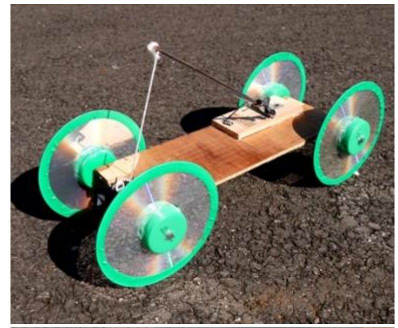
# Spring Loaded Volunteer Guide

This guide highlights some important information, questions, and principles to help you support teams in this challenge. Start by watching a video about the *Goals and Objectives* (7:55) of the Engineering Academy and another one explaining some useful *Facilitation Techniques* (10:30). You can also read about general *facilitation tips* when working with youth.



## The design challenge

Students will work in teams to design and build a vehicle that uses the elastic potential energy stored in a mousetrap for propulsion. This is the rather famous mousetrap car challenge.

- Success criteria
    - The vehicle must have at least three wheels. Many important design considerations will involve the wheels – their size, their weight, the traction that they provide.
    - The vehicle must be able to cover a minimum distance of 10 m on a single 'charge'. This pushes the bounds and makes the challenge quite difficult to meet without a good understanding on the mechanics principles involved.
- Constraints
    - No push starts of vehicles are allowed.
    - Students must work within a given time.

## Possible design solutions

It is very likely that all team's vehicles will look very similar on the surface. However, there are numerous design decisions that teams will need to make and balance that will drastically affect how well their vehicles perform. Watch the video called *1st place Mousetrap Car Ideas- using SCIENCE* (14:05) for an excellent overview of the basic mechanics of mousetrap vehicles.

Specific considerations that teams will need to think about include:

- **Mechanical advantage** – The mechanical advantage of the mousetrap vehicle is determined by the ratio of the length of the mousetrap arm to an arm extension and the ratio of the diameter (or radius) of the driven axle to the driven wheels. The smaller the mechanical advantage, the smaller the force that will drive the wheels but the greater the distance over which this force will be applied. This results in very slowly accelerating vehicles that tend to travel farther.
- **Vehicle mass** – Newton's Second Law says that the force applied to an object is equal to its mass multiplied by its acceleration ($F = ma$). The greater the mass of a vehicle, the more force will be needed to achieve the same acceleration.

### FACILITATION NOTE

Teams will be expected to compete in at least two races – a distance race and a speed race. Some implementers may add other kinds of events, such as the following:

- Having the vehicle stop as close to a designated finish line as possible (e.g., 6 m (20 ft)).
- Reversing the vehicle after a set distance and having it stop as close to its starting position as possible.

- **Wheel mass** – The same principle as above applies to wheels, except that we are dealing with torque and angular acceleration.
- **Traction** – Wheels with greater traction (friction between the wheel and ground) will be able to transfer greater force to the ground, meaning that the ground can transfer greater force to the vehicle, accelerating it more quickly.
- **Center of mass** – If a vehicle's center of mass is near to or over the driven wheels, greater traction can be achieved. If a wheel's center of mass is near to or at the center of rotation, it will wobble less and loose angular momentum less quickly.
- **Steering** – Vehicles that travel straight achieve a greater distance.
- **Friction** – Friction is the ultimate enemy stealing kinetic energy and transforming it into heat and sound and, therefore, causing the vehicle to travel a shorter distance.

## Key design questions

Here is a list of questions you can use to prompt teams when they are thinking about the design of their mousetrap vehicles.

1. How can the energy stored in the spring be used to turn the vehicle's wheels?
2. Are you going to design a distance or speed vehicle? Can you design a vehicle good at both? Why or why not?
3. Are you going to use a front or rear wheel drive design? Which is better? Why?
4. How can you change the mechanical advantage of your vehicle? What happens if you make the mousetrap lever arm longer? What happens if you make your wheels bigger? What is the best lever length and wheel size to use?
5. What is the best material to use for your lever arm and driven axle? What trade-offs exist between mass and stiffness? Does stiffness matter?
6. What role does friction play in your vehicle design? Which parts of your vehicle do you think will experience the most friction? How can this be reduced? Is air resistance a problem? How can this be reduced?
7. How will the mass of your vehicle affect its performance? How can you add or remove mass?
8. How will your vehicle's center of mass affect its performance? Where should the center of mass ideally be?
9. How much traction do your driven wheels need? How can this be increased if necessary?
10. How can you ensure the vehicle travels in a straight line?

## Key testing question

Use these prompts to help teams with their modelling and testing.

1. What effect does changing the length of the lever arm and the diameter of the axle and/or the wheels have on distance covered and/or the rate of acceleration?
2. What effect does using a vehicle or wheels of different mass have on distance covered and/or the rate of acceleration?
3. What effect does altering the traction of your wheels have on performance?
4. What effect does using different kinds of string or thread have on vehicle performance and how does how it is attached to the lever arm and axle affect performance?

**FACILITATION NOTE**

Encourage teams to draw their design ideas in as much detail as possible so that they can identify as many potential problems as possible 'on paper' rather than when building their prototypes.

**FACILITATION NOTE**

Help teams to get into the habit of planning their tests and correctly recording test data rather than randomly testing their vehicles. They should test one change at a time. This will help them to better isolate specific problems and gather the data needed to make informed design change decisions.

5. What effect does changing the position of your mousetrap have on the performance of your vehicle.
6. What effect do different methods of friction reduction have on vehicle performance?
7. What effect do better balanced wheels and/or axles and wheels that don't move side to side have on vehicle performance?
8. Does your vehicle travel straight?

## Suggested final presentation questions

If you are part of a panel or the public audience for teams' final presentations, here are some questions you might like to ask.

1. Did you decide to design a distance or speed mousetrap vehicle? Why? What specific design decisions did you take because of this?
2. Was your vehicle rear or front drive? Why did you decide on this approach?
3. How did you reduce friction? What else do you think you could do to reduce friction even more?
4. If you had more time and or money, what improvements would you like to make to your mousetrap vehicle? Why would you choose these improvements and what effect do you think they would have? Do you think you could build a vehicle that could travel 50 m (160 ft)?
5. What was the most interesting thing you learned about engineering by doing this challenge?
6. Did doing this challenge make you want to be an engineer more? Why or why not?