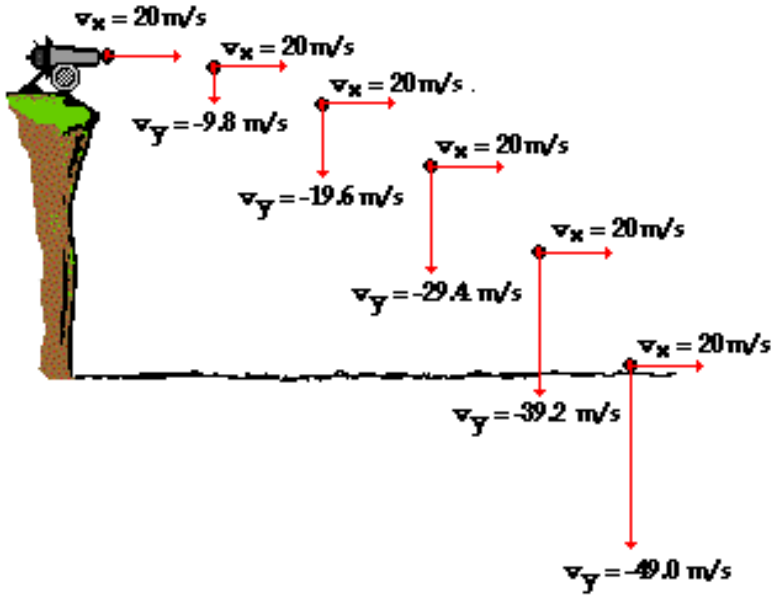
Name _____
Date _____ Per_____

Bull's Eye Lab

Purpose: To predict the landing position of a projectile.

Background:
A **projectile** is an object that is in **free fall**, meaning the only force acting on it gravity. In this lab the projectile will be a marble rolling off of a table. A projectile's path is determined by two factors: the horizontal velocity and vertical velocity. These two factors combine to create a curved path.



Refer to the diagram. The cannon ball exits the cannon with a **horizontal velocity** ($\mathbf{v_x}$) of **20m/s** which remains unchanged while the projectile is in **free fall** until it reaches the ground. However, the **vertical velocity** ($\mathbf{v_y}$) changes while the projectile is in free fall. Recall a **change in velocity** is the definition of **acceleration**. What is that cause of vertical acceleration in this case? Gravity! Once the ball exits the cannon it begins to accelerate towards the ground below at a rate of *9.8 meters per second every second* (**$g = 9.8 m/s^2$**).

Prelab:

1. **Write the equation** to **solve for velocity** of an object **given** a **distance** and **time**.

2. **Write the equation** to **solve for distance** an object travels in free fall **given acceleration** due to gravity and **time**.

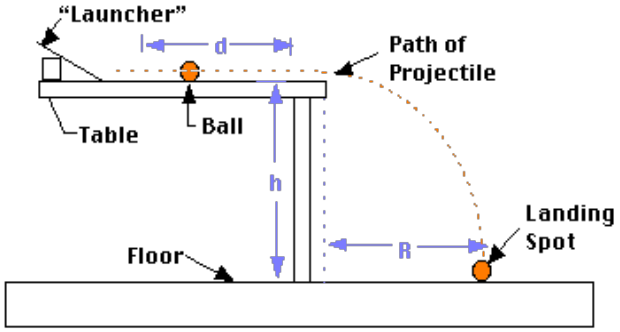
3. Looking at the diagram above, are the **vertical** and **horizontal velocities** independent of one another (in other words will the change in one velocity cause a change in the other)?

4. Refer to the diagram above. If a cannon ball was dropped from rest from the same height of the cannon, will it hit the ground at the same time as a cannon ball that was shot from the cannon?

Procedure:

1. **Assemble a ramp on your table**. Make it sturdy as possible so the marble rolls down smoothly and reproducibly. The ramp should not sway or bend. The marble must leave the table *horizontally*. The **vertical height of the ramp** (labeled "launcher" in the diagram) should be **15 cm** high and the **horizontal distance** (end of ramp to the table edge - **d** in the diagram) should be **at least 0.60 m**.
2. Use a stopwatch to measure the time it takes the marble to travel from low end of the ramp to the the edge of the table and becomes a projectile (catch the marble don't let it fall to the floor). **Record** the horizontal distance (**d**) and time for four trials in the **observations section step 1**. Use the **distance** and **time** measurements to **calculate the horizontal velocity**.
   Recall, velocity = distance / time (***v = d/t***).

3. **Calculate the average horizontal velocity** (*use equation from prelab question 1*) for the six trials. Show your work in the observations section step 1.
4. **Measure the height of the table (in meters)** and record this value in the **observations section** step 2. This measurement is labeled "**h**" in the diagram below.
5. Use the height of the table to determine the time the marble will be in the air. **Rearrange** the equation **$d = 1/2gt^2$** to **solve for** "**t**". The value for "**d**" in the equation is the height of the table (**h** in the diagram) **in meters** and **$g = 9.8\ m/s^2$**. Show your work in the observations section part 2.
6. **Solve for the range** (using the **average horizontal velocity** (v_x) and **time in free fall**), the distance from the table that the marble will travel before hitting the ground. **Rearrange** the equation **avg V_x = R/t** to solve for the range "***R***". Show all work in the observation sections part 3.
7. Now that you have **calculated where the marble should land** (the range (*R*)).
   Place the target on the ground where you expect it to land. Release the marble and see if it hits the target!



d = *distance* : ***the distance from the bottom of the ramp to the edge of the table.***

h = *height* : *the distance the marble will fall. This is equal to the height of the table.*

R = *range* : *the horizontal distance the marble will travel through the air.* ***This is distance you will place your bull's eye target from the desk.***

Observations:

1. **Calculating the horizontal velocity (V_X)**:
   Find the average of the six velocity values you calculated in the table. **Avg V_X** = _____

2. (A) **Calculating the time in free fall:**
   Measure the height of the table. **h =** _____
   Calculate the time the marble will be in the air.
   (B) Use $t = \sqrt{\frac{2*h}{g}}$ to solve for "**t**". **t =** _____

Distance (m)	Time (s)	V_X (m/s)

3. **Calculating the range (*R*) of the projectile**.
   Use **$R = V_X * t$** to solve for "***R***". ***R*** = _____

Interpretation:

1. What 3 things did you measure and what was the largest source of error in this lab?

2. If the marble is traveling with a greater **horizontal** velocity when it leaves the table will it land at a **further**, **shorter**, or **the same distance** from the table? (*It falls from the same height.*)

3. If the marble is traveling with a greater **horizontal** velocity when it leaves the table will it to take **more**, **less**, or **the same** amount of **time** to hit the ground? (*It falls from the same height.*)