A car powered only by a mousetrap ??!!?

We have been studying motion, velocity, acceleration, power and work. It is now time to put your knowledge to the test. In the next few weeks, you will design, build, and test a car that runs on the power of a single mousetrap. For your final analysis, you will write a detailed report that clearly communicates the results of your tests.

You have already picked your partners if you want one. You will be in groups of three or two, but choose wisely. Once you team is picked, there is no changing, and your only option will be to do it alone. Your homework for the weekend is to spend some time thinking about how you will build this car and start to build it. Think about the cars you saw in class. Think about the physics involved in the design. Friction and energy conversions should be two of your considerations. Think about what materials you could use for wheels, the car body and the rod. Think about how to attach the wheels to the car. If you can, start collecting these things so that you have them ready to go when you get tighter to build the cars.

The Rules:

1. Start building your car early. Give yourself plenty of time for testing and problem solving. You will also need time experiment and fine-tune your car.
2. Ask your parents, friends, and family to help you in either designing and/or building the car, but remember, it is **<u>your</u>** project.
3. Make sure that you get permission to use materials before you bring them to school. For example, your Mom's aluminum pie pans will make excellent drive wheels, but be sure to ask her before you make them a permanent part of your car.
4. You must use one standard brand mousetrap (1 3/4" x 3 7/8") to power the car.
5. The trap spring may not be altered.
6. The mousetrap does not need to be triggered. It can just be pulled back and let go.
7. The vehicle may be made out of any material and be of any size. (Legos / Kin'ex are acceptable)
8. You must <u>build</u> a car. Therefore pasting a mousetrap to your younger sibling's toy car is illegal (and cruel).
9. No kits are allowed.
10. It is perfectly legal (and highly encouraged) to get help from your parents or use any other resource available to you, just be sure <u>you</u> build the car and could fix it on race day.

<u>One Final Note:</u>

A superior car must not only go a long distance, but it must also travel in a straight path since a collision with the walls or locker effectively ends its journey. A curved path also reduces the car's measured travel distance. The distance will be measured in a straight line from the start line to the point the car stopped. Therefore, if your car curves, or starts to roll backwards, you will lose distance.

<u>Important Dates:</u>

First car work day/ Design due	May 1st
Plausible Car Day (Lab 1)	May 3rd
Race day (Lab 2)	May 5th
Part I (Lab 3-5)	May 8th
Part II (Lab 6-8)	May 10th
Part III (report due)	May 12th

Mouse Trap Powered Car Project
Final Draft - Car Design Worksheet

Name(s) ____________________
Period ______

This is your <u>final</u> copy of your car's design. Complete this entire sheet and have it approved. Make sure that you can actually get the materials that you list on this page by our first work day.

Supplies

1. The car body will be made of what material? ____________________
2. The front wheels will be made of what material? ____________________
3. The back wheels will be made of what material? ____________________
4. The axles will be made of what material? ____________________
5. The extension rod will be made of what material? ____________________
6. Additional materials ____________________

____

____

Design issues

In the spaces provided, summarize your group's discussion about the problem. Explain how you are going to solve the issue as presented in class.

1) Are you going for a light car, or a heavier car? Justify your answer.

____

2) Propulsion system:

a) Where will the mousetrap be placed?

____

b) Describe how will the mousetrap's motion be used to drive car forward?

____

____

3) How will the wheels be attached so that they can still roll but not fall off?

____

____

4) How will the wheels be kept stable so they do not wobble and bump against the body of the car?

____

____

5) How will the wheels be kept in alignment so they keep the car going straight?

____

____

6) How will friction be reduced among all of the moving parts?

7) How does your design allow the car to coast once the mousetrap has been spent?

8) How does your design prevent the string from slipping? How does your design allow for quick resetting of your car?

