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The Use of Trigonometry in Blood Spatter

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Abstract:

A common phrase to be heard in a class room setting is “When am I ever going to use trig?” Many do not value or appreciate the importance of trigonometry. However, Trigonometry holds a special place in the hearts of the blood spatter analyst. The blood spatter analyst work very hard using the known identities and trigonometric functions to find the angle of impact, that is, at what angle was the person struck, and at what angle the blood fell. Trigonometry is also used in determining the height of a person, using the angle of impact.

Blood Spatter:

When we speak of blood spatter, we mean the way that the blood is being distributed, the shape of the droplets when it hits the surface, and the angle of impact (Freeman, S 2014). There are many types of blood spatter. Because blood doesn’t always just drip out of the wound we don’t always have perfect droplets of blood. Instead we get what looks like smears, a droplet followed by an elongation (tear drop shaped) and or many tiny little droplets distributed about the surface they landed on.

The blood stain which is left is always bigger than the actual droplet; this is because the volume of blood is dispersed on the surface. When constructing a right triangle to determine at which angle the droplet fell, we must be certain that the angle outside the right triangle is equal to the right triangle on the inside. This way we can measure the bloodstain as seen in figure 1(Yonder, 2011).According to Yonder, Anita, when a blood drop appears to be tear drop shaped, it is several cross sections of the sphere (droplet). Something to keep in mind when determining what type of spatter you are dealing with is that chords diameter is completely dependent on the velocity of the drop (Yonder, 2011).

When a blood drop falls it will accelerate according to the gravitational force. It will then continue to fall until reaching equilibrium with gravity, and then come to a uniform velocity (Yonder, 2011); this is known as the Theory of Terminal Velocity. This theory was applied to blood spatter in order to gain some sort of reference sample of a constant velocity and known angles (Yonder, 2011). However, the problem in using this theory is that it depends on the mass of the blood drop. Blood is not uniform because people have different proportions of blood composition. Due to these different proportions variance is expected within the individual because of the different ratios within the many different organs.

Low Velocity Spatter

Low velocity spatter is one we are familiar with; it is anywhere from 1.5m/s or less. This spatter is formed after we have “received” our wound. For example, if I was to get cut in the arm and blood began to drip from the wound, I would then walk towards my first aid kit. The blood which hit the ground would have simply been dripping from my arm; there was no force applied to cause it to do anything else other than drip (see figure2). The drops which landed on the ground would be droplets. When the drop is traveling slowly the diameter of the chord will be wider as seen in figure 3(Yonder, 2011).What is interesting about blood is that it will increase in size the greater the distance is at which it falls, but will remain constant after 4ft. (Yonder, 2011).When dealing with low velocity spatter, we are able to apply the theory of terminal velocity. Why? We are able to do this because terminal velocity does not deal with force; as you would have to take into account when dealing with fast velocity blood spatter. This type of blood spatter gives an almost perfect sphere, but there are a few tails called spines surrounding the bloodstain left behind. These stains are about 3mm or larger diameter (Forident, 2008).

Medium Velocity Spatter

Medium velocity spatters are produced with more energy and force than low velocity spatter. This is because medium velocity deals with force, whereas low velocity is dependent on gravitational force. Medium velocity spatter is given by blunt force and stabbings. When droplets are dispersed they break off into smaller droplets of blood (see figure 4). When dealing with a stabbing, the bloodstain pattern will be relatively linear (see figure 5). This is because the surface area of the object is small and less blood being deposited from the wound(National Forensic Science Technology, 2013).However, when dealing with blunt force, the blood spatter left will be varied in size because the surface area is larger(National Forensic Science Technology, 2013).

High Velocity Spatter

High velocity spatter deals with gunshots, high speed collision, and explosions (Crime scene Forensics.com)**.** The bloodstain pattern given off by high velocity spatter looks like a mist (see figure 6), because of the high velocity. Let us note that when we say velocity we mean the measure of force that has been applied to the blood (Crime scene Forensics.com). With some high velocity spatter some of the spatter may travel backward toward the gun, known as *Back Spatter.* However, if the spatter moved in the direction that the bullet was traveling this would be known as *Forward Spatter* (Crime scene Forensics.com). When the gun is closer to its target the spatter will be greater in dispersion, the same applies to the bullet, the larger it is the more dispersion there is (Crime scene Forensics.com). The spatter tends to be 2mm to 4mm in diameter, and the force which causes this type of spatter is 25ft/s(Crime scene Forensics.com).The spatter which is associated with high velocity is 2mm in diameter or less, and the force that produces this spatter is 100ft/s!

