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A4_8 Don't aim at him!

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Abstract
This paper investigates the horizontal deviation due to gravity that would be experienced by a bullet fired from a rifle. The paper looks at the recent setting of a new sharpshooting distance record as a case study for the investigation. While the deviation quoted by the soldier involved significantly differed from that calculated we show that a significant deviation is measured.

Introduction

In May last year a new sharpshooting record was set after a corporal of the British army confirmed two shots at a distance of 2475m[1]. With the projectile travelling such a large distance the deflection of the bullet due to gravity needs to be considered when deciding where to aim the shot. In this paper we will attempt to calculate the deviation from the aimed at location to see how great an effect gravity has on the bullet as it travels.

Theory

Any projectile thrown on Earth follows a parabolic path assuming that air resistance is negligible. The path is parabolic rather than a straight line due to the attraction of gravity imparting a vertical force on the projectile causing it to fall towards the Earth. As the horizontal and vertical forces experienced by the projectile are independent we can calculate the range of the projectile using the following equation of motion

$$y = v_{0y}t - \frac{1}{2}at^2 . \tag{1}$$

In Eq. (1) v_{0y} is the initial velocity in the y direction which we will assume to be 0, *t* is the flight time and *a* is the acceleration in the y direction being experienced by the projectile, which will be acceleration due to gravity. In order to use Eq. (1) we need to have a value for the flight time. We can calculate the flight time quite easily as we have the distance the bullet travelled and we know that the muzzle velocity for the rifle used is 936ms^{-1}[2]. Using

$$t = \frac{d_x}{v_x} , \tag{2}$$

we can calculate a value for the flight time of the bullet, where d_x is the distance and v_x is the velocity the projectile is travelling at. As we are using a simple model that neglects air resistance the horizontal velocity of the bullet will remain constant until hitting the target . If we substitute Eq. (2) into Eq. (1) along with our value of 0 for v_{0y} we get the following relationship for the vertical distance the bullet is deflected by gravity

$$y = -\frac{1}{2} g \left(\frac{d_x}{v_x} \right)^2 . \tag{3}$$

Discussion

Using Eq. (3) and substituting in our values for d_x and v_x we can calculate the deviation in vertical distance as a result of gravity.

$$y = -34.30 \text{ m.}$$

We can see that during its transit the bullet falls a total of 34.30m below its starting point. We can see the force subjected to the bullet by gravity as it travels makes a considerable difference to the flight path of the projectile. Using trigonometry we calculate that this represents a deviation of 0.79° from the straight line connecting the end of the rifle and the target.

Conclusion

In the article discussing the shot [1] it mentions that the corporal had to aim 1.83m above his target to ensure he got the hit which is considerably different from the number we have calculated in this paper. The difference in the deviation claimed and calculated possibly arises from the conditions surrounding the event as in the calculation done by this paper it is assumed that the rifle was on the same level as the target. Also the scopes used on long-range rifles may have a mechanism that assists with aiming by automatically correcting for the curvature of the bullet due to gravity. Given more time a thorough study that included air resistance as well as other variables such as shooting height and angle could be completed to further refine the deviation calculated. Although the deviation quoted by the article differs from that calculated by the paper we have shown that a significant consideration for the deviation caused by gravity needs to be made.

References

[1] http://news.sky.com/skynews/Home/World-News/Afghanistan-Sniper-Corporal-Of-Horse-Craig-Harrison-Sets-Record-After-Killing-Taliban/Article/201005115624184

[2] http://www.army.mod.uk/equipment/support-weapons/1459.aspx