PBS UNIT 1 · CASE A · STATIC · PERIOD 1-2

Five Tests, One Question

The evidence analysis circuit that closes the investigation into the death of Marcus Bell, 34.

CASE	DATE	SCENE
STATIC (JH-26-0831-A)	**Thursday, September 17, 2026**	**Statik Sound, a neighbourhood recording studio**
BLOCK	STATIONS	WET LAB
80 minutes	**5 mini labs**	**SEC 03 only**

YOUR CHARGE TODAY

By the end of this block you will say whether the death of Marcus Bell was an accident or foul play, and you will back that with at least four exhibits drawn from at least three different evidence types.

YOU TURN IN

- **One completed packet**, every green block filled in.
- **Five graphs**, one per mini lab, plotted on the axes provided.
- **One verdict paragraph** in SEC 07, with four exhibits named across three evidence types.

Time: 80 minutes, in class. Every station is timed. You will not finish if you read ahead.

GREEN RULE	GOLD GROUND	GREY GROUND	RED GROUND
You write here. Nothing else on the page is yours to fill in.	Given to you. Do not re-derive it. Controls and reference values live here.	Instructions from Mr. Mendoza. Read before you start the step.	Safety. Read it before you touch any material.

SEC 01 How a test earns an answer

6 min

WHY THIS MATTERS

Forensic laboratories in the United States handle hundreds of thousands of evidence submissions a year, and the single most common reason a result is thrown out in court is not bad chemistry. It is a missing control. A test nobody can check is a test nobody has to believe.

READ THIS

Today is five short investigations, not five worksheets. Each one has the same three parts, and the whole point of the block is that you can name those parts by the end of it. This is the part of today that will be on next week's exam.

THE SHAPE OF EVERY TEST YOU RUN TODAY

INDEPENDENT

the one thing you change on purpose

DEPENDENT

the thing you measure because it responds

CONTROLLED

everything you deliberately hold the same

THE CONTROL GROUP

A run where you already know what should happen. If the control does not do what it should, every other result in that mini lab is void, no matter how good it looks.

Today every control is already set up for you, and the reason it is there is printed next to it.

The parts of one test. Read the three boxes before SEC 02 and keep them in view all block. It does not supply any variable for any of today's mini labs; you name those yourself in each green block.

YOUR WORK · YOU COMPLETE THIS

In one sentence of your own, what is a control group for?

A classmate says, "my result looks clean, so I do not need the control." Write the one sentence you would say back.

SEC 02 Mini lab 1 · The print on the surface

15 min

WHY THIS MATTERS

No two people have ever been found to share a complete fingerprint, which is why prints have been used to identify people for over a century. In the same century, wrongful convictions have also turned on print examiners who were sure and wrong. Both facts are true, and they are why the procedure below makes you classify before you compare.

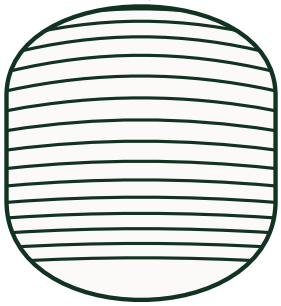
READ THIS

A print lifted from the scene is on the left of EXHIBIT FP-1. Five reference prints are on file. You work in two passes: **classify** the pattern, which narrows the crowd, then **compare minutiae**, which is the only step that can point at one finger.

Read this before you decide anything: a print proves that a finger touched a surface. It does not say when, and it does not say why. Some of the people on file have an ordinary reason to have touched the front edge of the mixing console.

STEP 1 REFERENCE: which of the three ridge patterns is it?

Every fingerprint belongs to one of three ridge patterns. Naming which one is called classifying the print. Do that first: it narrows the crowd, and it never names one person.

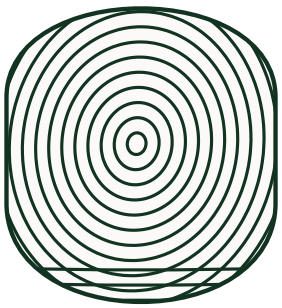


ARCH

Ridges enter one side, rise, and leave the other. No delta.

LOOP

Ridges turn back the way they came. One delta (the triangle).



WHORL

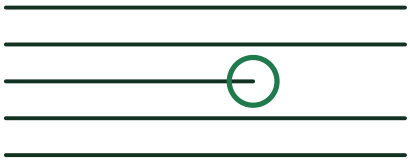
At least one ridge makes a full circle around the core.

The three ridge patterns. Use it for the first pass only. It does not supply the pattern of any print on the evidence sheet.

STEP 2 REFERENCE: the two marks you will count

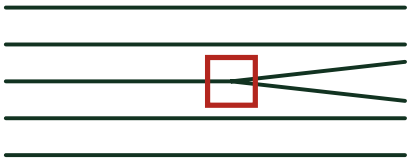
Minutiae are where ridges stop or split. Their positions relative to each other are what identify one finger.

RIDGE ENDING



One ridge simply stops.

BIFURCATION



One ridge splits into two.

The two minutiae marks. A circle is a ridge ending, a square is a bifurcation. It does not supply the position of any minutia on any print you have to compare.

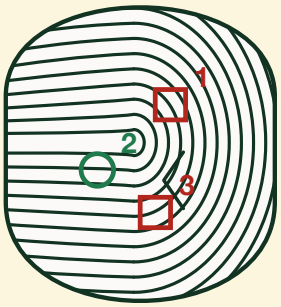
CONTROL GROUP · ALREADY SET UP FOR YOU

Your control is the victim's own reference print, printed on the reverse of your evidence sheet. Marcus Bell lived and worked at this scene, so that print should appear on scene surfaces. Check that your procedure finds it before you trust your procedure on anybody else. A method that cannot find the print you know is there has not earned an opinion about the prints you are unsure of.

DO THIS

1. Under each reference print in EXHIBIT FP-2, write which of the three ridge patterns it is: arch, loop or whorl. Naming it is called classifying the print.
2. Do the same for the scene print, and write it in your table below.
3. Cross out every reference whose ridge pattern is different from the scene print. Record how many are left.
4. For each remaining reference, compare the three numbered minutiae to the scene print: same type, same position relative to the core.
5. Record the number of minutiae that agree, out of three, for each remaining reference.
6. Plot your agreement counts on the graph. Then answer the two questions in the green block.

