



Physics: An Incredible Shot and Feat of Human Ability

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A Physics analysis and explanation of the famous sniper shot by Matt Hughes, a Welsh Royal Marine Sniper during the 2003 Iraqi Invasion.

Background Information

During the Iraqi Invasion in 2003, British Royal Marine Marksman Corporal Matt Hughes displayed an incredible feat of the human ability to estimate and calculate Physics without external aid from any sources. Corporal Hughes conducted a sniper's shot and kill that will live forever in the history of the profession.

Perched on an elevated cliff, Corporal Hughes spotted and identified a hostile Iraqi target halting a crucial advance of other marines on the ground attempting to make an advance. The Iraqi was standing behind a concrete wall, with only his upper chest, neck, and head exposed. Corporal Hughes knew it was crucial to take out this target, even with a fierce 20 mph cross wind, and with a rifle whose projectile could not reach the standing with its maximum velocity. "I saw I had a clear shot at my man — he was in what he thought was a secure position, but his head and chest were exposed. He was still wearing his green Iraqi uniform and was holding the rifle he'd been using to shoot at Marines."

"It was a bit like David Beckham taking a free kick. I knew I only had one shot and had to get the angle exactly right. It was hot and the wind was blowing strongly from left to right as we crept up to a vantage point about 860 meters from the target." Corporal Hughes made quick rough estimates in his head and took the shot, aiming 56 feet to the left and 38 feet above the target in his cross hairs. The bullet struck the target directly in the chest and dropped him, killing him instantly.

This historic shot from Corporal Hughes is not only an amazing shot in sniper history, but one of amazing human feat and ability. The kill allowed the ground marines to safely advance and take over an essential village for the continuation of the Iraqi Invasion. We will use physics analyze this shot, and compare our calculations of the horizontal and vertical angles which the shot should have been taken and Hughes' estimated aim.

The Question

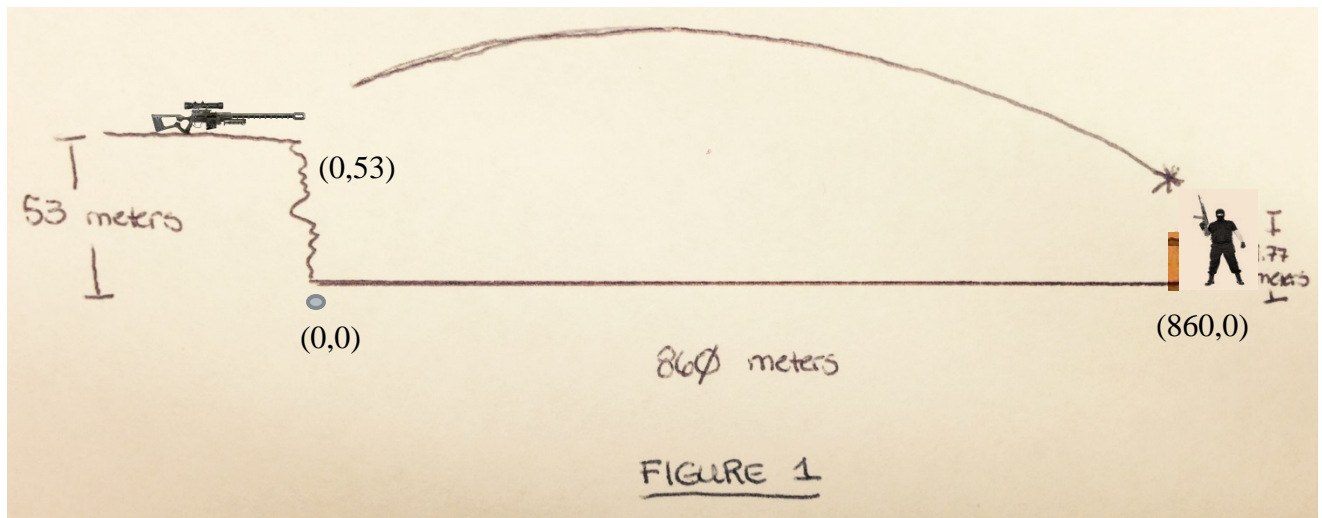
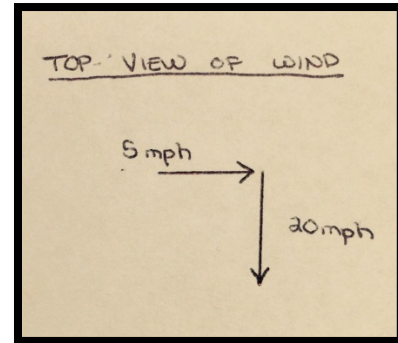
Corporal Hughes is encamped on a cliff 860 meters away and 53 meters above an Iraqi target which is wreking havoc upon his men. The target is shielded behind a concrete wall 1 meter tall, with only his head, neck, and chest exposed. Use the average height of a man (1.77 meters) in this problem. There is a 20 mph cross wind blowing from left to right. Calculate the horizontal and vertical angles measured from the horizon which he should make his shot in order to hit the target.

