Name _____ Date _____ Period _____

Lab: Energy-Rubber Band Cannon

CONCEPTUAL PHYSICS: UNIT 4

Objectives:

1) *Find the **energy stored** within the rubber band cannon for various displacements.*
2) *Find the **spring constant** in the rubber band.*
3) *Recognize the **transformation of energy** in the cannon when firing.*
4) *Calculate the distance needed to pull back to hit various targets.*

Overview: In this lab your group is responsible for finding how fast the canon shoots for various rubber band ***displacements*** and then fire the cannon at a 45 degree angle to hit targets. To begin this process you will first have to find the ***spring constant*** of the rubber bands so that you may solve for the energy stored at different displacements. Using these energies you will then find the exit velocity of the projectile for the displacements. Finally, your group will compete to hit targets randomly placed throughout the room.

Procedure:

1. Determine the **mass** of the rubber band projectile using a digital scale: ***m*** =_____(***kg***)

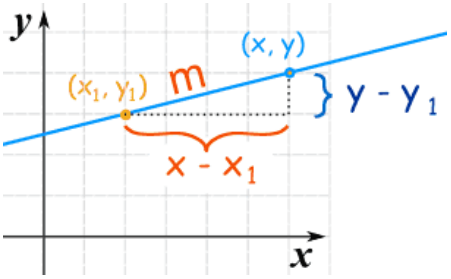
2. Connect your rubber band to a **20N force scale** and pull back until there is tension. Record the force to stretch the rubber band 5 cm (.05m), 20 cm, 25 cm, etc. in Data Table #1. ***NOTE****: Start your measurements based on the length of the rubber band before you begin stretching it.* Continue to record this force until 50cm, the spring scale has "maxed out", or until the band will not stretch any more. ***CAUTION****: Carefully hold the rubber band cannon as you pull back on rubber band with the spring scale.*

3. Plot **Force (*Newtons*)** (y-axis) vs. **rubber band displacement (*meters*)** (x-axis) on page 3. Don't forget to label the axes and include units! ***NOTE****: Graph should be a straight line.*

4. Find the <u>slope</u> of the line of the **Force vs. displacement** graph. This is your **spring constant** (***k***). Record this value in Data Table #1. *Show your work below***.**

$$slope = \frac{change\ in\ y}{change\ in\ x} = \frac{y - y_1}{x - x_1}$$

HINT*: (Use the diagram below to identify **x**, **x_1**, **y**, and **y_1**)*



Taken and modified from: physicsplayground.webs.com

5. Using the equation for **Elastic Potential Energy** $\boldsymbol{PE_e = \frac{1}{2}kx^2}$, find the energy stored in the band for each $\boldsymbol{PE_e}$ displacement and the ***KE*** as well (*Remember that the elastic potential energy is transformed into kinetic energy when launched*). Where (**k**) is the spring constant and (**x**) is the displacement (how far in meters you stretched rubber band). Show one sample calculation below.

6. Using the Kinetic energy equation $\boldsymbol{KE = \frac{1}{2}mv^2}$ find the speed (**v**) the projectile will leave for each displacement. Show one sample calculation**.** (*Rearranged, the equation looks like this*)

$$\boldsymbol{v = \sqrt{\frac{2(KE)}{m}}}$$

7. Now it's time to **fire your rubber band cannon (*CHECK WITH TEACHER FIRST*)**. Fire the cannon by pulling back the rubber band to the same displacements you calculated energies and velocity for. Complete data table with range (horizontal distance traveled). ***CAUTION****: Be cautious of others and wear eye protection?*

8. Plot **Range** (y-axis) **vs**. **rubber band displacement** (x-axis). Don't forget to label the axes and include units!