EXHIBIT FP-1: the print lifted from the scene



Lifted from the surface named in your case pack.

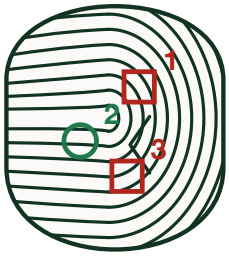
Its three minutiae are circled and numbered 1, 2, 3.

Circle = ridge ending. Square = bifurcation.

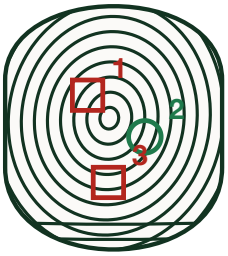
What this print can establish: that this finger touched that surface at some time. Not when. Not why.

Name the ridge pattern first. Then compare the three marks.

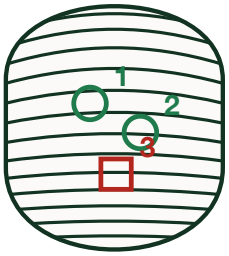
EXHIBIT FP-2: the five reference prints on file



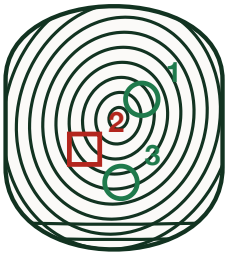
T. Cole
business partner
arch, loop or whorl? _____



R. Vasquez
rival studio owner
arch, loop or whorl? _____



D. Okoye
ex-bandmate
arch, loop or whorl? _____



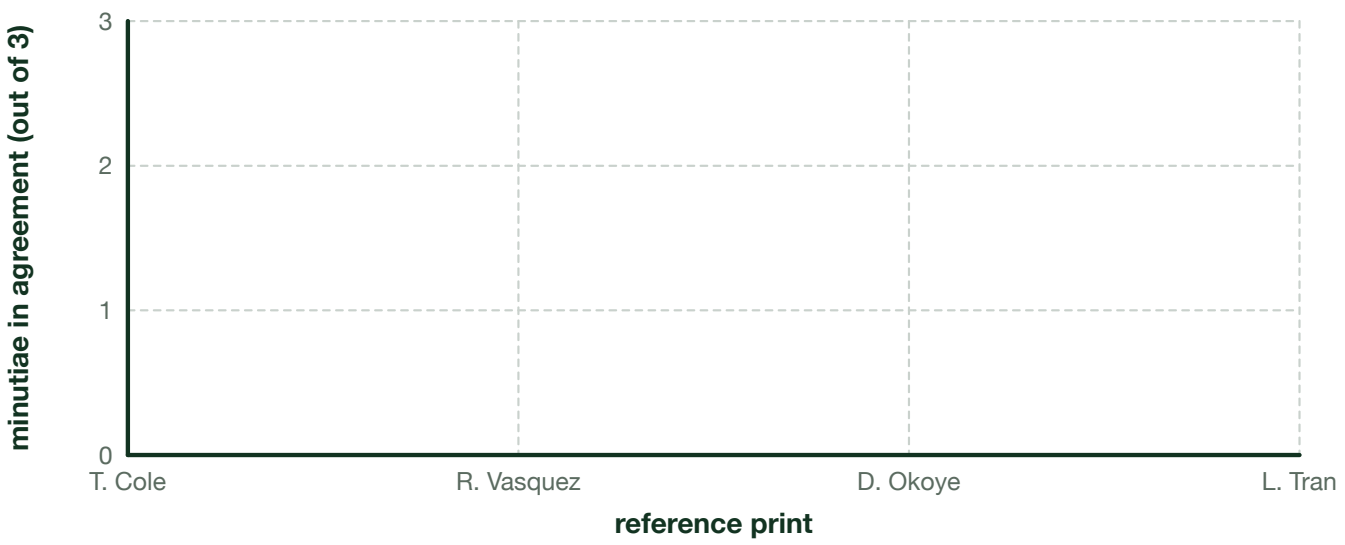
L. Tran
building owner
arch, loop or whorl? _____

Write arch, loop or whorl under each print. Then decide which of them the scene print could have come from.

The scene print and the four references. It does not supply a ridge pattern, a minutiae count, or a match. Those are the three things you produce.

MINI LAB 1 · RECORD YOUR COMPARISON

Reference print	**Ridge pattern** arch, loop or whorl	**Same pattern as the scene print?** yes / no	**Marks in agreement** out of 3
T. Cole			
R. Vasquez			
D. Okoye			
L. Tran			



Plot one bar per reference. It does not supply any bar height.

YOUR WORK · YOU COMPLETE THIS

Which reference print could the scene print have come from, and which step told you: naming the ridge pattern, or comparing the marks?

That person has a reason to have touched the front edge of the mixing console that has nothing to do with this death. Write it. Then write what the print does and does not prove.

SEC 03 Mini lab 2 · Serial dilution, the only wet lab today

20 min

WHY THIS MATTERS

A presumptive blood test can find blood that has been wiped, washed and painted over, at dilutions far below what an eye can see. That sensitivity is why investigators still swab a scene that looks clean, and the number you measure today is exactly the number that decides whether a faint pink result means anything at all.