Drawing

Draw a picture of what your car will look like when it is built. Place any measurements on the drawing.
Top View:

Side View:

MTPC Car Grade Sheet

Names:

Scores:

Design in on due date	_____________ /5 points
Had a car on Car Trial Day	_____________ /5 points
5 meters on Race Day	_____________ /20 points
Changes made to the car	_____________ /10 points
Total Car Points (Scored as Lab points)	**_____________ /40 points**

Final design with measurements:

Top

Side

Car Improvements and Results

- ❑ **Improvement 1**

- ❑ **Result**

- ❑ **Improvement 2**

- ❑ **Result**

- ❑ **Improvement 3**

- ❑ **Result**

- ❑ **Improvement 4**

- ❑ **Result**

The Mouse Trap Powered Car
Lab Booklet

Physical Science Class

This project is divided into three separate sections listed below:

1. Design and build a mousetrap powered car.
2. Test your car with a set of experiments.
3. Write and type a detailed report that clearly communicates the results of your experiments.

Name (s) ______________________________
____

You will perform each of the next eight labs. These labs will give you most of the information needed to write your final report. It is important that you understand why and how you did each lab. When you are doing a calculation, remember to always start from a basic equation. For the final report, you will need to show two examples of your calculations of time, velocity, and acceleration. You also need to show the calculations for average force, work, power, and IMA.

Lab 1: Accurately measure the specifications of your car.

Find the mass of your car. Measure the height, length, and width (at the widest part) of the car. Measure the ground clearance, which is the distance from the ground to the lowest point of the car. Measure the wheelbase, which is the distance between the widest wheels. Put all your data on the MTPC Car Grade Sheet. You will also put this information in your report.

Lab 2: Design a lab that accurately describes your car's motion. (Done in class)

1) Run your car three times and measure the total distance traveled. Take the shortest distance traveled and divide into ten equal distances.
2) In the area provided, mark out the ten distances.
3) As a class, we will measure the total time it takes to get to each point. There will be three timers at each point to give you three times in one trial.
4) Make a table to record your information. (Done before timing day). You will need these headings: Total Distance, Total Time, Average Total Time, Interval Distance, Average Interval Time. Under the Total Time column, you need a place to record trials 1-3. See below for an example data table.
5) Name the table "Distance and Time Data"
6) Record the times to the tenth of a second.

For example, let's say that your car travels 6.0 m in 1.0 minutes. Dividing your 6.0 m distance by ten gives you ten increments of 60 cm each.

Distance and Time Data

Total Distance (cm)	Total Time (sec)			Average Total Time (sec)	Interval Distance (cm)	Interval Time (sec)
	Trial 1	Trial 2	Trial 3			
0	0	0	0	0	60	0
60	5.0	6.0	5.4	5.5	60	5.5
120	12.5	13.0	12.8	10.2	60	4.7
180	14.0	14.0	14.3	12.8	60	1.5

7) Place in the table shown below and plot total distance vs. total time on graph paper. Time is the independent variable. Remember to follow graphing procedures and conventions such as labeled axes, proper units and a title. Your report will have several data tables and graphs, so be sure to carefully label each table and graph.
8) The next two labs will fill in the big table we are trying to create. The table will have total distance, total time, interval distance, interval time, velocity, and acceleration. The title of this table should be "Combined Data." An example is shown below:

Combined Data

Total Distance (cm)	Total Time (sec)	Interval Distance (cm)	Interval Time (sec)	Velocity (cm/s)	Acceleration (cm/s^2)

Combined Data

Total Distance (cm)	Total Time (sec)	Interval Distance (cm)	Interval Time (sec)	Velocity (cm/s)	Acceleration (cm/s^2)

Lab 3: Calculate the velocity

1) We want to calculate the average velocity for each or our ten intervals. The velocity equation is: velocity = distance / time or v = d / t. To get the velocity over each interval, use the interval distance and time.
2) Place your data in the data table as shown:
3) Plot velocity vs. total time on graph paper. Time is the independent variable.

