7B Work and Energy

NAME ____________________

How does a system get energy?

PER ______

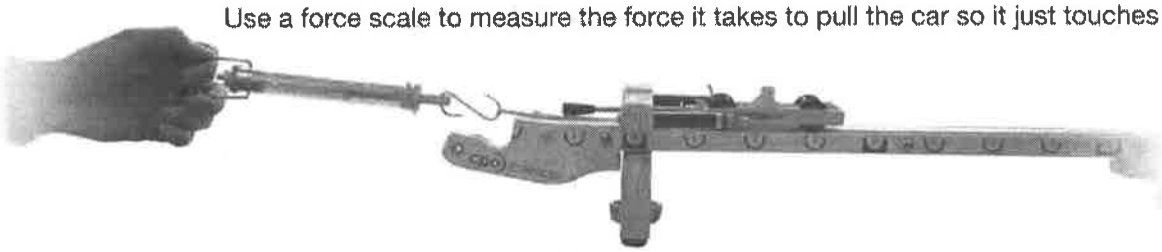
Energy comes from somewhere. When you lift a box off the floor the increase in energy of the box comes from the work you do on the box. The box has a net increase in energy due to the additional potential energy you gave the box by doing work when you lifted the box. This stored potential energy does not always have to be in the form of gravitational potential energy. It can be stored through pressure, compression, or even elastic potential energy. In this Investigation you will examine the conversion of work into stored elastic energy, and then predict its conversion into kinetic energy.

Materials

- Energy Car
- Data Collector and photogates
- Electronic scale (or triple-beam balance)
- Metric ruler
- String
- 10 N Force scale

1 Measuring the work done

Use a force scale to measure the force it takes to pull the car so it just touches the screw



1. Set up the long straight track with a rubber band at one end and a clay ball at the other end.
2. Adjust the threaded screw until the distance between the screw and the front of the rubber band is one centimeter (see diagram).
3. Tie a knot in the string and pass the string through the hole in the car and under the notch just below the screw. Tie a loop in the other end of the string.
4. Use a spring scale to measure the force when the car is just touching the screw.

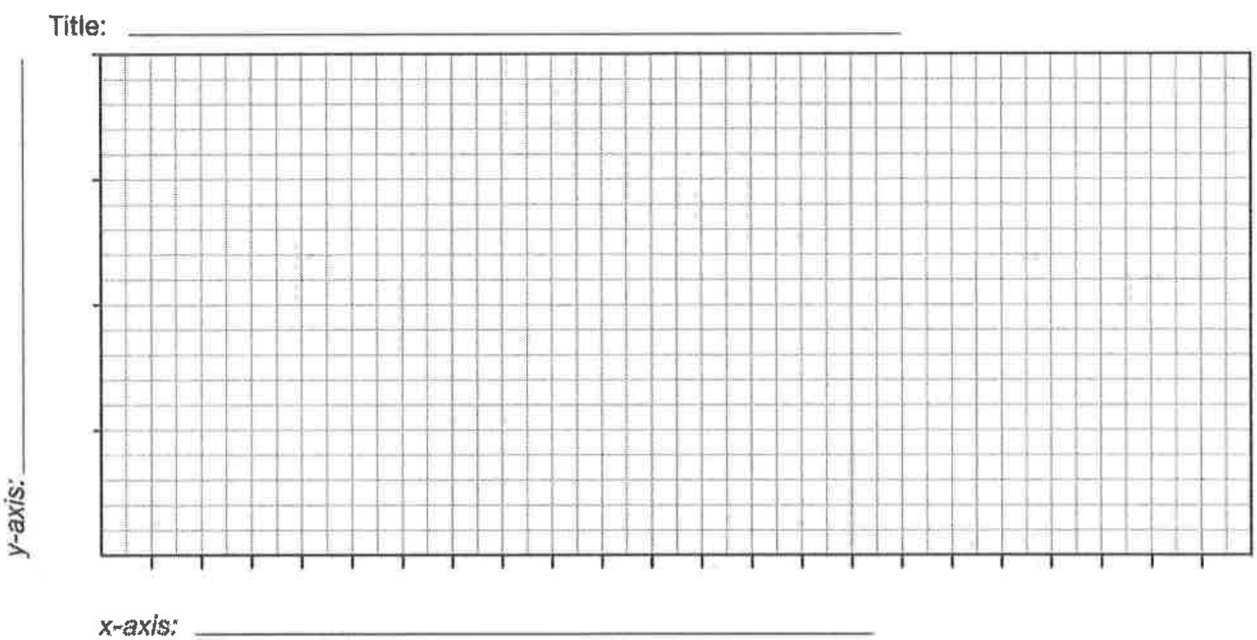
5. Adjust the screw for distances of 2, 3, 4, and 5 centimeters. Measure the force for each distance. Record your measurements in Table 1.

