Mousetrap Car Project

Objective: Make a mousetrap car that travels at least 3 meters while predicting and calculating data as it relates to the topics we've covered this year (Motion, Forces, Friction, KE, PE, Machines, Mechanical Advantage, etc.).

Rules/Guidelines

- You will be provided one victor mousetrap, cardboard, tape, and string.
- Mousetrap must travel 3 meters. (-15 points if it doesn't)
- **No kits.** But we will supply tape, glue/glue guns, cardboard, string. You can buy 4 CD's and 4 Skewers for $1 if you'd like
- Must make your own car, no groups.
- Teachers may modify rules at any point to preserve a level playing field.
- Grand Finale Extra Credit available for Longest Distance, Fastest Velocity (over 3m)

Part A-Prelab Brainstorm

Parts of Car	Possible Materials
Body	
Wheels	
Axles	
Lever Arm	
String	
Other/Miscellaneous	
Drawing/Sketch	

Part B- Build Your Car

1. Mass (in kg) of completed car-	2. Length (in m) of mousetrap spring arm (with arm extension)	3. Force required to pull back the mousetrap arm with original design (no extra "arm" added yet.
4. Force required to pull back mousetrap spring arm with extra arm attached using Vernier Force Probe	**5. Radius of wheel axle (in m) that the string/rope is wrapped around**	**6. Radius of rear car wheels (in m)**

Part C- Calculate Work to "set" your Mousetrap Car.

The work done on the mousetrap arm to set it (pre-launch) is found using the formula W = F × d, where F is the force (in Newtons) applied to the mousetrap car spring arm and d is the distance (in m) through which the force is applied. You have already calculated the force in Part B.

Now you must calculate the distance the end of your mousetrap arm moves as you set it in place. This is circular motion, so use the following steps to figure out the distance the end moves to set into place

Step 1: Write down the length of your mousetrap arm in meters, B2. This is your radius. Record	
Step 2: Determine the circumference of the circle the mousetrap arm would make if it made an entire rotation. Use your radius from step 1. Show work and answer in the box. C=2πr = ______m	
Step 3 Using a protractor to determine what degree (out of 360 degrees for a full circle) your mousetrap arm will move. This must be 180 degrees or less.	
Step 4 Determine Distance Traveled by the end of mousetrap arm ((Step C3 Ans.)÷(360)) x Step C2 Ans.	
Step 5 Determine Work. Work = Force x distance Force from Part B4, distance from Part C4	

Part D- Calculate Elastic Potential Energy

ELASTIC POTENTIAL ENERGY (EPE). The energy stored in a mousetrap spring is found using the formula : EPE = ½ · k · θ^2, where k is spring constant of the mousetrap spring, a measure of how "tough" the spring is and θ is the angle (in radians) the torsional mousetrap spring compresses. Let's find how much of the work (W) that we put in from Part C actually ended up as EPE in the mousetrap spring.

STEP 1: Find θ, the angle your arm goes through in Radians. C3 x $\left(\frac{\pi}{180}\right)$	θ =
STEP 2: The spring constant "k" of a mousetrap is about 1.3 N/m. Now find your mousetrap's EPE: EPE = ½ · k · $(D1)^2$ =Joules	

Part E- FRICTIONAL LOSSES.

At this point, some of our initial energy has converted into heat due to frictional losses. The amount of heat generated is simply the difference between our initial energy input into the mousetrap as Work and the EPE that the mousetrap has.

$Heat_{(frictional\ losses)}$ = Work – EPE = __?_Joules (C5) (D2)	

Part F- CALCULATING THE FORCE AT THE WHEELS.

We now will find out how much force is accelerating the car forward initially. This is not the force that you measured with the Vernier Force Probes in Part A. We must use the principles of mechanical advantage to find what force, ideally, made it to back wheels.

STEP 1: Mechanical advantage (M.A.) is all about ratios and proportions. The ratio for M.A. is between the force applied (F_1) and the distance over which it is applied (d_1) compared to the force output (F_2) and the distance over which it is applied (d_2).

