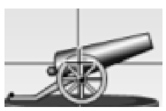
# Projectile Motion Virtual Lab	Name: ___ANS. KEY_________ Period _____ Date: _____________
preAP Physics ☛ Weight = 1	**Lab**

DIRECTIONS: Work in groups of two but one paper per person must be handed it. Put your answers in the blanks/spaces provided for them.

PROJECTILE MOTION LAB PhET. Shoot the Target.

STEP 1: A. Go to the website: http:// phet.colorado.edu/sims/projectile-motion/projectile-motion_en.html Don't **download** the simulation, just **run** it from the location. If you can't get to it directly, try www.phet.colorado.edu or just do a search for phet.colorado.edu. Then go to the Sims page → Physics → Motion → and scroll down the page. Choose the simulation that says **Projectile Motion**.

B. Play around with the Flash presentation to get familiar with your tools. You will be varying the location of the following:

• the cannon 	• the target (bull's eye) 	• the tape measure 

C. You can raise and lower the cannon's firing angle, its height above ground, and the target's height above ground. You can also vary the projectile's initial speed and its diameter, and even put in air resistance. You can throw different projectiles for fun including a person and a Buick. To fire, hit the **Fire** button in the green control panel on your screen.

STEP 2. A. Reset all your values. Make sure your cannon is at ground level, there is no air resistance, and that you are shooting the standard 0.1 diameter cannon ball.

B. Decide how far away you will put your target: _EX: 15_ m (has to be greater than 5m and less than 30 m). To measure accurately put the cross hairs (**+**) of the tape measure on top of the cross hairs of the cannon. Extend your tape measure horizontally until it reads the horizontal distance you decided on and place the middle of the target (bull's eye) at the cross hairs of the end of the tape measure (this way the cannon and target are at the same height, as well).

C. Try to "eyeball" a "good" launch angle (not 45°) and "good" initial speed to hit the target. *After how many tries* did you hit the target? _EX: 4_.

D. Write down the **firing angle** that worked: __EX: 62°_ (the angle is in the green box on the screen)

E. Write down the **initial speed** that worked: _13_ m/s (the initial speed is in the green box on the screen)

STEP 3. A. Don't change your initial speed. At what ***other angle*** (lower than 45° if your answer to Step. 2.C. was greater than 45° and greater than 45° if your answer to Step 2. C. was less than 45°) could you shoot at *the same speed* and still hit the target in exactly the same place? ___28°_____ It turns out that **complementary angles** will hit the same spot, angles that are the same distance away from 45 degrees, angles which, when added together = 90° .

B. Compare the two angles. How far away are the two angles from 45°? _17°______.

C. You just discovered a rule. State it here by circling the letter of the right answer:

MULTIPLE CHOICE: "When you shoot a projectile at the same initial speed from angles that are

a. complementary ***b. obtuse*** ***c. supplementary*** ***d. acute***

…the projectile will go <u>the same</u> <u>horizontal</u> <u>distance</u> (range)."

(Note:** it won't be perfect because the program has a little flaw in it**)

STEP 4. A. *How far* (in m) did your projectile go horizontally (range)? Measure. __15 m______

B. *How long* (in sec) was the projectile in the air? Look at the green box screen output. _2.34 s__

C. If you have the **horizontal distance** (in m) and **time** (in sec), how do you find the **horizontal speed** (in m/s)? __$v = \frac{d}{t} = \frac{15\ m}{2.34\ s} =$______________________________________

D. What is the horizontal speed (in m/s) of the projectile that you fired? ____6.41 m/s______

STEP 5. A. For *how many seconds* did the projectile rise? __1.17 s <u>(total time in air divided by 2)</u>

B. For *how many seconds* did the projectile fall? __1.17 s________________

C. ____d.____ **MULTIPLE CHOICE:** What is the vertical motion formula for finding the final vertical speed in this particular situation?

a. $\mathbf{v_y = v_{yo}}$ **(the initial speed)**

b. $\mathbf{v_y = -v_{yo} - gt}$

c. $\mathbf{v_y = -gt}$

d. $\mathbf{v_y = v_{yo} - gt}$

(where v_y = final vertical speed (in m/s), v_{yo} = initial vertical speed (in m/s), g = gravity (in m/s^2), t = time (in sec))

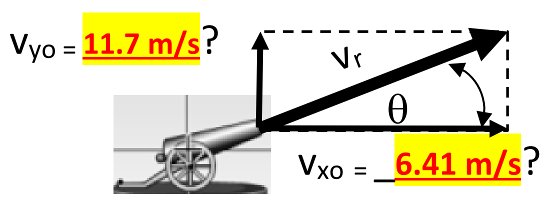
The formula in Ans. d., as in the softball lab, shows that the cannonball has positive initial vertical velocity, v_{yo}. The other answer choices show that there is constant velocity, negative initial vertical velocity, or no initial vertical velocity.

