Reading bloodstain patterns

EXTENSION. Bloodstain pattern analysis is NOT a PBS Unit 1 activity. Run it only if you have spare time or want a trigonometry tie-in.

CLAIM CEILING. READ THIS FIRST.

- **Polygraph.** It records breathing and heart rate. A change in either one is a physiological response. It is not a measurement of lying, and nothing in this unit produces a deception call.
- **Hair.** Microscopic similarity can support consistency or support exclusion. It cannot identify one person.
- **Fingerprint.** Pattern class can narrow a field or exclude a person. By itself it cannot name a source, and it never says when or why a finger touched something.
- **Timeline.** A scheduled event is not proof the person was there. Time of death is not established in the early case evidence.

READ THIS BEFORE YOU SCHEDULE IT

This module is an **extension**. PBS Unit 1 has no bloodstain pattern activity: the blood work in the course is ABO typing in Activity 1.1.4 and DNA in Activities 1.1.5 and 1.1.6. Nothing here is required for the case, and nothing in the case depends on it. It earns its place as a trigonometry application and as a second worked example of a method whose own field has been criticised for overstatement. Skip it without penalty if your days are tight.

Anna Garcia Forensic Methods Unit. Analysis module.

Every stain, measurement, coordinate, and answer on this card is invented practice data written for this module. None of it comes from the case evidence, and none of it describes any real person.

Vocabulary used on this card.

- **Spatter.** Small stains made by drops that flew through the air and landed.
- **Drip.** A stain made by blood falling straight down under its own weight.
- **Transfer.** A stain made by a wet surface touching a dry one. The shape comes from the object, not from flight.
- **Void.** A gap inside a pattern where no drops landed because something blocked them.
- **Minor axis (width).** The short measurement across an elliptical stain.
- **Major axis (length).** The long measurement along an elliptical stain, not counting any thin tail.
- **Impact angle.** The angle between the drop's flight path and the surface, measured in degrees.
- **Area of convergence.** A flat region on the surface that the drops came from, found by drawing lines backwards.
- **Region of origin.** The area of convergence plus a height above the surface. This is three-dimensional.

What this analysis can and cannot tell you

- **Claim ceiling.** This analysis supports bounded statements about direction, angle, and a region in space. Every conclusion you write is about drops and surfaces. None of them is about a person.
- **It can estimate three things.** The direction a drop was travelling when it landed, the angle at which it struck the surface, and an approximate region that a group of drops came from. All three are estimates with real error bars attached, and you have to write the error bars down.
- **It cannot identify who bled, when it happened, or why.** A stain carries no name. It carries no clock. It carries no reason. Blood typing and DNA answer the "who" question, and even they answer it weakly. Nothing in the shape of a stain says whether an event was an accident, a fall, or anything else.
- **This discipline has been criticised for overstatement.** A National Academy of Sciences review found that bloodstain pattern conclusions in real casework had often been stated far more strongly than the underlying science supported (NAS-2009). A later study of practising analysts found that different analysts reading the same patterns often reached different conclusions (Hicklin-2021). That history is why your language on this card stays bounded. Write "the drops came from a region roughly this wide and this high." Do not write anything more.

Before you start: what you need

- The printed stain photograph or the actual practice surface, with a scale.
- A ruler marked in millimetres, and a longer ruler or tape marked in centimetres.
- A calculator with sine and tangent, set to **degrees**. Check the mode before you touch anything else. Type sin 30. If the screen shows 0.5, you are in degrees. If it shows -0.988, you are in radians and every answer you get will be wrong. Check tan 45 too. It should be exactly 1.
- A fine-tip pen, a pencil, and a long straightedge or a length of string.
- Graph paper, or a grid drawn on the surface in chalk or tape.
- Sticky flags or numbered labels, one per stain.
- Your recording sheet.

The formulas, explained

1. Impact angle

The formula.

> sin(theta) = width / length

What every symbol means.

- **width** is the minor axis of the stain, the short measurement straight across the ellipse at its widest point, in millimetres.

- **length** is the major axis, the long measurement from one end of the ellipse to the other, in millimetres. It does not include the thin tail or any satellite specks past the end of the main body.
- **theta** is the impact angle in degrees, measured from the surface, not from a line standing up off the surface. Straight down onto a floor is 90 degrees. A drop skimming almost flat along a wall is close to 0 degrees.
- Because you divide millimetres by millimetres, the units cancel. The answer is a plain number between 0 and 1, and you take the inverse sine of it.

