the chassis strong yet light is a problem you will have to solve.



## Select a Drive System

Levers, gears, and/or pulleys can be used to convert the linear motion of the mousetrap to rotary motion.

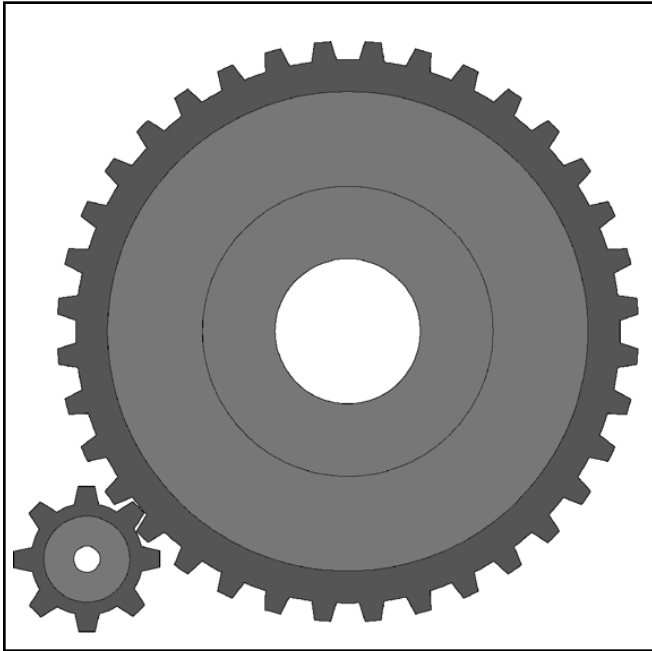


Figure 30: How can a mousetrap be used to turn a set of gears? What size of gears will provide the best performance? Should the large or small gear be placed on the drive axle?

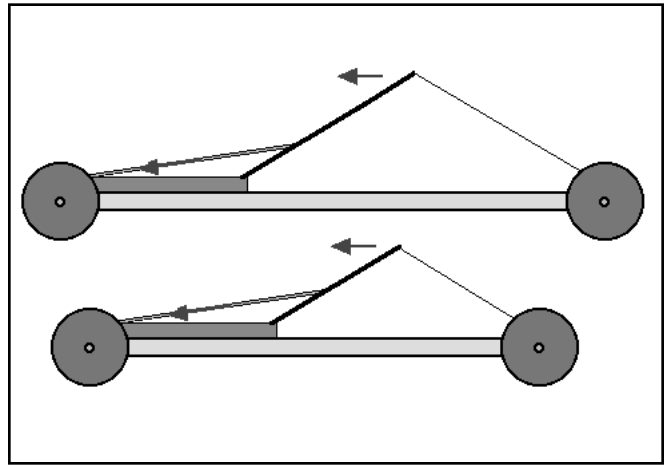


Figure 29: Should the lever arm be long or short?

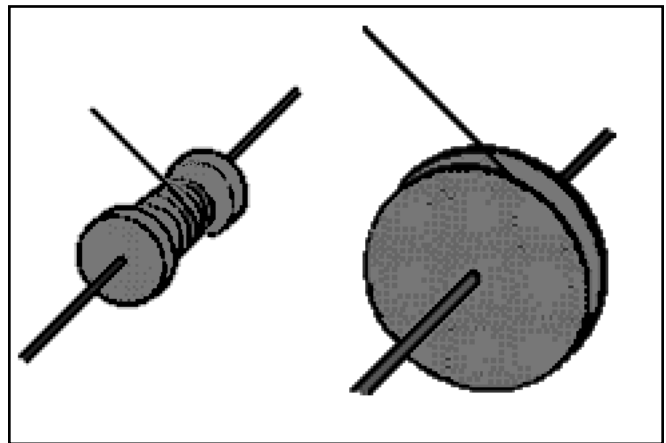


Figure 31: Should the axle pulley be large or small?

## Position the Mousetrap for Maximum Performance

In a lever drive system, the position of the mousetrap and length of the lever arm will determine the amount of pulling force applied to the axle. Moving the mousetrap away from the drive axle and making the lever arm longer will decrease the pulling force over a longer distance. Moving the mousetrap closer to the drive axle with a shorter arm will increase the pulling force, but will decrease the distance of pull.

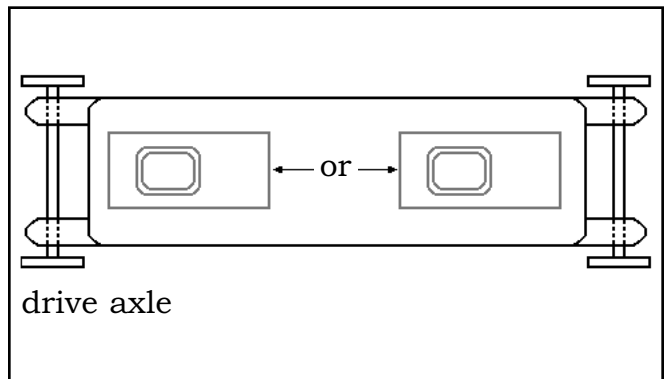


Figure 32: The wheels spin when the mousetrap is triggered. Should the trap be moved toward or away from the drive axle to solve this problem?

# Steps 1, 2, 3, and 4

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## Designing Your Vehicle

### 1. Complete the Technical Report

The purpose of the technical report is to summarize the nature of the problem, the specifications and materials, and the method of testing. Complete the technical report after you have read this book. The specifications marked with an asterisk (\*) will vary with each student.

Number of mousetraps used
Length of balsa wood for rails
Length of balsa wood for platform
Number of wheels
Front wheel diameter
Rear wheel diameter
Drill size for ball bearing
Drill size for axle hole

### 2. Brainstorm Solutions

Study the sketches and diagrams in this book. Brainstorm ideas for building your mousetrap vehicle. What vehicle shape and what type of construction will provide the best performance?

Make notes and sketches of what you think will work best.

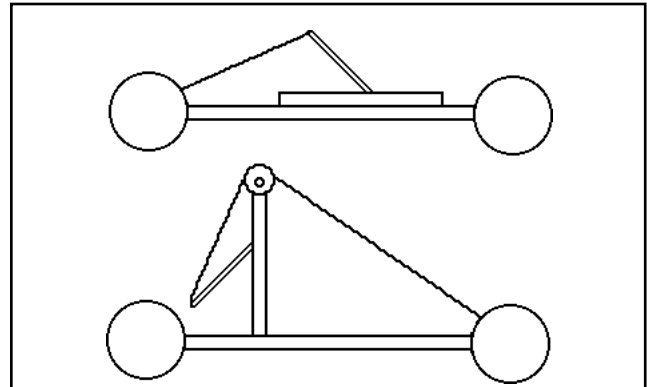


Figure 44: Brainstorm solutions



Figure 45: Basic vehicle with a long lever arm