Combined Data

Total Distance (cm)	Avg. Total Time (sec)	Interval Distance (cm)	Interval Time (sec)	Velocity (cm/s)	Acceleration (cm/s^2)
0	0	60	0	0	
60	5.5	60	5.5	10.9	
120	10.2	60	4.7	12.8	
180	12.8	60	1.5	40.0	

Lab 4: Calculate the acceleration of your car

1) Acceleration = (final velocity - initial velocity) / time for change or a = $(v_f - v_i) / t$
2) Remember, the time value you need is the time for the change in acceleration. With our set-up, the time for the change to occur is the interval time. Do not use the total time for this calculation!
3) Place your results in the data table as shown below.
4) Plot acceleration vs. time on graph paper. Note that you will have negative accelerations. Time is the independent variable.
5) The Combined Data table should be complete at this point.

Combined Data

Total Distance (cm)	Avg. Total Time (sec)	Interval Distance (cm)	Interval Time (sec)	Velocity (cm/s)	Acceleration (cm/s^2)
0	0	60	0	0	0
60	5.5	60	5.5	10.9	2.0
120	10.2	60	4.7	12.8	0.4
180	12.8	60	1.5	40.0	18.1

Lab 5: Determine the average force of mousetrap

1) Get a Newton force meter and a protractor.
2) Measure the force of the mousetrap spring every 20 degrees from zero to 180 degrees. Be sure to connect the scale to the mousetrap and pull perpendicular to the mousetrap arm. The data shown below is from my spring.
3) Collect data from your spring carefully and organize it in a table called Spring angle vs. Force, like the one shown.
4) Make a graph of spring force vs. angle. The angle is the independent variable.
5) The average of all spring forces in Table four will give you the average force that the mousetrap exerts on your drive wheel. To calculate the average, add up all of the forces and divide by the number of data points that you have. For the car shown by the data in the example, the average force = 7.9 N.
6) Place this answer in the table.

Spring Angle vs. Force

Spring angle(degrees)	Spring Force(Newtons)
0	0
20	2.8
.	.
.	.

Lab 6: Calculate the average work done by your car

1) We will be using the equation for work. It is Work = Force x Distance traveled, or W = F x d.
2) Plug in the average force of the mousetrap and the total distance traveled for your car's work output. (Remember that 1Nm = 1 J). The labeling for work is a Joule (J).
3) For the example car, W = F x d = 7.9 N x 6.0 m = 47.4 Nm = 47.4 J.
4) Include this value in your final report with the calculations. Remember, this is the measured energy put out by the mousetrap.

Lab 7: Calculate your car's average power

1) Power = Work / Time, or P = W / t
2) For the example car, Power = W / t = 47.4 J / 60.0 s = 0.79 J/s = 0.79 Watts
3) Include this value in your final report with the calculations.

Lab 8: Draw a force diagram of your car

1) Draw a picture of your car. (It does not need to be a work of art)
2) Clearly label and define all of the forces acting on your moving car.
3) Explain in a paragraph how each force affects the car's movement.
4) Below are the four forces you should be concerned with.

    Fn = Normal Force =
    Fg = Gravity =
    Fe = Effort force =
    Ff = Friction force =

Mouse Trap Powered Car
Final Report

The final step of this project is to publish the results of the MTPC project. In the packet, you will be doing nine labs. Most of the labs can be done at home. Therefore, little class time will be dedicated to the labs of the MTPC project. This write-up, like all lab write-ups, should contain the following as headers to each section.

<u>Title:</u> Give the report a title.
<u>Purpose:</u> The purpose is to study the motion of a mousetrap powered car.
<u>Materials:</u> List what you used to build your car.
<u>Introduction:</u>
This section contains three parts as discussed below:

1) A description of your car including the specifications measured in **lab one**. Place the table from lab one here.