Weapons Information:

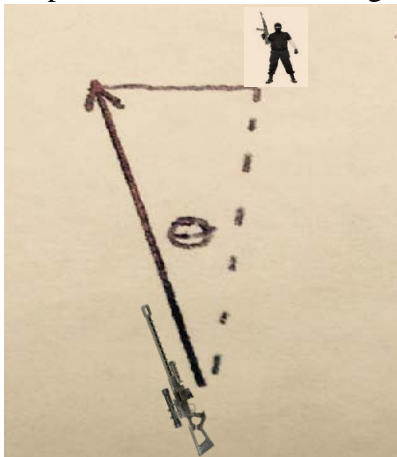
Battlefield 4 L96 Bolt-Action Sniper Rifle



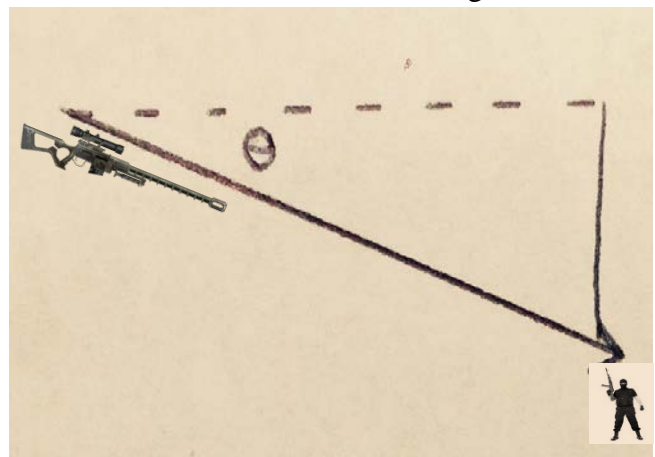
Bullet Velocity: 540 meters/second



Top View of Horizontal Angle



Side View of Vertical Angle



The Physics and Calculations

In this problem there are a few physics concepts which are involved. In order to begin the problem, it is necessary to calculate when the bullet would reach the target. This can be found in using equation 2-18 from Chapter 2 involving Motion along a straight line.

$$\text{Equation 2-18: } \Delta x = V_0 t - \frac{1}{2} a t^2$$

We can solve this equation for time since we are given the change in the horizontal direction and the velocity which the bullet is shot from the rifle...

$$860\text{m} = \left(\frac{540\text{m}}{\text{s}}\right)(t) - \frac{1}{2}(0)t^2$$

*Acceleration is 0 in the Horizontal direction due to the only force of acceleration acting on the bullet being gravity. There is no case of acceleration in the horizontal direction.

So, time = 1.59s

Once time is calculated, we must move to another Chapter of Physics concepts involving projectile motion in Chapter 4. We have to break this problem into two parts, as the separate angles cannot be calculated with one sole equation. Therefore, the problem will be broken into its Horizontal and Vertical components.

Firstly, the Vertical angle:

The angle from which the bullet should be shot with respect to the horizontal can be calculated using equation 4-22.

$$\text{Equation 4-22: } \Delta y = (V_0 \sin \phi_0)t - \frac{1}{2} g t^2$$

So,

$$1.77 - 53.0 = \left(\frac{540\text{m}}{\text{s}}\right)(\sin \phi_0)(1.59\text{s}) - \frac{1}{2}\left(\frac{9.81\text{m}}{\text{s}^2}\right)(1.59^2)$$

$\phi_0 = -2.59^\circ$ * Negative means downward angle.

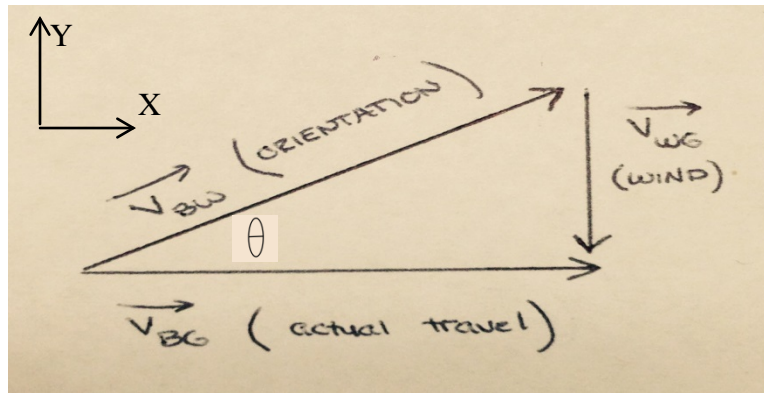
In order to determine the angle from which the bullet should be shot with respect to the vertical it is a bit more complicated due to the wind effects on the bullet. It is necessary to use Relative Motion in Two Dimensions, found in Chapter 4. To calculate this angle, it is necessary to build the equation:

