

Engineering Mechanics Report

Forensic Science - Blood Pattern **analysis**

By

Aaryan Sharma (C1-1)

16010123012





SOMAIYA
VIDYAVIHAR

K J Somaiya College of Science & Commerce



Introduction -

Forensic engineering uses the concepts of mechanical, chemical, civil, and electrical engineering as tools in the reconstruction of crimes and accidents for the determination of their cause. A major component of that work involves traffic accident reconstruction. To determine what may have caused the accident, forensic engineers use evidence such as skid marks; damage to cars and their positions after the accident; road and environmental conditions; injuries to drivers, passengers, and pedestrians; and witness accounts.

Bloodstain pattern analysis (BPA) is a specialized field within forensic science that involves the examination and interpretation of the various patterns created by blood at crime scenes or accident sites. These patterns provide crucial evidence that can reveal important details about the nature of an incident, including the dynamics of bloodshed, the movements of individuals involved, and the sequence of events leading up to the event. As such, BPA serves as a valuable tool in criminal investigations, accident reconstructions, and legal proceedings.

Bloodstains can take on a wide range of forms, including spatters, drips, pools, and smears, each conveying different information about the event. By carefully analysing the size, shape, distribution, and characteristics of these bloodstains, forensic analysts can deduce key aspects such as the angle and velocity of blood droplets, the distance from which they were projected, and the types of forces involved in their creation. This analysis is informed by principles of physics, mechanics, biology, and mathematics, as well as empirical research and experimentation.

Bloodstain pattern analysis is a complex and multifaceted discipline that requires specialized training, expertise, and attention to detail. Forensic analysts must carefully document and photograph bloodstain patterns, conduct systematic examinations, and apply established methodologies and protocols to ensure accuracy and reliability in their analyses.

Additionally, they must consider various factors such as surface textures, environmental conditions, and potential alterations to the scene that may affect the interpretation of bloodstain patterns.

The goal of bloodstain pattern analysis is to reconstruct the events that occurred at the scene, providing investigators with valuable insights into what transpired. This may involve determining the location of the victim and perpetrator(s), the type of weapon or object used, the manner in which injuries were inflicted, and the movements of individuals within the environment. Such information can be critical in establishing timelines, corroborating witness testimonies, identifying suspects, and ultimately, achieving justice.

Literature Review –

Trained bloodstain pattern analysts can examine the blood evidence left behind and draw conclusions as to how the blood may have been shed. From what may appear to be a random distribution of bloodstains at a crime scene, analysts can categorize the stains by gathering information from spatter patterns, transfers, voids and other marks that assist investigators in recreating the sequence of events that occurred after bloodshed. This form of physical evidence requires the analyst to recognize and interpret patterns to determine how those patterns were created. Mechanics principles are essential in understanding the behaviour of blood when it is in motion. By applying principles of fluid dynamics and the laws of physics, forensic analysts can interpret bloodstain patterns to determine factors such as the angle and velocity at which blood droplets impacted a surface, the direction from which they originated, and the type of force that caused their creation. This analysis aids in reconstructing the events surrounding a crime, such as the position of the victim and assailant, the type of weapon used, and the sequence of actions.

To analyse a bloodstain pattern, an expert relies on three main interrelated elements: the size, shape and distribution of bloodstains. Blood drops that fall straight down, with little bit gravity and air resistance affecting them, make round stains. Blood moving at an angle and sped along by some force, however, tends to make elongated marks, especially when it strikes a nonporous surface. As a rule, following the long axis of the stain from the blunter end to the sharper, more disturbed edge reveals the direction the blood travelled. If a number of stains radiate outward, analysts can draw lines backward along these axes to an area of convergence. But this gives them an area in only two dimensions. Investigators must also determine the blood's impact angle. The lower the angle at which blood strikes a surface, the thinner and more elongated the stain. The converse holds true as well. For example, if a blood droplet has a 10-degree drop, it creates a highly elongated stain, whereas a droplet with a 90-degree (vertical) drop leaves a round stain. Measuring a stain's width and length, analysts use the following mathematical formula to calculate the impact angle:

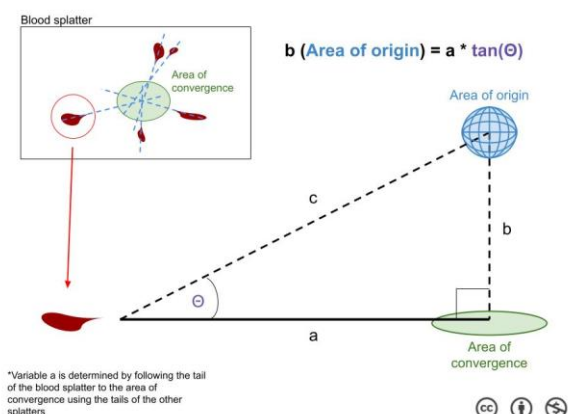
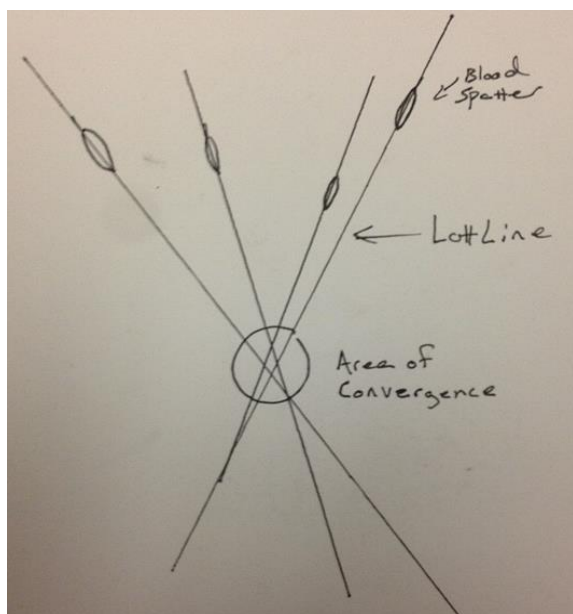
angle of impact = $\arcsin(\text{stain width}/\text{stain length})$

The greater the difference between the width and length, the sharper the angle of impact. For example, imagine a bloodstain 0.08 inches wide by 0.16 inches long (2 by 4 millimeters). The width divided by the length equals 0.5. The ArcSin of 0.5 is 30, meaning the blood hit the surface at a

30-degree angle. In a bloodstain measuring 0.04 by 0.16 inches (1 by 4 millimeters), the impact angle comes out to about 14.5 degrees.