READ THIS

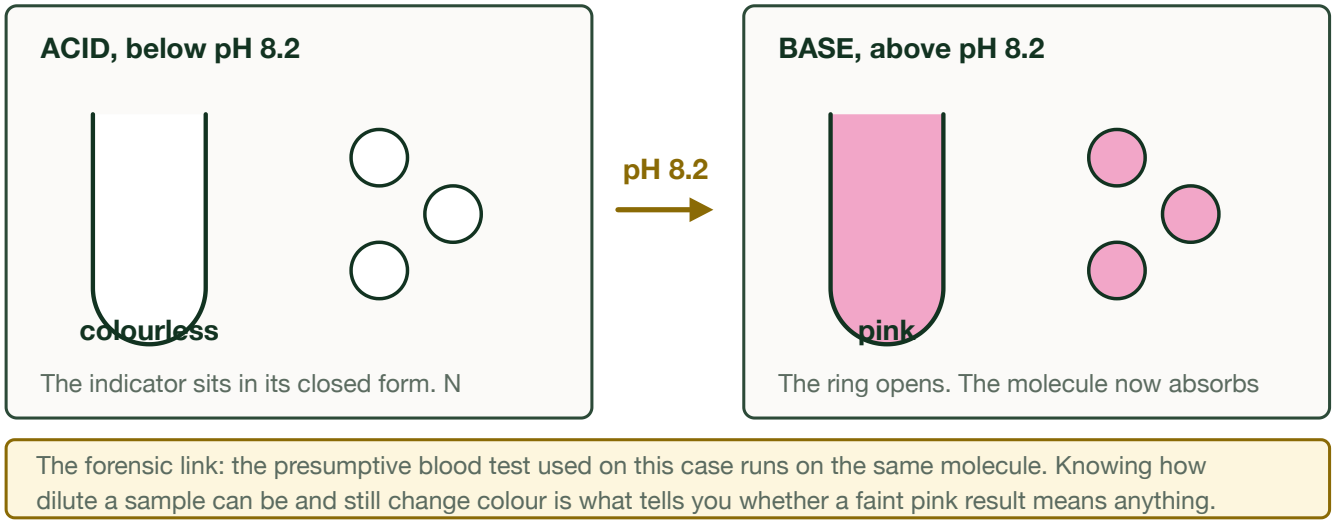
This is the only wet lab today. You are making a serial dilution of hydrochloric acid and using phenolphthalein, the same indicator molecule that sits inside the presumptive blood test used on this case, to find how far you can dilute something and still detect it.

A **serial dilution** is the same dilution done over and over. Each tube takes 1.0 mL from the tube before it into 9.0 mL of water, so each tube is one tenth the concentration of the one before it. Five tubes gets you from the stock down to one hundred thousandth of it, using nothing but a pipette.

SAFETY · READ BEFORE YOU TOUCH ANYTHING

- **Goggles on before the rack is in front of you.** Aprons on. Long hair tied back.
- 0.1 M hydrochloric acid and 0.1 M sodium hydroxide are both dilute, and both still burn eyes. Neither goes near a face.
- The phenolphthalein solution is made up in alcohol and is flammable. There is no flame at this station and none is permitted.
- Anything spilled on skin goes straight under the tap for a full minute, then you tell me. You do not clean it up first.
- Everything in the rack is rinsed into the labelled waste carboy, not the sink.

WHY THE COLOUR CHANGES, AND WHY THAT IS USEFUL TO AN INVESTIGATOR



The forensic link: the presumptive blood test used on this case runs on the same molecule. Knowing how dilute a sample can be and still change colour is what tells you whether a faint pink result means anything.

Why the colour changes. The indicator is colourless in acid and pink above pH 8.2. It does not supply the pH of any tube in your rack.

CONTROL GROUP · ALREADY SET UP FOR YOU

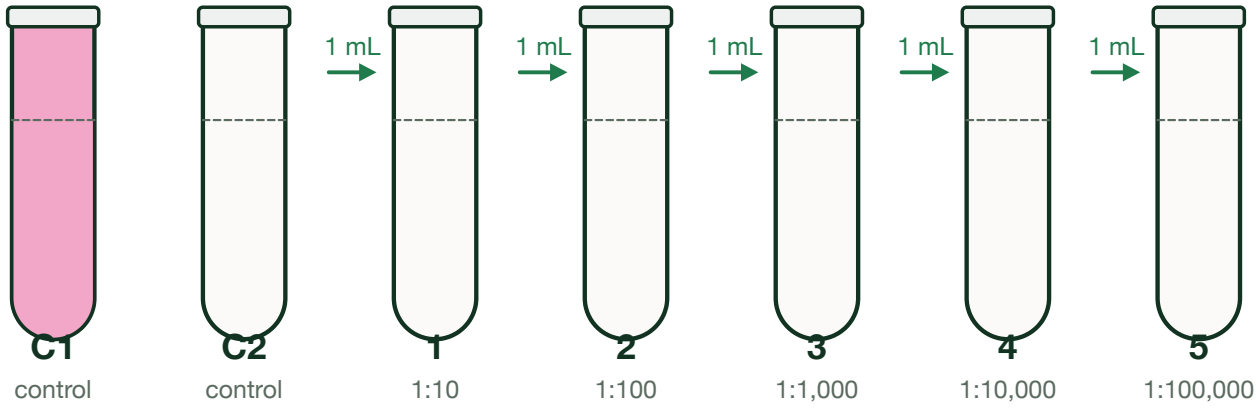
Two control tubes are already made up and already in your rack.

- **C1, base plus indicator, no acid.** Stays pink for the whole block. It proves the indicator in your rack is working. If C1 is not pink, your indicator is dead and every colourless tube you report is meaningless.
- **C2, distilled water plus indicator only.** Stays colourless. It proves that water and glassware alone do not produce a colour. If C2 turns pink, something in your glassware is contaminated and the run is void.

Check both before tube 1 and again at the end. Record both checks in the table.

SET-UP: the rack as it will be waiting at your station

Each tube already holds 9.0 mL of distilled water. You add 1.0 mL from the tube to its left, mix, and move on.



C1: base plus indicator, no acid added.
Stays pink. Shows the indicator works.

C2: distilled water plus indicator only.
Stays colourless. Shows water alone is not the cause.

The rack as it will be waiting. The two control tubes are drawn with their colours because a control is given to you. It does not supply the colour, the drop count or the concentration of any of the five dilution tubes.