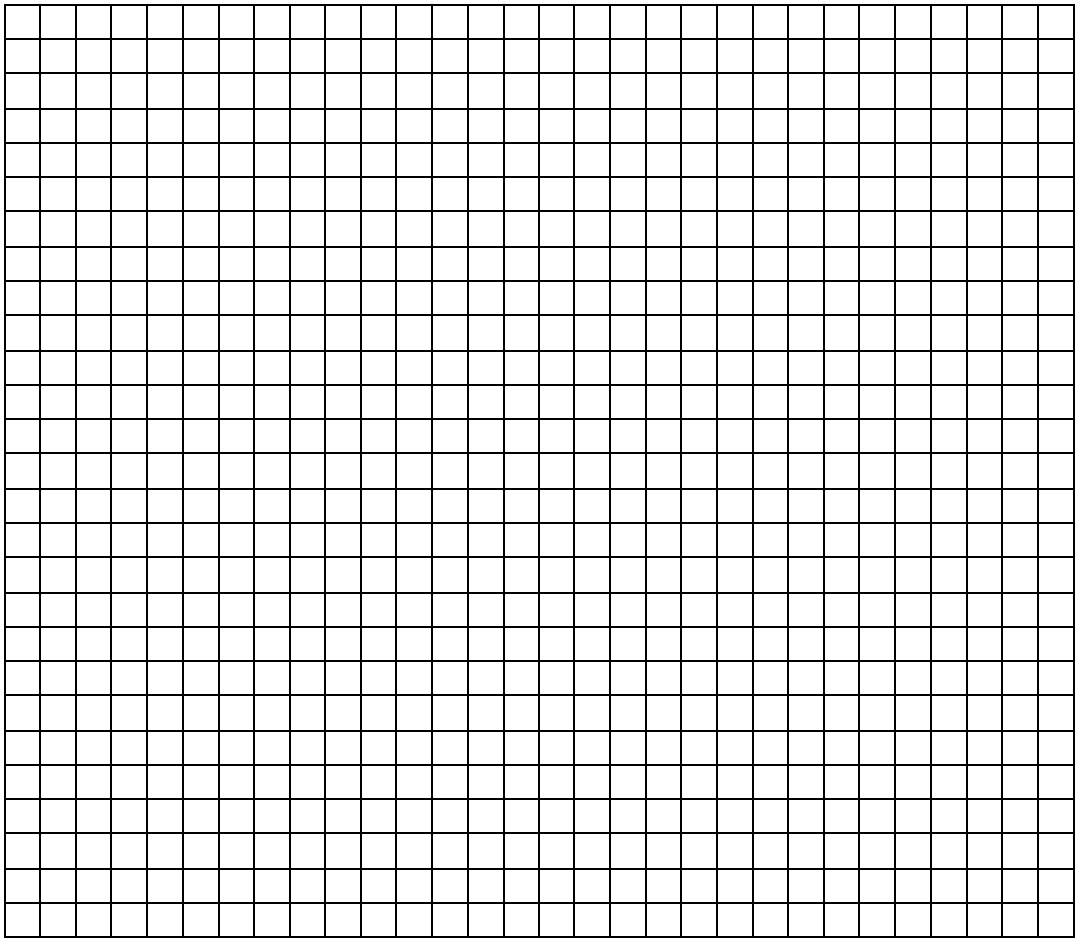
9. Answer all Conclusion Questions.

10. Complete calculations for 4 targets placed at different distances on the floor (on page 4). Each group will fire their rubber band cannons and record how accurate their shot was for each target.

DATA TABLE #1

Rubber Band Displacement (meters)	Force (N)	Spring Constant (N/m)	Elastic Potential Energy (Joules)	Kinetic Energy at Release (Joules)	Velocity (m/s)	Range Distance in (meters)
.05		*This value does not change. The spring constant (**k**) is the <u>slope</u> of a force vs. displacement graph.*				
.10						
.15						
.20						
.25						
.30						
.35						
.40						
.45						
.50						