Angle of impact:

The angle of impact tells us the angle at which the blood hit the surface. For instance, if my arm were bleeding and I held it straight out the angle would be 90 degrees. To calculate the angle of impact we take the width measurement and the length measurement of the blood stain, keeping in mind not to measure the tail, (see figure 7). We do not measure the tail because it is caused by gravitational force and the force of the weapon. We should expect to see a larger tail the smaller the angle of impact, see figure 8. To calculate, do the following:

Ex 1: Let us say that the width is 9mm and the length is 18mm. (Riley, 2013).

STEP 1: $\sin^{-1}$(9mm/18mm) = 30̊

The angle of impact was 30̊ .

Ex. 2: Let us say the width is 1.5 cm and the length of the blood stain is 3.0cm (Crime scene Forensics.com)

STEP 1: $\sin^{-1}$(1.5cm/3.0cm) = 30̊

The angle of impact was 30̊ .

Ex.3: Let us say the width is 3.0 cm and the length of the blood stain is 6.0cm

STEP 1: $\sin^{-1}$(3.0cm/6.0cm) = 30̊

The angle of impact was 30̊ .

Ex 4: let us say that the width is 1.73cm and the length is 2cm

STEP 1: $\sin^{-1}$(1.73cm/2cm) ≈ 59.99̊ (close to a 60̊ angle)

The angle of impact was approximately 59.99̊

When calculating the angle of impact it is important to keep in mind that ($\sin^{-1}$) does not mean (1/sin). Instead, it means the inverse sin function. When dividing we make sure to divide the smaller number by the larger number to get a number less than one.

Area of convergence:

The area of convergence tells us where the spatter may have originated. To do this strings are taken and are attached to each blood stain down its axis (see figure 9), this will show us where they converge (see figure 10) (How Stuff works 2008). After stringing we are able to see if the spatter is moving in an upward direction or a downward direction. Sometimes looking at the tail isn't enough because the gravitational force will simply pull it down anyway. When dealing with blunt force blood spatter, it is important to look up to the ceiling, as the blood spatter there is likely from the blood that was on the object and was put there due to the swinging of the object. It is important to look at directionality, because this will show you which spatter is due to swinging the object backward and which is due to forward motion. If we know where the perpetrator was, we can get a much clearer understanding on whether the person is right handed or left handed.

There are times when the assailant will attempt to make a killing appear as a suicide. Area of convergence plays a very big role in this. It shows if there are any discrepancies. The beautiful thing about math is that it doesn't lie. If the area of convergence doesn't match where the body should be, this is a good time to start thinking that foul play may be involved. There are several times in which there is no blood spatter but a gun was used for the "suicide". Because a gun is high velocity it is likely that the spatter is small. However, for there to be absence of spatter is just not likely.

Determining height:

It is important to determine the height at which the blood fell, because it tells us the height that the blood drop originated from. It is possible that the victim and the assailant both leave spatter evidence. Due to this, it is important to take notes of the heights and find where any inconsistency may lay. Knowing the height of the victim we may deduce that a certain blood stain originated from the perpetrator or the victim. Let us say that we find a blood stain 10ft. away from the source and we have determined that the angle of impact is 70̊. To determine the height we construct the following, see figure 11. Now we calculate:

STEP 1: $\tan 70^\circ = X/10$

STEP 2: $10(\tan 70^\circ) = 27.5$ft.

The height at which the blood fell was 27.5 ft.

Ex 2: Let's say that the blood stain was 15ft. away and the angle of impact was 80̊ see figure 12.

STEP 1: $\tan 80^\circ = X/15$

STEP 2: $15(\tan 80^\circ) = 85.1$ft.

The height at which the blood fell was 85.1ft.

Ex 3: Let's say that the blood stain was 10ft. away and the angle of impact was 75̊

STEP 1: $\tan 75^\circ = X/10$

STEP 2: $10(\tan 75^\circ) = 37.3$ft.

The height at which the blood fell was 37.3ft.

