RANGE OF A PROJECTILE

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Purpose

To use mathematical and physical methods to predict the impact position of a projectile launched horizontally from a laboratory table and verify this position experimentally.

Theory

A projectile launched horizontally from a laboratory table is subject to gravitational acceleration in the vertical direction (call upward the +y direction) and zero acceleration (if air resistance is neglected) in the horizontal direction (let the x-axis lie horizontally). Therefore, we can write:

$$a_x = 0 \qquad a_y = -g$$

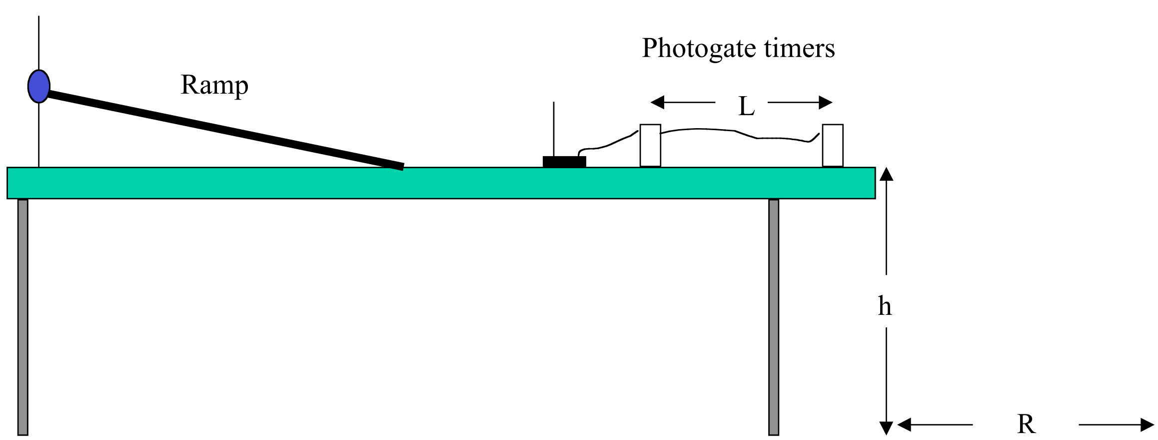
Take your origin of coordinates at the edge of the table where the projectile is launched, $x_\circ = 0$ and $y_\circ = 0$, and assume the height of the table is h.

Using the appropriate kinematics equations in 2-D, calculate, R, the horizontal displacement of the projectile in the air (see figure below).

Procedure

<u>NEVER</u> DISASSEMBLE YOUR APPARATUS UNTIL YOU HAVE COMPLETED YOUR DATA ANALYSIS AND ERROR ANALYSIS (PH 4A ONLY).

1. Set up the ramp so that the ball rolls down the incline in the direction of the edge of the table. Be sure the ramp is secured so that it does not move during the course of the experiment. Allow about a meter along the surface of the table to measure the velocity.



2. Set up the timing gates a (carefully measured) distance L apart on the table so that the projectile passes through them sequentially. It is better practice to set up the distance between the gates at a reasonable distance and then measure that distance rather than to try to set the gates at a predetermined separation. For example, if you want the gates 1.00 m apart, set them about a meter apart, measure the true value and use the measured value. Do not try to position the gates 1.000 m apart
3. Put some masking tape at the base of the ramp to cushion the bounce. Make sure the starting gate is beyond the "bounce area".
4. Be sure the ramp and gates are securely fastened to the table so they do not move during the course of the experiment. Set the photogate timers to the PULSE setting.
5. Measure the height h of the table by hanging a plumb-bob off the edge of the table to determine vertical.
6. Release the ball from a reproducible point on the ramp and measure the time required to traverse the distance L. Repeat the measurement at least 5 times taking care to release the ball from the same point on the ramp with zero initial velocity each time. (Estimate the possible error in the starting position?)
7. Average all times measured with the photogates and use this average time to calculate the (average) velocity of the ball as it leaves the edge of the table. You will need to use a kinematics equation.
8. Calculate the distance R, from the table's edge, where you predict the ball will impact the floor.
9. Place your target (a piece of paper with an "X" is sufficient) on the floor where you predicted that the ball will strike. Tape it in place so that it does not move when the ball strikes it. Since measurements of the range *R* will be taken from where the plumb-bob touches the ground to the impact site, carefully note the location f the blumb-bob. Now place carbon paper on top of the target and release the ball from the ramp exactly as you did in the velocity measurements.
10. Observe where the ball strikes the target. If it misses the target entirely, check your calculations. Something is wrong. If it strikes the target area, repeat the experiment at least 4 more times. You should now have at least 5 marks on the target from the ball striking the carbon paper.

Further Analysis

1. Measure the distance from the blumb-bob to each of the strike marks closest to your predicted target. You need to have at least 5 measurements of *R*.
2. Average the R values you measured above and call this $R_{measured}$.
3. Compare the measured and predicted *R* values.
4. NOTE: If you are doing *error propagation* on this lab, realize that it is good practice but is rather ambiguous because a handbook value does not exist and both $R_{measured}$ & $R_{predicted}$ have some experimental error. For error propagation practice you must let $R_{theoretical} = R_{measured}$ and $R_{experimental} = R_{predicted}$ since an equation is needed for the experimental value.