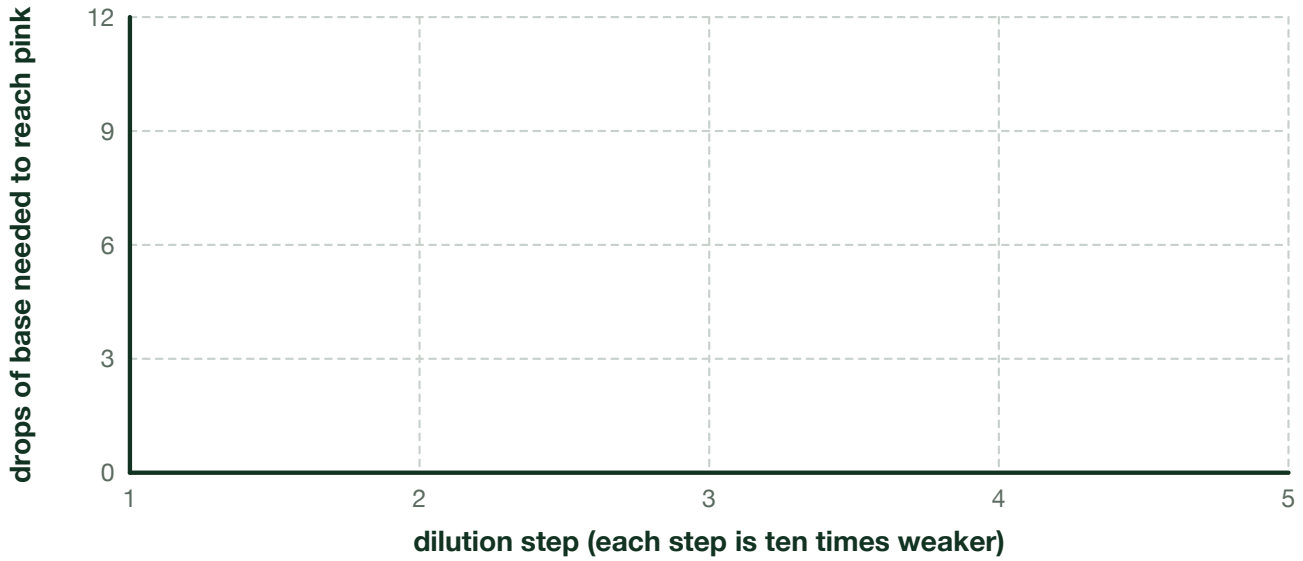
DO THIS

1. Check C1 is pink and C2 is colourless. Record both in the table. If either is wrong, stop and raise your hand.
2. Tube 1 already holds 9.0 mL of water. Add 1.0 mL of the stock acid. Cap and invert three times.
3. Move 1.0 mL from tube 1 into tube 2. Invert three times. Repeat down the row to tube 5, new tip each time.
4. Add two drops of phenolphthalein to every tube, 1 through 5.
5. Add 0.1 M sodium hydroxide to tube 1 one drop at a time, swirling after each drop, until the pink stays for a full five seconds. Record the number of drops.
6. Repeat step 5 for tubes 2, 3, 4 and 5. Record every drop count.
7. Re-check C1 and C2. Record. Then plot drops against dilution on the graph.

MINI LAB 2 · RECORD YOUR DILUTION SERIES

Tube	Dilution from stock factor	Concentration mol/L	Drops of base to reach pink drops	Colour before base pink / colourless
C1	**('control',)**	**('0.1 M base',)**	**('none needed',)**	
C2	**('control',)**	**('water only',)**	**('none needed',)**	
1	**('1:10',)**	**('0.010',)**		
2	**('1:100',)**	**('0.0010',)**		
3	**('1:1,000',)**	**('0.00010',)**		
4	**('1:10,000',)**	**('0.000010',)**		

5	('1:100,000',)	('0.0000010',)		



Plot one point per tube, then join them. The shape of the line is the answer, not any one point.

Plot drops against dilution step. It does not supply any point, the shape of the line, or the detection limit.

YOUR WORK · YOU COMPLETE THIS

Each step is ten times weaker than the one before. What happened to the drop count at each step, and does the pattern match that?

Which tube was the last one where you could still tell something was there? That is your detection limit. Write the tube and its concentration.

Exhibits E2-console and E2-floor gave a faint pink on the presumptive test, and the two controls on file, E2-ctrl-soda and E2-ctrl-rust, are there because both can also turn a presumptive test pink. Using your detection limit, write one sentence on what a faint pink does prove and one on what it does not.

SEC 04 Mini lab 3 · Gel electrophoresis of the scene swabs

15 min

WHY THIS MATTERS

DNA profiling has freed more than two hundred wrongly convicted people in the United States and has identified thousands of others. It does both jobs with the same property: fragments of different lengths travel different distances through a gel. Everything below is that one idea, used carefully.

READ THIS

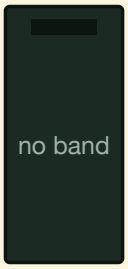
DNA is cut into fragments, loaded into wells at the top of a gel, and pulled through by an electric field. DNA carries a negative charge, so it travels toward the positive end. **Short fragments travel further than long ones**, because the gel is a mesh and small pieces slip through it faster.

Lane 1 is a **ladder**: fragments of known size, printed on the figure. You use the ladder to build a **standard curve**, and then read every unknown band off that curve. That is the whole method.

CONTROL GROUP · ALREADY SET UP FOR YOU

Two control lanes are already on your gel and they do two different jobs. Look at both before you read a single sample lane.

THE TWO CONTROL LANES, AND WHAT EACH ONE RULES OUT



NO-TEMPLATE CONTROL

Everything except DNA. If a band appears here, the reagents are contaminated and every lane is void.

POSITIVE CONTROL

DNA known to amplify at 800 bp. If nothing appears here, the run failed and an empty sample lane means nothing.

