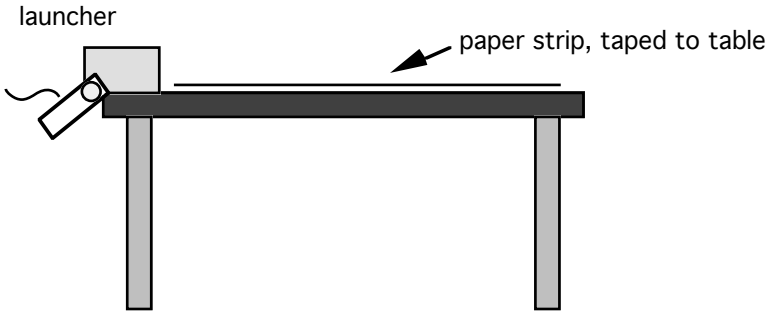
Lab 3-4: **Projectile Range**

Purpose:
1. To experimentally determine the initial launch angle that will give the maximum range of a projectile with a given initial speed.
2. To experimentally determine the relationship between angles that give the same range of a projectile with a given initial speed.
3. To derive an equation that gives the range of a projectile given a projectiles initial speed and launch angle.
4. To mathematically derive your experimental results.

Materials:
1 projectile launcher
1 meter stick
1 paper strip
1 c-clamp
1 carbon paper



Procedure:
1. Clamp the projectile launcher to the end of your lab bench so that it will launch the ball bearing down your lab bench from the level of the table top. (Use the guide on the side of the launcher to see the initial launch position.)
2. Tape a strip of paper to the lab table so that the ball bearing will land on it.
3. As best you can, fire the projectile and record the range for 5º intervals, from 10º to 85º. You can assume that the angle of 0º will have a range of 0 cm. Fire the projectile to see about where it lands, place the carbon paper at that spot, and relaunch the projectile to measure its range. Try 3 launches per angle. Measure the distances to the average landing spot for each angle.
4. Make a graph of Range vs. Initial Angle. Don't print it yet!

Data:

Launch Angle (º)	Range (cm)
90	0
85	
80	
75	
70	
65	

Launch Angle (º)	Range (cm)
60	
55	
50	
45	
40	
35	

Launch Angle (º)	Range (cm)
30	
25	
20	
15	
10*	
0	0

Questions:
1. Based on your data and graph, what is the relationship for launch angles that will have the same range?

2. Which angle will give the maximum range?

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3. Derive an expression for the range of a projectile, fired with an initial speed v and angle θ over flat horizontal area. (Use g to represent the acceleration due to gravity.) (Hint: it may help to use the trig identity $2\sin\theta\cos\theta = \sin(2\theta)$)

4. Use your expression from number 3 to show how your answer to number 1 is true.

5. Using your expression from question 3, derive the angle for maximum range.

6. Add a new calculated column that is the sine of twice the launch angle. (Make sure Logger Pro is using degrees under "File/Settings for ----.xmbl") Insert a second graph in Logger Pro that is then range vs sine (2-theta). Add a regression line, check with your teacher and print.

7. From your data, what is the equation that relates range and launch angle?

8. From your best fit line, what is the initial speed of the projectile?

9. Would your results have been the same if the projectile were fired off a cliff? Explain.