2) At least 3 paragraphs explaining why your car was built the way it was. For example, why did you use a dowel, big wheels, balsa wood, and heavy wheels? The reasons you cite must be scientific. In other words, you need to connect your design to Newton's laws, energy, work and simple machines. If you do not defend your design with these four topics, don't expect a good grade. You can use other science topics as well. (i.e. momentum)

3) A paragraph or two discussing the difficulties you had to overcome. In it, you should give the three changes you made and the outcome of those changes. (**MTPC grading sheet.)**

<u>Procedures:</u>
- Explain how you got the distance and time data. (One paragraph or a numbered list of steps)

<u>Observations:</u>
- Include all data tables and graphs including: **(Labs 2 - 4)**
    a) Distance and Time data table
    b) Combined data table
    c) graph of total distance vs. total time
    d) graph of speed (velocity) vs. total time
    e) graph of acceleration vs. total time.
    f) table of spring angle and force **(Lab 5)**
    g) Graph of spring force vs. angle
- Include the force diagram of your car with the paragraph explaining how each force affects your car. **(Lab 8)**

<u>Calculations:</u>
- Include two sample calculations (from your data) of interval time, velocity and acceleration.
- Include the calculations of average spring force, work **(Lab 6)**, power **(Lab 7)**, Show all work!

Conclusion:

In your conclusion, discuss the following questions:

1) Was your car a speed demon, or does slow and steady describe it better? Using your graphs as support, describe the motion of your car. Note in your description, times when it was speeding up, slowing down, and traveling at a constant speed.

2) Describe how this car was powered, in other words how was potential energy transformed to kinetic energy. Be sure to account for all of the energy transformations that occur including "lost" energy.

3) If asked to build another mousetrap-powered car, what would it look like? What do you think the "best" design would have and why? Use physics to support your conclusion.

Spelling and neatness is taken into account. I will start reading you paper. After four errors in spelling, grammar, or in comprehension, I will stop reading and return it back to you scored on what I have read to that point. For example, if all four errors occur in the first paragraph, then your score is based on only the first paragraph. You can fix the errors and re-submit it once. Please have someone read it before turning it in.

MTPC Final Report Grade Sheet (Test Score)

Name (s)______________________________

Hour __________

<u>TITLE & PURPOSE & MATERIAL</u> _____ / 5

<u>INTRODUCTION</u> _____ / 25

Description of car, with measurements (5 pts)
Reasons for Design - Newtons Laws, Energy and Work, Simple Machines (15 pts)
Trouble Shooting (5 pts)

<u>PROCEDURE</u> _____ / 5

Explain how Lab 2 was done to get the original distance / time data.
Explain how the average spring force was determined.
Explain how the IMA was determined.

<u>OBSERVATION</u>

Tables: (correct information & easily read) _____ / 20

Tot. Distance / Tot. Time / Int. Distance / Int. Time / Speed / Acceleration (15 pts)
Spring force / Angle (every 20 degrees) (5 pts)

Graphs: _____ / 20

Distance vs. Time (Title, Axes Labeled, Units Labeled, Even Steps, Pattern) (5 pts)
Velocity vs. Time (Title, Axes Labeled, Units Labeled, Even Steps, Pattern) (5 pts)
Acceleration vs. Time (Title, Axes Labeled, Units Labeled, Even Steps, Pattern) (5 pts)
Spring Force vs. Angle (Title, Axes Labeled, Units Labeled, Even Steps, Pattern) (5 pts)

Force diagram with <u>explanation and impact</u> on car of each force _____ / 10

<u>CALCULATIONS</u> _____ / 15

Shows work for all calculations.
Velocity (2 calculations), Acceleration (2 calculations), Avg. Spring Force, Work, Power, IMA for lever and wheel and axle.

<u>CONCLUSION</u> _____ / 35

Describing Motion – refers to graph, correct conclusion (15 pts)
Energy Transformations – how powered, where lost (15 pts)
Perfect Car (5 pts)

TOTAL ____ / 135

COMMENTS: