Projectile Motion

PHYS 211L – H02

Tuesday 10:05am – 12:05pm

Abstract

We investigated the initial velocity of a projectile by measuring the projectile’s range and compared it to the initial velocity by timing the projectile as it crossed a known distance. We also investigated the effect that the launch angle of the projectile has on its range. We found that the range is greatest when the launch angle is 45 degrees, and that the initial velocity of the projectile was (5.926 ± 0) m/s when using the distance over time method, and (5.148 ± 1.039) m/s when using the range equation.

Introduction/Background

Procedure

Our equipment includes a caliper, a ballistic pendulum, an angle apparatus, a clamp, an electronic timer attached to a photogate, a meter stick, and a metal ball. (Also that metal thing with an adjustable height that we used for the ball to land on, not really sure what the hell it’s called. There’s also that carbon paper that the lab mentions that we didn’t actually use)

\*insert diagram of setup here\*

With this setup, we launched the ball from angles of 5°, 15°, 30°, 45°, 60°, and 70°. We made sure that the ball landed on the surface at the same height from which it was launched in order for our equations to be valid. We measured the range using a meter stick, and the time the ball spent blocking the gate’s sensor using the electronic stopwatch. Then, we measured the width of the ball using the caliper and determined that the width is 0.016 meters. With this data, we now have the range and initial velocity at each launch angle.

Results/Analysis/Physics

Going into this experiment, we know from basic kinematics and trigonometry that the equation for the horizontal distance the projectile travels, or in other words, the range, is . is the magnitude of the initial velocity, is the acceleration due to gravity, and is the angle from which the projectile is launched. In our experiment, we had measured the range and magnitude of the initial velocity and were given the launch angles. As a result, we used this equation in three different ways. First, we used our given and measured values for and respectively to calculated the predicted values of .Second, we used our given and measured values for and respectively in order to solve for . Then, we used our original measurements for along with the same measured values of to calculate . We then calculated our uncertainties for and by finding the greatest deviation from the average, and we found our uncertainty for the range using:

, where is our uncertainty for and is our uncertainty for .

Range and Time at Launch Angle of 5° Range and Time at Launch Angle of 15°

|  |  |
| --- | --- |
| Range (m) | Time (s) |
| 0.315 | 0.0027 |
| 0.285 | 0.0027 |
| 0.300 | 0.0027 |
| 0.305 | 0.0027 |
| 0.290 | 0.0027 |

|  |  |
| --- | --- |
| Range (m) | Time (s) |
| 1.40 | 0.0027 |
| 1.45 | 0.0027 |
| 1.43 | 0.0027 |
| 1.41 | 0.0027 |
| 1.41 | 0.0027 |

Range and Time at Launch Angle of 30° Range and Time at Launch Angle of 45°

|  |  |
| --- | --- |
| Range (m) | Time (s) |
| 2.59 | 0.0027 |
| 2.62 | 0.0027 |
| 2.61 | 0.0027 |
| 2.58 | 0.0027 |
| 2.60 | 0.0027 |

|  |  |
| --- | --- |
| Range (m) | Time (s) |
| 2.96 | 0.0027 |
| 2.92 | 0.0027 |
| 2.95 | 0.0027 |
| 2.95 | 0.0027 |
| 2.92 | 0.0027 |

|  |  |
| --- | --- |
| Range (m) | Time (s) |
| 1.8796 | 0.0027 |
| 1.83 | 0.0027 |
| 1.82 | 0.0027 |
| 1.84 | 0.0027 |
| 1.83 | 0.0027 |

Range and Time at Launch Angle of 60° Range and Time at Launch Angle of 70°

|  |  |
| --- | --- |
| Range (m) | Time (s) |
| 2.58 | 0.0027 |
| 2.56 | 0.0027 |
| 2.57 | 0.0027 |
| 2.59 | 0.0027 |
| 2.58 | 0.0027 |

Initial Speed at Each Launch Angle (using v = d/t where d is the width of the ball 0.016m)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Launch Angle (degrees) | Trial 1 (m/s) | Trial 2 (m/s) | Trial 3 (m/s) | Trial 4 (m/s) | Trial 5 (m/s) | Average (m/s) | Uncertainty (m/s) |
| 5 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 0 |
| 15 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 0 |
| 30 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 0 |
| 45 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 0 |
| 60 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 0 |
| 70 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 5.926 | 0 |

Initial Speed at Each Launch Angle (using the range equation and solving for v)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Launch Angle (degrees) | Trial 1 (m/s) | Trial 2 (m/s) | Trial 3 (m/s) | Trial 4 (m/s) | Trial 5 (m/s) | Average (m/s) | Uncertainty (m/s) |
| 5 | 4.218 | 4.013 | 4.117 | 4.151 | 4.048 | 4.109 | 0.109 |
| 15 | 5.241 | 5.334 | 5.297 | 5.260 | 5.260 | 5.278 | 0.056 |
| 30 | 5.417 | 5.448 | 5.437 | 5.406 | 5.427 | 5.427 | 0.021 |
| 45 | 5.389 | 5.352 | 5.380 | 5.380 | 5.352 | 5.371 | 0.019 |
| 60 | 5.406 | 5.385 | 5.396 | 5.417 | 5.406 | 5.402 | 0.017 |
| 70 | 5.356 | 5.285 | 5.270 | 5.299 | 5.285 | 5.299 | 0.057 |