Why this works. A flying blood drop is close to a sphere. Drop a sphere straight down onto a flat floor and it spreads out evenly in every direction, so the stain is a circle. Width equals length, width divided by length is 1, and the inverse sine of 1 is 90 degrees. Now send that same sphere in at a slant. The sphere still spreads about one drop-width sideways, but it also skids forward along its direction of travel, so the stain stretches into an ellipse. The width stays close to the drop's own diameter. The length grows. The shallower the angle, the longer the stretch, the smaller width divided by length becomes, and the smaller the angle the formula returns.

Assumptions built in. The drop was roughly spherical in flight. The surface is flat and hard where the stain sits. The stain's edges are clean enough that you can find the true width and the true length.

When it breaks. It breaks on a rough surface, because the edges scallop and there is no single width to measure. It breaks on fabric or paper, because the blood wicks along fibres and spreads past the shape the drop actually made. It breaks on a stain smaller than about 1 mm, because your ruler cannot resolve it. It breaks on any stain above about 80 degrees, because a near-circle can be a degree or two off in either direction from tiny measurement error and you cannot tell 85 degrees from 90 degrees by eye.

At your desk. Put a numbered flag beside the stain. Lay the ruler along the longest straight line you can find across the stain body and read the length to 0.1 mm. Turn the ruler 90 degrees to that line, slide it until you find the widest point across, and read the width to 0.1 mm. Write both numbers with units. Divide width by length and write that number down before you touch the calculator's sine key.

You are done with this step when: a width in mm, a length in mm, the division result, and an angle in degrees to one decimal place are all written next to that stain's number.

2. Area of convergence

The method. There is no equation for this one. You draw it.

Every elliptical stain points back along the way its drop came. The long axis of the stain lies on the drop's line of travel. Extend that line backwards across the surface. Do it for many stains. The lines will cross each other in a cluster. That cluster is the **area of convergence**. It is a flat, two-dimensional region on the surface. It has a length and a width. It does not have a height, and it never will, because it lives on the surface.

What every symbol means. Positions are read off a grid you lay over the surface, in centimetres, with one corner as (0, 0). A stain's position is the centre of its body. Its direction is the compass line its long axis sits on.

Assumptions built in. Every drop flew in a straight line when seen from directly above. That part is fair, because gravity pulls straight down and does not push a drop sideways. All the stains you used came from the same event.

When it breaks. It breaks if you include a drip, because a drip falls straight down and its long axis points nowhere useful. It breaks if you include a transfer stain, because a transfer's shape comes from the object that made it. It breaks if two separate events happened and you mixed their stains together, because you will get one meaningless cluster instead of two real ones. It gets badly weak if all your stains sit close together, because nearly parallel lines cross at a very sharp angle and a half-degree error in your pen moves the crossing point a long way.

At your desk. Lay the straightedge along the long axis of stain 1. Draw the line backwards, away from the direction the drop was moving, all the way across the grid. Repeat for every measurable stain. Circle the region that contains the crossings. Read the centre of that circle off the grid, and measure how wide the circle is in centimetres.

You are done with this step when: a drawn line runs back from every measurable stain, a circle is drawn around the crossings, and both the centre coordinates and the width of that circle are written in centimetres.

3. Height of origin

The formula.

> tan(theta) = height / horizontal distance
>
> so height = horizontal distance x tan(theta)

What every symbol means.

- **theta** is the impact angle in degrees for one stain, from step 1.
- **horizontal distance** is the straight-line distance across the surface from that stain to the centre of the area of convergence, in centimetres.
- **height** is how far above the surface the drop started, in centimetres.
- Both distances are in centimetres, so the answer comes out in centimetres.

Why this works. Picture a right triangle standing up off the floor. The bottom side runs from the stain to the convergence point. The upright side runs from the convergence point straight up to where the drop started. Tangent of the angle is the upright side over the bottom side, so multiplying the bottom side by the tangent gives the upright side.