The ratio set up comes from the Law of Conservation of energy and the work formula. The Law of Conservation of Energy states that the amount of work in must equal the work out.

$$W_{in} = W_{out}$$

$$F_1 \cdot d_1 = F_2 \cdot d_2$$

F_1=the force on the mousetrap spring lever arm (part B4)
d_1=the length of the mousetrap spring lever arm (part B2)
d_2=the estimated/actual radius of the axle (use ruler, B5)
F_2= Force turning the rear axle. (unknown)

STEP 2: Now we need to do the process again for the wheel and axle. The axle transmits its force (F_2) to the wheel (F_3). The axle has a small radius (d_2) and the wheel has a big radius (d_3). So we will lose a little bit of mechanical advantage going from axle to wheel.

$$W_{in} = W_{out}$$

$$F_2 \cdot d_2 = F_3 \cdot d_3$$

F_2=Force at the wheels, turning the rear axle. (answer from prior step)
d_2=the estimated/actual radius of the axle (use ruler, B5)
d_3=the estimated/actual radius of the wheel (use ruler, B6)
F_3= Force at the wheels. (Unknown)

Part G- Forces and Motion

According to Newton's 2nd Law, when a force (in N) is applied to a mass, that mass will accelerate (in m/s2). The wheels are pushing on the ground with a force F_3 that we found in PART F. Using Newtons' 3rd Law, for every action there is an equal and opposite reaction so the ground pushed back on the mousetrap car making it go. So now we'll find the initial acceleration of the car using Newton's 2nd Law assuming none of the energy has been lost due to friction.

F_3=m x a solve for a (F_3 and m are in past steps)

Part H- RUN YOUR CAR- Teacher must be present for this part

1. Total distance traveled	
2. Total displacement traveled d_{real}	
3. Time for arm to fully discharge	
4. Total Time that car is moving	
5. Average Speed s=d/t	
6. Average Velocity v=d/t	

Part I- IDEAL DISTANCE

To find the theoretical (ideal) distance, d_{ideal}, use the following formula:

1. $d_{ideal} = ½ \cdot a \cdot t^2$ where a is the acceleration you just found in Step G, and t is the time you recorded in your data table H3
2. Now compare d_{ideal} with d_{real} (d_{real}/ d_{ideal})x100= % you were able to travel compared to ideal situation

Part J- WORK DONE AGAINST FRICTION. We will find the work done against friction by comparing W_{ideal} with W_{real}. d_{real}= H2

$W_{frict} = \Delta W = \mathbf{F_3 \cdot d_{ideal} - F_3 \cdot d_{real}}$ = _____J

Part K- Run car over 3m distance. Teacher must be present for this part.

1. Average Speed over 3 meters s= 3m/time FILL THIS IN FROM	
2. Velocity over 3 meters v=3m/time FILL THIS IN FROM	
3. Calculate the Final Velocity (Vf) from 2.75m to 3.25m Record the time it takes to go this .5 m distance at the end to calculate the final velocity at this point.	
4. Acceleration over the 3 meters $a = (V_f - V_i)/t$ Vf= K3 Vi= How fast was your car moving at the start?	
5. Forces of Device over 3m F= mass x acceleration Measured in Newtons	
6. Work of Device over 3m Work = Force x distance Measured in Joules	
7. Power of Device over 3m Power = Work/Time Measured in Watts	

Rubric

Part A- 5pts		______/5
Part B- 6pts		______/6
Part C- 6pts		______/6
Part D- 6pts		______/6
Part E- 5pts		______/5
Part F- 5pts		______/5
Part G- 5pts		______/5
Part H- 5pts		______/5
Part I- 5pts		______/5
Part J- 5pts		______/5
Part K- 12pts		______/12
Moving 3 meters- 15 pts		______/15
Participation/Time on Task-20pts		______/20
Total		______/100