The Levers Edge

The Purpose
To understand how the length of a mousetraps lever arm affects a mousetrap vehicles performance.

Background
In this activity you will build a basic mousetrap powered vehicle and then measure its average speed and travel distance through a series of trials or experiments. Between trials, the length of the mousetrap's lever arm will be shortened and then the mousetrap will be re-positioned closer to the drive axle. For each shortened length of lever arm you will time the vehicle through a 5-meter distance to determine its average speed and then measure its maximum travel distance. As the length of the lever arm gets shorter and shorter the average speed through 5 meters and the maximum travel distance will change. You will start with a 30-cm lever arm and then shorten it by 3-cm between each trial until the lever arm is only 9-cm long. You will make two graphs that will show the relationship between lever arm length and a mousetrap vehicles motion. The first will be a graph of lever arm length and time over 5 meters, the second graph will be of lever arm length and travel distance. These graphs will establish the relationship between the length of the mousetrap's lever arm and its performance.

Concepts and Principles

Describing Motion
An objects motion is described by the terms velocity and acceleration. Motion involves a direction of movement through both distance and time. We will see how these are related to each other.

Imagine a mousetrap vehicle placed at a start-line ready to be released. Once it is released, it will begin to accelerate or increase its speed over some distance until it reaches a maximum speed and then it will begin to decelerate or slow down until it comes to a stop. Throughout the journey of the vehicle the speed is constantly changing as the vehicle accelerates and then decelerates so if the speed could be measured at any given point along the vehicles journey it would be called the instantaneous speed at that point; if the speed was calculated over some distance the speed would be called an average speed, the distance traveled divided by the time it took to cover the distance is average speed.

In everyday conversations we tend to use the words speed and velocity interchangeably but it needs to be pointed out the speed and velocity are slightly different. Speed and velocity are not the same thing, when we talk about your speed, we mean how fast you are going. When we talk about your velocity, we mean not only how fast you are going but in what direction. By adding the direction to an objects motion we change it from speed to velocity. By measuring the change in velocity we get an objects acceleration.

Velocity has the following mathematical expression:

$$\text{Velocity} = \frac{\text{distance}}{\text{time}}$$

Describing Force

A force, in simple terms, is a push or a pull. To cause an object to change its state of motion you have to push or pull on it. How hard you push or pull determines how quickly you will change the objects state of motion. When an object changes its state of motion we say that it is accelerating (or decelerating), the amount of acceleration is directly proportional to the size of the force, in other words, by doubling the force that is applied to an object you will also double the acceleration.

With a mousetrap, the length of its lever arm determines the size of its pulling force. A shorter lever arm on a mousetrap vehicle will have more pulling for than using a longer arm, more pulling force means greater acceleration.

Force has the following mathematical expression:

Force = mass x acceleration

Describing Torque

Torque is used to cause an object to change it state of rotation. Torque is a force that “twists” or “turns” an object around a pivot point. Torque is a relationship that depends on the size of the force and at what point the force is applied to cause the “twisting” or “turning” motion.

As torque relates to a mousetrap-powered vehicle, a torque is applied to the wheels by pulling the wound string from the drive axle. The mousetrap’s lever arm applies a force to the drive axle that causes the drive axle to pivot or rotate thereby causing the vehicle to move. By changing the diameter of the drive axle or by changing the length of the mousetraps lever arm you control the torque that is applied to the wheels. For the mousetrap, the torque that the spring on the base of the mousetrap applies to the lever is always the same no mater how long the lever but by changing the length of the lever arm you change its radius (the lever arm length) and force. Shorter lever arm on a mousetrap have more force at there levers tip than longer levers.

Torque has the following mathematical expression:

$$\text{Torque} = \text{Force x radius}$$

Materials

* A build mousetrap vehicle (the basic kit in this book)
* A stopwatch
* A meter tape or tape measure
* A long corridor or place to conduct the experiment.
* Graph paper
* Masking tape (the blue painters tape)
* A Dremel tool (or hobby saw)

Hypothesis

Your hypothesis is your best educated guess as to what you think your results will show from this experiment. Based on what you already know about mousetrap cars and/or the information that is presented in this book, write down what you think that you will observe from this experiment. Predict what the shape of the lines will be on the graphs so that you can compare your hypothesis to the final results.