Assumptions built in, and this is the one that matters. The formula treats the drop's flight as a **straight line**. Real drops do not fly in straight lines. Gravity bends every flight path downward into a curve. Because the path curves down, the drop is falling more steeply at the moment it lands than it was when it left. Your straight line is traced back at that steeper landing angle, so it climbs faster than the real path did and passes **above** the true starting point.

So the height is always an overestimate. The number you calculate is a ceiling, not a measurement. The true origin sits at or below it. And the error grows with horizontal distance, because a longer flight gives gravity more time to bend the path. A stain 30 cm from the convergence carries a small overestimate. A stain 3 metres away carries a large one.

When else it breaks. It breaks if the surface is not level, because the "height above the surface" you calculate is measured off a surface that is tilted. It breaks if the stain is very close to the convergence area, because then a small error in where you put the convergence is a large fraction of a short distance, and that error is multiplied straight into the height. It breaks completely if the angle came from a stain you should not have measured.

At your desk. Measure with the long ruler from the stain's flag to the centre of your convergence circle. Write that distance in centimetres. Put the angle for that stain in the calculator, press tan, and multiply. Write the answer and write the word "ceiling" beside it so you do not forget what it is.

You are done with this step when: a horizontal distance in cm, a tangent value, and a height in cm are written for at least two stains, and the word "ceiling" is written next to each height.

Worked example, done all the way through

Imani is working a practice surface called PRACTICE-BS, a sheet of smooth vinyl floor tile with a chalk grid on it in centimetres. Nothing on this surface is case evidence. Imani flags three usable stains and a fourth mark that turns out not to be usable.

Step 1. Measure the three stains.

Calculator check first. sin 30 reads 0.5, so the calculator is in degrees.

Stain	Position (x, y) cm	Width mm	Length mm	width / length	Angle
PRACTICE-BS-1	(115, 140)	4.0	8.0	0.5000	30.0 degrees
PRACTICE-BS-2	(75, 108)	6.0	8.5	0.7059	44.9 degrees
PRACTICE-BS-3	(67, 76)	8.0	8.5	0.9412	70.3 degrees

The arithmetic, written out.

- BS-1: 4.0 divided by 8.0 is 0.5000. Inverse sine of 0.5000 is 30.0 degrees.
- BS-2: 6.0 divided by 8.5 is 0.7059. Inverse sine of 0.7059 is 44.9 degrees.
- BS-3: 8.0 divided by 8.5 is 0.9412. Inverse sine of 0.9412 is 70.3 degrees.

BS-3 is nearly round, which fits a steep angle. BS-1 is stretched to twice its width, which fits a shallow one.

There is a fourth mark at about (30, 30). It is roughly oval but one whole edge is feathered into thin threads. Imani looks closer and finds it sits across a seam between two tiles where the vinyl has lifted. Blood wicked into the seam. Imani writes "PRACTICE-BS-4, not measurable, wicked into tile seam" and does not put a number on it. Recording a stain and refusing to measure it are two different jobs, and both of them count as work.

Step 2. Find the area of convergence.

Imani lays the straightedge along the long axis of each of the three usable stains and draws each line backwards across the grid. Three lines make three crossing points, not one.

- Line 1 crosses line 2 at about (53, 58).
- Line 1 crosses line 3 at about (57, 62).
- Line 2 crosses line 3 at about (56, 59).

Those three points sit inside a triangle about 5 cm across. Imani draws a circle around all three, reads the centre as **(55, 60)**, and writes that the convergence area is about 5 cm wide. That width is not a failure. It is the honest uncertainty, and it gets used again in the next step.

Step 3. Distances from each stain to the convergence centre.

Imani measures with the long ruler and checks each one with the grid.

- BS-1 at (115, 140). Across is 115 minus 55, which is 60. Up is 140 minus 60, which is 80. Distance is the square root of (60 x 60) plus (80 x 80), which is the square root of 3600 plus 6400, which is the square root of 10000, which is **100 cm**.

- BS-2 at (75, 108). Across is 20, up is 48. Square root of 400 plus 2304 is the square root of 2704, which is **52 cm**.
- BS-3 at (67, 76). Across is 12, up is 16. Square root of 144 plus 256 is the square root of 400, which is **20 cm**.

Step 4. Height from two stains.

