Lab - Target Shoot
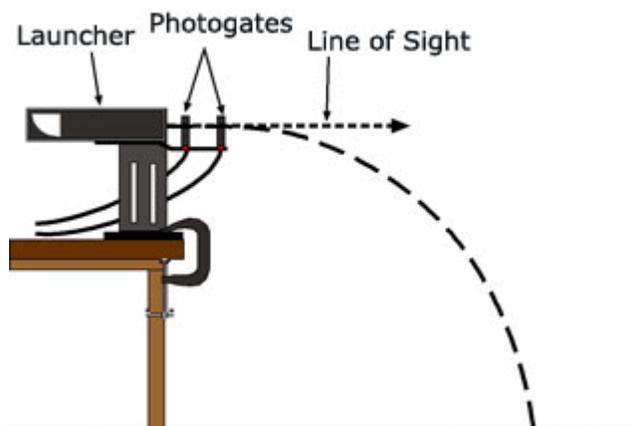
Problem: To accurately predict the range of a projectile in the lab.

Background: When a projectile is launched at a prescribed angle, θ, the range of the shot can be calculated knowing the *initial velocity* and the *initial height*.

Set Up:
1. Projectile launcher
2. A meter stick for measuring the maximum vertical height of the projectile
3. Target paper and carbon paper

Pre Lab: Determine the initial speed of the launcher by using the photo gate to complete the chart below: Why do all three launch positions. Why launch from all three angles at each position?

Table 1: Table of Initial Velocities (m/s):

launch	Angles		
position	15°	45°	75°
Short			
Med			
Long			

Initial Conditions

Init Height: _____

Gravity: _____

Angle: _____°

Launch Range: S - M - L

Procedure: Get a set of initial conditions from your instructor and record them above:

1. Set the angle of the launcher to your desired angle. Measure the height of the launcher from the ground to the center of the ball. Record.
2. Calculate the range of the shot using one of two methods:
   a. Focus on the max. height. At that time, what is true about the vertical speed? Once you find the time to the op, double it and you have the time it takes to get back to the original height. But this is NOT the total time of flight. You now need to determine how long it takes to go from the height of the launcher to the ground.
   b. Focus on the moment of impact. At this point, you know the vertical height (why is it negative?), the acceleration, and the initial vertical speed. Choose an equation and solve for time. The equation you get can only be solved using the *quadratic formula*. This time will be the *entire* time of flight.
3. When you have the total time of flight, make a chart for the horizontal direction and determine the range of the shot.

4. Set up the target on the ground, with carbon paper on top. Put your safety goggles on and take five (5) shots. You can eliminate one of the shots and count the four best in your analysis.
5. Be sure to double check all measurements and settings before you shoot!
6. Your grade will be based--in part--on how close you came to the target (If you totally mess up you can go back and refigure then shoot 4 shots for points).

Table 3 – Determining Range

	r (m)	v_0 (m/s)	v (m/s)	a (m/s^2)	t (s)
x	*range*	$v_0 \cdot \cos\theta$	$v_0 \cdot \cos\theta$	**0**	
y	*-Init. Height*	$v_0 \cdot \sin\theta$		**-9.80**	

Remember,
$x = v_{0x} \cdot t + 1/2 \cdot a_x \cdot t^2$
$x = v_0 \cos\theta \cdot t$

$y = y_0 + v_{0y} \cdot t + 1/2 \cdot a_y \cdot t^2$
$y = v_0 \sin\theta \cdot t - 4.90 \cdot t^2$

Use the above equations and/or the other kinematic equations. <u>NOTE</u>: for your initial velocity your group will have to examine the *Table of Initial Velocities* and choose the value that best fits your initial conditions.

Theoretical Range (m): _____

Actual Range (m): _____

Determine the percent of error using the formula:

$$\frac{theoretical\ \ range - actual\ \ range}{theoretical\ \ range} \times 100$$

Table 4: Actual Ranges

Shot #	Range (m)	% Error
1		
2		
3		
4		
Average		

Calculations: Be sure to show the following calculations...
- finding components of initial speed.
- finding time of flight and the predicted range of the shot.
- finding the % error.

Questions:

1.) Describe the projectile's motion in the vertical and horizontal directions throughout the entire flight (draw a picture).

2.) Why do you need a *plumb line* at the end of the table?

3.) Which other method(s) can be used to determine the initial speed of the ball?

4.) When launching from the ground what two angles will give the same range? What will be different for those two angles?

5.) In this lab which angle yields the *maximum range*? How could you find it?

Error Analysis
What was the error in your calculated range? What factors (that you could not control) were responsible for this error?

Conclusions
What did you do? What did you find? What generalizations can you make?

Extension: Redo your calculations with taking air resistance into account. The horizontal deceleration caused by air resistance is: **a* = k·A·v²/m** where v is the velocity of the ball, A is the cross sectional area of the ball, k is the mass density of air (use k ≈ 1.0 kg/m3), and m is the mass of the ball. Vertically, the acceleration would not be g but $(g - a^*)$.