D. What is the *vertical speed, v_y,* (in m/s) of your ball at the ***top*** of its flight? ___0 m/s___

At the top of the flight the cannonball is not rising or falling momentarily. It is just moving horizontally.

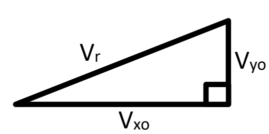
E. What is the value of gravity, *g* (in m/s^2)? __–10 m/s____

F. Plug v_y, *g*, and *t* into your *vertical speed* formula (**Step 5. C.**) and find v_{yo}, your ball's *initial vertical speed* (in m/s). Place your answer in the blank at right. While you are at it, label your *horizontal speed* from **Step. 4. D.** in the blank provided as well.



To find the vertical velocity, v_{yo}, just use the mental math trick from before once again, as in the softball lab. If it takes 1.17 seconds to get to the top of the cannonball's flight and gravity takes off 10 m/s every second off of the cannonball's vertical velocity, then the initial vertical velocity of the cannonball must have been 1.17 s × 10 m/s per second = **11.7 m/s**

STEP 6. *v_r, the resultant speed* shown in the vector diagram above*,* is the same as the **initial speed (in m/s)** shown in the green box on your screen. Use the *Pythagorean Theorem* to verify that they are the same and that the software is accurate.



A. What the green box says on your screen for speed (in m/s): __13 m/s____________

B. What the Pythagorean Theorem says for speed (in m/s): _____$13.34\ m/s$ ___________

Show work for credit:

Just as in the softball lab, when you know the lengths of two sides of the right triangle, you can find the third side using Pythagorean Theorem.

$a^2 + b^2 = c^2 \rightarrow c = \sqrt{a^2+b^2} \rightarrow c = \sqrt{(6.41\frac{m}{s})^2 + (11.7\frac{m}{s})^2} \rightarrow c = \sqrt{177.98} = \mathbf{13.34\ m/s}$

Notice that the answer we got for initial velocity through the software program and the answer we got mathematically are very close to each other verifying that we did our work right.

STEP 7. θ, the *launch angle* shown in the velocity vector diagram above, is the same as the **angle (in degrees)** shown in the green box on your screen. Use *S.O.H.C.A.H.T.O.A.* to verify that they are the same and that the software is accurate.

A. What the green box says (in degrees): ___**62°**_**(this was the original angle I fired at)**

B. What S.O.H.C.A.H.T.O.A. says (in degrees): ___$\mathbf{61.3}°$__________

Show work for credit:

Again, just as in the softball lab, to find the angle in a right triangle when given the lengths of the sides, you have to use the inverse trigonometric functions such as $\tan^{-1}$, $\sin^{-1}$, and $\cos^{-1}$. These are accessed via the [2nd] [TAN], [SIN], and [COS] buttons on your graphing calculators. Make sure your calculator is in degree [MODE].

Since I have all the sides of my right triangle I can use any of my inverse functions.

$$\theta = tan^{-1}\left(\frac{opp.}{adj.}\right) = tan^{-1}\left(\frac{11.7}{6.41}\right) = tan^{-1}(1.83) = \mathbf{61.3}°$$

$$\theta = sin^{-1}\left(\frac{opp.}{hyp.}\right) = sin^{-1}\left(\frac{11.7}{13.34}\right) = sin^{-1}(0.877) = \mathbf{61.3}°$$

$$\theta = cos^{-1}\left(\frac{adj.}{hyp.}\right) = cos^{-1}\left(\frac{6.41}{13.34}\right) = cos^{-1}(0.48) = \mathbf{61.3}°$$

Notice that the angle we got through the software program and the answer we got mathematically are very close to each other verifying that we did our work right.