Name ________________________
Block ________

BULL'S EYE

Projectile Motion

The shot:

A viral video from 2009 showed a huge waterslide on a ski slope in the summer. A man slides down the slide and is launched across the valley into a two foot deep swimming pool. The reality is that this video was a fake created for Microsoft in Germany. It's a good fake, but still fake. However, physics can be, and is, used to predict outcomes of various projectile scenarios. You can actually predict where a projectile will land based on the launch speed, the angle of launch, and the vertical launch position relative the landing area. Your task is to use projectile physics to properly place your own "swimming pool" and safely shoot your volunteer into it…on the first try. The following information will guide you through the process…

The task and data:

You will predict the landing spot of a volunteer (marble) projected from a spring launcher. A photogate is placed at the end of the launcher to determine the time it takes the launched marble to pass through a beam of light. You will also need to measure the height that the launcher is above the floor. Record all this information in the table below. On the next page you will use this data to predict the range of the marble as it is projected horizontally from the launcher. Then you will place your "pool" and test your prediction.

Launch Position	**Marble Diameter**	**Time Thru Photogate**	**Launcher height**

The Equations:

A projectile's parabolic path can be resolved into two straight-line motions: one is vertical and the other is horizontal. The vertical motion undergoes acceleration due to gravity, but the horizontal motion keeps a constant velocity. For the horizontal motion you will use "gravity free" equations and for the vertical motion use the free-fall equations.

Eq (1) For the horizontal motion where the marble would just keep traveling at a constant velocity write horizontal velocity equation:

Eq (2) While traveling at a constant velocity the marble will cover the same amount of distance each second it travels. Now rearrange the horizontal velocity equation so that horizontal displacement is alone on the left side of the equal sign:

Eq (3) Now for the vertical component…the time a projectile is in the air is directly related to its vertical displacement relative to the ground. You will need the equation for the displacement of an object in freefall and then rearrange this equation so that the time is alone on the left side of the equal sign.

Teacher Approval _____________

***The prediction*:…you don't want to just launch someone into a cliff! Do you?**

1. **Horizontal Motion:** Calculate the velocity of the marble as it leaves the launcher. This is based on the marble's diameter and its time through the photogate.
   Use **Eq (1)**. **Show K-U-E-S**

Teacher Approval ____________

2. **Vertical Motion:** Calculate the time that will be required for the marble to fall vertically from the launcher down to the floor. Use **Eq (3)** and **g = 980 cm/s^2**. **Show K-U-E-S**

Teacher Approval ____________

3. **Projectile Range:** Remember, the marble will travel the horizontal **and** vertical distance simultaneously and in the same amount of time. With that in mind, combine the information from the previous two steps to predict the horizontal distance (its range) the marble should travel from the launcher. Use **Eq (2)**. This is the ***predicted range.*** **Show K-U-E-S**

Teacher Approval ____________

4. When steps 1-3 are approved you will place your "pool" at your predicted range. Make sure the launch and landing areas are clear…and launch your volunteer(s).
5. How many volunteers did it take before you hit the "pool"? **Launch ____________**

Questions: Answer these questions on a <u>separate paper</u>

1. What experimental factors do you think might have caused the error in your prediction? (if you lost any volunteers)
2. What force(s) acted on the marble once it left the launcher, but before it hit the pool? In what direction(s) did the forces(s) act?
3. Would the time for the marble to fall from the table to the floor change if the marble was launched faster? Explain.
4. Sketch a side view of the launcher and landing area. Draw the marble's path after it was launched. Show approximate velocity vectors (horizontal and vertical) at three points along that path. You do not need to know the exact velocities, just show the relative length vectors that might properly represent the velocities of the marble as it falls.