Force vs. **Rubber Band Displacement**



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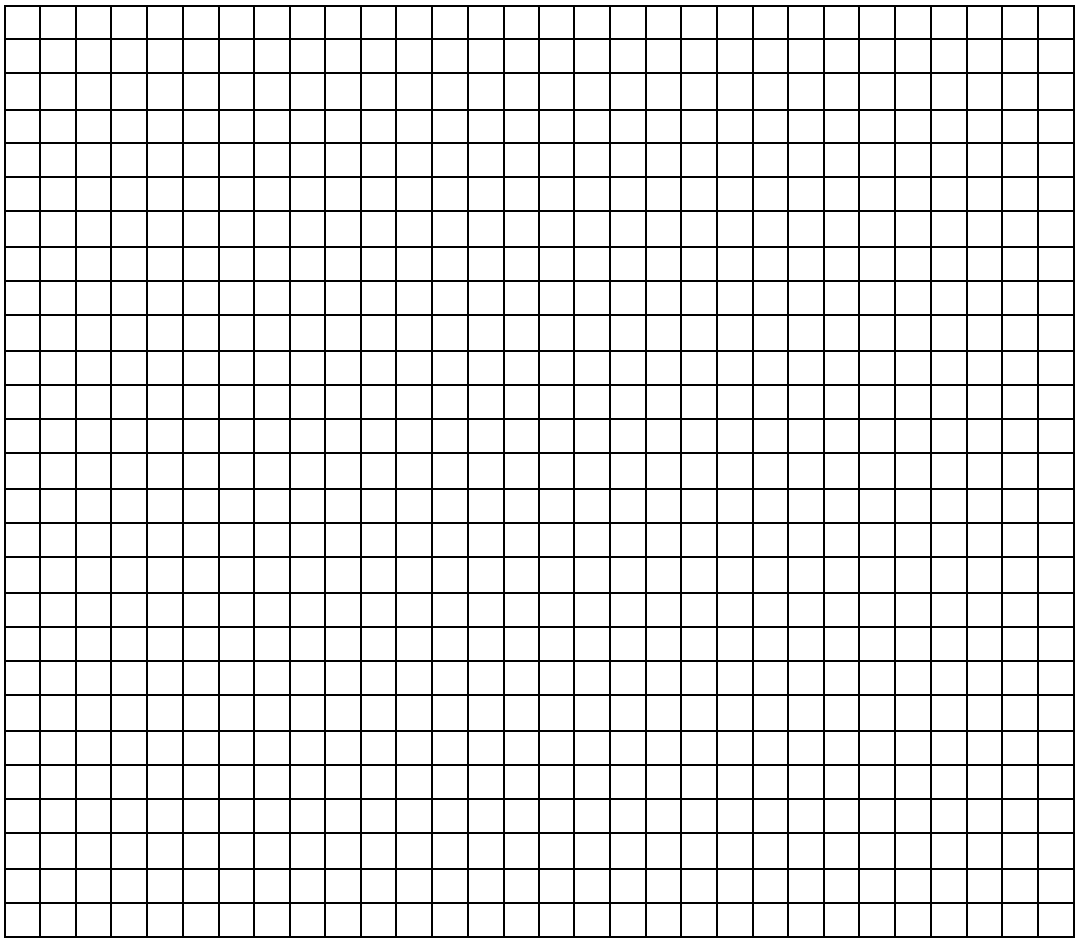
Range vs. **Rubber Band Displacement**



Conclusion Questions:

1. Describe the transformation of energy from being pulled back to the point where the projectile (rubber band) hits the target. *(Include work done, potential and kinetic energy)*

2. To <u>increase</u> the **velocity** of the projectile would it be better to double the rubber band displacement or decrease the projectiles mass by half. EXPLAIN WHY.

3. Discuss <u>three</u> sources of error in this lab. Operator errors do not count.

Competition: Calculate the rubber band displacements to hit the 4 different targets. You must make all four of these calculations before the competition begins.

1) Target 1:
Calculation:

How close were you? 1 2 3 4 5

3) Target 2:
Calculation:

How close were you? 1 2 3 4 5

2) Target 3:
Calculation:

How close were you? 1 2 3 4 5

4) Target 4:
Calculation:

How close were you? 1 2 3 4 5