Velocity of Bullet to Ground = Velocity of Bullet Relative to Wind + Velocity of Wind Relative to Ground.

$$\text{In short-hand: } \vec{V}_{BG} = \vec{V}_{BW} + \vec{V}_{WG}$$

*(BG = Bullet to Ground, BW = Bullet to Wind, and WG = Wind to Ground)

To visually depict the problem:



By calculating the “Y” components through the figure, the following numbers are plugged into the equation above:

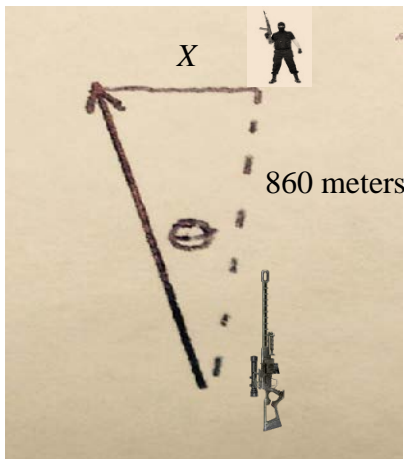
$$0 = 540\sin\theta - \left(\frac{8.94\text{m}}{s}\right)\cos 90^\circ$$

Therefore,

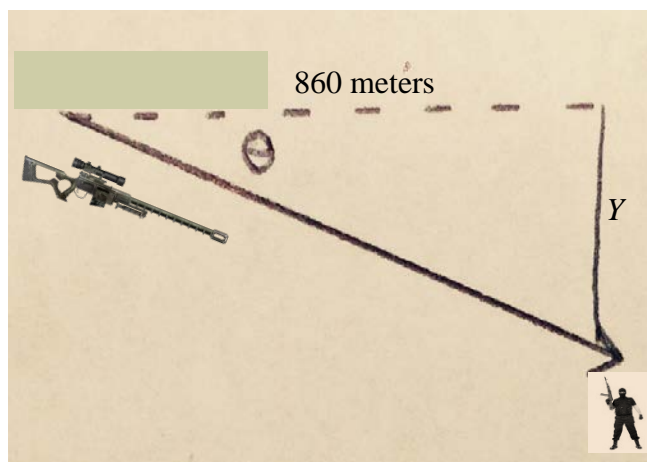
$$\theta = 0.95^\circ$$

Now, let’s compare Corporal Hughes’ shot compared to our calculated shot angles:

Hughes’ shot was aimed 17 meters left of the target, and by calculating $\tan(.95^\circ) = \frac{x}{860\text{m}}$, we get that “X” is 14.26 meters according to our angle of .95°. This is relatively close to Hughes’ shot of 17 meters.



Now to analyze the vertical angle. Hughes' shot was aimed 11.58 meters above the target, and by calculating $\tan(-2.59) = \frac{Y}{860\text{m}}$, we get that "Y" is 38.9m. Subtract 38.9m (found) and 1.77m (human height) from the total height of 53m and get 12.33m. This is fairly close to Hughes' shot of 11.58m above the target.



The Takeaway

Incredible, isn't it? A human was able to accurately make the assumptions of multiple variables in physics and apply his estimates within split seconds in order to take out a dangerous target to his men. By going through these calculations it is easy to see how in-depth a problem of this type can become, and it is a tribute to Corporal Hughes and a testament to the intuitive human brain.

By utilizing the tools and methods we have learned thus far in Physics I of Relative Motion, Projectile Motion, and Movement along a Straight Line, it was possible to analyze this real-life example and gain insight into the task of calculating a Sniper's ability to take out targets. As one has noticed through these calculations, there was some error in my calculations compared to the actual shot. The angle I calculated for the horizontal is a bit off from the actual shot due to the absence of drag calculation. There is drag caused by the air as well as my assumption of constant velocity. In the vertical calculations, there was not much of a difference, giving error for the aim on the body, about .5 of a meter.

Another amazing feat of this shot is the fact that most snipers work in teams, one spotter and one shooter. The spotter normally does mental calculations and tells the sniper when, where, and how to aim and fire. Corporal Hughes did both jobs as a single-team sniper, and still completed the mission. This was one amazing shot from an amazing sniper.

References

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