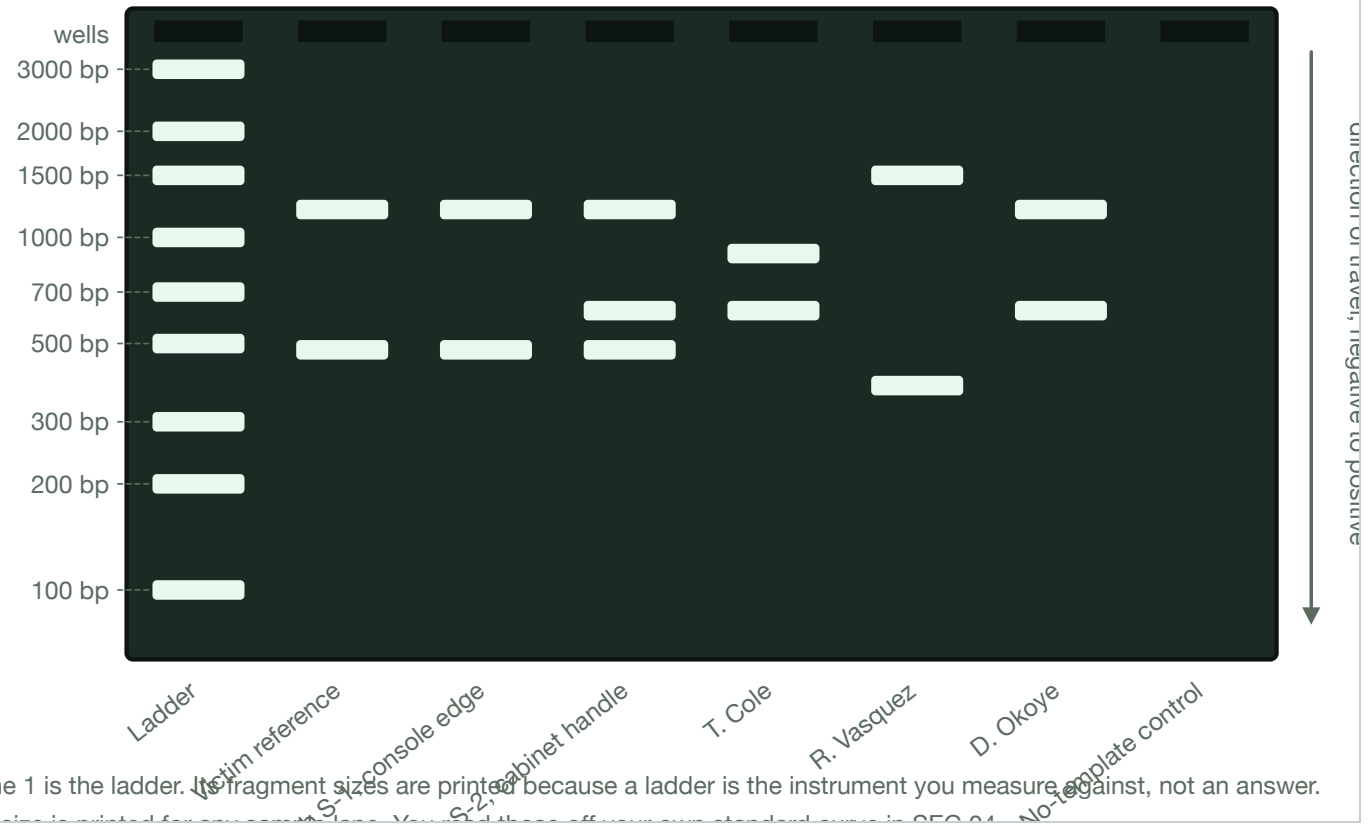
The two control lanes. It does not supply whether either control on your own gel passed; you check that yourself in step 1.

DO THIS

1. Check the no-template control lane is empty and the positive control shows its band. Record both. If either fails, the gel is void and you write that instead of results.
2. With a ruler, measure from the bottom of each well to the centre of each band, in millimetres. Record every distance.
3. Plot the ladder on the graph: distance travelled on the x axis, fragment size on the y axis. The y axis is already spaced by powers of ten.
4. Draw the best straight line you can through the ladder points. That line is your standard curve.
5. For each sample band, find its distance on the x axis, go up to your line, and read the size across. Record the sizes.

6 Compare the scene lanes to the reference lanes band by band, and fill in the green block.

EXHIBIT GEL-1: the evidence gel, as it came off the imager

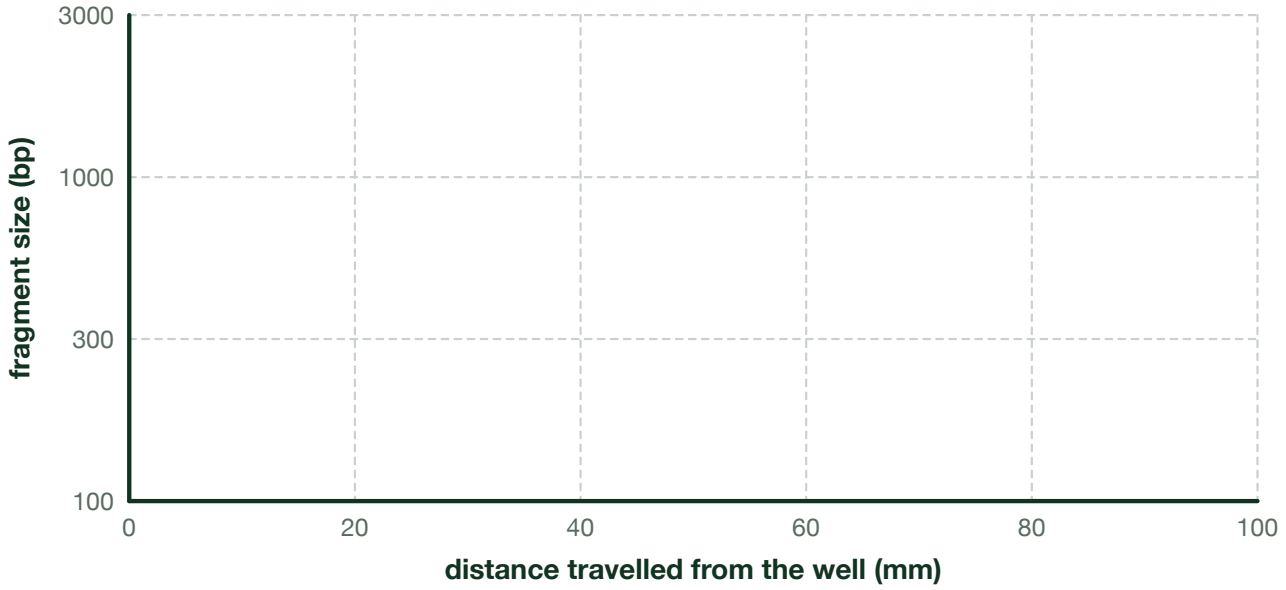


Lane 1 is the ladder. Its fragment sizes are printed because a ladder is the instrument you measure against, not an answer. No size is printed for any sample lane. You read those off your own standard curve in SEQ 04.

The evidence gel. Ladder sizes are printed because the ladder is the instrument. It does not supply the size of any sample band, and it does not mark any lane as a match.

MINI LAB 3 · READ YOUR GEL

Lane	**Distance to band 1** mm	**Distance to band 2** mm	**Size of band 1** bp	**Size of band 2** bp
Victim reference				
Scene swab S-1, console edge				
Scene swab S-2, cabinet handle				
T. Cole				
R. Vasquez				
D. Okoye				
No-template control				



Plot the nine ladder bands first, draw one straight line through them, then read your unknowns off it.

Build the standard curve here. It does not supply a single ladder point or the line.

YOUR WORK · YOU COMPLETE THIS

Do the two scene swabs share every band with the victim reference? Write which bands match and which do not.