- BS-1: tan 30.0 degrees is 0.5774. Height is 100 x 0.5774 = **57.7 cm**, call it 58 cm. Ceiling.
- BS-2: tan 44.9 degrees is 0.9966. Height is 52 x 0.9966 = **51.8 cm**, call it 52 cm. Ceiling.

Imani runs BS-3 as well, out of curiosity. tan 70.3 degrees is 2.793. Height is 20 x 2.793 = 55.9 cm, call it 56 cm.

Step 5. Here is where Imani gets stuck.

Three numbers. 58, 52, and 56. Imani's first move is to add them and divide by three, which gives 55.3, and write "origin height 55 cm." That looks tidy and it is wrong, for two separate reasons.

The first reason is BS-3. That stain sits only 20 cm from the convergence centre, and the convergence area is about 5 cm across, so the centre could honestly be 3 cm off in any direction. Imani tests what that does to each stain by redoing the height at the short distance and the long distance.

- BS-1, distance 97 to 103 cm: heights 56.0 to 59.5 cm. A swing of about 3.5 cm.
- BS-2, distance 49 to 55 cm: heights 48.8 to 54.8 cm. A swing of about 6 cm.
- BS-3, distance 17 to 23 cm: heights 47.5 to 64.2 cm. A swing of about 17 cm.

BS-3's number, 56 cm, sits nicely between the other two. Its error band, 47 to 64 cm, is so wide it says almost nothing. A short distance under a steep angle multiplies every small mistake. Imani drops BS-3 from the height report and writes down why.

The second reason is the averaging itself. Both heights are ceilings. Averaging two ceilings does not give you a better guess at the truth. It gives you a number that looks like a measurement and is not one.

Step 6. Resolve it honestly.

Imani lines up the two surviving error bands.

- BS-1 says 56 to 60 cm.
- BS-2 says 49 to 55 cm.

They do not overlap. There is a 1 cm gap between them. Imani stares at that for a while, because two stains from one event ought to agree.

Two explanations fit, and both are ordinary. Either the real measurement error is a little larger than the 3 cm convergence wobble Imani allowed for, which is likely given a ruler read by hand. Or the drops genuinely left from slightly different points, which is what real spatter does, because blood does not leave from one dot in space. It leaves from a region.

Neither explanation lets Imani pick a winner. So the report covers both bands and says so.

The written conclusion.

> Three measurable stains on practice surface PRACTICE-BS gave impact angles of 30.0, 44.9, and 70.3 degrees. Their back-lines converge in an area about 5 cm across, centred near grid position (55, 60). Using stains BS-1 and BS-2, the height of origin above the surface calculates as 58 cm and 52 cm. With the convergence uncertainty carried through, those become 56 to 60 cm and 49 to 55 cm. I report the region of origin as an area about 5 cm across near (55, 60), at a height between roughly 49 and 60 cm above the surface. Both heights are ceilings, because the straight-line method ignores the downward curve gravity puts on a flight path, so the true origin sits at or below these numbers.
> Stain BS-3 was measured but excluded from the height report, because at 20 cm from the convergence its height swings 17 cm on a 3 cm shift of the centre.
> Stain BS-4 was recorded but not measured, because it wicked into a tile seam.
> This result describes a region in space. It does not describe a person, an action, or a time.

Imani's partner reruns the two heights cold and gets 57.9 and 51.6. That is within 0.3 cm on both. The measurements are repeatable. The uncertainty is real and it comes from the method, not from sloppy hands.

Environmental and surface factors that change the answer

Factor	What it does to the stain	What you must record
Smooth surface (tile, glass, gloss paint)	Clean elliptical edges. Width and length are readable. This is the surface the formulas were built for.	Name the material and write "smooth, edges clean."
Rough surface (bare concrete, brick, textured wall)	The edge scallops into small lobes. There is no single width, so the angle you calculate depends on which bump you measured to.	Name the material, write "edges irregular," and record the range of widths you could get. Do not report one angle.
Fabric, carpet, paper, unsealed wood	Blood wicks along fibres and grain. The stain spreads past the shape the drop made, and it usually spreads more in one direction than the other.	Name the material and write "wicked, shape not the drop's shape." Do not calculate an angle.
Surface absorbency	A porous surface pulls blood in and shrinks or blurs the visible edge. A sealed surface holds the drop on top.	Write porous or non-porous, and note any visible soak-in ring.
Drop volume	A larger drop makes a larger stain at the same angle. Size alone tells you nothing about angle, because the ratio is what matters.	Record width and length, never size alone.
Fall height	A greater fall height means a faster drop, a wider stain, and often small satellite specks thrown around the main stain.	Record whether satellite specks are present and how far out they sit.