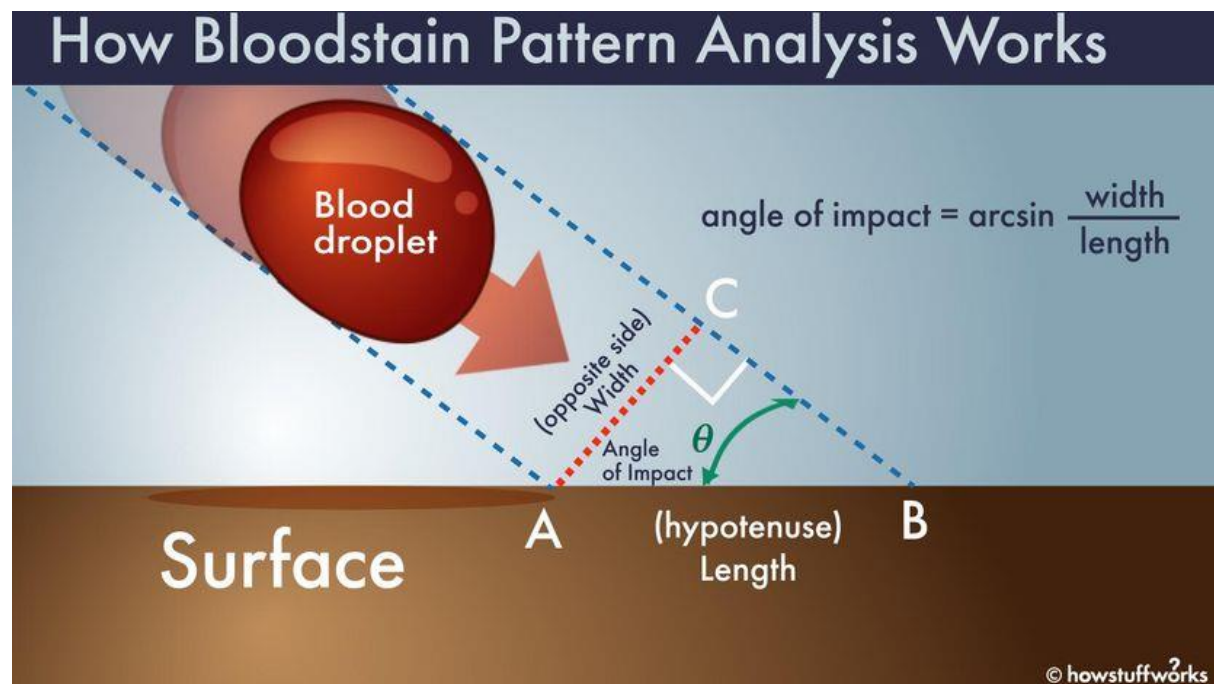
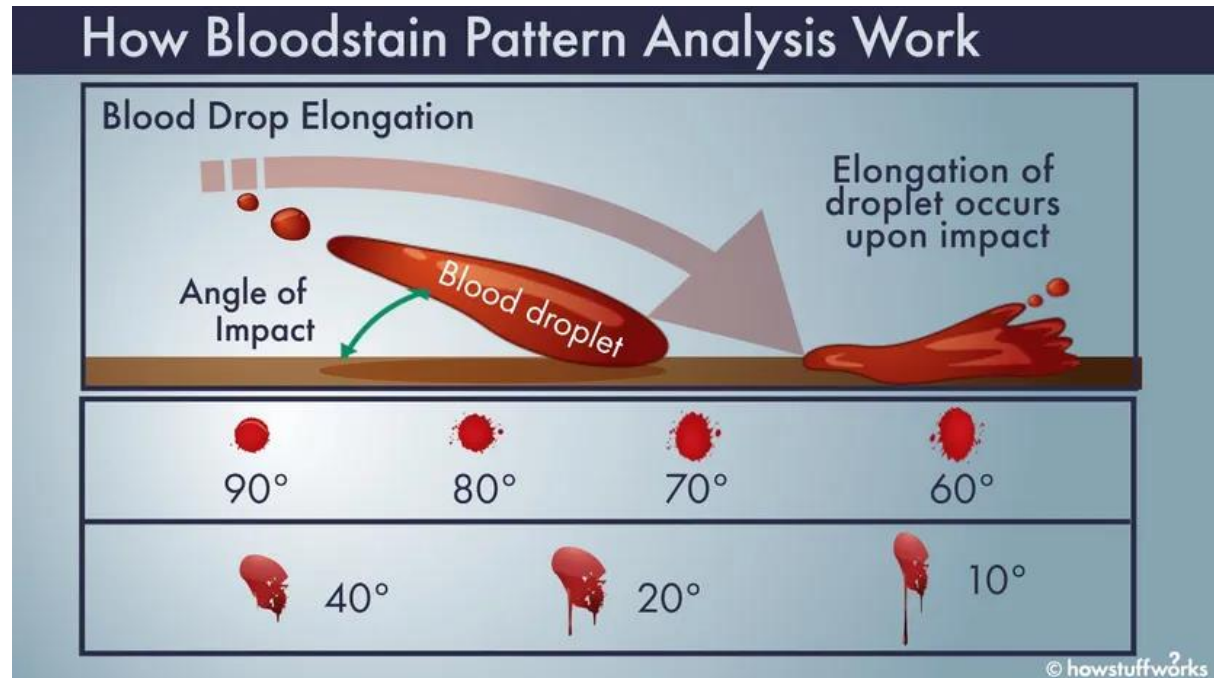
If the bloodstain has a tail, as can occur in droplets striking a surface at certain angles and speeds, it should be left out of this calculation. Once analysts know all three angles, they can move on to the most visually striking part of the process, the technique of stringing. Stringing involves running strings from the rear edges of the bloodstains upward at the appropriate angles to find where they roughly meet — the area of origin. This technique provides only an approximation, however, and is mainly used to establish whether a victim was seated, standing or lying down when the event occurred. The presence or absence of blood on other surfaces, combined with common sense, also aids in this analysis.



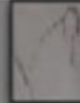



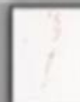




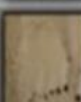

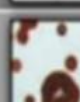
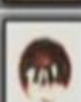


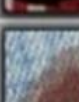
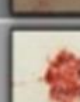
Bloodstain pattern analysis will most likely always play a critical role in forensic investigations. With the help of certain blood testing methods, analysts can not only properly identify areas of blood, but they can also extract DNA evidence from it. Afterwards, they can then categorize the blood so that events of the crime can be learned. Human-based methods of bloodstain pattern analysis are being questioned for their reliability and accuracy due to the confusion and error surrounding classification and convergence. Because of this, exploring computerized methods could greatly improve the quality of science and thus reduce the amount of false convictions in the future. However, further research needs to be conducted to provide a solid method of computerized bloodstain pattern analysis that can be utilized for all types of stains.



Above figure shows how to determine area of convergence from blunt trauma blood spatter.

Diagrams –



Passive	Transfer	Projected	Miscellaneous
Clot 	Pattern Transfer 	Arterial 	Capillary 
Serum Separation 	Swipe 	Cast-Off 	Fly Spot 
Drop 	Wipe 	Spatter 	Void 
Flow 		Expiratory 	Skeletonized 
Pool 		Back Spatter 	
Saturation Stain 		Spine 	

Result and Implications –

1. Accurate Reconstruction of Events: By applying mechanics principles such as fluid dynamics and projectile motion, forensic analysts can accurately reconstruct the events that led to the formation of bloodstain patterns. Understanding the behaviour of blood droplets in motion allows analysts to determine factors such as the angle of impact, the velocity of the blood source, and the distance between the source and the target surface. This precise reconstruction provides valuable insights into the dynamics of violent events, aiding investigators in establishing timelines and identifying crucial details about the incident.

