

Free Fall

Procedure

To calculate the muzzle velocity of a projectile (the speed at which the projectile emerges from the gun).

- Level the spring cannon using the built-in bubble level. Adjust the height of the legs by turning the feet.
- Use the C-clamp to attach the gun base rigidly to the lab bench. This will prevent recoil of the gun. Ensure that the base is still level even after the C-clamp is attached.
- Load the projectile into the spring cannon.
- Align the edge of the spring cannon with the edge of the table.
- Test fire the cannon and observe approximately where the projectile strikes the floor.
- Use masking tape to attach a piece of white paper to the floor near that location.
- Place (do not tape) a sheet of carbon paper shiny side down on top of the white paper.
- Reload and realign the spring cannon. Fire several shots.
- **Do not remove the white paper from the floor** before you have taken the horizontal distance measurements from the ball bearing to the marks.
- For the uncertainty in horizontal distance, Δx , use the uncertainty of the average.
- Measure the height of the projectile from the floor.
- Use a value of $g = 9.80 \text{ m/s}^2 \pm 0.01 \text{ m/s}^2$.

Error analysis

- Find the muzzle velocity of the projectile and its propagated error: $v \pm \Delta v$. Do not find the time t or the error on the time Δt . Time is not a measured quantity; eliminate time as a variable from equations of projectile before propagating
- Should you measure the horizontal distance with the gun spring compressed or uncompressed? Why?
- Should you measure the height from the **top**, **middle**, or **bottom** of the ball bearing to the ground? Why?
- Identify at least two sources of statistical error.
- Identify at least two sources of systematic error.