Table 1: Force vs. distance data

Distance rubber band is stretched (cm)	Force (N)

2 Thinking about what you observed

a. Graph the force from the rubber band vs. the distance.



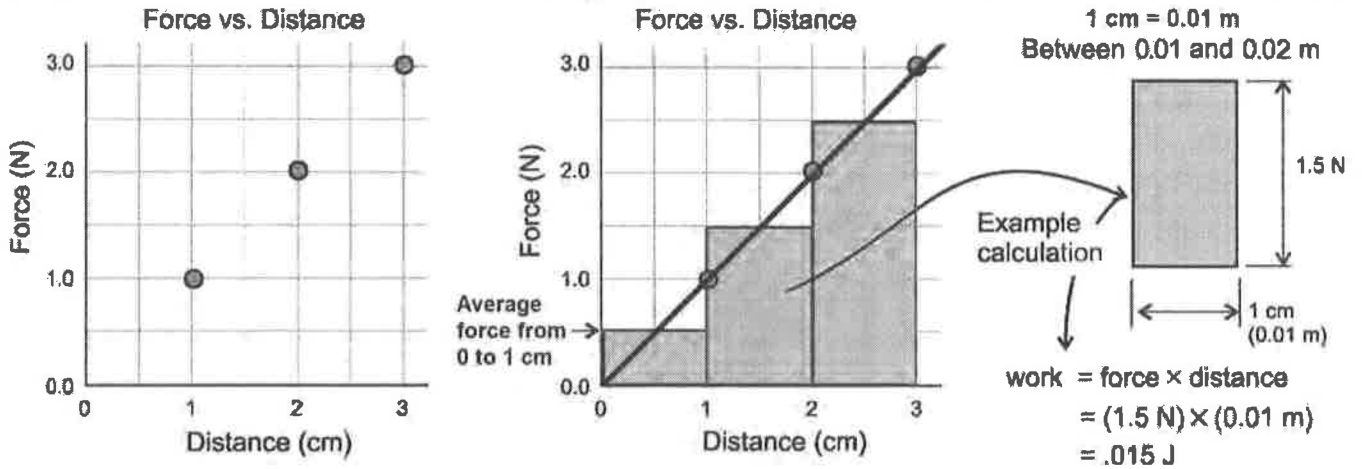
b. Write down a one sentence definition of work in physics.

c. You would like to know how much work the rubber band does on the car during a launch. Since the force changes with distance, use the graph to do some averaging. Divide your graph up into bars each representing one centimeter of distance. Make the height of each bar the average force over the distance interval covered by the bar. The area of each bar is the work done over that interval of distance. Your graph will have data out to 5 cm. The sample graph below shows data from 0 to 3 cm as a demonstration that you can follow for your entire graph.