One scene lane carries an extra band that the victim does not have. Which references also carry that band? Name every one of them.

You have one shared band and more than one person who carries it. Write the one sentence that says honestly what this gel can and cannot establish about who else touched that item.

SEC 05 Mini lab 4 · Bloodstain shape and angle of impact

12 min

WHY THIS MATTERS

Bloodstain pattern analysis answers a question no other evidence at a scene can: where in the room was the person when it happened, and how high off the floor. That single number, the height of the origin, is often the difference between a fall and a blow.

READ THIS

A drop that falls straight down lands round. A drop that arrives at a shallow angle lands stretched into a long ellipse, and it stretches in a predictable way. Measure the short axis and the long axis and the ratio gives you the angle it arrived at.

The four stains in EXHIBIT BS-1 were recorded on the front face of the mixing console and are drawn at the scale they were measured at, so your ruler works directly on the page.

CONTROL GROUP · ALREADY SET UP FOR YOU

Three control stains were dropped on purpose, from one fixed height, onto the same surface, at angles we set to 90, 60 and 30 degrees. Only the angle changed, so the angle is the independent variable and the shape of the stain is the dependent variable. Their measurements are printed for you. Check the formula against these three before you measure a single stain from the scene.

CONTROL SET: three drops released at angles we set on purpose

Same fluid, same height, same surface. Only the angle changed. Check the formula on these before you touch the evidence.

angle set: 90 deg

width: 26 mm
length: 26 mm
w / l = 1.00

sin of your angle should match w / l

angle set: 60 deg

width: 24 mm
length: 28 mm
w / l = 0.86

sin of your angle should match w / l

angle set: 30 deg

width: 16 mm
length: 32 mm
w / l = 0.50

sin of your angle should match w / l

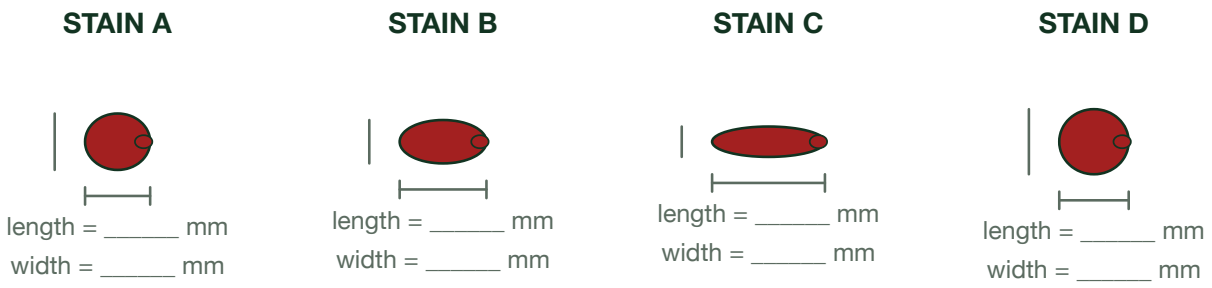
The control set. Widths and lengths are printed because a control is given. It does not supply the angle of any scene stain.

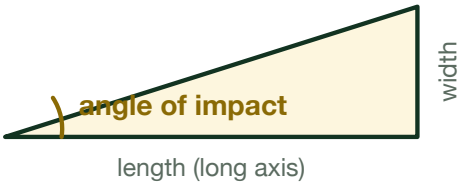
DO THIS

1. Measure the width and length of each control stain and check that width divided by length matches the sine of the angle we set. Use the sine table in the index.
2. Measure the width and the length of stains A, B, C and D with your ruler, in millimetres.
3. For each stain, divide width by length. Record the ratio to two decimal places.
4. Look each ratio up in the sine table in the index and record the angle of impact.
5. Plot ratio against angle on the graph so you can see the relationship, not just four numbers.
6. Answer the green block. The last question is the one your verdict rests on.

EXHIBIT BS-1: four stains from the scene, drawn at actual measured scale

Measure the width (the short axis) and the length (the long axis) of each stain with your ruler, in millimetres.





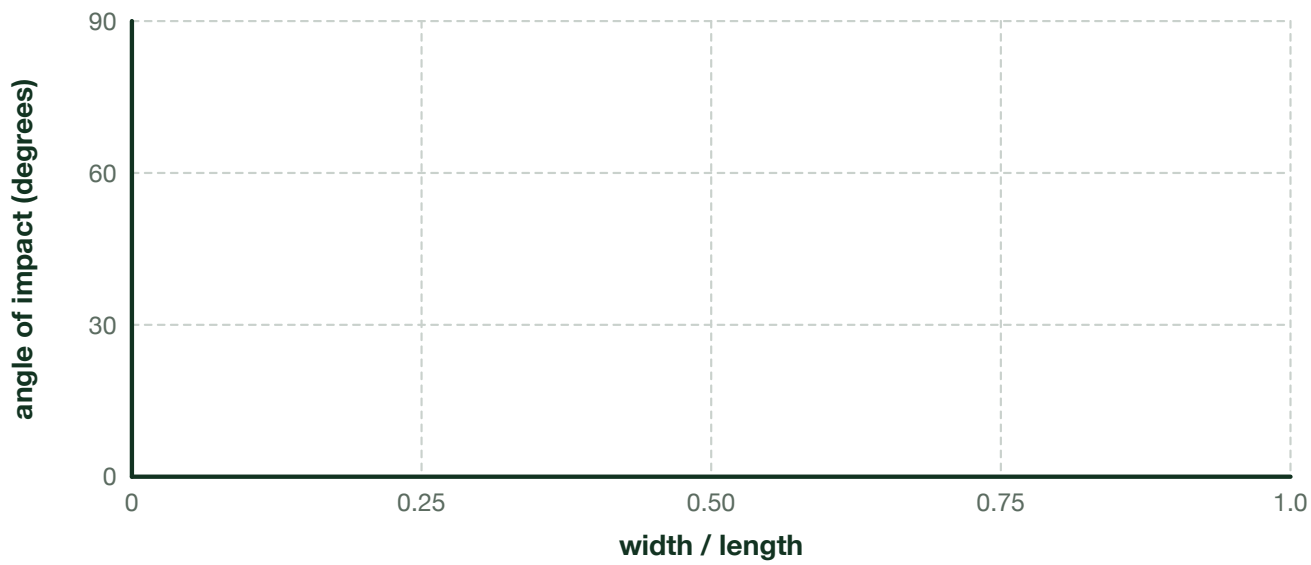
sin (angle of impact) = width / length

A round stain means the drop fell straight down, near 90 degrees. A long thin stain arrived at a shallow angle.

