# Bloodstain Pattern Analysis
## ONEXYS Read-ahead

### Introduction

Bloodstain Pattern Analysis is a technique employed by forensic scientists in order to determine the type of weapon and location of attack at a crime scene. This scientific method has been popularized and simplified on television shows like *Numb3rs* and *Dexter* which leave the audience believing it is a straightforward process that can determine a multitude of details about the crime. In reality bloodstain pattern analysis is rarely conclusive, but is still used to get an idea about the speed, height, and direction of the blood spatter.

Figure 1: The TV show Dexter uses stringing.

In this application, we will examine how one aspect of bloodstain pattern analysis works. We will do real analysis of blood spatter that could be presented at a crime scene and investigate the role of trigonometry in determining the height and location of a wound.

### Instructions

After reading through *Bloodstain Pattern Analysis* context and questions below, you should complete the reflection assignment in Canvas. Note: *you will have a chance to talk further with your coach before answering the questions below in detail*. The point of this read-ahead and the reflection is to "prime the pump" for further conversations with your coaches.

### Bloodstain Pattern Analysis

The diagram below left shows the relationship between the height from which the blood droplet falls

and the diameter of the bloodstain, while the diagram below right shows the relationship between the impact angle of the blood droplets and the shape of the bloodstain.

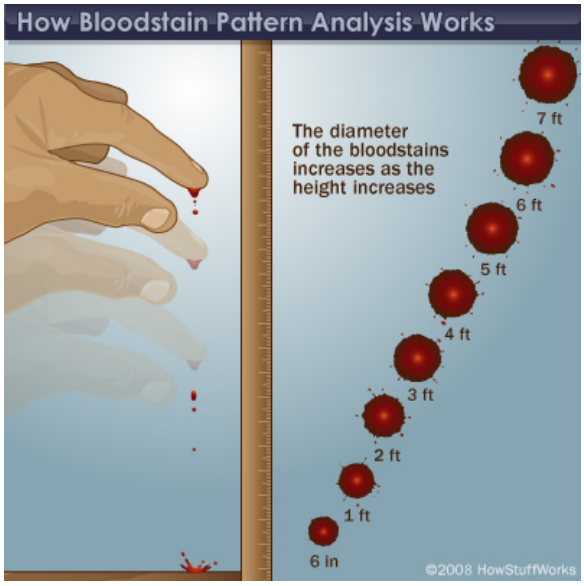



Figure 2: Bloodstain diameter vs. height

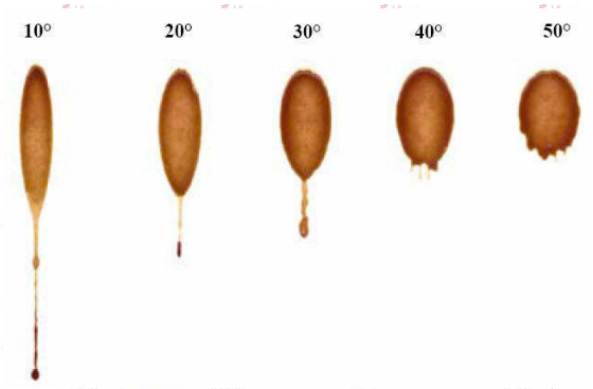
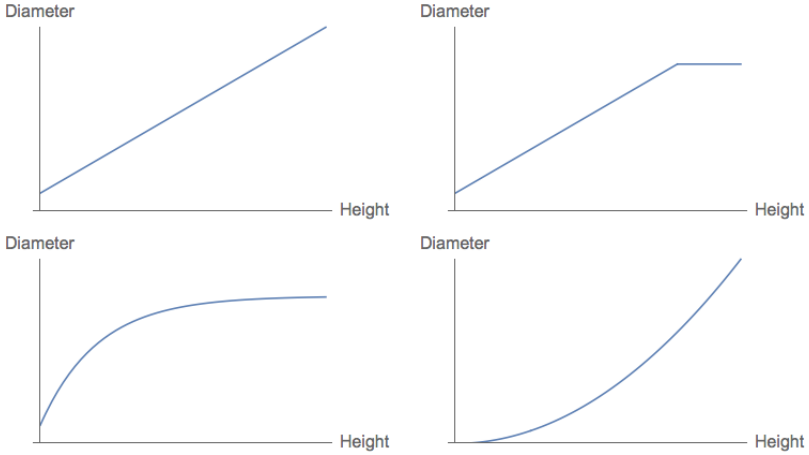



Figure 3: Bloodstain shape vs. impact angle

## Questions

1. (Graded for completeness only.) Consider a single drop of blood falling from a height onto a flat surface. Looking at Figure 2, it is clear that the bloodstain diameter is an increasing function of height. Which of the following graphs best matches the data given in the diagram? Explain.