Step 1: Graph force vs. distance

Step 2: Divide graph into 1 cm bars

Step 3: Calculate work for each bar

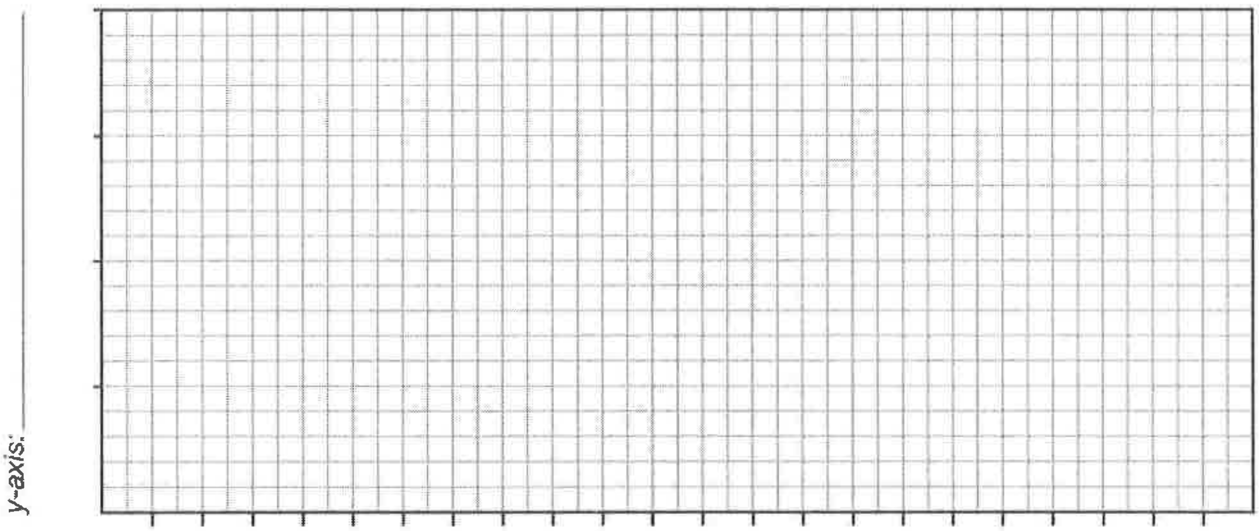


d. To get the total work done on the car you need to add up all the work done as the rubber band straightens out and moves the car forward. Use the table below to calculate the work done.

Rubber band deflection	4 - 5 cm		3 - 4 cm		2 - 3 cm		1 - 2 cm		0 - 1 cm		Total work done
1 cm										=	
2 cm								+		=	
3 cm						+		+		=	
4 cm				+		+		+		=	
5 cm		+		+		+		+		=	

e. Make a graph showing the work done on the *y*-axis and the deflection of the rubber band on the *x*-axis.

Title: ______________________________



x-axis: ______________________________

f. Assume all the work done becomes kinetic energy of the car. Derive a formula for the speed of the car that depends only on the car's mass and the work done by the rubber band.

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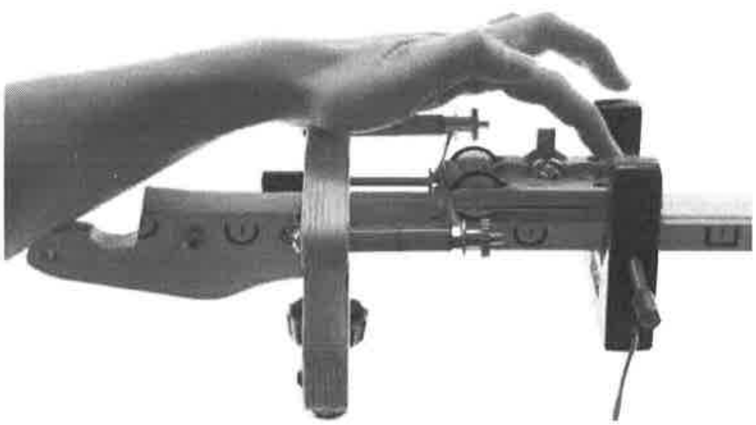
3 Testing the theory

Set the photogate just ahead of the flag when the rubber band is straight.

Launch the car at the same measured deflections for which you measured the force.



1. Put a photogate on the track so the flag on the car breaks the light beam about one centimeter after leaving the rubber band.

2. Use the adjustment screw to launch the car at the same measured deflections of the rubber band for which you measured the forces (1, 2, 3, 4, and 5 cm).
3. Measure the speed of the car for each deflection of the rubber band.
4. At each deflection, take data using cars with one steel ball of added mass. Record the speed in the column for "measured speed".

Table 2: Deflection, mass, and speed data

Deflection of rubber band (cm)	Mass of car (kg)	Photogate time (s)	Measured speed (m/s)	Predicted speed (m/s)

