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Teacher Overview

Bullet Trajectory Analysis

Background

This resource is designed to be a quick overview on using trigonometry to determine the trajectory of a bullet. We have included some information on how ballistics experts would use these calculations in an investigation as well as highlighting some ways you can turn your lesson into an interactive crime scene.

Finding the Impact Angle

The starting point for bullet trajectory analysis is looking at the bullet hole. In almost every case, a bullet hole will be elliptical in shape. The only way a bullet hole can be perfectly round is if the gun was shot exactly perpendicular to the target. In general, a shot will be taken at even the slightest angle leading to an elliptical hole. This angle is called the impact angle. Determining what the impact angle is the first process in bullet trajectory analysis.

The angle at which a bullet enters a target will determine the shape of the hole. We call this the impact angle. Only, an impact angle of 90° will leave a perfectly round bullet hole.

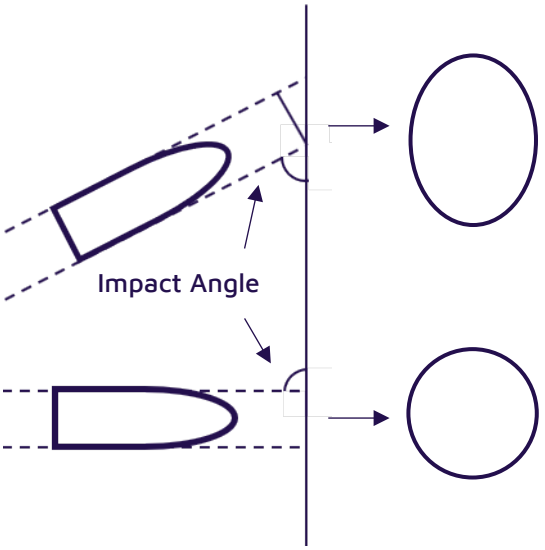

Fig 1. How different shaped bullet holes are made.

To find the impact angle, we first need to find the major and minor axis of the ellipsis. The picture to the right represents a bullet hole in a wall. The major axis of is the vertical line and the minor axis is the horizontal line.

With these values, we can use trigonometry to determine the impact angle.

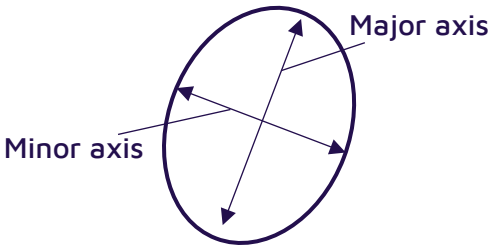

Fig 2. The major and minor axis of a bullet hole.

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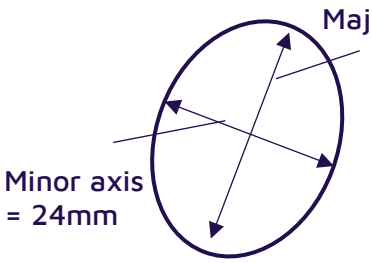
Using SOH- CAH – TOA, we can determine the impact angle.
Sin = opposite/ hypotenuse
Cos = adjacent / hypotenuse
Tan = opposite/ adjacent



sin(x) = (minor axis/major axis)

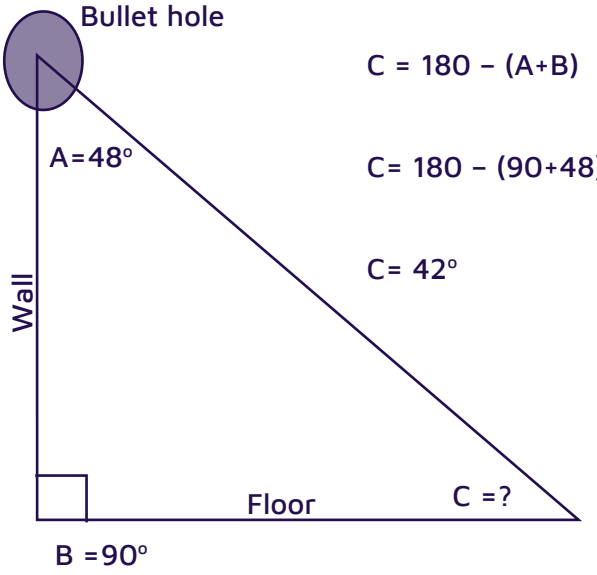
sin(x) = (24/32)

$x = \sin^{-1}(24/32)$

x = 48°

Locating the Shooter

We can even use a single bullet hole at a crime scene to reconstruct the events that took place. To do this we will use the properties of triangles. We know that the angles inside a triangle add up to 180 degrees. We also know, that we will have a right angle at our crime scene, this is the angle between the wall and the floor. Therefore, if we know one other angle (the impact angle) we can determine the third angle.



