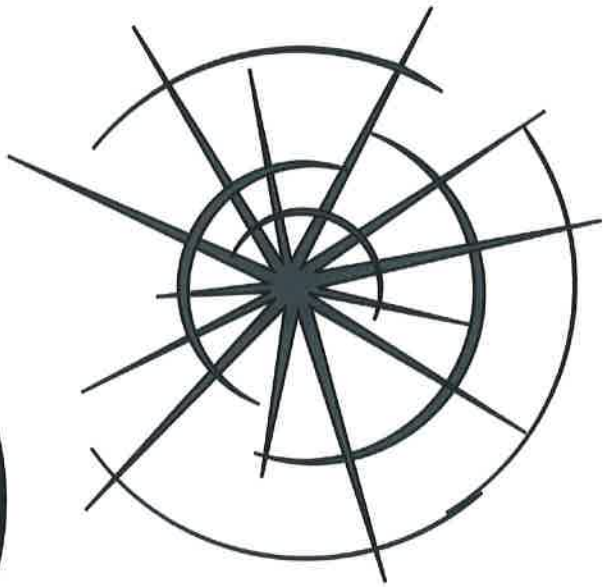
Bullet Trajectory



21st Century 21 Math Projects

BULLET TRAJECTORY

Rubric

Standards		Exemplary	Proficient	Developing
HSG-MG.A.1	use geometric shapes and their measures to describe objects			
HSG-SRT.D.8	use trigonometric ratios			
	use trigonometry to solve right triangles in applied problems.			
Math Processes		**Exemplary**	**Proficient**	**Developing**
Skills & Mechanics	*accurately performs calculations*			
	demonstrates fluency with mathematical skills and processes			
Applications	*accurately interprets word problems and addresses them with appropriate math skills*			
	can articulate the meaning of calculations in the context of the problems.			
Use of Evidence & Analysis	*can determine what evidence is appropriate to answer a question*			
	utilizes mathematical outcomes to support their conclusions			

Comments:

BULLET TRAJECTORY

Ideal Unit: Trigonometry	**Time Range:** 2-3 Days	**Supplies:** Rulers, String/Fishing Line, Crime Scene Tape (Optional) Pencil & Paper

Topics of Focus:

- Trigonometry
- Sine, Cosine & Tangent Application

Driving Question *"How do investigators use trigonometry when analyzing a crime scene?"*

Culminating Experience A crime scene analysis

Common Core Alignment:

G-MG.1	Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).★
G-SRT.8	Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.

Procedures:

A.) In "Blood Spatter Analysis", students are guided through developing a strategy using trigonometry to calculate the angle of impact of a blood spatter. They are asked follow up questions about the height of the killer; however, the killer could be crouching, on a piece of furniture, etc., which could affect the investigation.

B.) In "Area of Convergence", students will be guided through the area of convergence. However this activity doesn't lend itself so well to paper, so I've provided tables with data. Ideally, you'll be recreating crime scenes so they can get the full effect! ☺

C.) In "Crime Scene Investigation", you will create crime scenes for students to calculate and interpret. You can be as creative with this as you'd like. Blood spatters are provided, but you may prefer to make your own. I've made them a little larger than real life just to make measuring a little easier. When you set up crime scenes, you will want to make sure that the area of convergence is solvable (see diagram in the second assignment). I recommend staying in a 2-D space and making sure that the area is there. In the resource students are asked to sketch the crime scene and calculate it and interpret it. I've included an extra sheet that you can duplicate for as many crime scenes as you would like them to solve!

* Aspects of the project can be completed independently. The entire project does not need to be completed to have a great learning experience, though it is suggested because it will best scaffold the skills and context.