The four scene stains, drawn at measured scale. It does not supply a width, a length, a ratio or an angle for any of the four.

MINI LAB 4 · MEASURE THE STAINS

Stain	**Width** mm	**Length** mm	**Width / length** to 2 dp	**Angle of impact** degrees
Control 90				
Control 60				
Control 30				
A				
B				
C				
D				



Plot your three controls first. If they do not sit on a smooth curve, your measuring is off before the evidence is touc

Ratio against angle. It does not supply any point or the curve.

YOUR WORK · YOU COMPLETE THIS

Which stain arrived closest to straight down, and which arrived at the shallowest angle? Give the stain letter and its angle for each.

Your case pack records that these stains sit between 1.3 and 1.5 metres above the floor. Was the person upright or already on the floor when these stains were made? Answer, then give the measurement that made you say so.

Write the one thing this mini lab cannot tell you, no matter how carefully you measured.

SEC 06 Mini lab 5 · Force, fall height and injury

12 min

WHY THIS MATTERS

Emergency physicians and crash investigators use the same energy arithmetic you are about to use, because the human body responds to energy delivered, not to how frightening an object looks. An object that seems harmless can carry enough energy to break bone, and a heavy object that barely moved cannot.

READ THIS

The speaker cabinet at this scene ended up on the floor across part of the body. The question is whether it could have caused the fatal injury, and that is an arithmetic question before it is anything else.

An object held above the floor stores energy. When it falls, that stored energy is delivered on impact. **Energy equals mass times gravity times height.** Mass and height come from the case record. The multiplication is yours.

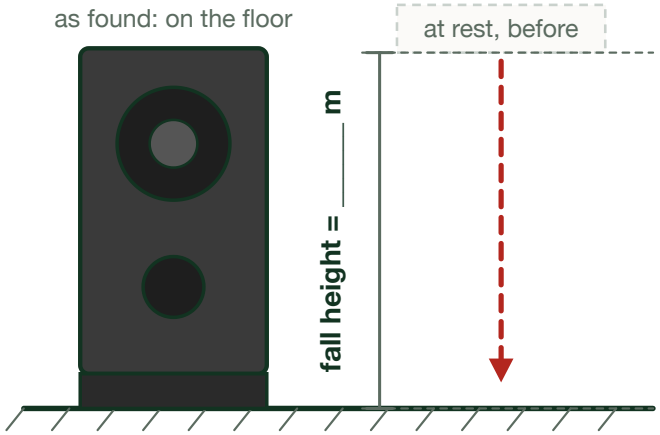
CONTROL GROUP · ALREADY SET UP FOR YOU

These two numbers are from the case record and are given to you. Do not estimate them and do not re-derive them.

- **Mass of the speaker cabinet:** 38.0 kg, weighed by the evidence unit.
- **Height it fell:** 1.10 m, measured at the scene from its mounting to the floor.
- **Gravity:** 9.8 m/s squared.

The reference band of published injury thresholds is also given. You place your own answer on it.

EXHIBIT FR-1: the speaker cabinet and the distance it fell



ENERGY AT THE MOMENT OF IMPACT

E = m x g x h

m = mass of the object, in kilograms
g = 9.8 metres per second squared
h = height it fell, in metres
E comes out in joules

Mass is printed in your case pack.
Height is yours to measure from the scene photograph scale. Both go in SEC 06.

What this exhibit can establish: how much energy the falling object carried. Not whether it fell on its own.
That second question is the one your whole case turns on, and it takes more than this one number to answer.

The speaker cabinet and its fall. It does not supply the energy; that is the calculation you do in the table below.

DO THIS

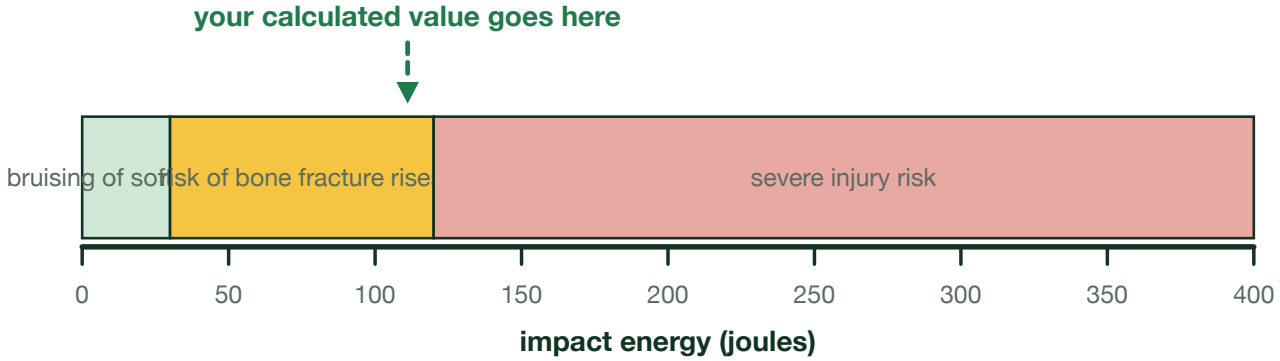
1. Write the mass and the height from the case record into the table.
2. Multiply mass by 9.8 by height. Write the answer in joules. Show the multiplication, not just the result.
3. Mark your answer on the reference band with an arrow.
4. Read across to the injury range your value lands in and write that range down.
5. Plot the energy that this object would carry from four different heights on the graph, so you can see how fast energy grows with height.
6. Answer the green block.