2. Validation of Witness Testimonies: Bloodstain pattern analysis supported by mechanics principles can serve to validate or corroborate witness testimonies regarding the sequence of events. By objectively examining bloodstain patterns, analysts can assess the consistency of witness accounts and identify any discrepancies or inconsistencies. This validation adds credibility to witness statements and strengthens the overall reliability of the investigative process.

3. Identification of Critical Evidence: Mechanics-based analysis allows forensic experts to identify and interpret subtle details within bloodstain patterns that may otherwise go unnoticed. By analysing factors such as spatter size, shape, and distribution, analysts can discern patterns indicative of specific actions or events, such as the use of different weapons, the number of assailants, or the movements of individuals within the crime scene. This identification of critical evidence provides investigators with valuable leads and insights that can help narrow down suspects and reconstruct the sequence of events with greater accuracy.

4. Enhanced Courtroom Presentations: Mechanics-based bloodstain pattern analysis enables forensic experts to present their findings in a clear, concise, and scientifically sound manner in the courtroom. By using principles of physics and mathematics to explain the formation of bloodstain patterns, analysts can effectively communicate their conclusions to judges, juries, and legal professionals. This enhances the persuasiveness and credibility of the forensic evidence presented, thereby strengthening the prosecution or defense's case and contributing to the administration of justice.

5. Development of Advanced Analytical Techniques: The application of mechanics to bloodstain pattern analysis continues to drive innovation and the development of advanced analytical techniques within forensic science. Researchers continually refine existing methodologies, conduct experiments, and explore new technologies to improve the accuracy, reliability, and efficiency of bloodstain pattern analysis. This ongoing research contributes to the advancement of forensic science as a whole, ensuring that investigators have access to the latest tools and techniques for analysing bloodstain patterns and interpreting their significance in criminal investigations.

Conclusion –

The application of mechanics principles to bloodstain pattern analysis represents a crucial advancement in forensic science, yielding significant benefits and implications for the investigation and resolution of criminal cases. By leveraging principles of fluid dynamics, projectile motion, and material behaviour, forensic analysts can accurately reconstruct the dynamics of violent events, validate witness testimonies, identify critical evidence, enhance courtroom presentations, and drive innovation in analytical techniques.



SOMAIYA
VIDYAVIHAR

K J Somaiya College of Science & Commerce



The meticulous examination and interpretation of bloodstain patterns guided by mechanics principles enable investigators to uncover crucial details about the sequence of events, the actions of individuals involved, and the mechanisms behind bloodshed. This precise analysis provides valuable insights that aid law enforcement agencies in establishing timelines, identifying suspects, and ultimately, achieving justice.

Furthermore, the application of mechanics-based analysis contributes to the ongoing advancement of forensic science by driving research, innovation, and the development of advanced analytical techniques. By continually refining methodologies, conducting experiments, and exploring new technologies, researchers ensure that forensic analysts have access to the latest tools and techniques for analysing bloodstain patterns with accuracy and reliability.

Overall, the integration of mechanics principles into bloodstain pattern analysis enhances the credibility, accuracy, and effectiveness of forensic investigations, ultimately contributing to the administration of justice and the advancement of forensic science as a whole. As technology continues to evolve and research progresses, the application of mechanics to bloodstain pattern analysis will remain a cornerstone of modern forensic science, ensuring that investigators have the tools and expertise needed to unravel the mysteries hidden within bloodstained crime scenes.

References –

[Bloodstain Pattern Analysis: Introduction \(forensicsciencesimplified.org\)](https://forensicsciencesimplified.org/Bloodstain-Pattern-Analysis-Introduction)

<https://science.howstuffworks.com/bloodstain-pattern-analysis3.htm>

https://books.google.co.in/books?id=8_fKBQAAQBAJ&pg=PA43&source=gbs_selected_pages&cad=1#v=onepage&q&f=false

[https://www.sciencedirect.com/topics/medicine-and-dentistry/bloodstain-pattern-analysis#:~:text=Second%20Edition\)%2C%202019-,Bloodstain%20Patterns,regard%20to%20the%20bloodshed%20event](https://www.sciencedirect.com/topics/medicine-and-dentistry/bloodstain-pattern-analysis#:~:text=Second%20Edition)%2C%202019-,Bloodstain%20Patterns,regard%20to%20the%20bloodshed%20event)
[viewcontent.cgi \(duq.edu\)](https://duq.edu/viewcontent.cgi)

https://www.researchgate.net/publication/373512225_Blood_Stain_Pattern_Analysis_A_Comprehensive_Review_of_Methods_Reliability_of_Computerized_Analysis_and_Future_Advancements



SOMAIYA
VIDYAVIHAR

K J Somaiya College of Science & Commerce