C = 180 – (A+B)

C= 180 – (90+48)

C= 42°

The angle labelled C, is our angle of elevation or depression, or the angle the shooter's arm was raised or lowered when the shot was taken. If the bullet hole is angled down, the bullet's path was upwards and vice versa.

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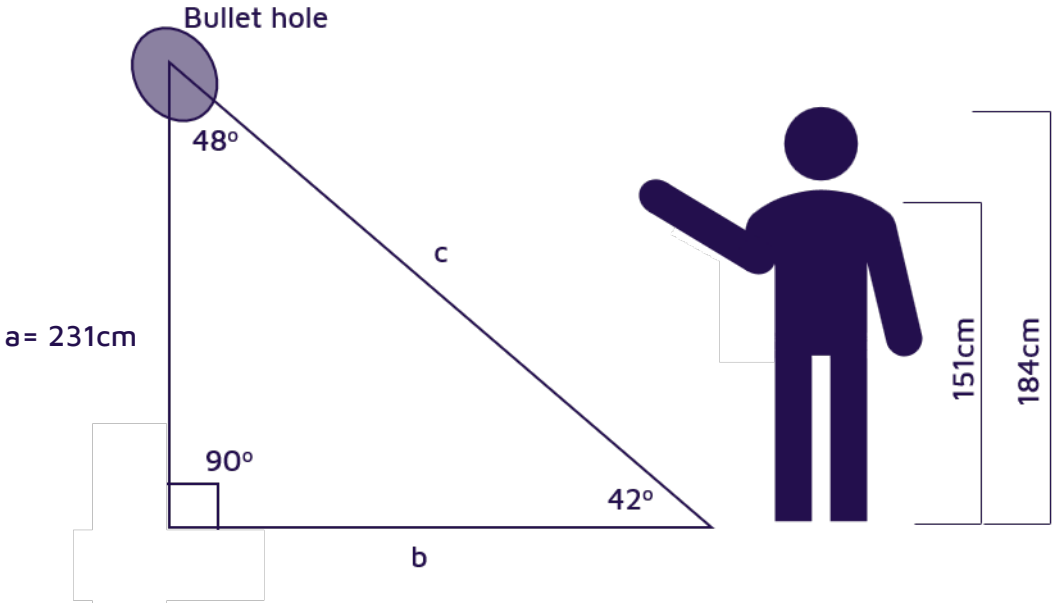
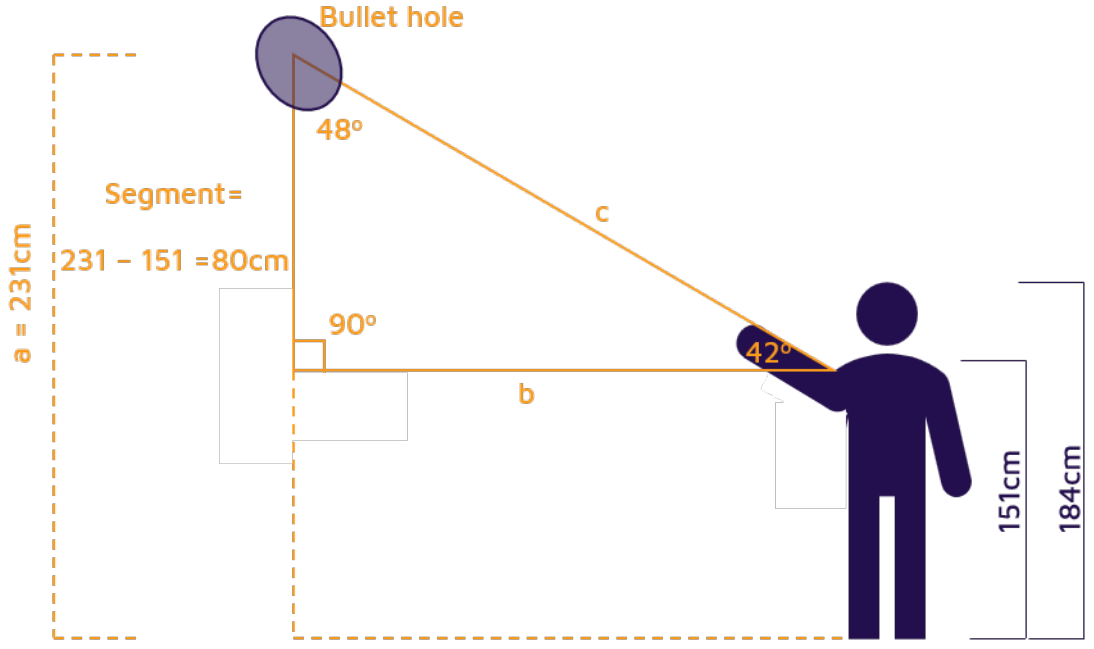
From here, we can use the distance of the bullet from the floor, the height of our suspects or the distance of the shooter from the target to fill in the blanks of our investigation. Using the geography and layout of the crime scene this can give crime scene officers enough evidence to eliminate or keep investigating the suspects. See the examples below.

