Computational Final

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1 Goals

The goal of the project was to program a rudimentary calculator to account for the bullet drop of a 0.338 Lapua 300gr bullet over a user-supplied range.

2 Shooting Conventions

While researching the topic, several conventions made themselves clear.

- The general weight of a bullet is not usually given in grams, but grains, where 7000 grains = 1 pound. That being said, Lapua is an exception, as they supply bullet weights in both units.
- Angle compensation in shooting is not usually measured in degrees, but rather "Minutes of Angle" (MOA) where 1 MOA is $\frac{1}{60}$ of 1 degree
- For most calculations, the values were originally calculated using a reference bullet (usually G1, although there are others.). These values are usually scaled based on the desired bullet's aerodynamic relationship to the reference bullet, this scaling factor is called the Bullet Coefficient (BC)
- More complicated calculators use 6 degrees of freedom (6DOF) to more accurately calculate ballistics using each standard axis of motion (X, Y, and Z) alongside rotations about each axis. this allows for compensation for stabilizing and destabilizing effects due to its rotation and environmental forces. However, for simplicity, the mass-point model has been used, as many of the forces accounted for in the 6DOF models are small enough to avoid influencing trajectory until extreme ranges have been reached.

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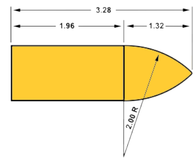

Figure 1: G1 reference bullet

3 Equation Derivation

The forces should be split into the two vectors on which they act, X and Y. All calculations were performed under the standard temperature and pressure conditions to avoid the need to compensate,

3.1 X forces

- The primary force acting on the round is the ignition of the powder which launches the round down the barrel. This has been accounted for by using the average muzzle velocity V_0 found through experimentation by the manufacturer.

- once the round leaves the barrel, it becomes subject to drag, which was calculated using the equation

  $$\text{Drag} = C_d \rho V^2 \frac{A}{2}$$

  where:

  - ρ is the average air density
  - C is a coefficient based on the aerodynamics of the object
  - V is the velocity for that given time
  - A is the cross sectional area. in other words, the area that the force will be acting on.

3.2 Y forces

- The only acceleration experienced in the Y axis is the gravitational constant $g = 9.81m/s^2$. After calculating for departure angle (the angle formed by the muzzle and the x axis, the equation can be changed to accommodate using the velocity in Y calculated by $V_0 Sin(\theta)$ where θ is the departure angle and V_0 is the initial velocity

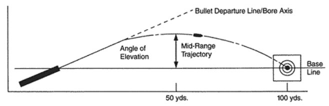

Figure 2: Exaggerated Diagram for trajectory

3.3 diagram and angle compensation

once the bullet drop y_d is found using Euler's method, the adjustment angle can be found using trig functions to bring the rifle into "zero" for that given range. Angle = $\frac{y_d}{Range}\frac{180}{\pi}$

4 Citations

- Klimi, George (2016). Elements Of Exterior Ballistics: long range shooting first edition. XLIBRIS.
- .338 Lapua Magnum. (n.d.). Retrieved from https://www.lapua.com/cartridges/338-lapua-magnum/
- The Drag Equation. (n.d.). Retrieved from https://www.grc.nasa.gov/WWW/K-12/airplane/drageq.html