Conclusion:

As you have seen, Trigonometry has a large and important role in bloodstain analysis. Without it we would not be able to find the height, angle of impact or area of convergence. Unfortunately, there are murders, and unfortunately for the murderers trying to flee there is trigonometry. Where there is blood stain, there is trigonometry and “absence of evidence is not evidence of absence.”

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Figure 1:

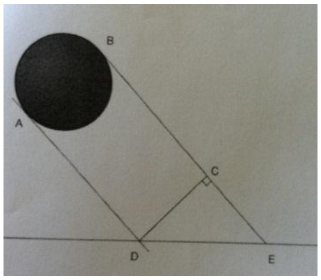
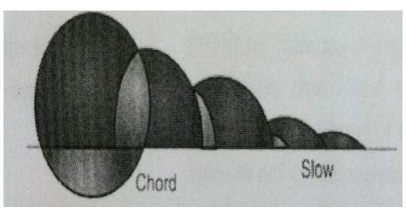


Figure 2:

Figure 3:



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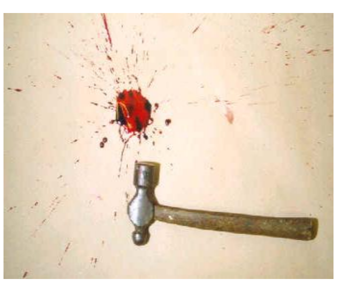

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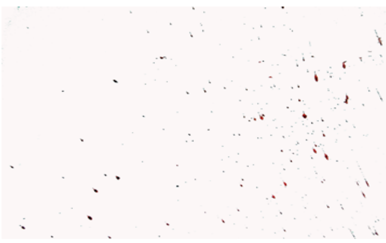
Figure 5:

Figure 6:



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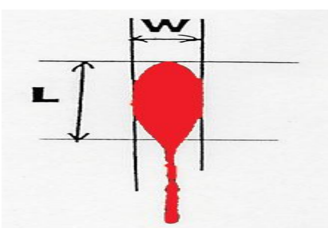

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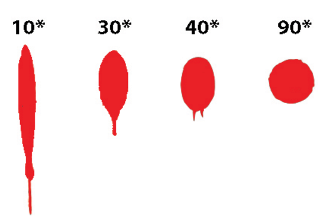

Figure 9:

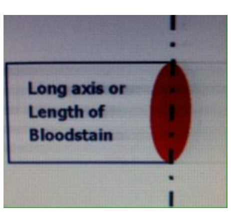

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Figure 10:

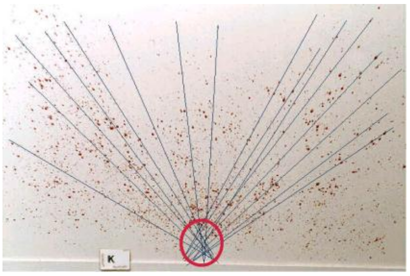


Figure 11:

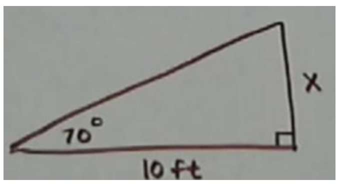
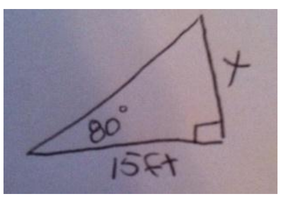


Figure 12:



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Work Cited

- Yonder, Anita. “Trigonometry in Bloodstain pattern evidence, math use in question” Elsevier, 2011. http://www.sciencedirect.com/science/article/pii/B9780123704825500586
- http://www.crimescene-forensics.com/Spatter_VS_Transfer.html
- Freeman, Shanna. "How Bloodstain Pattern Analysis Works" 24 April 2008. HowStuffWorks.com. <http://science.howstuffworks.com/bloodstain-pattern-analysis.htm>28 April 2014.
- Wonder, A.Y. “Blood Dynamics” Forident, 2008. http://hemospat.com/terminology/index.php?cat=projected&sub=LVIS
- National Forensic Science Technology Center “A simplified guide to bloodstain pattern analysis” 2013 http://www.crime-scene-investigator.net/SimplifiedGuideBloodstainPatterns.pdf
- Riley, Pat, “Blood Drop Analysis” 2013 http://www.youtube.com/watch?v=DKW5agx-Cqw