2. The diameter of the bloodstain is roughly proportional to the kinetic energy of the droplet at impact. The kinetic energy (KE) of an object is given by $\text{KE} = \frac{1}{2}mv^2$, where $m$ is the mass and $v$ the speed. Neglecting air resistance, the velocity of a falling object $t$ seconds after being released is $v = 32t$ feet per second, and the distance traveled is $d = 16t^2$ feet. Use these relationships to express the kinetic energy of a droplet at impact as a function of its mass $m$ and the height $h$ it has fallen from.
3. (Graded for completeness only.) Are your answers to Questions 1 and 2 consistent? If not, explain

the inconsistencies.

Figure 3 above indicates that bloodstains with smaller impact angles are more elongated. (Not shown is the bloodstain corresponding to 90 degrees, which would be a perfect circle.) The impact angle is defined as the angle between the path of the droplet and the surface. It is labeled $\alpha$ in Figure 4 below.

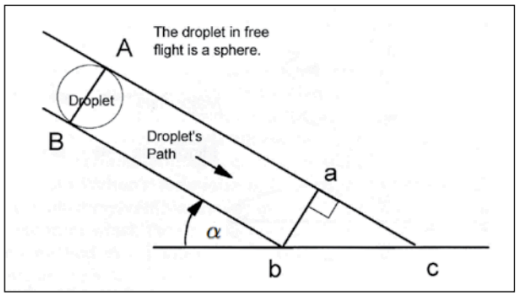



Figure 4: Definition of impact angle

4. Looking at Figure 4, express the sine of the impact angle $\alpha$ in terms of the width $x$ and the length $y$ of the ellipse that corresponds to the bloodstain. Hint: Assume the droplet is spherical and thus has a uniform diameter.[1] In Figure 4, $y$ is the distance between points $b$ and $c$.
5. Find the impact angle $\alpha$ for each of the following bloodstains, whose length and width are given in centimeters.

| length | width | impact angle |
|---|---|---|
| 3 | 1 | |
| 4.5 | 3 | |
| 7 | 3.5 | |

6. Assuming the spherical droplets of blood have a fixed diameter, draw a graph of the impact angle $\alpha$ as a function of the length $y$ of the stain. Hint: What would a graph of $y$ as a function of $\alpha$ look like?

[1] This is actually a reasonable assumption, given the surface tension of blood.

7. In Figure 5 below, the path of the blood droplet is projected onto the wall and the floor.

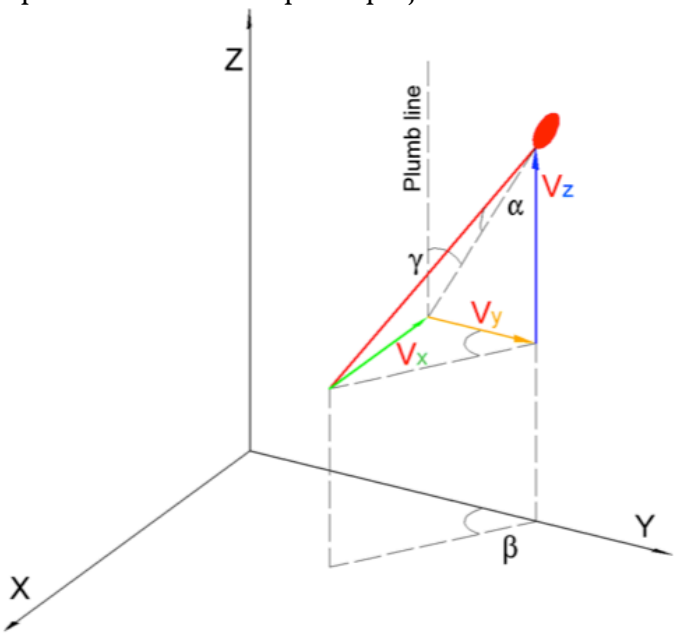



Figure 5: Location of Wound Analysis

The impact angle $\alpha$ is shown, along with the angle $\beta$ that the projection of the path onto the floor makes with the wall, and the angle $\gamma$ that the projection of the path onto the wall makes with the vertical. These three angles are all important in reconstructing the path of the blood droplet. We have seen how $\alpha$ can be computed from the degree of elongation of the bloodstain, and, as long as $\alpha$ less than 90°, $\gamma$ can be measured directly from the semi-major axis of bloodstain. Find a relationship between $\alpha, \beta$, and $\gamma$.

8. Suppose the angle $\gamma$ is 30° for all three bloodstains in Question 5. Find the angle $\beta$ in each case.

**Instructions, part deux**

After reading and reflecting on these questions, complete the pre-read assignment on Canvas. This will give your coach some insight on your thinking in order to best help you before you are required to formally answer these questions.