May 29, 2014

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)
1	
2	
3	
4	
5	

2 Thinking about what you observed

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

Title: Force vs. rubber band stretch

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

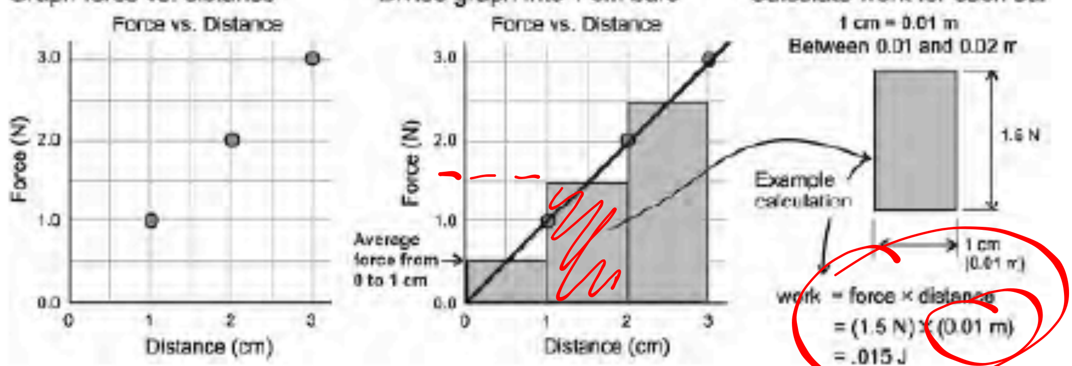
A force is applied over a distance.

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

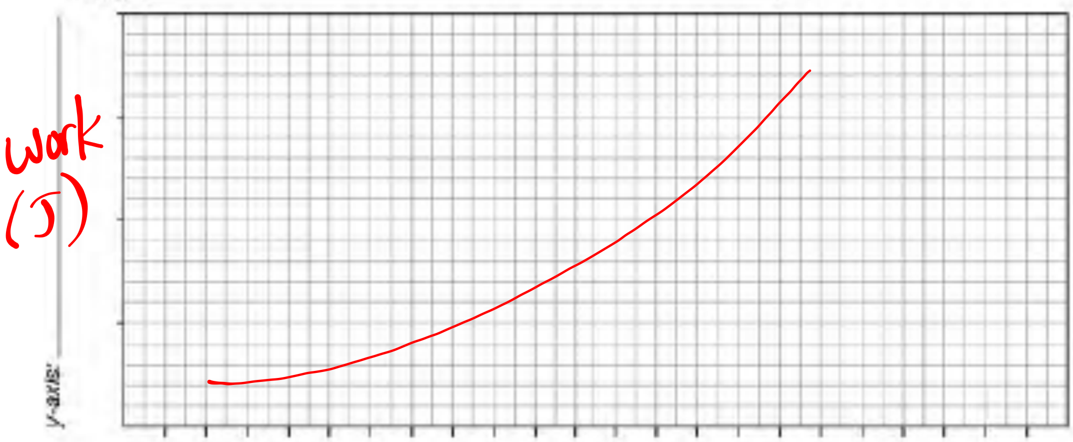


d. To get the total work done on the car you need to add up all the work done as the rubber band straightens out and moves the car forward. Use the table below to calculate the work done.

Rubber band deflection	4 - 5 cm		3 - 4 cm		2 - 3 cm		1 - 2 cm		0 - 1 cm		Total work done
1 cm										=	0.015 J
2 cm							0.015 J	+		=	0.085 J
3 cm						+		+		=	0.100 J
4 cm				+		+		+		=	0.300 J
5 cm		+		+		+		+		=	0.660 J

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

Title: Work vs. rubber band deflection



x-axis: deflection of rubber band (cm)

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.

speed ~ work

speed ~ $\frac{1}{\text{mass}}$

→ speed = $\frac{\text{work}}{\text{mass}}$

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".

$1 J = 1 kg \cdot m^2/s^2$

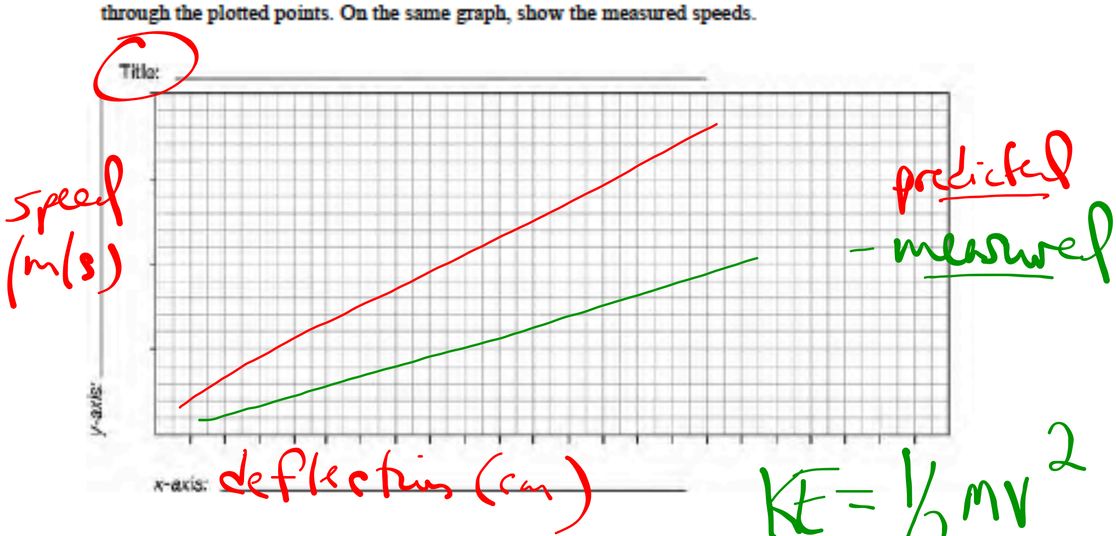
Table 2: Deflection, mass, and speed data

Deflection of rubber band (cm)	Mass of car (kg)	Photogate time (s)	Measured speed (m/s)	Predicted speed (m/s)
1	0.083		0.36	2.7
2			0.74	5.4
3			1.1	8.1
4			1.38	11
5			1.72	14

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.



$$KE = \frac{1}{2} m v^2$$

$$Work = \frac{1}{2} m v^2$$

$$v_{speed} = \sqrt{\frac{2 \cdot work}{mass}}$$

$$\left(speed = \frac{work}{mass} \right)$$

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.

yes - but prection trend was correct - the magnitude was off

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.