The bullet hole in our previous example was found in the wall at a height of 231cm. The suspect is 184cm tall, with a shoulder height of 151cm. To find the distance of the shooter from the wall (b), we need to use the tangent function.



First, we need to determine the length of the segment 'a' which is relevant.



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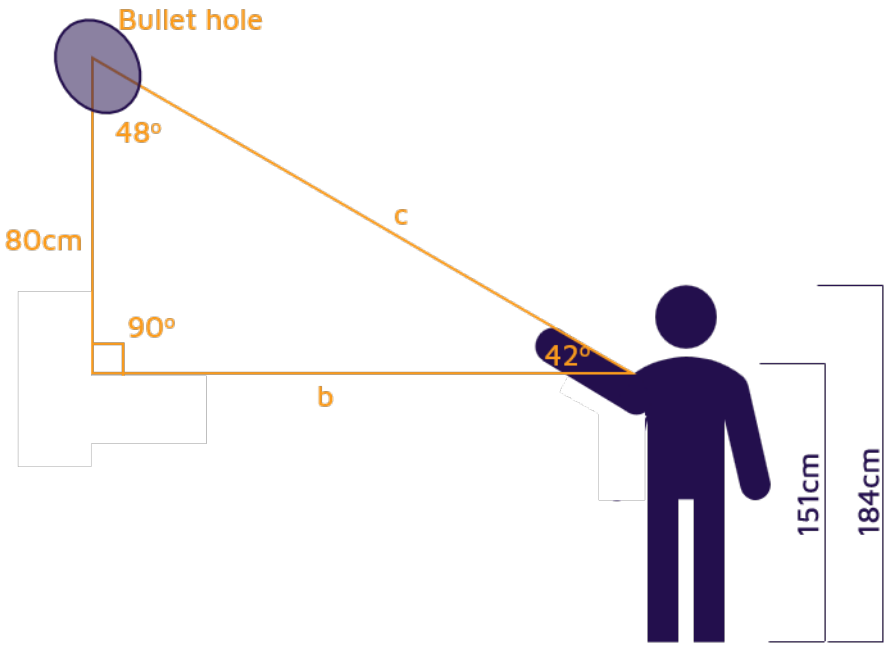
Then, we can use the tangent function to solve for b.



tan(42) = 80/b

b = 80/tan42

b = 88.85cm

In this example, the suspect would have been standing 88.85cm away from the wall. Investigators would use other evidence at the crime scene to determine if this is possible and thus decide whether to keep investigating the suspect.

Turning your classroom into a crime scene

If you want to introduce to your students to a practical example of how a ballistics expert would gather evidence at a crime scene you can place 'bullet holes' around your classroom for your students to measure. This can be done with stickers on the wall or drawings on your whiteboard. You might even want to cut some holes out of a foam core board, for a 3D effect.

To help the students visualise the bullet trajectory you can use string or a laser pointer. The laser pointer is particularly effective when using the foam core bullet holes.

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