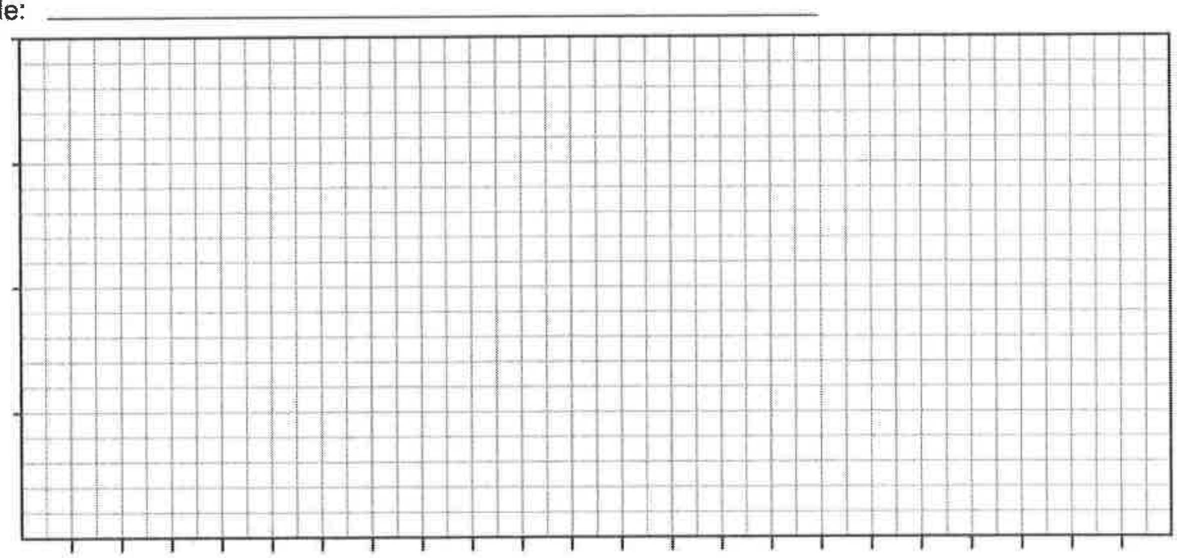
4 Thinking about what you observed

a. Use your formula to predict the speed the car should have at each combination of mass and deflection. Write the results in Table 2 in the column "predicted speed".

b. Graph the predicted speed of the car vs. the deflection of the rubber band. Draw a smooth curve through the plotted points. On the same graph, show the measured speeds.

Title: ______________________

y-axis: ______________________

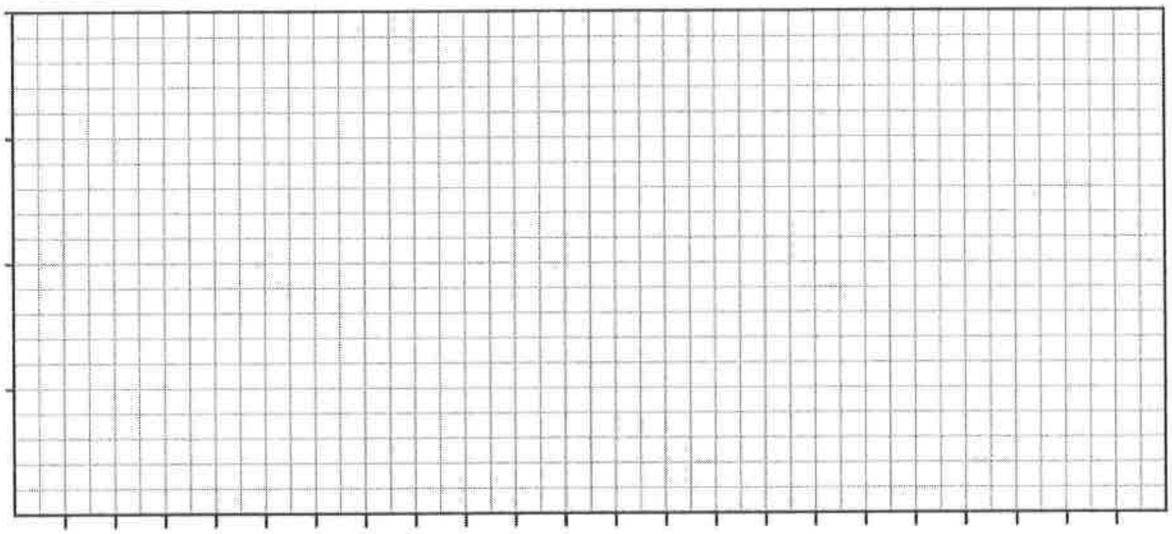


x-axis: ______________________

c. Graph the measured speed of the car vs. the deflection of the rubber band on the same graph as part c.

Title: ______________________________

y-axis: ______________________________



x-axis: ______________________________

d. Does your data support the theory that the energy of the car is equal to the work done by the rubber band? Your answer should provide evidence from your results and discuss possible sources of errors.

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e. Use your theory to predict the speed if a car with 2 and 3 steel balls is launched at a deflection of 3 cm. Do the experiment and see if your prediction is accurate.

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