Factor	What it does to the stain	What you must record
Target angle (is the surface vertical, horizontal, or tilted)	The impact angle is measured against the surface, so a tilted surface changes what the angle means in the room.	Record the surface's own orientation in degrees, and which surface each stain is on.
Whether the surface is level	The height you calculate is height above that surface. If the floor slopes, your height is measured off a sloping reference and is wrong by the slope.	Check with a level or a marble. Record "level" or record the slope.
Air movement (fan, open door, vent, someone walking past)	Small droplets are light. Moving air pushes them off a straight path, which changes both where they land and the angle they land at.	Record any fan, vent, or open door, and its position relative to the stains.
Stain type: drip	Blood that fell straight down under its own weight. Roughly round, and its long axis points nowhere useful.	Label it "drip." Keep it out of the convergence.
Stain type: spatter	Blood that flew through the air. These are the stains the formulas are for.	Label it "spatter" and measure it.
Stain type: transfer	A wet surface touched a dry one. The shape comes from the object, not from a flight path.	Label it "transfer," sketch the shape and size, and keep it out of every calculation.
Stain type: void	A gap where drops did not land because something blocked them.	Label it "void." Record its shape, its measured size, and its position.
Surface later disturbed, walked on, wiped, or cleaned	Smears, drag marks, and missing stains. A cleaned area can look exactly like a void and it is not one.	Record any smear, footprint, drag mark, cleaning-cloth streak, or damp patch, and note that a wiped area cannot be told from a void by shape alone.

The logic a real examiner uses

Measure many stains, not the convenient ones. The three biggest stains nearest your chair are a sample chosen by your comfort, and a sample chosen by comfort is not a sample. Work across the whole pattern. If a stain is measurable, measure it, even when it is awkward to reach.

Use stains from a range of positions. Two lines that cross at a sharp angle pin down a crossing point tightly. Two nearly parallel lines barely pin down anything, and a half-degree wobble in your pen slides the crossing point half a metre. Stains spread widely around the pattern give you crossings at wide angles. Stains clustered in one corner give you a long, smeared, nearly useless convergence.

Report the convergence as an AREA and the origin as a REGION with a height range. Not a point. Not a single number. The lines will not meet at one dot, and reporting one dot hides how much they disagreed. Draw the circle. Measure the circle. Report the circle, and report the height as a range with the word "ceiling" attached, because the straight-line method cannot come out too low.

Say what you excluded and why. A stain you refused to measure is part of the record. Write its number, write "not measurable," and write the reason in a few words. An examiner who reports six angles from ten stains and never mentions the other four has hidden the four that did not cooperate.

Never convert a pattern into a story about what a person did. The formulas give you a region in space at a range of heights above a surface. They do not give you a position, a posture, an action, or a sequence. Writing "the origin was about 55 cm above the floor" is inside the ceiling. Writing anything about who was where, what they were doing, or what happened first is outside it, and no amount of careful measurement earns you that sentence.

What a void tells you, and what it does not. A void is a gap inside a pattern where no drops landed. Something stood between the source and the surface and caught the drops that would have filled that gap. So a void tells you an object was there while blood was in the air, and it gives you the outline and the rough size of whatever blocked the drops. A void does not tell you what the object was. It does not tell you who put it there, or whether anyone put it there at all. It does not tell you when it was removed. And a wiped or cleaned patch can produce a gap that looks the same, so a void's shape by itself does not prove anything was ever there. Measure the gap, sketch it, write its position, and stop.

Practice problems

All data below is invented practice data. Work each one on paper before you look at the answers. Keep your calculator in degrees.

Problem 1. A stain on smooth tile measures 3.5 mm wide and 7.0 mm long. Find the impact angle.

Problem 2. A stain on the same tile measures 5.0 mm wide and 5.2 mm long. Find the impact angle. Then say in one sentence how confident you are in that answer and why.

Problem 3. A stain measures 2.0 mm wide and 11.5 mm long. Find the impact angle.

Problem 4. A stain sits on bare rough concrete. The length is clearly 9.0 mm. The width is the problem. The edge is scalloped into small lobes, and depending on which lobe you measure to, the width reads anywhere from 4.0 mm to 6.0 mm. The stain sits 60 cm from the convergence centre. What is the correct thing to do with this stain, and why? Support your answer with numbers.

Problem 5. A grid is marked on a floor in centimetres. Three stain back-lines have been drawn. Each line is given by two points it passes through.

- Line 1 passes through (10, 5) and (40, 35).
- Line 2 passes through (80, 10) and (50, 40).
- Line 3 passes through (20, 60) and (45, 45).

Find where each pair of lines crosses. Then state the area of convergence.

Problem 6. A student calculates a height of origin of 74 cm from a stain 2 metres away from the convergence area. Is the true origin more likely to be above 74 cm or below it? Explain why, and say what happens to the size of that error if the stain had been 20 cm away instead.

Answers to the practice problems

Answer 1.

3.5 divided by 7.0 is 0.5000. Inverse sine of 0.5000 is **30.0 degrees**.

Answer 2.

5.0 divided by 5.2 is 0.9615. Inverse sine of 0.9615 is **74.1 degrees**.

Confidence is low, and the reason is the shape. This stain is nearly round, which means the angle is steep, and steep angles are the ones the formula reads worst. Suppose your ruler was off by 0.1 mm and the true length was 5.3 mm. Then 5.0 divided by 5.3 is 0.9434, and the angle becomes 70.6 degrees. A 0.1 mm slip moved the answer 3.5 degrees. The same 0.1 mm slip on the stain in problem 3 moves the answer by less than a tenth of a degree. Report this one as "steep, approximately 74 degrees," and do not build a height calculation on it alone.

Answer 3.

2.0 divided by 11.5 is 0.1739. Inverse sine of 0.1739 is **10.0 degrees**.

Answer 4.

The correct action is to **record the stain and exclude it from every calculation**. Write "rough concrete, edges scalloped, width not determinable" beside its number, and move on.

Here is why, with numbers. Force the calculation at each end of the width range.

- Using width 4.0 mm: 4.0 divided by 9.0 is 0.4444, so the angle is 26.4 degrees. tan 26.4 degrees is 0.4965. Height is 60 x 0.4965 = **29.8 cm**.
- Using width 6.0 mm: 6.0 divided by 9.0 is 0.6667, so the angle is 41.8 degrees. tan 41.8 degrees is 0.8942. Height is 60 x 0.8942 = **53.7 cm**.

One stain, one honest length measurement, and a height that lands anywhere from about 30 cm to about 54 cm. That is a 24 cm spread produced by nothing except which bump on a rough edge you happened to put the ruler against. A number that can be moved 24 cm by the examiner's choice of measuring point is not evidence of anything. Excluding it costs you one stain. Including it poisons the whole average.

Answer 5.

First find the equation of each line. Slope is the change in y divided by the change in x.

- Line 1: slope is (35 minus 5) divided by (40 minus 10), which is 30 divided by 30, which is 1. Using the point (10, 5): y = x minus 5.
- Line 2: slope is (40 minus 10) divided by (50 minus 80), which is 30 divided by negative 30, which is negative 1. Using the point (80, 10): y = 90 minus x.
- Line 3: slope is (45 minus 60) divided by (45 minus 20), which is negative 15 divided by 25, which is negative 0.6. Using the point (20, 60): y = 72 minus 0.6x.

Now find each crossing.

- **Line 1 and line 2.** Set x minus 5 equal to 90 minus x. Then 2x = 95, so x = 47.5, and y = 47.5 minus 5 = 42.5. Crossing at **(47.5, 42.5)**.

- **Line 1 and line 3.** Set x minus 5 equal to 72 minus 0.6x. Then 1.6x = 77, so x = 48.1, and y = 48.1 minus 5 = 43.1. Crossing at **(48.1, 43.1)**.
- **Line 2 and line 3.** Set 90 minus x equal to 72 minus 0.6x. Then 18 = 0.4x, so x = 45.0, and y = 90 minus 45 = 45.0. Crossing at **(45.0, 45.0)**.

The area of convergence runs from x = 45.0 to x = 48.1 and from y = 42.5 to y = 45.0. That is a region roughly 3 cm by 2.5 cm, centred near (47, 44).

Report it as an area about 3 cm across near (47, 44). Do not report "(47, 44)" on its own. The three lines did not agree on a point, and the size of their disagreement is a result you owe the reader.

Answer 6.

The true origin is more likely to be **below 74 cm**. The calculated height is a ceiling.

Why. The formula draws a straight line from the stain back up to the origin, using the angle the drop was travelling at the instant it landed. A real drop does not travel in a straight line. Gravity pulls it down the whole way, so its path is a curve that gets steeper and steeper. The angle you measure at the stain is the steepest angle of the whole flight. A straight line drawn back at that steepest angle climbs faster than the real curved path ever did, so it finishes above the point the drop actually started from.

What happens at 20 cm instead of 2 metres. The error gets much smaller. Gravity needs time to bend a path, and a 20 cm flight takes far less time than a 2 metre flight. Over a very short distance the real path is nearly straight, so the straight-line assumption is nearly true and the overestimate is small. Over 2 metres the path has had time to curve a lot, and the overestimate is large.

That is why the error direction is fixed but the error size is not. It grows with horizontal distance.

The three mistakes that cost people most

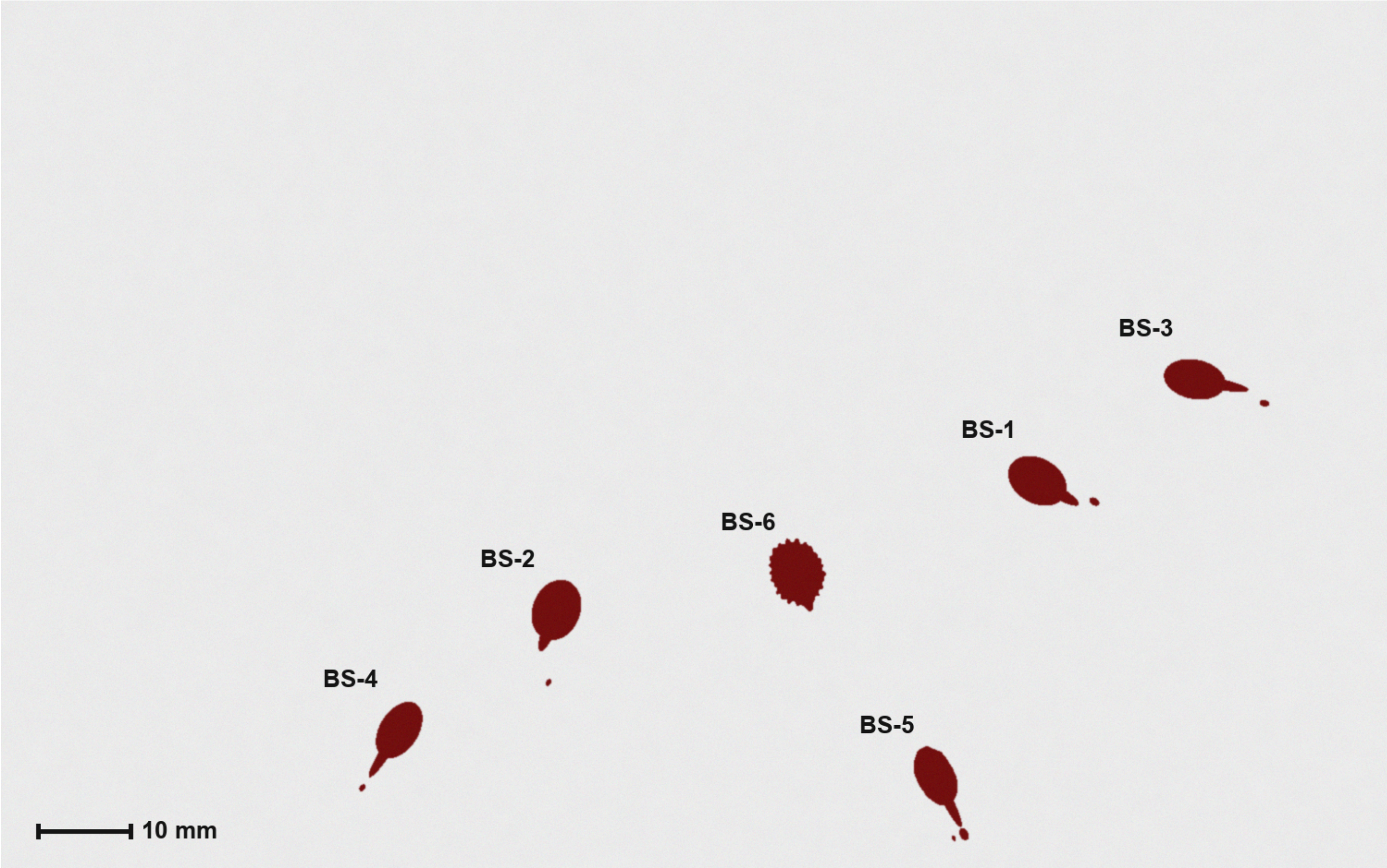
Measuring the wrong axis. Width is the short one. Length is the long one. Swap them and width divided by length comes out greater than 1, and your calculator returns an error instead of an angle, which at least tells you something went wrong. The mistake that does not announce itself is subtler. Students measure the length by including the thin tail that trails off the end of the stain, which stretches the length and makes the angle come out too shallow. Or they measure the width at the widest visible point of a stain that has a lopsided edge, which makes the angle come out too steep. Fix it mechanically. Find the longest line across the stain body first and mark both ends. Then turn exactly 90 degrees to that line and find the widest point across. Stop the length where the solid stain body stops, and do not follow the tail.