MINI LAB 5 · THE ENERGY ARITHMETIC

Quantity	Value	Unit
Mass of the speaker cabinet	**('38.0',)**	**('kg',)**
Gravity	**('9.8',)**	**('m/s squared',)**
Height of fall	**('1.10',)**	**('m',)**
Energy delivered (m x g x h)		**('joules',)**
Injury range this lands in		**('from the band',)**

REFERENCE BAND: published injury research, by energy range

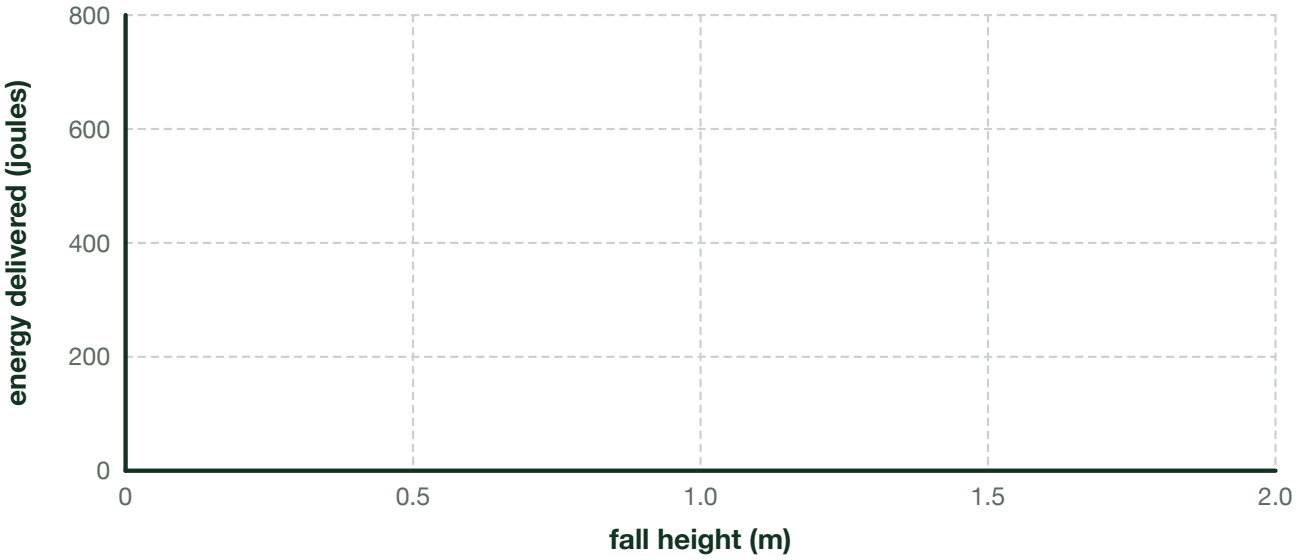
Given to you. You do not derive these. You place your own calculated value on the same scale and read across.



These ranges come from published biomechanics reviews and are printed in the index at the back of this packet.

A range is a risk, never a verdict: the same energy injures two people differently.

Published injury threshold bands. Given to you, with the sources in the index. It does not supply your calculated energy or where it lands.



Use the same mass for all four points. Change only the height. That makes height your independent variable.

Energy against fall height. It does not supply any point or the shape of the line.

YOUR WORK · YOU COMPLETE THIS

Write your energy value and the injury range it landed in.

Look at your graph. When you doubled the height, what happened to the energy? Write the relationship in one sentence.

Can this object have caused a fatal injury? Answer yes, no, or cannot tell from this alone, and give the number that decided it.

SEC 07 The verdict

6 min, finish at home if needed

WHY THIS MATTERS

A medical examiner has to put one word on a death certificate: natural, accident, suicide, homicide, or undetermined. Undetermined is a real and honest answer, and using it when the evidence has run out is a professional act, not a failure.

READ THIS

You now have five results. Put them together. The question this case has been asking since Day 1 is the one printed below.

DID THE SPEAKER CABINET CAUSE THE FATAL INJURY AS IT FELL, OR WAS THE INJURY ALREADY THERE WHEN THE CABINET CAME DOWN?

The rule for your verdict paragraph: at least four exhibits, drawn from at least three different evidence types, and every claim stops where the evidence stops. If two exhibits disagree, say so. A disagreement you name is worth more than a conclusion you force.

CONTROL GROUP · ALREADY SET UP FOR YOU

The claim ceilings for this case, unchanged since Day 1. Every one of them limits something you produced today.

- Classroom evidence supports a classroom finding. It cannot convict a real person.
- A fingerprint proves touch, not when and not why.
- One shared band is not a profile. It narrows a crowd. It does not name a person.
- A presumptive test says maybe. Only a confirmatory test says blood, and only DNA says whose.
- An injury range is a risk, not a verdict. The same energy injures two people differently.

YOUR VERDICT · YOU COMPLETE THIS · THIS IS THE GRADED PIECE

Fill the evidence line first. One row per exhibit you are going to use.

Exhibit	Evidence type	What it establishes	What it cannot establish

Your verdict, in one sentence. Accident, foul play, or undetermined.

_____

_____

Your reasoning. Name each exhibit as you use it. If two exhibits pull in different directions, say which and why you weighted one over the other.

The one test you would run next, and exactly what result would change your mind.

INDEX References, tables and sources

Sine table, for the bloodstain angles in SEC 05

width / length	angle of impact (degrees)
0.17	10
0.26	15
0.34	20
0.42	25
0.50	30
0.57	35
0.64	40
0.71	45
0.77	50
0.82	55
0.87	60
0.91	65
0.94	70
0.97	75
0.98	80
1.00	90

Round your ratio to the nearest value in the table.

Words used in this packet

- **Minutia** (plural minutiae): a point where a ridge stops or splits. Their relative positions are what identify a finger.
- **Serial dilution**: the same dilution repeated, so each step is a fixed fraction of the one before it.
- **Detection limit**: the weakest concentration a test can still find. Below it, a negative result means nothing.
- **Standard curve**: a line built from knowns, used to read unknowns.
- **Presumptive test**: a fast test that says maybe. A confirmatory test says yes.
- **Angle of impact**: the angle at which a drop met the surface, found from the shape it left.
- **Joule**: the unit of energy. One joule is roughly the energy of a small apple falling one metre.

Where the given numbers come from

- Injury threshold bands in SEC 06 are drawn from published biomechanics reviews of blunt impact tolerance. They are ranges of risk across a population, not thresholds for one person.

- The colour change point of phenolphthalein, pH 8.2, is the standard value for the indicator.
- Ladder fragment sizes in SEC 04 are the sizes printed by the supplier of a standard 100 bp ladder.
- Mass and fall height in SEC 06 are from the STATIC case record.

What this case is, and is not

STATIC (JH-26-0831-A) is a John Hay original teaching case written for this classroom. The scene, the persons of interest, the statements and every measurement in this packet were authored for instruction. No part of it is a real person, a real record, or a real death. Nothing produced in this packet can be used to make a claim about anyone outside this case.