Each Calculated Angle Compared to Each Given Angle

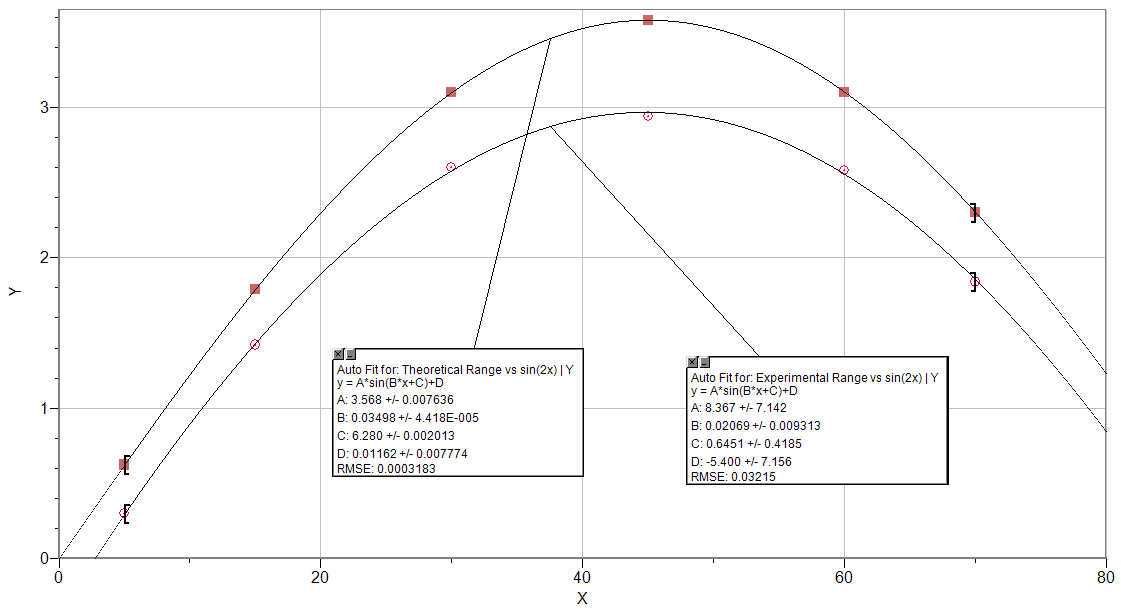
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Given Launch Angle (radians) | Trial 1 (radians) | Trial 2 (radians) | Trial 3 (radians) | Trial 4 (radians) | Trial 5 (radians) | Average (radians) | Uncertainty (radians) |
| 0.177 | 0.0441 | 0.0398 | 0.0420 | 0.0427 | 0.0405 | 0.0418 | 0.0023 |
| 0.5 | 0.201 | 0.209 | 0.205 | 0.202 | 0.202 | 0.204 | 0.005 |
| 0.866 | 0.404 | 0.411 | 0.409 | 0.402 | 0.406 | 0.406 | 0.005 |
| 1 | 0.487 | 0.477 | 0.484 | 0.484 | 0.477 | 0.482 | 0.005 |
| 0.866 | 0.402 | 0.398 | 0.400 | 0.404 | 0.402 | 0.401 | 0.003 |
| 0.643 | 0.276 | 0.268 | 0.267 | 0.270 | 0.268 | 0.270 | 0.006 |

Uncertainty in the Predicted Range at Each Launch Angle

|  |  |
| --- | --- |
| Launch Angle (degrees) | Uncertainty (meters) |
| 5 | 0.0162 |
| 15 | 0.0310 |
| 30 | 0.0179 |
| 45 | 0 |
| 60 | 0.0107 |
| 70 | 0.0329 |

Theoretical Range at Each Launch Angle

|  |  |
| --- | --- |
| Launch Angle (degrees) | Theoretical Range (meters) |
| 5 | 0.622 |
| 15 | 1.79 |
| 30 | 3.10 |
| 45 | 3.58 |
| 60 | 3.10 |
| 70 | 2.30 |



Free Body Diagram of the Projectile in Flight

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Fgravity

The force of gravity is constant

Conclusion

Lab Questions

1. Our initial velocity from the timer was always the same, and always greater than the velocity we calculated from the range and firing angle data.
2. Graph 1 tells me that as the launch angle increases from 0 to 45 degrees, the range increases up to a certain value, and then from 45 to 70 degrees, the range decreases. The graph is a good representation of the data for all firing angles.
3. Some mechanical energy is lost due to air resistance. I base this claim on some bullshit that I’m determined to never fully understand
4. To get the greatest range, the launch angle should be 45 degrees. Our data and calculations support this. Another way to think about it is by looking at the range as a function of sin(2x). If you plug 45 degrees into that equation, you get sine of 90 degrees which is 1. Since 1 is the largest value that sine can be, the range will be at its largest when the launch angle is 45 degrees.