Using a stain whose edges are scalloped by a rough surface. This one hides because the stain still looks like an oval from across the room. Up close, on bare concrete or brick or textured paint, the edge breaks into small lobes and there is no single width to measure. Answer 4 shows what that costs. One stain gave heights of 29.8 cm and 53.7 cm from the same honest length, depending only on which lobe the ruler touched. Every one of those answers is defensible and every one of them is different, which means the stain is not measuring anything. Check the edges before you measure, not after. If you cannot put the ruler down twice in a row and get the same width, record the stain and exclude it.

Turning a pattern into a narrative about who did what. This is the mistake with the longest and most damaging record, and it is the reason a National Academy of Sciences review criticised the discipline in the first place (NAS-2009). The pull is strong, because after an hour of careful measurement you have a region in space, and a region in space feels like it is almost a picture of what happened. It is not. Measuring that drops came from a region about 5 cm across at a height between 49 and 60 cm above a floor is a real, defensible, bounded result. Saying anything at all about a person being at that height, or in that position, or doing anything, is a different kind of claim that no stain measurement supports. The formulas describe drops and surfaces. Keep every sentence you write about drops and surfaces.

The lab. Read a bloodstain pattern

Six stains on one surface. Practice evidence, not the Anna Garcia case. Measure the elliptical body of each stain. Do not include the tail: it lengthens the long axis and gives an angle that is too shallow.



Scale bar is 10 mm. Measure width and length in millimetres, then compute sin(theta) = width / length.

Stain	Width (mm)	Length (mm)	Width / length	Impact angle	Usable? If not, why
BS-1					
BS-2					
BS-3					
BS-4					
BS-5					
BS-6					

ONE OF THESE SIX CANNOT BE MEASURED

One stain landed on a rough surface that scalloped its margin. Neither axis can be read reliably, so no angle should be reported for it. Writing "not measurable" there is the correct answer, and it is worth the same as a correct angle.

Area of convergence

Draw a line through the long axis of each usable stain, back along the direction the drop came from. Where the lines cross is the area of convergence.

Report it as an **area**. Measure the widest gap between your crossing points and write that down as the spread.

Height of origin

For two stains, measure the horizontal distance from the stain to your convergence point, then use height = distance x tan(theta).

Stain	Distance (mm)	Impact angle	tan(angle)	Height (mm)
Stain A				
Stain B				

WHICH WAY IS THIS NUMBER WRONG?

The calculation treats the drop's path as a straight line. Gravity curves the real path downward. Decide whether that makes your height too high or too low, then say how the error changes as the stain gets further from the origin.

Write the conclusion

One sentence on what this pattern supports, one on what it does not. Remember the ceiling: a pattern does not say who bled, when, or why.