Procedure

Step 1

You are ready to begin the experiment after you have selected a large corridor or location to conduct the activity.

Step 2

Build the Basic Mousetrap Powered Vehicle as shown in this book on pages ____. It is important not to glue the mousetrap to the chassis, the mousetrap will need to be secured to the chassis using some bolts as seen in the advance techniques section of this book.

Step 3

Locate your starting point and place a long (50 cm) strip of masking tape. Carefully measure from the starting point 5-meters and place another long strip of tape to mark the end of the timing distance.

Step 4

Place the front of your mousetrap vehicle at the start line and have someone ready to time the vehicle upon release through the 5-meter distance. Release and time the vehicle through the 5-meter distance then recorded the value. Allow the vehicle to come to rest.

Step 5

Measure the maximum travel distance from the start ling to the front of the vehicle and record this value.

Step 6
Use the following data table to record all your results for a 30- cm lever arm in data table #1. Keep in mind it is best to get an average by using the results from at least three trials using the same length lever arm. Also, calculate the average velocity over the 5-meters and record in the data table.

Data Table #1

Lever Arm Length (cm)	Time Over 5-meters (s)	Ave Velocity Over 5-meters (m/s)	Maximum Distance (m)
30			
27			
24			
21			
18			
15			
12			
9			

Step 7
Remove the mousetrap from the chassis. Remove the locking bar from the end of the lever arm. Using a dremel took or a hobby saw cut three centimeters off the end of the lever arm. Place the locking bar into the newly shortened lever arm. Re-position the mousetrap back on the deck-top making sure to move it 3-cm closer to the drive axle (you will need to drill four new holes to attach the mousetrap at its new location).

Step 8
Repeat steps 4 – 7 until you have completely filled in data table #1 for all lever arm lengths until the final length of the lever arm is 9-cm.

Step 9
Using data table #1 make a graph of lever arm length vs. time.

Label your graph so that lever arm length is on the y-axis and time is on the x-axis. Choose a large enough scale to stretch your graph across one sheet of graph paper. Plot all the points for lever arm length in centimeters and time in seconds. Once you have plotted all your points, draw a best fit line remembering that a best fit line may not touch all the points but will show the shaped of the line or curve.

Step 10
Using data table #1 make a graph of lever arm length vs. maximum distance.

Label your graph so that lever arm length is on the y-axis and maximum distance is on the x-axis. Choose a large enough scale to stretch your graph across one sheet of graph paper. Plot all the points for lever arm length in centimeters and time in seconds. Once you have plotted all your points, draw a best fit line remembering that a best fit line may not touch all the points but will show the shaped of the line or curve.

Conclusion
From your graphs and your data, describe any relationship that may exist between the length of a mousetrap's lever arm and the vehicles performance. Compare your results to those of your hypothesis and discuss any un-expected differences between the two. Use the data from your graphs to discuss how you would build a record setting long distance traveler and the super fast speed-trap racer over 5-meters. From your data point, is there or are there point that begin to deviate from the norm that could possible show that the relations ship between the lever arm and the performance is changing, in other words what might have happened if you made the lever smaller-and-smaller until there was no lever arm? Explain what would happen if you made the lever arm longer and longer.

Advance Discussion (Optional)
Based on your data, adjust your vehicles lever arm to travel 5 meters in X-seconds. (Your teacher will select a time)

Advance Discussion (Optional)
Make another graph that that shows the relationship between the average velocity over 5-meters and the maximum distance traveled. Is the relations ship a linear or exponential relationship? Can you conclude from this graph if faster cars over 5-meters travel further? Discuss your answer as it relates to your graph.

Questions
How does the length of the lever arm effect speed?
How does the pulling force effect the acceleration?
Is the amount of energy changed by adjusting the length of the lever arm?
Is there a way to change the speed without changing the lever arm length?
How does the amount of force change with the length of the lever arm?
How does the torque change with the length of the lever arm?

TEKS
(6.8) Force, motion, and energy. The student knows force and motion are related to potential and kinetic energy. The student is expected to:
(A) compare and contrast potential and kinetic energy;
(B) identify and describe the changes in position, direction, and speed of an object when acted upon by unbalanced forces;
(C) calculate average speed using distance and time measurements;
(D) measure and graph changes in motion