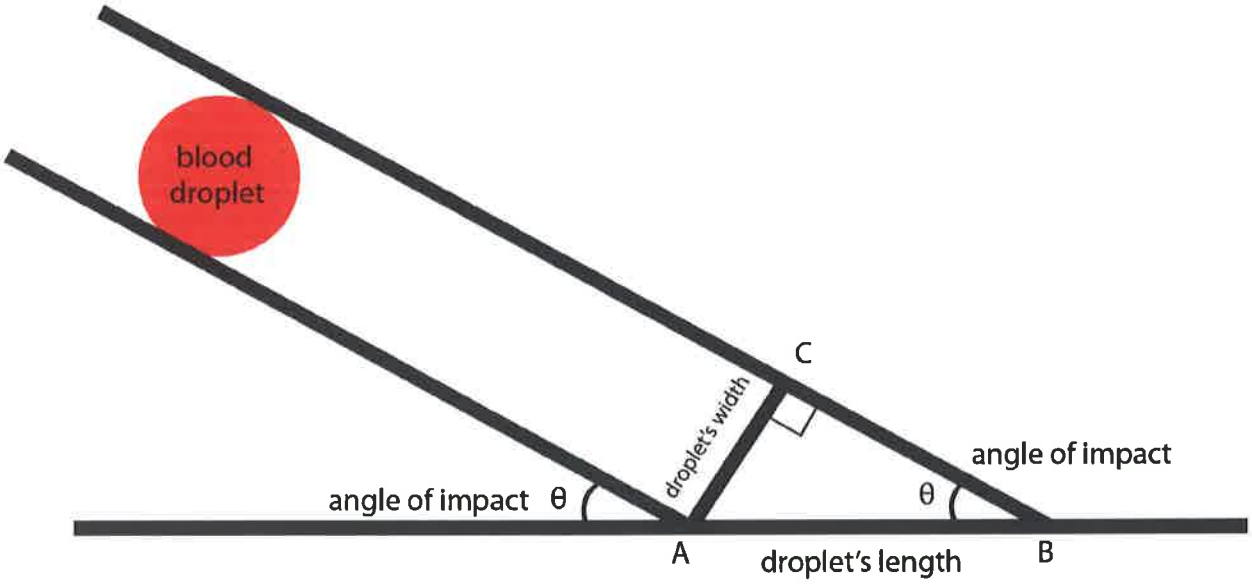
Blood Spatter Analysis

Name _____ Date _____

An unfortunate reality in our world is that homicides happen. In order to bring justice for the victims, crime scenes have to be carefully dissected to bring about evidence to find and convict a criminal. One way this happens is through a careful analysis of the blood spatter. The shape of a blood spatter tells a great deal about the angle in which it hit the ground. This can enlighten investigators when they are trying to determine the height or distance that the crime took place.

1. Consider these two blood spatters. Which one these do you believe would have hit the ground at a 90° angle (meaning it drops straight down)? And which do you believe hit the ground at an angle of around 10°?

2. While it's not always the case, would you suspect a shooter that is shorter than the point of impact to have a smaller angle (more elliptical drop) or a larger angle (more circular drop)? Explain your reasoning.



The diagram above shows a hypothetical blood droplet and how forensic scientists piece together evidence using trigonometry.

3. In the preliminary stages, investigators want to uncover the angle of impact. They can do this with the droplet's width and length. Write a trigonometric equation that can be used to calculate this angle.

Time to Apply

Evaluate the blood spatter from different crime scenes below. Use a ruler to find the measurements of the length and width and use them to calculate the angle of impact. The width is measured at the widest point and the length is the longest point.

Spatter 1

Spatter 2

Spatter 3

Spatter 4

Based on this evidence...

1. Which spatters indicate a bullet was most likely "going up" when it impacted the victim?

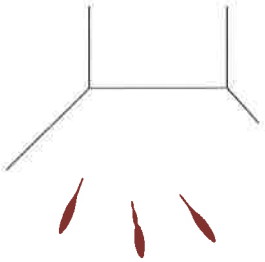
2. Which spatters indicate a bullet was most likely "going down" when it impacted the victim?

3. Suppose two of these blood spatters are from the same crime scene. Which two are most likely to have been in the same crime? Explain your reasoning.

Area of Convergence

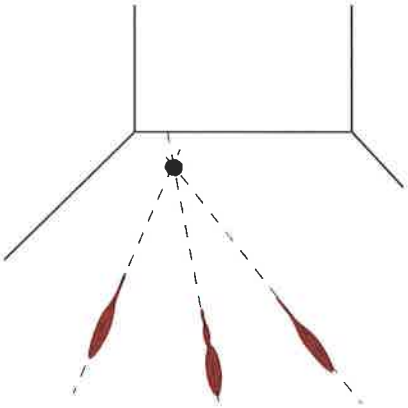
Name _____ Date _____

While the angle of impact is valuable, the area of convergence is often the more significant piece of evidence. Through seemingly simple forensics and trigonometry, investigators can estimate the height of the impact and the distance from the target.

