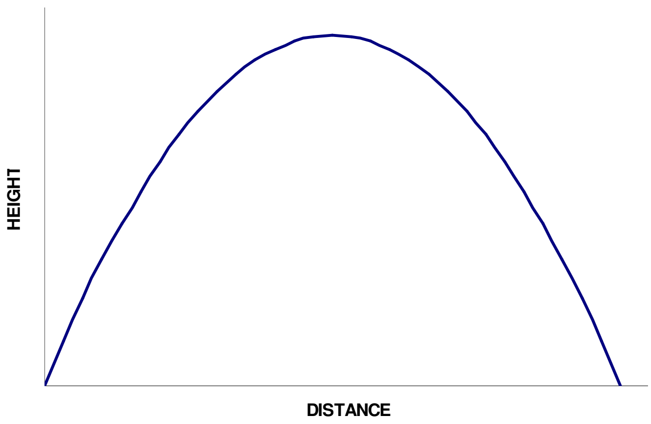
- THE SCIENCE OF SHOOTING (PART 1) -

THE PATH OF A BULLET

Whether you're talking about golf balls, military mortars, sniper bullets or shotgun pellets, it is usually possible to calculate the path a projectile will take.

Projectiles, in *theory* anyway, always follow an arc. This arc, as every overly-enthusiastic secondary school mathematics teacher will happily tell you all about, is more commonly known as a parabola and typically looks like this:

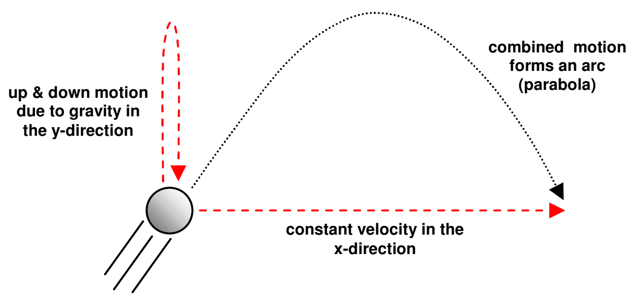


If you get your garden hose and point it at, say, 45 degrees to the horizontal, the path of the stream of water is a parabola too. Indeed, every single thing that flies through the atmosphere unpowered follows this rule (powered objects such as planes, rockets and the likes do NOT follow parabolic paths).

The reason all projectiles follow parabolas is because the only force (ignoring aerodynamics) acting on a projectile, once it has left its launching phase (ie. being shot, slung, or thrown), is gravity.

Now because gravity only works in the down direction (ie. it pulls you towards the earth), there's nothing interfering with the projectile as it flies forwards. This means that, as a projectile flies through the air, its speed (or velocity) in the forwards direction is **constant**.

However, the up & down directions (otherwise known as the y-axis) are not so easy to grapple with. The principle of movement in the y-axis can be explained as being exactly the same as throwing a ball directly upwards in the air; it leaves you hand traveling at its maximum speed, slows down as it gets higher and eventually comes to a stop somewhere above you. At this point, it begins to speed up again, but this time in the downwards direction. By the time it gets back to your hand, it should be traveling **at the same speed** as when it left your hand in the first place.



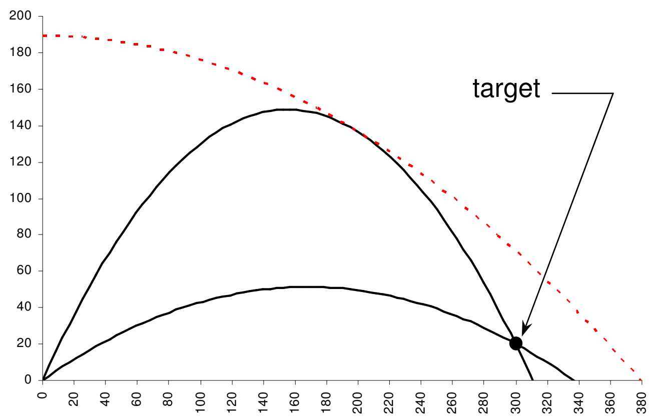
We can also work out how long it will take for our projectile to hit the ground. Say you get a stone and drop it from shoulder height (1.5m). It will take about 0.4sec to fall to the ground. Projectiles behave no differently in the y-direction. Now get your gun, shoulder it and shoot along a dead-flat path (ie. perfectly horizontally). It too will take 0.4sec for the projectile to hit the ground. This means that, if you're to shoot a target which is a long distance away, you actually need to aim above the target in order to give the projectile enough time to fall far enough down.

Herein lies a small complication as well; because projectiles follow parabolic paths, there are ALWAYS two paths which your projectile may follow if it is to hit its target, as the following example explains:

Say a solider fires a mortar at 200 fps and he wants to hit a target which is elevated 20m in the air and 300m away (unlikely, but this *is* theory).

To hit his target, he simply has to aim the mortar at an angle 31.4 degrees above the horizontal. However, he could also aim at 62.4 degrees above the horizontal and achieve the same thing!

Yes, it would take a lot longer for the 62.4 degree shot to hit its target which would mean it is more likely to be blown off course by gusting wind, however if the soldier had to fire over a tall obstacle then this would be his strategy.



The dotted line on the graph shows the maximum range of the projectile. It is impossible, no matter what angle the mortar is fired at, to hit any target which sits beyond this line. Mathematically this line depicts the path which would be followed if the soldier fired the mortar directly up in the air, then he (or she) climbed a ladder to the maximum height the previous mortar reached (in this case about 190m) and fired another mortar perfectly horizontally.

You'll note that the dotted line hits the ground at about 380m away. This is the maximum horizontal range of the projectile and corresponds to a firing angle of 45 degrees – the optimum firing angle for all ideal projectiles (ie. projectile is not subject to aerodynamic drag).

If you go to the military museum up in Darwin, they've got an old mechanical calculator which did all of this maths for them so that the gunners knew exactly which angle to fire their shells at to hit incoming ships. However, I suspect their calculator does take wind drag into account.

So there you go. You now know all about ballistics (being the science of projectiles) and thus, how to shoot better. No excuses now.

And just when you think you know what's going on, aerodynamics turns up and ruins everything...