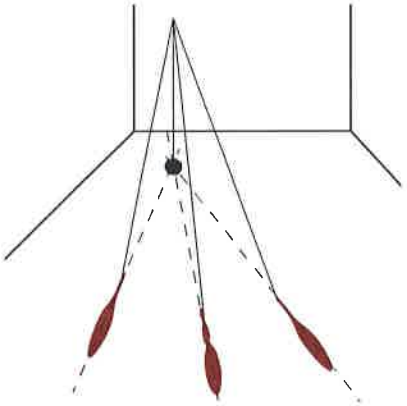


Suppose you walk into a crime scene with these blood spatters:

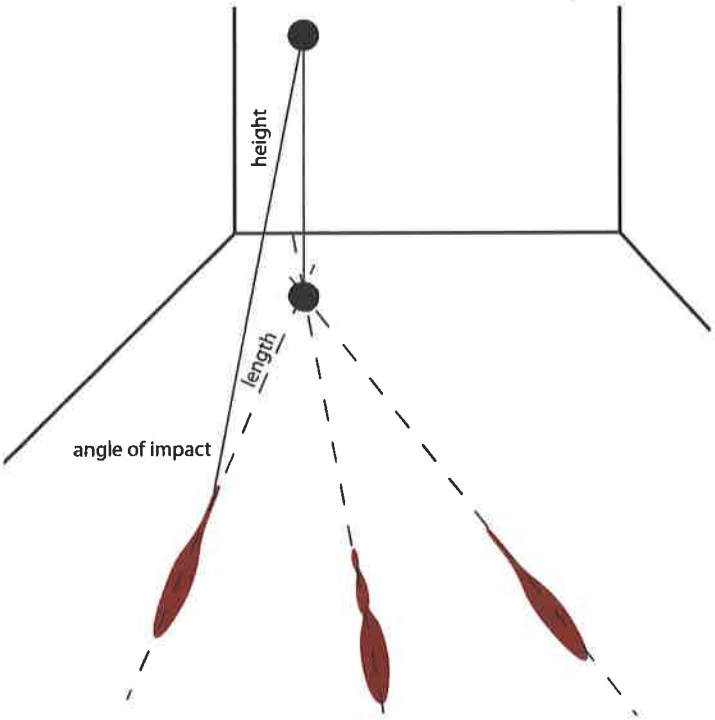
1. Investigators use fishing line or string to extend each of the blood spatters until they all meet at the *area of convergence.*



2. Given the angle of impact and this central point, investigators can recreate height with right triangles.



3. Investigators then have all the essential elements to reconstruct the crime using trigonometry.



Use the area of convergence and the angles of impact to estimate the height of the incident. Be sure to convert between units as necessary.

1. An investigation is analyzing two blood splatters and the information detailed below.

Spatter	Width	Length	Angle of Impact	Distance from Area of Convergence	Height (in feet)
A	0.75 in	1.2 in		9.2 ft	
B	0.68 in	1.4 in		9.4 ft	

a. Use your calculations to estimate the height of the impact.

b. Would you expect the bullet would have been "going up" or "going down" when it struck the victim?

c. Interpret the crime scene. What do you believe happened?

d. Considering the height the victim was struck, whether the bullet was "going up" or "going down", and the variance in where the gun may have been held, provide a range of heights that estimate the height of the killer.

2. An investigation is using three blood splatters and the information is detailed below.

Spatter	Width	Length	Angle of Impact	Distance from Area of Convergence	Height (in feet)
A	0.46 in	0.52 in		2.1 ft	
B	0.53 in	0.60 in		2.4 ft	
C	0.49 in	0.57 in		2.25 ft	

a. Use your calculations to estimate the height of the impact.

b. Would you expect the bullet would have been "going up" or "going down" when it struck the victim?

c. Interpret the crime scene. What do you believe happened?

d. Considering the height the victim was struck, whether the bullet was "going up" or "going down", and the variance in where the gun may have been held, provide a range of heights that estimate the height of the killer.

Crime Scene Investigation

Name _____ Date _____

Now it is time to put your skills into practice. Crime scenes have been set up, and it is your time to analyze and interpret them. Label the crime scenes on the space below and record measurements from each of the scenes. Can you help investigators bring justice for the victim and their family?

Crime Scene: _____

Sketch

Spatter	Width	Length	Angle of Impact	Distance from Area of Convergence	Height (in feet)

Calculations

Interpretation

CRIME SCENE: _____

SKETCH

Spatter	Width	Length	Angle of Impact	Distance from Area of Convergence	Height (in feet)

CALCULATIONS

INTERPRETATION

Blood Spatters