MATH · ANALYSIS & APPROACHES SL

Paper 2
the calculator paper

A complete revision guide for the technology-permitted paper — how the GDC changes the game, a slot-by-slot forecast built from fifteen past sittings, the four topics that actually carry Paper 2, and the calculator-era traps that quietly cost marks.

90 minutes · 80 marks · GDC required · formula booklet provided

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Read §1 (how the calculator paper works) and §2 (the forecast) first — the forecast is built from your own Paper 1 topic split and is the sharpest part of this guide. Then §3 patterns, the four topic sections, and the trap list. All worked examples are original.

How Paper 2 Works — the Calculator Paper

You have already sat Paper 1. The mathematics being examined is the same syllabus, the structure on the page looks almost identical, and the grading contract is unchanged. But Paper 2 is not "Paper 1 with a calculator to make the arithmetic easier." It is a different paper with a different centre of gravity, and the way you lose marks on it is different too. Read this section before you touch a past paper. As with Paper 1, most of the recoverable marks live here — in how you use the machine and how you write down what the machine did — not in the topic content.

How Paper 2 differs from Paper 1

The surface facts first. Paper 2 is **90 minutes, 80 marks, calculator allowed**. A clean copy of the formula booklet is provided, exactly as in Paper 1. The structure is the same two-section shape:

- **Section A** — roughly six shorter questions, around 50 marks, escalating in difficulty from a gentle Q1.
- **Section B** — three extended-response questions of roughly 13–17 marks, around 30 marks, each a chain of subparts where later parts lean on earlier ones.

Paper 2 is 40% of your final SL grade, the same weight as Paper 1.

So what actually changes? Three things.

The questions lean into computation, modelling, and "set up then interpret." On Paper 1 the numbers are chosen to stay clean — the integral evaluates to something exact, the quadratic factorises, the angle is a recognisable fraction of π. On Paper 2 the numbers are deliberately *ugly*, because the examiner expects the calculator to absorb the ugliness. A Paper 2 question is rarely "can you execute this algorithm by hand." It is more often "can you translate this real situation into a mathematical object, hand that object to your GDC correctly, and then interpret what comes back." The mathematical work moves to the two ends — the setting up and the interpreting — and the calculator owns the middle.

The topic emphasis shifts. Some topics are almost native to Paper 2 because they are practically impossible without technology. Statistics with messy data sets, the normal distribution, binomial probabilities, linear regression and correlation, and financial mathematics (compound interest, annuities, amortisation, depreciation) overwhelmingly live on Paper 2. You can be asked about these on Paper 1 only in stripped-down forms; on Paper 2 they appear in full. Calculus, trigonometry, sequences and functions still appear, but in their Paper 2 form they tend to be modelling-flavoured — a function fitted to a context, a rate of change you evaluate numerically, an area you integrate as a definite integral rather than finding an antiderivative by hand.

Exact form mostly stops being the demand. On Paper 1, $\pi/6$ and $\sqrt{3}/2$ and $\ln 2$ were final answers. On Paper 2, unless a question explicitly says "exact," the expected answer is a decimal — and the default convention is **3 significant figures**. The discipline of carrying precision is still essential, but it now happens *inside the calculator's memory* rather than on the page as surds.

The GDC operations you must be fluent in

You do not have time on Paper 2 to *work out* how to make the calculator do something. The button sequences must be reflexes. Below is the categorised reference — what each operation is for, and the one-line sense of how you invoke it. Keystrokes differ between a Casio fx-CG50 and a TI-84/Nspire; the *operation* is identical, so learn the operation and know where it lives on your own machine.

Solving and graphing

- **Solve a single equation.** For any equation in one unknown — polynomial or not. On Casio this is `SolveN` (in Run-Matrix, OPTN → CALC → SolveN); on TI it is the equation solver or `solve(`. Type the whole equation, including the `= 0` or `= 6`, and read the root(s). You can restrict the domain by adding the variable and the interval, which both speeds it up and filters out unwanted solutions.
- **Solve simultaneous equations.** The Equation menu (Casio: Equation → Simultaneous; TI: a matrix solve or `PlySmlt2`). Choose the number of unknowns, type the coefficients, read the solution.
- **Roots of a polynomial.** The Polynomial mode (Casio: Equation → Polynomial) takes the degree and the coefficients and returns every root at once — faster than `SolveN` when you want *all* roots of a quadratic or cubic.
- **Find roots / zeros from a graph.** Plot the function, then use the graph-solve root tool (Casio: G-Solve → ROOT). This is the visual route to "where does this cross the x-axis."
- **Find the intersection of two graphs.** Plot both, then graph-solve for the intersection. Equivalent — and often cleaner — is to plot the *difference* of the two functions as a single graph and find its roots: `y = f(x) − g(x)`, then ROOT.
- **Read a function value, or solve f(x) = k graphically.** Plot the function and use the y-calculate / x-calculate tools (Casio: G-Solve → Y-CAL gives y from an x; X-CAL gives every x from a y). This is also how you read an inverse value, $f^{-1}(k)$, from a graph.

Calculus

- **Numeric derivative at a point.** The GDC will not give you f′(x) as a formula, but it will give you f′(a) as a number — the gradient at a specific point (Casio: the d/dx template in Run-Matrix, or the tangent tool in Graph). Use it for "find the gradient at x = ..." and "find the rate of change when ...".
- **Tangent and normal lines.** From a graph, the sketch tools (Casio: Sketch → Tangent / Normal) draw the line at a chosen x and report its equation directly.
- **Definite integral.** The ∫dx template (Casio: Run-Matrix OPTN → MATH → ∫dx, or Graph → G-Solve → ∫dx) evaluates a definite integral between two limits. This is your tool for area under a curve, displacement from velocity, total change from a rate.
- **Area between a curve and the axis, or between two curves.** Where the function dips below the axis, a plain integral and the *area* differ. Integrate the absolute value for true area, or split at the roots. The graph-solve integral/area tools handle this; know which one your machine gives you.
- **Maximum / minimum from a graph.** Plot the function and graph-solve for the turning points (Casio: G-Solve → MAX / MIN). This is the technology route to optimisation — the maximum volume, the minimum cost, the greatest height — without differentiating by hand.

Statistics and probability

- **One-variable statistics.** Enter the data in a list (with a frequency list alongside if the data is tabulated), then run 1-Var Stats (Casio: Statistics → CALC → 1-VAR). It returns the mean, the standard deviation, the quartiles Q1/median/Q3, the minimum and maximum — everything for a summary or a box plot in one step.
- **Linear regression.** Enter the x-values in one list and the y-values in another, then run the linear regression (Casio: Statistics → CALC → REG → X → ax+b). It returns the regression line y = ax + b and the correlation coefficient r. Use the line to predict, and r to comment on the strength of the relationship.
- **Normal distribution — probabilities.** The normal cumulative density function — `normalcdf` on TI, `Ncd` on Casio — gives P(a < X < b) from a lower bound, an upper bound, the mean μ and the standard deviation σ. For a one-sided tail, use a very large or very small number as the open bound (e.g. lower = -1×10^9).
- **Normal distribution — inverse.** `invNorm` on TI, `InvN` on Casio, goes the other way: given a probability (an area) and the tail (left, right, or central), and μ and σ, it returns the value of x that cuts off that area. This is the tool for "find the mark below which 35% of students scored" and for finding quartiles of a normal model.
- **Binomial distribution.** `binompdf` / `Bpd` gives P(X = x) — the probability of *exactly* x successes — from n, p and x. `binomcdf` / `Bcd` gives P over a *range*, from a lower to an upper value — which is how you get "at most," "at least," "fewer than," "more than" by choosing the range correctly.
- **The finance / TVM solver.** The time-value-of-money solver (Casio: Financial menu; TI: Finance → TVM Solver) handles compound interest, loan repayments, annuities, depreciation and savings plans. You enter the values you know — N (number of periods), I% (interest rate), PV (present value), PMT (payment per period), FV (future value), P/Y and C/Y (compounding frequency) — leave the unknown blank, and solve for it. The sign convention matters: money coming *to* you and money going *from* you carry opposite signs.

You should be able to invoke every one of these without thinking. If any of them still requires you to hunt through menus, that is the single most valuable hour of practice left to you before the exam.

The cardinal rule: show your setup

This is the single most important sentence in this guide, so it gets its own section.

On a calculator paper, the method mark is earned by the visible setup — not by the calculator's output.

Think about what the examiner can and cannot see. They cannot see your calculator screen. They cannot see which menu you opened or what you typed into it. All they have is what is written on your page. So if your page says only

> *x = 4.73*

then, as far as the mark scheme is concerned, no method has been shown — even if your answer is perfectly correct. A bare answer on Paper 2 routinely scores **1 out of 3, or 1 out of 4, or zero**, because the M mark has nothing to attach to, and the A marks that were *gated behind that M* fall with it. A correct number with no setup is one of the most expensive mistakes you can make on this paper, precisely because it feels safe — you got the right answer, so what is there to worry about?

What "showing your setup" actually means, concretely:

- **Solving an equation:** write the equation you solved. `3x² − 5x + 1 = 2ˣ` then `x = …`. The written equation is the M; the value is the A.
- **A definite integral:** write the integral with its limits and integrand before the answer. `∫₁⁴ (2x + 3) dx = …`. The typed integral, reproduced on paper, is the method.
- **Normal distribution:** write `normalcdf` (or `Ncd`) with its arguments *named or shown* — `P(X < 180) where X ~ N(200, 15²)` or `normalcdf(−1E9, 180, 200, 15)`. The named distribution and bounds are the M.
- **Binomial:** write `X ~ B(12, 0.3)` and the probability statement `P(X ≥ 5)` before the number. Naming the distribution is the method mark.
- **Regression:** write the regression line `y = 8.8x + 33` before you use it to predict. The line itself is your evidence.
- **A maximum from a graph:** state the function and that you are finding its maximum, then give the coordinates. "Maximum of V(x) at x = …" — the named operation is the method.
- **Finance:** write down the values you put into the TVM solver — N, I%, PV, PMT, FV — before the result. Those entries *are* the method.

The principle is identical to Paper 1's "announce every method," but the stakes are higher because the temptation is stronger. On Paper 1 you had to show working anyway — you could not get the number without it. On Paper 2 the calculator hands you the number for free, and the only thing standing between you and full marks is the discipline to write down what you asked it. Write the question you typed into the machine. Every time. It is the cheapest, highest-yield habit on the entire paper.

The Paper-2-specific habits

These are the things that go wrong on a calculator paper specifically — the failure modes that did not exist on Paper 1.

Check the angle mode before anything trig. Your calculator is in either *radians* or *degrees*, and it does not warn you which. An AA SL paper works in radians unless a question is explicitly in degrees, and a model set up in radians will return quiet nonsense if the machine is in degree mode. The fix is a five-second reflex: before any question involving sin, cos, tan, or their inverses, glance at the mode indicator and confirm it. Do it at the start of the paper, and again any time a trig answer looks wrong.

Store intermediate values; carry full precision; round only the final answer. When a question has parts, and part (b) uses a value from part (a), do not write down a 3-significant-figure version of (a) and then re-type that rounded number into (b). Use your calculator's memory — store the result in a variable (A, B, x, …) and recall it in full precision for the next part. Premature rounding contaminates the later answer, and the mark scheme withholds the *later* accuracy mark with a note like "rounded value used in subsequent working." The page should still *show* a 3 s.f. version of the intermediate answer for the reader; the calculator should still *hold* every digit.

Default accuracy is 3 significant figures. Unless the question says otherwise — "give your answer correct to 2 decimal places," "find the exact value" — every numerical final answer should be given to 3 significant figures. Money is the common exception where context dictates 2 decimal places. Giving 3 s.f. is not optional politeness; an over- or under-rounded final answer loses the accuracy mark.

"From the graph" / "using technology" means a clean GDC read beats a failed algebraic attempt. When a question says "use your graphic display calculator" or "from the graph," it is *inviting* you to use the machine, and a confident, well-labelled calculator answer is exactly what is wanted. Do not try to be clever and do it algebraically — if your algebra stalls, you have spent time and produced nothing. The reverse is also true: even when a question does *not* say "use technology," on Paper 2 the GDC is almost always the intended route. If you find yourself doing heavy algebra on Paper 2, pause — there is probably a calculator operation you have forgotten.

"Show that" and "hence" still demand written work, even with a calculator. A calculator does not excuse you from a derivation. "Show that" questions on Paper 2 work exactly as on Paper 1: a forward, step-by-step argument from premise to the given conclusion, every step visible, no working backwards. The calculator can *check* your answer, but it cannot *be* your answer. And "hence" is still binding — you must use the previous part's result; an independent calculator method does not earn the marks. Treat these parts as if no calculator existed.

Sketches from the GDC must still be labelled with values. "Sketch the graph" does not become "copy the calculator screen." A sketch still needs its qualitative features marked with their *values*: every intercept with coordinates, every asymptote drawn dashed and labelled with its equation, every turning point indicated. The calculator gives you those values cleanly — read them off with the graph-solve tools — but you must transfer them onto your sketch. An unlabelled curve, however accurate its shape, earns almost none of the marks.

Mark-scheme grammar on a calculator paper

The grading contract is the same five letters you learned for Paper 1. Here is the quick recap, with the calculator-paper twist on each.

- **M — method mark.** Rewards a correct *approach*. On Paper 2, the M is most often awarded for "correct setup seen" or "their values substituted" — the integral you typed, the equation you solved, the distribution you named, the TVM entries you listed. The setup *is* the method. A method that happened only inside the calculator is, for marking, no method.
- **A — accuracy mark.** Rewards a correct result, in the form asked for (3 s.f. by default). On Paper 2 you will often see "**A1 from GDC**" or "A1 from technology" in the scheme — this explicitly confirms that the calculator-produced number is acceptable. But the A is still usually *gated* by the M above it: no visible setup, no method mark, and the accuracy mark can fall with it.
- **R — reasoning mark.** Rewards an explicit justification in words. "Since r = 0.975, there is a strong positive correlation." "The model predicts a negative value, which is not physically meaningful." Interpretation parts on Paper 2 — commenting on a correlation coefficient, judging whether a

prediction is reliable, explaining what a parameter means in context — are pure R marks. The conclusion feels obvious; write the sentence anyway.

- **FT — follow-through.** If you make an error early and propagate it correctly, the later marks are still available — *but only if the working is visible*. On Paper 2 this means: show the intermediate values you fed into the next part. No visible values, no follow-through.
- **AG — answer given.** The answer is printed; you must derive it. Every step visible, forward only, the AG line itself unmarked. A calculator does not change any of this.
- **OE / AEF — or equivalent.** A different-but-equivalent form still earns the mark. When self-marking, check equivalence before docking yourself.

The implication is unchanged from Paper 1, just sharper: a student who shows a full setup and misreads one digit out-scores a student who writes a bare correct number. The IB grades mathematical understanding, and on Paper 2 the *only evidence of your understanding* is the setup you wrote down.

The keystone habits for Paper 2

Drill these until they are automatic. They are the Paper 2 analogue of the Paper 1 six habits — not knowledge, reflexes.

1. **Write down what you typed into the calculator.** The equation you solved, the integral with its limits, the distribution named with its parameters, the TVM entries. This single habit protects the M mark — and the A behind it — on almost every question.
2. **Check the angle mode before any trigonometry.** Radians unless told otherwise. A five-second glance at the mode indicator at the start of the paper, and again whenever a trig answer looks wrong.
3. **Store intermediate results in calculator memory and recall them at full precision.** Never re-type a rounded number into the next part. Show 3 s.f. on the page; carry every digit in the machine.
4. **Round only the final answer, to 3 significant figures unless told otherwise.** Watch for money (2 decimal places) and explicit instructions ("exact form," "to 4 s.f.").
5. **When the question invites technology, use it confidently — and when it says "show that" or "hence," do the written work anyway.** Match the route to the command term. A clean GDC read beats a stalled algebraic attempt; a "show that" still demands a forward derivation.
6. **Name the distribution, label the sketch, state the interpretation.** `X ~ N(μ, σ²)` or `X ~ B(n, p)` before any probability; intercepts, asymptotes and turning points marked with values on any sketch; a sentence of reasoning on any "comment," "interpret," or "explain" part.
7. **In Section B, attempt every part (a) and (b) before any part (d) or (e).** Mark-mass is front-loaded — roughly 60% of a chain's marks live in its first half. Skipping openers to "save time for the hard bits" trades easy marks for hard ones.

Exam-morning and pacing

The pace is **1.125 minutes per mark**, the same as Paper 1 — 80 marks in 90 minutes. Section A is mark-rich and the questions are short; move briskly, but not so fast that you skip writing down your setups. The time sinks are the **Section B closers** — the extended modelling questions, the optimisation-and-interpretation chains, the multi-part statistics problems. Budget extra for them, and remember the hardest question on the paper is almost always the last one.

A practical pacing note specific to Paper 2: the calculator can swallow whole minutes if you let it. If an operation is not working — the solver returns nothing, the graph window is wrong, the regression looks absurd — do not sit there fighting it. Note where you are, move on, and come back. A single jammed calculator step is not worth four minutes of a 90-minute paper.

On the morning of the exam:

- **Check your calculator the night before, not on the way in.** Fresh batteries or a full charge. Memory cleared if your school requires it. Mode set to radians. Know that it works and you will not think about it again.
- **Re-read your seven habits aloud.** Especially the first one: *write down what you typed in.* That is the habit that will save you the most marks tomorrow.
- **Skim the GDC operations list.** Not to learn anything new — there is no time to learn anything new — but to refresh *where* each operation lives on your machine, so the first one you reach for in the exam is instant.
- **Re-read one worked Paper 2 question you have already done.** Recognition, not learning. See the shape of a good solution one more time.
- **Then stop.** Eat normally. Sleep was the study technique last night; this morning is for arriving calm and early. No fresh timed papers — a paper that goes badly an hour before the exam only spikes anxiety, and there is nothing new left to consolidate.

The deepest finding about Paper 2 is the same boring truth as Paper 1: there is no trick. The calculator does not make the paper easier; it moves the difficulty to the setting-up and the interpreting, and it adds a whole new category of marks you can lose by *not writing down what the machine did for you*. The student who treats the GDC as a tool whose every use must be documented will out-score the faster student who treats it as a black box that produces answers. Show your setup. Everything else is bookkeeping.

Paper 2 — The Definitive Forecast

This supersedes the earlier draft forecast. It was rebuilt after a methodology audit and a rigorous re-analysis. It is deliberately honest about what the data can and cannot tell us — an over-confident forecast is worse than a calibrated one.

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1. What was done, and what the audit changed

The pipeline: 15 past Paper 2 papers read question-by-question; 5 independent prediction models; 14 past Paper 1 papers read for matched roll-ups; a definitive file-code mapping built to fix labelling errors; a methodology audit; and a clean P1↔P2 correlation study.

The audit found the original "sharpened" forecast was not trustworthy. Its appealing headline — *"your Paper 1 was Functions-heavy and Number-&-Algebra-empty, so Paper 2 must do the reverse"* — rested on a "within-sitting compensation" hypothesis that, when tested properly, **does not hold**. Three things were wrong with the first attempt: the paper labels were confounded (filenames disagree with cover pages), the sample is tiny, and five "independent" models were really one base rate seen five times.

So this forecast does two honest things: (1) it **leads with the P2 base rate**, which *is* solid and well-evidenced; (2) it reports the pairing study truthfully — including that it came back **inconclusive**.

2. The pairing study — tested properly, and it does not hold

Using the verified file-code mapping, **14 clean same-session, same-time-zone (Paper 1, Paper 2) pairs** were assembled, each normalised to 80 marks. Two tests:

Test 1 — per-topic correlation. If "compensation" were real, a topic heavy on Paper 1 would be light on Paper 2 — a *negative* correlation.

Topic	r(P1, P2)	95% confidence interval	Verdict
Number & Algebra	−0.23	[−0.68, +0.34]	inconclusive — CI straddles 0
Functions	**+0.32**	[−0.26, +0.73]	inconclusive, and *positive*-leaning
Geometry & Trig	−0.18	[−0.65, +0.39]	inconclusive
Statistics & Prob	−0.10	[−0.60, +0.46]	inconclusive
Calculus	−0.39	[−0.76, +0.18]	inconclusive

Every confidence interval straddles zero. At n = 14 the data simply cannot distinguish "compensation" from "no effect" from "the opposite." Functions even leans *positive* (heavy P1 → heavy P2, not light).

Test 2 — is there a fixed "pair budget"? Compensation needs P1+P2 to sum to a stable per-topic total. It doesn't: across the 14 sittings, the P1+P2 Functions total ranged from **12.5 to 51 marks**. There is no fixed budget being topped up.

Conclusion: the within-sitting compensation effect is not supported by the evidence. It is an appealing story, but the IB does not visibly build Paper 2 as a counterweight to Paper 1. **Your Paper 1 topic split is therefore, at most, a very weak tie-breaker — not the basis of this forecast.**

3. The forecast — the Paper 2 base rate

This is what Paper 2 reliably looks like, measured across the 15 Paper 2 papers — **re-derived from question-level data in a methodology re-audit so every paper reconciles to exactly 80 marks** (the original draft used source roll-ups that under-counted, mostly Calculus). Bands are honest: they reflect the real spread, they are not tightened by a model.

Topic	Central estimate	Likely band	What it means
Statistics & Probability	**~23 marks**	18–33	Co-dominant. Almost certainly owns a Section B chain.
Calculus	**~23 marks**	13–34	Co-dominant (a re-audit correction — it was under-counted before). Kinematics + woven through the modelling chains.
Geometry & Trigonometry	~16 marks	8–27	Triangles, 3-D, sectors, sinusoidal models.
Number & Algebra	~9 marks	3–19	Binomial expansion near-certain; finance *possible*.
Functions	~8 marks	0–17	Structurally marginal — usually embedded, rarely standalone.

The honest headline: Statistics and Calculus **co-dominate** (~23 marks each), Geometry & Trig is solid, Functions is thin. That is true of essentially every Paper 2 and it does not depend on your Paper 1 at all. *(An earlier draft of this guide put Statistics clearly first and Calculus second — a data-integrity error caught and corrected in the re-audit. See "How this forecast was built" for the full account.)*

On Number & Algebra specifically — the earlier forecast called this "back and bigger than usual," driven by compensation. The data does not support that. NA sits at its normal ~10 marks. Binomial expansion is genuinely likely (it appears on ~7/15 papers as a Section A question regardless). A *finance* question is **possible but not probable** — finance appeared as a substantial question in only ~3 of 15 papers. Treat finance as "worth a refresher, not a priority."

4. Section A — the recurring six

Section A is stable. These genres fill the six short slots; frequency is out of 15 papers (this *is* calibrated — it is corpus frequency):

Genre	Frequency	≈ probability	Marks
Normal distribution (normalcdf / invNorm)	13/15	~85%	4–8
Linear regression (line, r, predict)	11/15	~73%	4–7
Kinematics (velocity model → times, distance)	9/15	~60%	6–7
Binomial expansion (coefficient / solve for k)	7/15	~47%	4–7
Triangle / sine-cosine rule (often bearings)	7/15	~47%	5–6
Sector / circle geometry	7/15	~47%	5–6
Discrete probability distribution (find k, E(X))	6/15	~40%	5–6
3-D geometry · box plot · calculus warm-up	~5/15 each	~33%	4–7

A normal-distribution question, a regression question and a kinematics question are very nearly guaranteed to be three of your six.

5. Section B — the three chains

Every Section B question fits one of these templates. Frequency out of 15:

Template	Freq	Drillable shape
A · Statistics chain	~8/15	Normal + binomial; recover μ or σ by invNorm (often a two-equation solve); conditional-probability finish.
D · Sinusoidal / kinematics chain	~7/15	Periodic or motion model; period & events; rate via derivative; distance via definite integral.
C · Geometry / optimisation chain	~5/15	Composite-solid surface-area or volume; derive expression (often "show that"); minimise on the GDC.
B · "Compare the models" chain	~3/15	Exponential vs logistic; evaluate; interpret a parameter; verbal "which is better". Rising in recent papers.
E · Finance chain	~3/15	Salary/savings series → geometric sum → compound interest → solve for n or rate.
F · Function-exploration chain	~3/15	Inverse, asymptotes, intersections, area between. Rarest on P2.

Most likely three: one **Statistics chain** + one **sinusoidal/kinematics chain** + one rotating third (geometry-optimisation, or — less likely — finance or compare-the-models).

Who owns the hardest closer (Q9)? This is **genuinely unresolved.** Historically the Statistics chain owned it; the two most recent papers handed it to Calculus/kinematics. The models split here and the data cannot break the tie. **Prepare for either** — a Statistics closer *or* a kinematics/modelling closer.

6. The single most-likely paper — slot by slot

A best-guess paper, with the internal consistency a real paper has. Treat it as a prior, not a script.

Q	Section	Most likely	Marks	Confidence
1	A	Linear regression — line, r, predict	4–6	corpus freq ~73%
2	A	Triangle / 3-D — sine & cosine rule	5–7	judgement, moderate
3	A	Binomial expansion — coefficient / solve for k	4–5	corpus freq ~47%
4	A	Discrete probability distribution + E(X)	5–6	corpus freq ~40%, but stable slot
5	A	Kinematics — at rest, distance via ∫\	v\	dt
6	A	Normal distribution — tail prob + invNorm	6–8	corpus freq ~85%
7	B	Geometry / optimisation OR function+calculus chain	13–15	judgement, moderate
8	B	Sinusoidal / "compare the models" modelling chain	14–16	judgement, moderate
9	B	**Statistics chain OR kinematics closer — unresolved**	16–18	genuinely split

7. What your Paper 1 actually tells us

Your reported Paper 1 TZ2 split — roughly 4 Functions, 2 Stats, 2 Geometry/Trig, 1–2 Calculus, ~0 Number & Algebra — was the intended basis for "sharpening" this forecast. Honestly: **it barely moves the needle.**

- The data shows no reliable P1→P2 compensation (Section 2).
- Even if there *were* a weak effect, it would point: a bit less Functions on P2, a bit more NA. But Functions is *already* near its floor on every P2 (~7 marks), so "even less" is a non-change. And "more NA" is exactly the call the correlation specifically fails to support.
- **Sensitivity check:** your P1 split is a *recollection*, converted to marks by estimate. We tested three versions of it (as recalled; Functions over-recalled; one "Functions" question really Functions+Calculus). None changes the forecast above — because the forecast no longer leans on it.

So: your Paper 1 is reassuring context, not a predictive lever. The forecast stands on the 14-paper base rate.

8. Anti-predictions — what is unlikely

- **A standalone Functions question** (inverse / asymptotes / composite as a whole question). Functions is the marginal P2 topic; expect it embedded in a modelling chain if at all.
- **A by-hand algebra question.** Every P2 question needs the GDC.
- **Exact-form answers as the norm.** P2 answers are decimals to 3 s.f. unless a question explicitly says "exact".
- **A trig-identity proof.** That is a Paper 1 genre.

- **Number & Algebra "bigger than usual."** The earlier forecast claimed this; the data rejects it. NA sits at its normal ~10 marks.

9. The GDC-skill checklist — possibly your biggest lever

The single most robust finding across every paper: **the GDC is load-bearing on every question.** Being fluent in these operations may matter more than which topic is 13 vs 18 marks. Make sure you can do each *cold*:

- **invNorm** — including the two-equation setup to recover μ or σ from two probabilities
- **normalcdf** — tail and between-bounds probabilities
- **binompdf / binomcdf** — "exactly", "at least", "at most"
- **Linear regression** — getting the line and r, predicting, regressing the *right* variable
- **Numeric definite integral** — area, displacement, total change from a rate
- **Equation solver & intersection finder** — including restricting the domain
- **Max / min from a graph** — the optimisation route
- **Finance / TVM solver** — N, I%, PV, PMT, FV, P/Y, C/Y, sign conventions

10. Tonight — priority order

1. **The Statistics Section B chain** — normal + binomial, invNorm parameter recovery, conditional probability. Highest marks, hardest marks, near-certain.
2. **Normal distribution & regression Section A technique** — these two are ~85% and ~73% to appear.
3. **Section A kinematics** — velocity model → times at rest → distance via ∫|v| dt. ~60%, and quick to bank.
4. **GDC fluency** (Section 9) — drill the operations until they're reflexes.
5. **A light pass over geometry** — sine/cosine rule, sectors, 3-D — and a *refresher* (not a deep dive) on the finance solver and binomial expansion.

Functions does not make the list — not because of your Paper 1, but because it is structurally thin on every Paper 2.

Honesty note: the corpus is 14–15 papers; corpus-frequency percentages (Sections 4–5) are calibrated, the Section B and slot-level calls (Sections 5–6) are qualitative judgement. The forecast is a well-grounded prior, not a leaked paper. Its real value is telling you where to spend tonight — and that answer is robust.

What the Papers Show — Paper 2 Patterns

*Built from a question-by-question reading of fifteen Paper 2 sittings (May 2022 through November 2025, both time zones where supplied, plus November TZ3 papers). Every paper and its mark scheme was read; the genre map below is what survives aggregation. Topic codes: **NA** = Number & Algebra, **F** = Functions, **GT** = Geometry & Trigonometry, **SP** = Statistics & Probability, **C** = Calculus.*

1. The shape of the paper

Paper 2 is structurally identical to Paper 1 — **90 minutes, 80 marks, Section A (six short questions, ~40 marks, 4–8 marks each), Section B (three extended questions, Q7–Q9, ~40 marks, 12–18 marks each)** — with one difference that changes everything: **the calculator is allowed, and it is load-bearing on every single question.** Across fifteen papers there was not one question that could be completed start-to-finish without a GDC. Even the questions that open like algebra ("integrate this", "expand this") resolve into something the calculator checks or finishes.

The hardest question is almost always the closer — **Q9 in roughly three papers out of four, Q8 in the rest**. The 17–18 mark question, when a paper has one, is the synthetic peak.

2. Topic distribution — averaged across fifteen papers

Multi-topic questions split proportionally. Figures normalised to 80 marks:

Topic	Avg marks/paper	Share	On Paper 1, for contrast
Statistics & Probability	~24	**30%**	usually the *lightest* topic (~6–15m)
Calculus	~20	25%	the heavyweight (~22–30m)
Geometry & Trigonometry	~17	21%	~7–15m
Number & Algebra	~10	13%	~14–30m
Functions	~8	10%	a must-know genre, 5–6 of 6 papers

The single biggest structural fact about Paper 2: the topic hierarchy inverts. On Paper 1 calculus dominates and functions is a reliable big-mark genre. On Paper 2, **Statistics & Probability dominates** — it is the heaviest topic on almost every paper and owns the hardest Section B closer more often than any other topic — and **Functions is structurally marginalised**, rarely exceeding 6–8 marks and occasionally absent as a standalone topic entirely (it appeared for 0 marks on two of the fifteen papers).

The reason is mechanical: normal distribution, regression, binomial probability and financial maths are *barely doable without a calculator*, so the IB parks them on Paper 2. Functions, being the most algebra-and-sketch topic, migrates the other way to Paper 1.

Time-zone 2 specifically

The student sits **TZ2**. Restricting to the five TZ2 papers in the corpus (May 2025, May 2024, Nov 2023, May 2023, May 2022), the tilt is even sharper: **SP averages ~26 marks, Functions averages ~5.** TZ2 leans harder into statistics and harder away from functions than the overall average. The TZ1/TZ2 pairing matters here — the structural agents found Nov 2023 TZ1 and TZ2 to be near-identical twins, confirming the IB builds the two time zones of a sitting from one structural template. **The TZ2 papers in this corpus are reliable templates for what the student will see.**

3. Section A — the recurring six

Section A is remarkably stable. Across fifteen papers, the same handful of genres fill the six short slots. Frequency out of fifteen:

Section A genre	Frequency	Marks	What it is
Linear regression — find the line, find r, predict	~11/15	4–7	regression mode on the GDC; pick the right line (y-on-x), interpret r, substitute to predict
Normal distribution — cdf and/or invNorm	~13/15	4–8	normalcdf for a probability; invNorm for a cut-off; sometimes recover μ or σ
Kinematics — velocity model, times, distance	~9/15	6–7	given v(t); find times at rest / direction change; total distance via ∫\
Binomial expansion — find a coefficient / solve for k	~7/15	4–7	the one genuinely Paper-1-flavoured question; the GDC just checks it
Triangle / sine & cosine rule — often with bearings	~7/15	5–6	messy-number triangle; the calculator does the arithmetic
Sector / circle geometry	~7/15	5–6	arc, sector, segment; solve for r or θ from a condition
Discrete probability distribution — find k, find E(X)	~6/15	5–6	Σp = 1 to find the unknown; then expected value
3-D geometry — distance, angle between line and plane	~5/15	5–6	coordinates in space, or a solid
Box plot / summary statistics	~5/15	4–7	median, IQR, outlier fence, compare two distributions
Calculus warm-up — integrate, reconstruct from f′	~5/15	5–6	find the constant of integration from a given point
Sinusoidal / exponential model (short version)	~6/15	4–6	read or fit parameters of a model

Read that table as a checklist. A typical Section A is *some six of these*, and a regression question, a normal-distribution question and a kinematics question are very nearly guaranteed to be three of the six.

4. Section B — the chain templates

Every Section B question fits one of a small number of multi-part shapes. Recognising the template tells you what the later parts will demand before you have finished part (a).

Template A — Statistics chain *(the most reliable Paper-2 Section B bet)*

> Normal model and/or binomial model set up → tail probabilities → recover a parameter (μ or σ) by inverse-normal, often via a simultaneous-equation solve → finish with conditional probability or an expected-value argument.

Appeared in roughly **8 of 15** papers, and was the **Q9 closer** in most of those. The signature hard step is *working backwards through the model* — using invNorm to recover a standard deviation from a stated probability, a reasoning direction Paper 1 never asks for.

Template B — "Compare the models" modelling chain

> Two or three models for one real-world quantity (linear regression / exponential / logistic) → evaluate each → interpret a parameter in context → compare growth rates or fit → end on a verbal "which model is better, and why" mark.

Appeared in **~3 of 15** but is a clear recent signature (Nov 2024 and Nov 2025 both used it). Unusually verbal — several marks are *interpretation* (R) marks, not computation.

Template C — Geometry / optimisation chain

> A figure (3-D solid, window, composite shape) is parameterised → derive an expression for area / volume / surface area, often via a "show that" → optimise it with the GDC → substitute back.

Appeared in **~5 of 15**. The Paper-2 cousin of Paper 1's geometry-optimisation closer, but here the optimisation is done on the calculator rather than by hand.

Template D — Sinusoidal / kinematics modelling chain

> A periodic or motion model is given or fitted → period, count of events, first time at a value → rate of change via the derivative → distance via a definite integral.

Appeared in **~7 of 15**. Fuses GT or C with modelling. The kinematics version is the calculator-paper relative of Paper 1's kinematics closer.

Template E — Finance chain

> Salary or savings series → geometric-series sum → compound-interest future value → combine, then solve for a number of periods or an interest rate with the finance solver.

Appeared in **~3 of 15** as a full 12–15 mark Section B question — **a genre that does not exist on Paper 1 at all.**

Template F — Function-exploration chain

> Function defined → inverse, asymptotes, intersections with the inverse, area enclosed, a derivative feature.

Appeared in only **~3 of 15** — the rarest Section B template on Paper 2, because Functions is marginalised here. (On Paper 1 this template is in two-thirds of papers.)

What Section B will most likely look like

The three Section B slots, across the corpus, are most often:

- **One Statistics chain** (Template A) — frequently the Q9 closer. The safest single bet on the paper.
- **One modelling or kinematics chain** (Template B or D) — calculus-and-context heavy.
- **One geometry/optimisation or finance chain** (Template C or E) as the third — the rotating slot.

A standalone Functions Section B question (Template F) is the *least* likely of the templates.

5. How Paper 2 differs from Paper 1 — the six structural facts

1. **The topic hierarchy inverts.** SP dominates; Functions is marginal. Plan revision time accordingly — do not pour the evening into functions.
2. **Every question is calculator-load-bearing.** There is no by-hand warm-up. Expect to use the GDC from Q1.
3. **Questions are context-wrapped modelling tasks**, not self-contained technique tests. The work is translating a scenario into the right GDC operation and interpreting the output back into context. Command terms like *interpret*, *comment on reliability*, *justify*, *determine which* appear on Paper 2 and almost never on Paper 1.
4. **Finance exists.** Compound interest, the finance/TVM solver, annuities — an entire genre with no Paper 1 analogue.
5. **Kinematics relocates.** On Paper 1 it is a full Section B closer; on Paper 2 it is compressed into a ~6–7 mark Section A item.
6. **The hardest closer demands "working backwards through a model"** — invNorm to recover a parameter, integrating a difference and pinning the constant from an initial condition. This reasoning direction is Paper-2-specific and worth drilling explicitly.

6. Honest caveats

- **Sample:** fifteen Paper 2 papers, every one read question-by-question through its mark scheme. The corpus is entirely 2022–2025 — the current syllabus (first examined 2021). The genre map is reliable; specific mark allocations and section placements shift between sittings and time zones.

- **TZ1/TZ2 twinning** means the TZ2 templates are trustworthy, but "twin" means *structurally similar*, not identical — the numbers and contexts always change.
- **Rotation is real.** SP is the most reliable heavyweight but is not guaranteed to dominate every paper (May 2024 TZ1 was GT-heavy). The de-emphasised topic rotates — usually Functions, occasionally NA.
- **The file-naming in the papers folder is unreliable** — several files carry session labels that disagree with their own cover pages. Dates above are taken from cover pages and barcodes, which are authoritative. This does not affect the aggregate patterns.

Calculus on Paper 2

The Paper 1 guide already taught you the calculus syllabus — the chain rule, classifying stationary points, the constant of integration, area as a signed-then-unsigned quantity. None of that changes for Paper 2. What changes is *who does the arithmetic*. On Paper 1 you are the calculator: every derivative and integral is exact-form and by hand. On Paper 2 the GDC is the calculator, and your job shifts from *executing* the calculus to *recognising which calculus is needed, setting it up correctly, and interpreting what the machine hands back*.

That shift sounds like it makes calculus easier on Paper 2. It does — but only if you respect two facts. First, **the marks are still mostly method (M) marks**, and the GDC does not earn them; *you* earn them by writing down the integral, the equation, or the derivative you are about to solve. A bare number copied off a screen with no setup is, on a 6-mark question, often a 1-mark answer. Second, **Paper 2 calculus is forecast to be prominent for your sitting** — it shows up in Section A as short modelling warmups and in Section B as the modal closing question, the one built around a rate function. This section is the Paper-2 lens: where calculus appears on the calculator paper, the GDC technique each task rewards, and the traps that are specific to working this way.

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1. How calculus shows up on Paper 2

Calculus on Paper 2 almost never looks like "differentiate this polynomial". It looks like a *context* — a population, a temperature, a volume of water, a profit — with calculus hidden one layer down. Here are the recurring shapes.

1.1 Numeric definite integrals

A definite integral on Paper 2 is a number you read off the GDC, not an antiderivative you construct. The integrand is frequently something you *could not* integrate by hand at SL — an exponential with an awkward coefficient, a trig function inside another function, a messy quotient. That is deliberate: the IB is testing whether you can *set up* the right integral, not whether you can find an antiderivative.

The classic framing is a **rate of change given, total change wanted**. If you are told the rate $\frac{dP}{dt}$ at which a population is changing and the population at one moment, the population at a later moment is the starting value plus $\int$ (rate) dt over the elapsed interval. The integral is the *accumulated change*; you add it to the *initial amount*. This is the fundamental theorem doing real work in a context.

1.2 Stationary points and max–min from the graph

On Paper 1 you find a maximum by solving $f'(x)=0$ algebraically and confirming with f''. On Paper 2 you find it by **graphing f on the GDC and using the built-in maximum/minimum finder**. The calculator gives you the coordinates directly. You do not need f'' at all for the *classification* — the graph shows you it is a peak.

This appears as "find the maximum value of the profit", "find the time at which the height is greatest", "find the minimum surface area". The command term is usually *find*, and a context word like *greatest*, *least*, *maximum*, *most* is the trigger.

1.3 Intersections

"Where do these two curves meet" is an *intersection* on the GDC: graph both, use the intersection finder. This matters for calculus because intersections are how you get the **limits of an area-between-curves integral**, and how you solve a "for what x is the rate zero" type equation when it cannot be done by hand.

1.4 Solving $f'(x)=0$ numerically

When a question wants the exact location of a stationary point but the function is not a polynomial — say it involves e^{kx} and a trig term — you cannot solve $f'(x)=0$ by hand. The Paper-2 move is: differentiate (by hand if the function is standard, or let the GDC give f' at points), then **use the equation solver or graph $y=f'(x)$ and find its x-intercept**. Either way you write the equation $f'(x)=0$ down first.

1.5 Area between curves with the calculator

You still need the principle from Paper 1 — area is $\int_a^b (\text{top} - \text{bottom})\,dx$, and you must know which curve is on top. But on Paper 2 you **find a and b as intersection points on the GDC**, and you **evaluate the integral numerically** rather than antidifferentiating. The thinking is identical; only the arithmetic is delegated.

1.6 Kinematics with the GDC — the modal Section B closer

A velocity or a rate function is given, often one you could not integrate by hand. You are asked for displacement (a signed integral of v), distance travelled (an integral of $|v|$, or split at the times $v=0$), times at rest ($v=0$), or acceleration (v', evaluated on the GDC). Paper 2 dresses this up in many costumes — water entering a tank, a particle on a track, a drone's velocity — but the structure is rigid, and it is very often the last big question on the paper.

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2. GDC technique: which operation for which task

Think of the GDC as having a small menu of operations. Calculus on Paper 2 is mostly a matter of mapping the question to the right menu item — and then *writing down what you fed in*.

Task	GDC operation	What you must write
Evaluate $\int_a^b f(x)\,dx$	Numeric definite integral	The integral expression, with limits and integrand
Find a max or min value	Graph, then max/min finder	The function graphed; state the coordinate found
Find where two curves meet	Graph both, intersection finder	The two equations; state the intersection point
Solve $f(x)=k$ or $f'(x)=0$	Equation solver, or graph and find root	The equation being solved
Find $f'(a)$ — gradient at a point	Numeric derivative at a value	$f'(a)$ and the value of a
Find $f'(x)$ as a function	By hand if standard; else evaluate at points	The derivative expression or the values used

2.1 The discipline of writing the setup

This is the single most important Paper-2 calculus habit, so it gets its own heading. **The GDC does the arithmetic; you must show the demand of the mark.**

Concretely, when a question is worth, say, 4 marks and reduces to one numeric integral, the marks are typically split something like: method for recognising you need an integral, the correct integral expression with correct limits, a correct intermediate value, and the final answer to 3 significant figures. If you write only the final number, you are eligible for only the final mark — and if the number is slightly wrong because of a rounding slip, you may get **zero**.

So for an integral, write $$\int_{0}^{6} 250\,e^{-0.04t}\,\mathrm{d}t = 1343.6\ldots$$ *before* you write the final rounded answer. The integral expression is a mark. For a maximum, write "graphing $y = P(x)$, maximum at $(3.20, 47.6)$" — naming what you graphed banks the method. For solving $f'(x)=0$, write the equation $f'(x)=0$ (with f' shown) and then "solving gives $x = \ldots$". You are not showing off; you are leaving a paper trail that an examiner can award marks against. The mark scheme's own note says it explicitly: M marks and intermediate A marks *can* be scored even when presented in calculator notation, **provided the evidence clearly reflects the demand of the mark**. No evidence, no marks.

2.2 Calculator notation is for working, not for answers

You may write `fnInt(...)` or `solve(...)` or `normCdf(...)` in your *working* — that is fine, it counts as evidence. But the **final answer must be an ordinary number** (or exact value), to 3 significant figures unless told otherwise. A final line that reads `fnInt(2x, x, 1, 5) =` and stops, or that gives the answer *as* the calculator expression, does not score the final A mark. Convert it.

3. Worked micro-examples

All numbers below are invented; the shapes mirror genuine Paper-2 calculus.

3.1 Rate given, total change wanted (Section A, ~6 marks)

A reservoir is losing water. The rate of change of the volume V (in m³) is modelled by $\dfrac{dV}{dt} = -820\,e^{-0.06t}$, where t is the time in hours since midnight. At midnight the volume was $54\,000$ m³. Find the volume at 09:00.

The rate is given, the total change is wanted — so integrate the rate over the 9-hour interval and add to the start.

1. Set up the change as a definite integral. Write it down:

$$\Delta V = \int_{0}^{9} -820\,e^{-0.06t}\,\mathrm{d}t$$

1. Evaluate on the GDC: $\Delta V = -6299.3\ldots$ m³. (Write this intermediate value.)
2. Add the initial volume:

$$V = 54\,000 + (-6299.3\ldots) = 47\,700.6\ldots$$

1. Final answer to 3 s.f.: $V \approx 47\,700$ m³.

The two method marks live in step 1 (recognising an integral is needed *and* writing it correctly) and step 3 (adding to the initial value). A student who just types numbers and writes "47700" is gambling three marks on the answer being exactly right.

3.2 Maximum from the graph (Section A, ~4 marks)

A company's daily profit, in dollars, from selling x units is $P(x) = 90x - 0.7x^2 - 2^{\,0.05x}$ for $0 \le x \le 120$. Find the maximum daily profit.

You cannot solve $P'(x)=0$ neatly by hand because of the $2^{0.05x}$ term. Use the graph.

1. Graph $y = P(x)$ on $0 \le x \le 120$ on the GDC.
2. Use the maximum finder: it returns the vertex at approximately $(63.4,\ 2848.6)$.
3. Write: "from the GDC, maximum of P occurs at $x = 63.4$, giving $P = 2848.6\ldots$".
4. The question asks for the maximum *profit*, not the number of units — so the answer is $\$2850$ (3 s.f.).

Note the Paper-1 discipline that *still* applies: answer the question that was asked. The trap here is reporting $x = 63.4$ as "the maximum". That is where the maximum occurs; the maximum profit is the y-value.

3.3 Gradient at a point, then an equation (Section A, ~5 marks)

The temperature of an oven, in °C, t minutes after it is switched on is $T(t) = 220 - 195\,e^{-0.18t}$, $t \ge 0$. (a) Find $T'(10)$. (b) Interpret $T'(10)$ in context. (c) Find the time at which the oven is heating at a rate of 5 °C per minute.

(a) The function is standard, so you *could* differentiate by hand: $T'(t) = 35.1\,e^{-0.18t}$. Or get the numeric derivative at $t=10$ directly from the GDC. Either way, write what you did. $T'(10) = 5.80\ldots \approx 5.80$ °C per minute.

(b) "At $t = 10$ minutes the oven's temperature is increasing at about 5.80 °C per minute." (Rate of change in context = derivative, with units and a direction.)

(c) "Heating at a rate of 5 °C per minute" means $T'(t) = 5$. Write the equation: $$35.1\,e^{-0.18t} = 5$$ Solve on the GDC (equation solver, or graph $y = T'(t)$ and $y = 5$ and intersect): $t = 10.8\ldots \approx 10.8$ minutes. The equation $T'(t)=5$ is the method mark — the GDC only supplies the root.

3.4 Area between curves, calculator throughout (Section A or B, ~6 marks)

Find the area of the region enclosed by $y = 12 - x^2$ and $y = 3^{|,x} - 4$.

1. Find the intersections on the GDC: graph both, intersect. They meet at $x = -2.66\ldots$ and $x = 2.41\ldots$. These are the limits.
2. Decide which curve is on top. Testing $x = 0$: the parabola gives 12, the other gives -3, so $y = 12 - x^2$ is on top across the interval.
3. Write the integral (top minus bottom, GDC limits):

$$A = \int_{-2.66\ldots}^{2.41\ldots} \left[(12 - x^2) - (3^{x} - 4)\right] \mathrm{d}x$$

1. Evaluate numerically: $A = 53.1\ldots \approx 53.1$.

Use the *stored, unrounded* intersection values as the limits — keying in -2.66 and 2.41 instead propagates rounding error into the area (see §4.1). Most GDCs let you carry the exact intersection values straight into the integral; do that.

3.5 Kinematics with a rate function (Section B closer, ~14 marks)

Water flows into a tank. The rate of flow, in litres per second, is modelled by $r(t) = 8 + 6|sin(0.5t)$ for $0 |le t |le 30$, where t is in seconds. The tank contains 40 litres at $t = 0$. (a) Find the rate of flow at $t = 12$. (b) Find the total volume of water that flows into the tank in the first 20 seconds. (c) Find the volume of water in the tank at $t = 20$. (d) Find the time in the interval $0 |le t |le 30$ at which the rate of flow is greatest.

First — **radian mode**. The model uses $\sin(0.5t)$ with t a number of seconds; this is a real-number argument, so the GDC must be in radians. Set it before you touch the question (see §4.2).

(a) Substitute: $r(12) = 8 + 6\sin(6) = 8 + 6(-0.279\ldots) = 6.32\ldots \approx 6.32$ litres per second.

(b) "Total volume that flows in" over $[0,20]$ is the integral of the rate: $$\int_{0}^{20} \bigl(8 + 6\sin(0.5t)\bigr)\,\mathrm{d}t = 174.3\ldots \approx 174 \text{ litres.}$$ Write the integral down — it is the method mark.

(c) Volume in the tank = initial volume + volume that flowed in $= 40 + 174.3\ldots = 214.3\ldots \approx 214$ litres. (Same "initial + accumulated change" structure as §3.1.)

(d) "Rate of flow is greatest" — graph $y = r(t)$ on $[0,30]$ and use the maximum finder. Maximum at $t = 3.14\ldots \approx 3.14$ seconds. (You could also reason that $\sin$ peaks when its argument is

$\frac{\pi}{2}$, i.e. $0.5t = \frac{\pi}{2}$, $t = \pi$ — but the GDC graph is faster and safer here.)

Notice how *every* part is a different menu item: substitution, numeric integral, integral-plus-initial-value, graph-and-maximise. Recognising which is which is the whole skill.

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4. Traps specific to Paper 2 calculus

These are not the Paper-1 traps. These are the failure modes that *only* appear once a calculator is in your hand.

4.1 Premature rounding propagating through

This is the dominant Paper-2 calculus error, full stop. You compute an intermediate value — an intersection point, a σ, a stationary x — round it to 3 significant figures, write it down, and then *re-enter the rounded value* into the next calculation. The error compounds, and your final answer is wrong in the third figure. The mark scheme penalises the final answer; you lose A marks you had earned everything else for.

The fix is mechanical: never re-key a rounded number. Use the calculator's memory — store the intersection points, the unrounded derivative value, the unrounded integral — and carry the *full-precision* value into the next step. Round **once, at the very end**, to 3 s.f. The rounded value goes on your paper as a *display*, not as an *input*. In §3.4, the limits of integration must be the stored intersection values, not -2.66 and 2.41.

A subtle version: when a part (a) answer feeds part (b), use your *exact* part (a) value, not the 3-s.f. version you wrote in the box. The mark scheme explicitly allows the 3-s.f. value to be re-used, but it also notes the cleaner answer comes from the exact one — and "allows" is not "rewards".

4.2 Radian vs degree mode in calculus-with-trig

Any calculus involving a trig function — differentiating $\sin(0.5t)$, integrating $\cos\!\big(\frac{2\pi t}{5}\big)$, finding the maximum of a sinusoidal model — **requires the GDC in radian mode**, because the standard derivatives ($\frac{d}{dx}\sin x = \cos x$ and so on) are only true for radian arguments. A trig model whose argument is a plain real number (a time, a length, a count) is implicitly in radians. If your GDC is in degree mode, every derivative, integral and maximum involving that trig term will be quietly, completely wrong — and there is no error message to warn you.

The flip side: a few Paper-2 questions are *posed in degrees* (a bearing, an angle of elevation, a sine rule triangle). Those want degree mode. The practical rule: **check the mode indicator before each question, and switch deliberately.** Treat "what mode am I in" as the first question you ask on any trig-flavoured part.

4.3 Giving a calculator-notation answer instead of a number

Covered in §2.2, but it earns repeating because it is so cheap to avoid. `fnInt(...)`, `solve(...)`, `nDeriv(...)` are working, not answers. The final answer is a number to 3 s.f. (or an exact value if the question says "exact"). Leaving the calculator expression as your final line throws away the final A mark on a question you have otherwise done correctly.

4.4 "Show that" still needs algebra — even on a calculator paper

A calculator paper still contains "show that" parts, and the calculator **cannot do them for you**. If a question says "show that $\frac{(x-1)^2}{x} = x - 2 + \frac{1}{x}$", you must produce the algebraic steps — expand, divide term by term — exactly as on Paper 1. Verifying it numerically for one value of x is *not* a proof and scores nothing. Likewise "show that the area is $\ldots$" or "show that $\theta = 2.08$" wants genuine reasoning that lands on the given value; you cannot just type and assert.

There is a related discipline. If a "show that" gives you a value to use later, and you could not complete the "show that", you must still **use the given value** in subsequent parts — the mark scheme will not follow through from a wrong self-derived value when the correct one was printed for you. And if you *can* do the "show that" to higher accuracy than the printed (rounded) value, you may — and you should carry your unrounded value forward, per §4.1.

4.5 Distance vs displacement — sign discipline survives the calculator

The GDC will happily evaluate $\int_a^b v(t)\,dt$ for you. It will *not* tell you whether that signed number is the answer the question wanted. **Displacement** is the signed integral $\int v\,dt$ — positive and negative velocities cancel. **Distance travelled** is $\int |v|\,dt$ — never negative, and equal to the displacement *only if v does not change sign* on the interval. If v changes sign, distance travelled means: find the times where $v = 0$ (solve on the GDC), integrate v over each sub-interval, take the absolute value of each piece, and add. Many GDCs can integrate $|v(t)|$ directly — that also works, and is quick — but you must *recognise* that the question wants $|v|$ in the first place.

The trap is reading "find the total distance travelled", typing $\int v\,dt$, and reporting a number that is too small (or negative) because the negative part cancelled the positive part. The calculator did exactly what you asked; you asked the wrong thing. Decide *which quantity* before you press a key.

4.6 Trusting a graph window you have not set

A smaller, quieter trap: the GDC's maximum/minimum/intersection finders only see what is *in the window*. If a function's true maximum is off-screen, or two curves intersect twice but your window shows only one crossing, the calculator returns a confident, wrong answer. Always set the window to the domain stated in the question (e.g. $0 \le x \le 120$), and glance at the whole picture before you trust a feature-finder. A calculus answer from an un-considered window is a guess wearing a number.

If you remember nothing else

- **Write the setup, every time.** The integral expression, the equation being solved, the function being graphed — these are the method marks. The GDC supplies the number; you supply the evidence. A bare answer on a 6-mark question is a 1-mark answer.
- **"Rate given, total wanted" = integrate the rate, then add the initial amount.** This single structure covers most Section A modelling and most Section B kinematics. Final amount = initial amount +

$\int$ rate dt.

- **Round once, at the end.** Never re-key a rounded intermediate value — store full precision, carry it forward, round only the final answer to 3 s.f. Premature rounding is the number-one Paper-2 calculus error.
- **Check radian/degree mode before any trig calculus.** Trig models with real-number arguments need radians; the standard derivatives demand it. There is no warning if you get this wrong.
- **The final answer is a number, not `fnInt(...)`.** Calculator notation is fine as working, never as an answer.
- **"Show that" still needs algebra.** The calculator cannot prove anything. Produce the steps; numerical checking is not a proof. And always use a given value in later parts, even if you could not derive it.
- **Decide displacement vs distance before you integrate.** $\int v\,dt$ is signed displacement; distance travelled is $\int |v|\,dt$, split at $v = 0$ if v changes sign. The GDC will not catch this for you.

Statistics & Probability on Paper 2

The Paper 1 guide already taught you the syllabus: sample spaces, the addition rule, conditional probability, tree and Venn diagrams, expected value, the binomial and normal *concepts*. This section does not re-teach any of that. Its job is the **Paper 2 lens**.

Statistics and probability is the single topic most transformed by the calculator. On Paper 1 you meet probability machinery you can run by hand and the *interpretation* of data-handling ideas — but you almost never compute a normal probability or fit a regression line, because you can't without a GDC. Paper 2 is where those live. **Normal distribution and linear regression are effectively Paper-2-only sub-topics**, and across recent papers they reliably appear as a Section A question each plus a slice of a Section B chain. Binomial calculations also migrate here once *n* is large. So if you map your revision time by where the marks are, P2 stats deserves a serious share — it is forecast to be a substantial part of your paper.

The skill being tested shifts. On P1 the question is "can you do the maths". On P2 it is "can you **set up the right calculator command, then interpret and present the result**". That sounds easier. It is not — it just relocates where marks are lost, and this section is built around exactly those relocation points.

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1. Normal distribution on the GDC

Everything here assumes $X \sim N(\mu, \sigma^2)$. Your GDC has two commands that do all the work; the entire skill is choosing the right one and reading the question to know what goes where.

normalcdf — probability from a range

`normalcdf(lower, upper, μ, σ)` returns the *probability* that *X* lies between two values. You give it an interval, it gives you back an area (a number between 0 and 1).

- For "less than *a*", the lower bound is −∞. Enter a very large negative number — `−1E99` is the standard trick.
- For "greater than *b*", the upper bound is +∞ — enter `1E99`.
- For "between *a* and *b*", just enter both.

The mark-scheme reality: examiners want to see *what you fed in*. Writing `P(X > 13) = 0.0668` with the setup `P(X > 13)` shown earns the method mark; a bare `0.0668` is fragile. And note the GDC takes **σ, not σ²** — if the question states the variance, square-root it first.

invNorm — value from a probability

`invNorm(area, μ, σ)` is the reverse: you give it a probability (an area *to the left*), it returns the *value* of *X* with that much area below it.

The non-negotiable detail: **invNorm works with left-tail area**. If a question says "the top 10% of values exceed *k*", the area to the *left* of *k* is 0.90, so you enter `invNorm(0.90, μ, σ)`. Feed it 0.10 and you get the wrong tail. Sketch the curve, shade what you're told, and convert to a left area before touching the calculator.

Finding μ or σ from a given probability — the "set up an equation" technique

This is the highest-value P2 normal technique and it appears constantly. The question gives you a probability and asks for the missing parameter. The standard route:

1. Write the probability statement, e.g. $P(X < 60) = 0.88$.
2. Standardise: the z-value with 0.88 of the area to its left is `invNorm(0.88, 0, 1)` = 1.1750....
3. Set up the equation **$z = (\text{value} - \mu)/\sigma$** with the z you just found.
4. Solve for the unknown.

So if μ is known and σ is wanted: $1.1750... = (60 - \mu)/\sigma$ rearranges directly to σ. If σ is known and μ is wanted, rearrange for μ. The *method mark is the standardisation equation* — show it explicitly. An equivalent route some calculators allow is to set a `normalcdf(...)` expression equal to the given probability and solve numerically; mark schemes accept that too, but you must show the equation.

Symmetric-band reasoning

A favourite shape: "$P(a < X < b) = 0.88$, where a and b are symmetric about the mean". Symmetry is the unlock. If the central band holds 0.88, the two tails together hold 0.12, so **each tail holds 0.06**. That converts the band statement into a single-tail statement — $P(X < a) = 0.06$ — which you can standardise. Students who don't spot the symmetry try to handle the whole band at once and stall.

P2 normal-distribution question shapes

- **Straight probability**: "Find the probability a randomly chosen item is heavier than 13 kg." — one `normalcdf`.
- **Inverse**: "Below which value do 90% of items fall?" — one `invNorm`.
- **Find a parameter**: given a probability, find μ or σ via the standardisation equation.
- **Symmetric band**: given a central probability symmetric about μ, find the band edges or a parameter.
- **In a chain**: the normal probability becomes p for a later binomial part — "each item independently has this probability; out of 20 items...".

Worked micro-example — normal

A bakery's sourdough loaves have mass M grams, where $M \sim N(\mu, \sigma^2)$. Quality control records that 88% of loaves weigh less than 540 g, and that 3% weigh less than 470 g.

(a) Find μ and σ.

Two probability statements, two unknowns. Standardise both.

- `invNorm(0.88, 0, 1)` = 1.17498... , so $(540 - \mu)/\sigma = 1.17498...$
- `invNorm(0.03, 0, 1)` = −1.88079... , so $(470 - \mu)/\sigma = -1.88079...$

Two linear equations in μ and σ. Subtracting: 540 − 470 = (1.17498 + 1.88079)σ, so 70 = 3.05577σ, giving **σ = 22.9 g** (3 s.f.). Back-substituting: μ = 540 − 1.17498 × 22.908... = **513 g** (3 s.f.).

(b) Find the probability a loaf weighs between 500 g and 530 g.

Now μ and σ are known, so this is a direct `normalcdf`. Use the *unrounded* stored values, not 513 and 22.9:

`normalcdf(500, 530, 512.077…, 22.908…)` = **0.479** (3 s.f.).

Two things to notice. The setup in (a) — the two standardisation equations — *is* the method, so it must be on the page. And in (b) we reused the full-precision μ and σ; rounding them to 3 s.f. first would shift the final answer in the third figure.

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2. Linear regression on the GDC

Regression is pure Paper 2: you cannot fit a least-squares line by hand at SL. The GDC's linear regression routine (often `LinReg(ax+b)`) takes two lists and returns *a*, *b*, and the correlation coefficient *r* in one shot.

Getting the line and the correlation coefficient

Enter the *x*-data and *y*-data into two lists, run linear regression, read off **y = ax + b**. The same output gives **r**, Pearson's product-moment correlation coefficient. (If your GDC doesn't show *r*, the diagnostics setting needs turning on — know how to do this *before* the exam.)

Interpreting r. It measures the strength and direction of the *linear* relationship, $-1 \le r \le 1$. Describe it in words with two components — strength *and* direction: "r = 0.93 indicates a strong positive linear correlation." Values near 0 mean weak *linear* correlation (not necessarily "no relationship" — the data could be strongly curved). Quote *r* to 3 s.f. like any other answer.

Using the line to predict

To predict, substitute into y = ax + b. If asked for the arm span at a foot length of 19.8 cm, put 19.8 in for *x* and compute. Round sensibly for the context (a person's arm span to the nearest cm).

The danger of extrapolation

Predicting *inside* the range of the data is interpolation — reasonably safe. Predicting *outside* it is **extrapolation**, and it is unreliable: there is no evidence the linear pattern continues beyond the data. Examiners ask for this as a one-mark *reasoning* point — "Explain why this estimate may be unreliable" — and the answer is literally "the value lies outside the data range, so this is extrapolation." That mark is free if you say the word and lost if you compute a number instead.

y-on-x vs the wrong way round

There are two regression lines. The line of **y on x** is built to predict *y* from *x*; the line of **x on y** predicts *x* from *y*. They are different lines. The rule:

> Regress the variable you want to **predict** *on* the variable you are **given**.

Want to predict arm span from foot length? Use **arm span on foot length**. Given a *y*-value and want the *x*? You need **x on y** — do *not* rearrange the y-on-x equation, and do *not* just use y-on-x backwards. Mark schemes are explicit and unforgiving here: a recent paper awarded *zero* for predicting with the wrong line even though the arithmetic was perfect, and separately awarded a reasoning mark purely for the statement "should not use the line of y on x to predict x from y."

Both lines do pass through the mean point $(\bar{x}, \bar{y})$ — that fact occasionally lets you find the means by intersecting them.

Worked micro-example — regression

A coach records, for 9 swimmers, their weekly training hours *h* and their time *T* (seconds) for a 100 m freestyle. Linear regression gives the line of *T* on *h* as $T = -1.34h + 78.6$, with $r = -0.918$.

(a) Interpret r in context. $r = -0.918$ is a strong negative linear correlation: swimmers who train more hours tend to record faster (lower) times.

(b) A swimmer trains 12 hours per week. Estimate their 100 m time. Substitute: $T = -1.34 \times 12 + 78.6 =$ **62.5 s**. The training hours in the data ran from 6 to 14, so 12 is inside the range — interpolation, reasonable.

(c) Comment on using this line to estimate the time of a swimmer who trains 30 hours per week. 30 hours is far outside the data range (6–14), so this would be extrapolation and the estimate is unreliable — the linear trend cannot be assumed to continue, and indeed the line would eventually predict an absurd negative time.

(d) The coach wants to estimate how many hours a swimmer training for a target time of 60 s should do. Can the line above be used? No — that line is *T* on *h*, built to predict *T* from *h*. To predict *h* from *T* you need the regression line of *h* on *T*, a different line, refitted on the GDC.

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3. Binomial on the GDC

Once *n* is more than about 5, binomial probabilities are calculator work — that is why they live on Paper 2. $X \sim B(n, p)$ and the GDC has two commands.

binompdf and binomcdf

- `binompdf(n, p, r)` = $P(X = r)$, the probability of *exactly* r successes.
- `binomcdf(n, p, r)` = $P(X \leq r)$, the probability of *at most* r successes — it sums from 0 up to and including r.

Translating the words

This is where marks live. The English has to become the right command:

Phrase	In symbols	Command
exactly r	$P(X = r)$	`binompdf(n, p, r)`
at most r	$P(X \le r)$	`binomcdf(n, p, r)`
at least r	$P(X \ge r) = 1 - P(X \le r-1)$	`1 − binomcdf(n, p, r−1)`
fewer than r	$P(X \le r-1)$	`binomcdf(n, p, r−1)`
more than r	$P(X > r) = 1 - P(X \le r)$	`1 − binomcdf(n, p, r)`
between a and b inclusive	$P(a \le X \le b)$	`binomcdf(n,p,b) − binomcdf(n,p,a−1)`

The two killers are the **off-by-one** ("at least 3" needs `1 − binomcdf(n,p,2)`, not `binomcdf(n,p,3)`) and the **"at least one = 1 minus none"** pattern: $P(X \ge 1) = 1 - P(X = 0)$. That last one is so common it is worth burning in — never sum many cases when the complement is one term.

Expected value in context

For a binomial, **E(X) = np** — straight from the formula booklet. On P2 it is usually dressed in context: "out of 250 components, how many are expected to be faulty?" is just np. Watch for two-stage versions where the binomial probability you computed earlier becomes the *p* for an expected-value part, or where you multiply an expected count by a cost or score.

Worked micro-example — binomial

At a fairground stall, each attempt to ring a bell succeeds independently with probability 0.18. A player pays for 15 attempts.

(a) Find the probability of exactly 4 successes. `binompdf(15, 0.18, 4)` = **0.179** (3 s.f.).

(b) Find the probability of at least 2 successes. "At least 2" = $1 - P(X \le 1)$: `1 − binomcdf(15, 0.18, 1)` = 1 − 0.18937... = **0.811** (3 s.f.).

(c) The stall expects 400 players in a day. How many bells, in total, are expected to be rung? Per player, $E(X) = np = 15 \times 0.18 = 2.7$. Across 400 players: $400 \times 2.7 =$ **1080 rings**.

Note (b): the setup `1 − P(X ≤ 1)` is the method mark. And note we did not write `binomcdf(15,0.18,2)` — "at least 2" is *not* "at most 2".

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4. Harder probability — the calculator does the arithmetic, not the thinking

Tree diagrams, conditional probability and "given that" questions still appear on P2, often as part of a Section B chain. The calculator helps you multiply ugly decimals quickly and without slips — but **the setup is entirely yours**. There is no command for "draw the right tree".

Tree diagrams

The two rules are unchanged from P1: **multiply along a path**, **add between paths**. On P2 the branch probabilities are just messier numbers — say 0.37 and 0.63 rather than 1/2 — so the calculator earns its place in the arithmetic, but you still draw the tree, label every branch, and decide which paths the question wants.

Conditional probability and "given that"

The formula is in the booklet: **$P(A \mid B) = P(A \cap B) / P(B)$**. The reasoning discipline:

1. Identify the *condition* — the event after "given that". It goes in the **denominator**.
2. Find $P(A \cap B)$: the probability of the *path(s)* where both happen — usually a product (or sum of products) read off the tree.
3. Find $P(B)$: the *total* probability of the condition — sum every path that ends in B.
4. Divide.

The direction trap from P1 still bites: $P(A \mid B) \neq P(B \mid A)$. Read which event is given.

Worked micro-example — conditional

A delivery firm uses two depots. 65% of parcels are handled by depot North, the rest by depot South. A parcel from North is late with probability 0.08; a parcel from South is late with probability 0.15.

(a) Find the probability a randomly chosen parcel is late. Add the two "late" paths: P(late) = 0.65 × 0.08 + 0.35 × 0.15 = 0.052 + 0.0525 = **0.1045**.

(b) Given that a parcel is late, find the probability it was handled by depot South. The condition is "late" — it goes in the denominator. P(South | late) = P(South ∩ late) / P(late) = 0.0525 / 0.1045 = **0.502** (3 s.f.).

The calculator did the multiplications and the division; the *structure* — which products to add, which goes on the bottom — was the actual exam skill, and it earns the method marks.

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5. Traps specific to P2 stats

These are the relocation points — where P2 stats marks actually go missing. Most have nothing to do with not knowing the maths.

Rounding before feeding back into the calculator. The headline P2 error across *all* topics, and stats is a prime offender. If you find $\sigma = 22.908...$ in part (a), use the *stored, full-precision* value in part (b) — not 22.9. Mark schemes routinely show two answer strings, one "from the use of 3 s.f. values", precisely because students round mid-chain and drift in the third figure. Store intermediate results; round only the final answer.

Mixing up invNorm and normalcdf. `normalcdf` takes values → gives a probability. `invNorm` takes a probability → gives a value. Ask "what am I given and what do I want?" Given a range, want a probability → `normalcdf`. Given a probability, want a cut-off value → `invNorm`. Using the wrong one produces a number, so nothing looks broken — but it is the wrong number.

invNorm tail confusion. `invNorm` always works with *left* area. "Top 15%" means left area 0.85. Sketch and shade before entering anything.

Regressing the wrong variable. Predict the *unknown* on the *known*. Want *y* from *x*: y-on-x. Want *x* from *y*: x-on-y — a different line, refitted. The wrong line scores zero even with flawless arithmetic.

Writing calculator notation as the final answer. `normalcdf(500,530,512,22.9)`, `binompdf(15,0.18,4)`, `LinReg` output — these are *working*, not answers. They are fine (even helpful) as evidence of method, but the final answer line must be the actual number, e.g. `0.479`. Calculator notation alone in the answer space does not score the answer mark.

The "at least one = 1 minus none" pattern. P(at least one) = 1 – P(none). Reach for the complement instead of summing cases — and more generally, "at least r" = `1 − binomcdf(n, p, r−1)`, minding the r–1.

Forgetting to show the setup, so the method mark is lost. This is the quiet killer. A P2 stats part is often M1 (correct setup) then A1 (correct value). If you only write the answer and it's wrong — a mis-typed bound, a slipped digit — you get *zero*, not 1 of 2, because the method was never shown. Always write the probability statement, the standardisation equation, the `1 − P(X ≤ ...)` expression, the tree, the conditional-probability formula with the question's letters. The setup is cheap to write and it banks marks even when the final number goes wrong.

Using σ^2 where σ belongs. The GDC's normal commands and the standardisation formula both take the standard deviation. If the question states the *variance*, square-root it first.

If you remember nothing else

- **normalcdf**: values in → probability out. **invNorm**: probability (left area) in → value out. Pick by asking what you're given and what you want.
- **Find μ or σ from a probability** by setting up the standardisation equation $z = (\text{value} - \mu)/\sigma$ with z = `invNorm(area, 0, 1)`. That equation is the method mark — show it.
- **Symmetric band**: a central probability symmetric about μ splits its complement equally between the two tails — convert to a single-tail statement.
- **Regression**: predict the unknown variable *on* the known one. y-on-x and x-on-y are different lines. Extrapolation (outside the data range) is unreliable — and saying so is a free reasoning mark.
- **Binomial words → commands**: "exactly" = `binompdf`; "at most" = `binomcdf`; "at least r" = `1 − binomcdf(n,p,r−1)`; "at least one" = 1 – P(none). E(X) = np.
- **Conditional**: the *given* event goes in the denominator; P(A|B) ≠ P(B|A). The calculator does the arithmetic; the tree and the setup are yours.
- **Never round mid-chain**; never leave calculator notation as the final answer; always write the setup so the method mark survives a slipped digit.

Number & Algebra (and Financial Maths) on Paper 2

This is the **Paper 2 lens** on Number & Algebra. The Paper 1 guide (`1-number-algebra.md`) already teaches sequences, series, exponents, logs, the binomial theorem and proof from the ground up — that content is **not** re-taught here. What changes on Paper 2 is that the **calculator does the arithmetic**, so the marks move away from clean manipulation and towards two new skills: (1) **setting up the right model or the right GDC command**, and (2) **interpreting and reporting the number it gives you correctly**. This section covers the parts of NA that are *only really doable with a calculator* — above all **financial maths** — plus how sequences, logs and exponentials change character when a GDC is in your hand.

Why this section matters for your sitting. The Paper 1 (TZ2) you sat reportedly had almost no Number & Algebra in it. Across a paired TZ, the IB tends to balance topic exposure — so Paper 2 is *likely* to carry the NA load, and **financial maths is the single most Paper-2-exclusive sub-topic in the whole syllabus**. Compound interest with awkward compounding frequencies, and especially the **finance/TVM solver**, simply cannot be done without a calculator, so they live here or nowhere. Expect a Section A finance question, and be ready for a Section B chain that fuses finance with sequences (the past papers do this repeatedly: a prize paid monthly *and* a lump sum invested monthly, totalled together).

Financial maths

Compound interest and the *kn* exponent

The formula booklet gives compound interest as

> **FV = PV (1 + r/(100k))^(kn)**

where **PV** is the present value (the amount you start with), **FV** is the future value, **r** is the **nominal annual interest rate as a percentage**, **n** is the number of **years**, and **k** is the **number of compounding periods per year**.

The single idea you must internalise: the annual rate is *quoted* per year but *applied* per period. So you **divide the rate by k** and **multiply the time by k**. That is the whole content of the `kn` exponent.

Phrase in the question	k
compounded annually / yearly	1
compounded half-yearly / semi-annually	2
compounded quarterly	4
compounded monthly	12

So "a nominal annual rate of 5% compounded monthly" means each month the balance is multiplied by `1 + 5/(100·12) = 1 + 0.05/12`, and after `n` years that has happened `12n` times. It does **not** mean 5% per month, and it does **not** mean 5% per year applied once.

Worked micro-example (compound interest by formula). You invest \$6 000 at a nominal annual rate of 3.6% compounded quarterly. Find the value after 7 years. Here `PV = 6000`, `r = 3.6`, `k = 4`, `n = 7`. `FV = 6000(1 + 3.6/(100·4))^(4·7) = 6000(1.009)^28`. Type `6000·1.009^28` into the GDC: `FV = 7717.59` (2 d.p.). The interest earned is `7717.59 − 6000 = 1717.59`.

Notice you keep the `1.009` and the exponent `28` exact inside the calculator — you do **not** work out `1.009^28` to 3 s.f. and then multiply. That is the rounding trap (see Traps below).

The GDC finance / TVM solver

Every IB-approved GDC has a **finance app** (on the TI it is the *TVM Solver*; on Casio it is *Compound Interest* inside the Financial menu). It solves the same compound-interest relationship, but it can solve for **any** of the variables — and it handles regular payments, which the bare formula cannot. The mark schemes explicitly accept "an attempt to use a financial app" as a valid method, and award the method mark for **at least two entries seen** and the accuracy mark for **all entries correct**. So if you use the solver, **write the variable list in your working** — it is literally how you earn the M and A marks.

The variables:

Variable	Meaning
N	total number of *payment periods* (see the P/Y note below — this is often `k·n`, not `n`)
I%	the **nominal annual** interest rate, as a percentage (enter `5`, not `0.05`)
PV	present value — the amount at the start
PMT	the regular payment made each period (0 if there are no regular payments)
FV	future value — the amount at the end
P/Y	payments per year
C/Y	compounding periods per year

To solve, you fill in every box you know, put the cursor on the box you want, and **SOLVE**.

P/Y, C/Y and N — the bit everyone gets wrong. There are two consistent conventions, and you must pick one and stick with it:

- **Convention A — "N counts years."** Set `P/Y = 1` and `C/Y = k`. Then `N = n` (number of years). The solver internally still compounds `k` times a year because `C/Y = k`.
- **Convention B — "N counts periods."** Set `P/Y = k` and `C/Y = k`. Then `N = k·n` (number of compounding periods).

The May 2022 mark scheme shows *both* lines side by side as equally valid: for 10 years compounded half-yearly it accepts either `N = 10, P/Y = 1, C/Y = 2` **or** `N = 20, P/Y = 2, C/Y = 2`. Both give the same answer. What you must **never** do is mix them — e.g. `N = 20` with `P/Y = 1`, which silently computes 20 *years*.

When there **are** regular payments, you almost always want `P/Y` to equal the payment frequency (e.g. `P/Y = 12` for monthly payments) and `C/Y` to equal the compounding frequency, and `N` then counts payment periods.

Worked micro-example (solving for the rate). \$30 000 is invested for 6 years in an account compounded quarterly, and grows to \$41 000. Find the annual rate `r`. The unknown is the rate, so this *has* to be the solver (the formula would need a 24th root). Enter: `N = 24`, `PV = −30000`, `PMT = 0`, `FV = 41000`, `P/Y = 4`, `C/Y = 4`. Solve for `I%`. Result: `I% = 5.23` (2 d.p.) — so `r ≈ 5.23%`. (Equivalently `N = 6, P/Y = 1, C/Y = 4` — same answer.)

Sign conventions — money in vs money out

The TVM solver uses a **cash-flow sign convention**: money flowing *away from you* (a deposit into the bank, a payment you make) is **negative**, and money flowing *back to you* (the maturity value you withdraw) is **positive**. The non-negotiable rule the mark scheme states explicitly:

> **PV and FV must have opposite signs.**

If you put \$30 000 *in*, that is `PV = −30000`, and the \$41 000 you eventually take *out* is `FV = +41000`. If you make both the same sign, the solver returns a nonsense rate (often negative, or an error). For a *plain* lump-sum problem with no payments you can get away with both positive — but the moment `PMT ≠ 0`, the signs must be coherent or every answer is wrong.

A clean way to think about it: stand in the **investor's shoes**. Anything you hand over is negative; anything you receive is positive.

Real vs nominal, inflation and depreciation

- **Nominal rate** is the rate as quoted ("nominal annual rate of 5%"). It is the headline figure you type into `I%`.
- **Real rate** adjusts for inflation — it is roughly the nominal rate *minus* the inflation rate. If your account pays a nominal 4% but inflation runs at 3%, your money grows in face value but its **purchasing power** grows only about 1% a year. A Paper 2 question may ask you to compare the maturity value against what the same goods will cost later.
- **Inflation** is modelled exactly like compound interest: a cost of `C` rising at inflation rate `i` per year becomes `C(1 + i/100)^n` after `n` years. To check whether an investment "keeps up", grow the investment with its rate and grow the target cost with the inflation rate, then compare.
- **Depreciation** is compound *decay*: an asset worth `V` losing `p%` of its value each year is worth `V(1 − p/100)^n` after `n` years. On the solver this is just a **negative I%**: enter `I% = −p`. A car worth \$24 000 depreciating at 15% per year is worth `24000(0.85)^n`; after 5 years, `24000·0.85^5 = 10 642.46`.

Annuities and amortisation (SL level)

At SL you are not expected to derive annuity formulas — you let the **solver** handle the regular payments through the `PMT` box.

- An **annuity / savings plan**: you pay a fixed amount in each period and it accumulates with interest. Set `PV` to the starting balance (often 0), `PMT` to the negative regular deposit, and solve for `FV` — or solve for `N` to answer "how many years until I have \$X".
- **Amortisation (a loan)**: you borrow `PV` (positive — money comes *to* you) and repay it with a fixed `PMT` (negative — money leaves you), with `FV = 0` at the end (the loan is cleared). Typical questions: find the monthly repayment, or find how long the loan takes to clear, or find the total amount repaid (`= |PMT| · N`) and hence the total interest (`total repaid − amount borrowed`).

Worked micro-example (a savings annuity). You deposit \$250 at the end of each month into an account paying a nominal 4.8% compounded monthly. How much is in the account after 5 years? Regular monthly payments ⇒ use the solver. Enter: `N = 60` (months), `I% = 4.8`, `PV = 0`, `PMT = −250`, `P/Y = 12`, `C/Y = 12`. Solve for `FV`. Result: `FV ≈ 16 950` (the calculator gives `16 950.0...`). You paid in `250·60 = 15 000`; the interest earned is about `1 950`.

Sequences & series on the GDC

The sequences and series *theory* is in the Paper 1 guide. What the calculator adds on Paper 2 is **brute-force evaluation** and **numerical solving**, which turns awkward problems into quick ones.

Summing a series numerically

Your GDC has a **sum + sequence** command (TI: `sum(seq(...))`; Casio: `Σ` in the menu). For any `Σ` you can type the general term, the index variable, and the limits, and read off the total — no closed-form formula needed. This is especially useful when a series is *neither* cleanly arithmetic nor geometric, or when you would otherwise have to identify `u₁`, `d`/`r` and `n` under time pressure. Even for a standard geometric series the booklet formula is faster, but the `sum(seq(...))` command is the safety net and a free way to **check** a formula answer.

Solving for *n* — "when does S_n first exceed …"

This is a flagship Paper 2 task. "Find the minimum number of months/terms before the total first exceeds \$X." On Paper 1 you would take logs; on Paper 2 you have three faster routes:

1. **Graph it.** Plot `y = Sₙ` (or the relevant expression) against `n`, plot `y = X`, and find the intersection. Then **round up to the next whole number** if `n` must be an integer.
2. **Use the equation solver** to solve `Sₙ = X`, then round up.
3. **Make a table** of `Sₙ` and scroll until it crosses `X`.

Whichever you use, the mark scheme wants to see that you checked the **integer either side**. The November 2023 finance chain is the model: the solver gave `m = 28.44…`, and the mark scheme explicitly credits showing `m = 28 ⇒ 254 707` (below target) **and** `m = 29 ⇒ 259 954` (above target), concluding **29 complete months**. Always state both neighbouring values — it both earns the mark and protects you from rounding the wrong way.

Worked micro-example (solving for n). A geometric series has first term 80 and common ratio 1.05. Find the least n for which $S_n > 5000$. $S_n = 80(1.05^n - 1)/(1.05 - 1) = 1600(1.05^n - 1)$. Solve $1600(1.05^n - 1) = 5000$ on the GDC: $n = 26.3\ldots$. Check: $n = 26 \Rightarrow S_{26} = 4936.6$ (not yet), $n = 27 \Rightarrow S_{27} = 5263.4$ (over). So the least n is **27**.

Mixing arithmetic / geometric with compound-interest contexts

The hardest NA questions on Paper 2 deliberately put **two different sequences in one scenario** and ask for their **combined** value. The November 2023 paper is the template: Daniela receives a *prize* paid monthly that grows 4% each month (a **geometric series** — sum it), while Sorin invests a lump sum compounded monthly (**compound interest** — one power expression), and the question asks for the **total of the two** and then for the first month the total exceeds a target. The May 2025 TZ2 "bouncing ball" question does the same trick the other way: heights form a **geometric** sequence but the per-bounce *distances travelled* end up forming an **arithmetic** sequence.

The strategy:

1. **Label each stream separately.** Decide for each whether it is arithmetic, geometric, or compound-interest, and write its expression on its own line.
2. **Get the timing aligned** — make sure both are measured in the same units (months, or years) and from the same start date.
3. **Add the expressions**, then graph / solve / table for whatever n the question wants.
4. Watch the **"first payment today"** subtlety: if a payment arrives on day 1 it has had *zero* periods of growth, so the count of compounding periods can be one less than the count of payments. Read the dates carefully.

Binomial, exponents and logs on Paper 2

These topics are *primarily* Paper 1 territory, but they still appear on Paper 2 — and the calculator changes how you attack them.

- **Binomial expansion.** Still tested (recent Paper 2s have a "find k given the coefficient of x^6 in $(2x + k)^{10}$" question). With a calculator you can compute `nCr` directly instead of building Pascal's triangle, and once you reduce the problem to a polynomial equation in the unknown (e.g. k or n), you **solve that equation on the GDC** rather than by hand. The setup — writing the general term $(nCr)\, a^{n-r} b^r$ and matching the power — is unchanged; only the final solve is automated.
- **Exponential and logarithmic equations.** On Paper 1 you take logs and leave an exact $(\ln 7)/(\ln 3)$ answer. On Paper 2 you have two extra options: **solve graphically** (plot both sides, find the intersection) or use the **equation solver**, and you **report a decimal to 3 s.f.** (unless told otherwise). This matters most when the equation **cannot** be solved algebraically at all — e.g. $2^x = 3x + 1$, or

a mixed equation from an exponential model. If you ever find yourself stuck doing algebra on a Paper 2 equation, **stop and graph it**: that is what the calculator paper is testing.

Worked micro-example (log/exponential equation on the GDC). A population is modelled by `P = 400·(1.18)ᵗ`, with `t` in years. Find, to 3 s.f., when the population first reaches 2 500. Solve `400·(1.18)ᵗ = 2500`. Graphically: plot `y = 400·1.18^x` and `y = 2500`, intersect ⇒ `t = 11.07…`. Or by hand as a check: `1.18ᵗ = 6.25 ⇒ t = ln 6.25 / ln 1.18 = 11.1` (3 s.f.). If the question asks for the first *whole* year the population reaches 2 500, that is year **12** — round **up**, because at `t = 11` it has not yet got there.

Traps — the Paper 2 NA mark-losers

- **P/Y and C/Y mismatch.** The most common finance error. Decide up front whether `N` counts **years** (`P/Y = 1`) or **periods** (`P/Y = k`), and make `N`, `P/Y`, `C/Y` mutually consistent. `N = 20` with `P/Y = 1` quietly means twenty *years*, not twenty half-years.
- **Sign errors on PV / FV / PMT.** `PV` and `FV` must have **opposite signs**; deposits and repayments (money leaving you) are **negative**, withdrawals and borrowed sums (money coming to you) are **positive**. Same-sign `PV` and `FV` give a garbage rate. If `PMT` has the wrong sign the solver computes a *withdrawal* plan instead of a *saving* plan.
- **Units of time.** "Monthly" means `k = 12` *and* the number you call `N` (if it counts periods) is in months. Mixing a monthly rate with a year-count for `N`, or vice versa, is an instant wrong answer. Convert everything to one unit before you start typing.
- **Rounding money mid-calculation.** Keep full precision **inside** the calculator and round **once** at the end. If a question says "give answers to two decimal places", that is the *final* answer only — the May 2022 mark scheme has an explicit note that *"the first time an answer is not given to two decimal places, the final A1 is not awarded."* Reusing a rounded intermediate value (e.g. a rounded `FV` fed into the next part) propagates error and costs the accuracy mark; use the calculator's stored exact value (`Ans`, or a stored variable) instead.
- **Reading "nominal annual rate compounded monthly" correctly.** This is **not** a monthly rate and **not** a once-a-year rate. It is an *annual* rate that is *divided by 12* and *applied 12 times a year*. Enter `I% = 5` (the annual figure) into the solver and set `C/Y = 12` — do **not** pre-divide it to `I% = 0.4167`.
- **Forgetting to round n the right way.** "Minimum number of complete months/terms/years" almost always means **round up** — and you should **state the value either side** of the boundary to prove it (and to bank the mark). "How many complete years has it been above X" can mean round *down*. Read which direction the context demands.
- **Calculator-notation answers.** A final answer must be a **number**, not `sum(seq(...))` or `solve(...)` or a TVM-solver screenshot description. Write the variable list as your *working* (that earns the method mark), then write the numerical result as your *answer*.
- **Geometric vs compound-interest "off-by-one".** A lump sum invested *today* and a payment received *today* are not the same: the lump sum compounds, the payment that just arrived has had

zero growth. When you add two streams, line up the period counts against the actual dates given.

If you remember nothing else (Paper 2 NA)

- **Financial maths is Paper 2's home turf** — expect a finance question, and use the **TVM solver**, writing out `N, I%, PV, PMT, FV, P/Y, C/Y` as your working.
- **`PV` and `FV` opposite signs; money you pay is negative.** Pick one `N`-convention (years *or* periods) and keep `P/Y`/`C/Y` consistent with it.
- **"Nominal annual rate compounded monthly"** ⇒ enter the annual rate, set `C/Y = 12`; never pre-divide.
- **"When does S_n first exceed X"** ⇒ graph or solve, then **state the integer either side** and round up.
- **Keep full precision; round once at the end** — a rounded intermediate value kills the final accuracy mark.
- If a log/exponential equation resists algebra, **graph it** — that is what the calculator paper rewards.

Geometry, Trigonometry & Functions on Paper 2

The Paper 1 guide already taught you *what* these topics are — the exact-value table, the sine and cosine rules, completing the square, inverses, transformations. This section assumes all of that and asks a narrower question: **what changes when the calculator is on the desk?**

The honest answer is that Paper 2 does not test different content — it tests the same content with the algebra grinding *removed* and the interpretation and set-up *amplified*. On Paper 1 you earn marks by manipulating cleanly. On Paper 2 you earn marks by choosing the right calculator operation, entering it without error, and then **saying what the number means**. The numbers are deliberately ugly (19.5, 58.1 million, 0.0145) precisely so that you cannot do it by hand. That is a gift — but only if your calculator discipline is solid.

Your Paper 1 (TZ2) was heavy on Functions and moderate on Geometry/Trig. Do not over-read that. The IB rotates emphasis between the two papers of a session and between sessions, but it never *drops* a topic. On Paper 2, Functions is the connective tissue of every modelling question even when it is not labelled "functions", and Geometry/Trig shows up in calculator-friendly forms — messy triangles, sinusoidal models, 3D solids. Expect both.

Part 1 — Geometry & Trigonometry on Paper 2

1.1 The radian/degree mode discipline — the single most important habit on the paper

Every other trap in this section is downstream of one decision: **what mode is your calculator in?**

The rule of thumb:

- **Triangles, bearings, 3D solids, angles of elevation** — these are almost always posed in **degrees** on Paper 2. Set the calculator to degrees.
- **Sinusoidal models, trig equations involving π, anything where the formula booklet's calculus or circle formulas are in play** — these are in **radians**.
- A sector or arc question (`s = rθ`, `A = ½r²θ`) is **radian-only as a formula**, but the question may *hand you the angle in degrees*. Convert first, then substitute.

The disaster scenario: a triangle question gives you an angle of 58°, your calculator is in radian mode left over from the previous question, and `tan(58)` returns a number near 1.6 instead of 1.6 (it actually returns `tan(58 rad)` ≈ 2.05... — silently, with no error). Every downstream value is wrong, and because Paper 2 chains parts, you can lose six or eight marks from one mode setting.

Build this into your routine: at the start of every trig question, glance at the mode indicator. If the question mixes both — e.g. a triangle (degrees) feeding into a sector (radians) — switch deliberately mid-question and note it. The May 2025 TZ1 sector question explicitly accepted *either* the radian formula `½r²θ` with `θ = 7π/6` *or* the degree formula `(210/360)πr²` — the markscheme does not care which, it cares that you were **consistent**. Pick a lane and stay in it.

1.2 Triangles in messy real-number contexts

On Paper 1 a triangle question gives you angles like 60° so the exact values fall out. On Paper 2 the triangle is embedded in a real situation — a crane, a field, a flight path — and the sides are 18.2 m and the angle is 58°. The *method* is identical to Paper 1 (decide: sine rule, cosine rule, or right-angled trig) but now you just type it in.

Worked micro-example. A surveyor stands at point P and sees the base of a tower at T and a flagpole at F. She measures PT = 84.0 m, PF = 61.0 m, and the angle TPF = 49°. Find the distance TF.

Two sides and the *included* angle — cosine rule. $TF^2 = 84.0^2 + 61.0^2 - 2(84.0)(61.0)\cos 49°$ $TF^2 = 7056 + 3721 - 10248 \cos 49° = 10777 - 6724.0... = 4053.0...$ TF = 63.66... ≈ **63.7 m** (3 s.f.)

The only Paper-2-specific skills here: calculator in **degrees**, do not round `cos 49°` to 0.66 before multiplying (keep the full value in the calculator), and quote the final answer to 3 s.f. unless told otherwise.

The ambiguous case still bites on Paper 2. When the sine rule gives you an *angle*, `sin⁻¹` on the calculator returns **only the acute value**. The calculator will not volunteer the obtuse partner `180° − θ`. You must decide yourself whether the obtuse triangle is also valid (does `(180° − θ) +` known angle stay under 180°?). This is the GDC equivalent of the Paper 1 trap — the machine does not save you, it just hands you one root.

1.3 3D solids and 3D trig with the calculator

The Paper 1 method holds completely: **there is no special 3D formula** — you drop the problem onto a right triangle (or a non-right triangle) constructed inside the solid, find the relevant lengths, and apply trig. What the calculator changes is only that the lengths come out ugly and you do not simplify surds — you evaluate.

Worked micro-example. A rectangular-based pyramid has base ABCD with AB = 24 cm and BC = 18 cm. The apex V sits directly above the centre of the base, and the slant edge VA = 31 cm. Find the angle that edge VA makes with the base.

The base diagonal $AC = \sqrt{(24^2 + 18^2)} = \sqrt{(576 + 324)} = \sqrt{900} = 30$ cm, so the centre is 15 cm from A. In the right triangle formed by A, the centre, and V: the angle at A has adjacent side 15 and hypotenuse VA = 31. cos(angle) = 15 / 31, so angle = $\cos^{-1}(15/31)$ = **61.1°** (3 s.f.).

Notice: the *only* exact step was the 3-4-5-scaled diagonal; everything else is a calculator evaluation. On Paper 2 you would not be embarrassed if the diagonal were also ugly — you would just store it.

Volume and surface-area formulas for cones, spheres, pyramids, cylinders are **in the formula booklet** — your job is to identify the solid and substitute. The May 2024 TZ1 cone question is the template: use trig to find the cone's radius from an angle and a distance (`r = 6.37 m` from `tan 58° = 18.2/(r+5)`), then substitute into the booklet's `V = ⅓πr²h`. Two ideas, two parts, both calculator-driven.

1.4 Sine/cosine rule chains and the "store, don't round" rule

Because Paper 2 questions chain — part (a) feeds part (b) feeds part (c) — the dominant Paper 2 mark-loss is **premature rounding**. If part (a) gives you `DE = 362.230...` and you write down `362` and then use 362 in part (b), your part (b) answer drifts and you can lose the final accuracy mark.

The fix is mechanical: **store every intermediate result in a calculator memory** (or use the `Ans` key / a variable) and recall it, rather than re-typing a rounded version. The markscheme is generous — it usually writes "*accept ... from the use of 3 s.f. values*" — but generous is not guaranteed. Carrying the full value costs nothing and removes the risk entirely. Write down the rounded value *to show the examiner*, but compute with the stored one.

1.5 Trig equations solved graphically on the GDC

This is the headline Paper-2 method for trig equations, and it is genuinely *different* from Paper 1. On Paper 1 you solve $2\cos^2 x - \cos x - 1 = 0$ by factorising. On Paper 2 you solve $3 \sin(2x) + 1 = 0.4x$ — which **does not factorise and has no exact solution** — by graphing.

The method:

1. Put the calculator in the correct mode (radians, unless the domain is given in degrees).
2. Graph $y_1 = 3 \sin(2x) + 1$ and $y_2 = 0.4x$ (i.e. the two sides of the equation as separate curves).
3. Use the calculator's **intersection** function to find each crossing point.
4. **Read off every intersection inside the stated domain** — and here is the trap, see below.

Worked micro-example. Solve $5 \cos(x) = x - 1$ for $0 \le x \le 2\pi$.

Graph $y_1 = 5 \cos x$ and $y_2 = x - 1$ on $[0, 2\pi]$. The wave crosses the line three times in that window. Asking the calculator for intersections gives approximately $x = 1.10$, $x = 3.98$, and $x = 5.30$ (3 s.f.). All three lie in $[0, 2\pi] \approx [0, 6.28]$, so all three are solutions.

The marks are: **M1** for the graphical set-up (the examiner needs to see the two-curve idea, or a sketch), then **A1 for each correct root**. Miss a root and you miss an A mark — directly.

1.6 Sinusoidal modelling — fitting y = a sin(b(x − c)) + d

This is the most reliable Geometry/Trig appearance on Paper 2: a periodic real situation (tide height, temperature, Ferris wheel, daylight hours, a passenger on a wheel) modelled by $y = a \sin(b(x - c)) + d$ or the cosine version. You are given **either** a maximum and a minimum and a period, **or** two data points, and asked to find the parameters.

The reliable route — from max/min/period:

- $d = (\max + \min) / 2$ — the principal axis (vertical shift).
- $a = (\max - \min) / 2$ — the amplitude (always positive when quoted as amplitude).
- $b = 2\pi / \text{period}$ — note: period in, b out, *not* the reverse.
- c — the horizontal shift, read from a known peak or trough.

Worked micro-example. The depth of water in a harbour over one day is modelled by $D(t) = a \sin(b(t - c)) + d$, where t is hours after midnight. High tide of 9.4 m occurs at $t = 4$, and the next low tide of 2.6 m occurs at $t = 10.25$.

- $d = (9.4 + 2.6)/2 = 6$ m

- $a = (9.4 - 2.6)/2 = 3.4$ m
- High tide to the *next* low tide is half a period, so $\text{period} = 2 \times (10.25 - 4) = 12.5$ hours, giving $b = 2\pi/12.5 = 0.5026...$
- A sine curve reaches its maximum a quarter-period after $x = c$. The maximum is at $t = 4$, and a quarter period is $12.5/4 = 3.125$, so $c = 4 - 3.125 = 0.875$.

Model: $D(t) = 3.4 \sin(0.503(t - 4 - ...))$ — but the cleaner Paper 2 move is: **use the calculator's sinusoidal regression** if the question gives you a *table* of data, or set up two equations and use the **equation solver** if it gives you specific conditions. The May 2025 TZ1 paper did exactly this — substituted two $(x, f(x))$ points to get two simultaneous equations and solved for the two unknown parameters. The calculator's simultaneous-equation solver does it in seconds; doing it by hand is the slow, error-prone route.

Interpreting the parameters in context is where R marks live: d is the *mean* water level, a is *half the tidal range*, the *period* is the time between successive high tides, and b itself is rarely interpreted directly — interpret the period instead.

1.7 Arc and sector with non-exact numbers

Same formulas as Paper 1 — $s = r\theta$, $A = \frac{1}{2}r^2\theta$, radian-only — but now $r = 19.5$ and θ arrives in degrees. The Paper 2 method: **convert the angle to radians first** (or use the degree-fraction form $(\theta°/360°) \times 2\pi r$ for arc and $(\theta°/360°) \times \pi r^2$ for area — the markscheme accepts both), then evaluate. Keep the full value; quote 3 s.f.

Part 2 — Functions on Paper 2

2.1 Function modelling — exponential growth/decay and logistic-feel contexts

On Paper 2, "functions" mostly means **modelling**. A quantity changes over time — a population, a temperature cooling, a drug concentration, the value of an asset — and you are handed a model, usually one of:

- **Exponential growth/decay:** $P(t) = P_0 a^t$ or $P(t) = P_0 e^{(kt)}$. Decay has $0 < a < 1$ or $k < 0$.
- **A "logistic-feel" bounded model:** something like $P(t) = L / (1 + Ce^{(-kt)})$ or a model with a horizontal asymptote the quantity approaches but never reaches. (SL does not require the full logistic differential equation, but it absolutely uses functions of this *shape* in modelling questions.)
- A sum or difference of exponentials, or an exponential plus a linear term.

The Paper 2 skills: **evaluate** the model at a given time (just substitute and compute), **find when** the quantity hits a target value (solve graphically or with the solver — see 2.2), and **interpret a parameter or a feature in context** (see 2.4).

Worked micro-example. A colony of bacteria is modelled by $N(t) = 480 e^{(0.094t)}$, where t is measured in hours and N is the number of bacteria.

(a) Find the number of bacteria after 12 hours. $N(12) = 480\ e^{(0.094 \times 12)} = 480\ e^{(1.128)} = 480 \times 3.0894... = 1482.9...$ ≈ **1480 bacteria** (3 s.f.).

(b) Find the time for the colony to first exceed 5000. Solve $480\ e^{(0.094t)} = 5000$ — graphically (intersect $y = 480e^{(0.094t)}$ with $y = 5000$) or with the equation solver. This gives $t = 24.95...$ ≈ **24.9 hours**. (You could also do this by hand with logs, but on Paper 2 the solver is faster and the markscheme accepts it.)

2.2 Finding parameters of a model from given conditions — the GDC equation solver

This is the Paper-2 workhorse and worth practising until it is automatic. A model has unknown constants; the question gives you conditions (data points, a known rate, an initial value); you turn the conditions into equations and let the calculator solve.

One unknown — use the equation solver directly. If $T(t) = 18 + 47\ e^{(-kt)}$ models a cooling cup of coffee and you are told $T(10) = 41$, you have one equation in one unknown: $18 + 47\ e^{(-10k)} = 41$. Type it into the solver, get $k = 0.07133...$.

Two unknowns — use the simultaneous-equation solver. If a model $y = a \sin(...) + b$ or $y = pe^{(qt)}$ has two unknowns and you are given two conditions, you get two equations. The calculator's simultaneous solver (or, for linear-in-the-unknowns systems, the matrix/poly solver) handles it. The May 2025 TZ1 paper did this with a `tan` model: two substituted points produced $a/\sqrt{3} + b = 5$ and $-a\sqrt{3} + b = 7$, solved to $a = -\sqrt{3}/2$, $b = 11/2$.

Three "or more" — for a model of the form $y = ax^2 + bx + c$ or a cubic fitted to data points, use the calculator's regression (quadratic regression, cubic regression) — it returns all coefficients at once.

The marking: **M1** for a correct attempt to set up the equation(s) from the conditions, **A marks** for the correct parameter values. The examiner wants to see *what equation you fed the machine* — show it. A bare answer with no equation risks the M1.

2.3 Reading features off the GDC graph — and solving f(x) = g(x) graphically

Paper 2 routinely asks you to find a **maximum, minimum, zero (x-intercept), y-intercept, or point of intersection** of a function that you could not analyse by hand. The method is always the same:

1. Graph the function in a window that actually shows the feature (this matters — see the traps).
2. Use the dedicated calculator tool: *maximum*, *minimum*, *zero*, *intersect*.
3. Write the feature as a **coordinate pair** (or an equation, for an asymptote), to 3 s.f.

Solving $f(x) = g(x)$ is just the intersection tool: graph both, intersect, read off the x-coordinates (and y, if asked). This is identical in spirit to the graphical trig-equation method in 1.5 — because it *is* the same method, applied to any pair of functions.

Worked micro-example. Given $f(x) = 3\ln(x + 2)$ and $g(x) = 0.5x^2 - 1$, find the x-coordinates of the points where the graphs meet, for $x > -2$.

Graph both. They intersect twice in the valid domain. The calculator's intersect tool gives approximately $x = -1.41$ and $x = 2.69$ (3 s.f.). Both satisfy $x > -2$, so both count.

Worked micro-example (max off the GDC). A function modelling profit is `P(x) = 60x e^(−0.04x) − 200` for `0 ≤ x ≤ 100`. Find the production level `x` that maximises profit, and the maximum profit.

Graph `P` on `[0, 100]`, use the maximum tool: it sits at approximately `x = 25.0`, `P = 351.8...`. So produce **25 units** for a maximum profit of **352** (3 s.f.). No differentiation needed — though differentiating and solving `P'(x) = 0` is equally valid and the markscheme allows either.

2.4 Domain and range in context — and interpreting parameters

Paper 2 modelling questions love to ask "for what values of `t` is the model valid?" or "what does the parameter `a` represent?". These are **A1 or R1 marks for a sentence**, and they are among the most-dropped marks on the paper because students treat them as throwaway.

- **Domain in context:** a time variable cannot be negative, so `t ≥ 0`; a model fitted to data from 2010–2025 should not be trusted for 2040 — that is **extrapolation**, and "unreliable because it is outside the range of the data" is a complete, mark-scoring answer (the Nov 2025 TZ1 paper awarded a mark for exactly this).
- **Range in context:** the bacteria count is bounded below by the initial value for a growth model; a cooling model's temperature is bounded below by room temperature (the horizontal asymptote `+18` in the coffee example) — the coffee can never cool below the room.
- **Interpreting a parameter:** in `B(t) = a + bt` for a population, `a` is the *rate of increase* (Nov 2025 TZ1 awarded R1 for "`a` represents the average rate of change in population"). In $B(t) = B_0 \times 1.007^t$, the `1.007` means a **0.7% annual growth rate** — and the markscheme insisted the description "*must include some reference to annual rate*". A vague "it makes it bigger" scores nothing.

The discipline: when a modelling question ends with "interpret" or "comment" or "explain", **write a full sentence that names the quantity, the units, and the context**. Treat it as worth its marks, because it is.

The Paper-2 trap list — Geometry, Trig & Functions

1. Radian vs degree mode — the #1 Paper 2 trig disaster. The calculator gives no error when it is in the wrong mode; it just returns a confidently wrong number that poisons every chained part. Check the mode indicator at the start of every trig question. Triangles/bearings/3D → degrees; sinusoidal models and π-domain equations → radians; convert deliberately when a question mixes both.

2. The GDC gives only one solution when the domain has several. $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$ each return a single principal value. A graphical intersection done in too narrow a window shows only the crossings you happened to look at. **Always work out how many solutions the domain should contain** — a sine curve over `[0, 2π]` can cross a line two or three times — and keep finding intersections until you have them all. Each missed root is a lost A mark.

3. Sketching from the GDC without labelling. When a question says "sketch", an unlabelled correct-shaped curve often scores **nothing**. Transfer from the calculator screen: axis intercepts as coordinates, maxima/minima as coordinates, asymptotes as equations, and endpoints of the given domain. The Nov

2024 TZ1 markscheme awarded its sketch marks specifically for *labelled* endpoints, intercepts, and maximum — the shape alone was not enough.

4. Model parameters not interpreted in context. "Find `a`" is a calculation; "what does `a` represent" is a separate mark requiring a sentence with the quantity, units, and meaning. `1.007` is "0.7% annual growth", not "growth". Do not leave these blank or vague — they are the cheapest R1 marks on the paper.

5. Accepting a GDC intersection without checking it is in the valid domain. The calculator will happily report an intersection at `x = −3.2` even though the model is only defined for `x > 0`, or a negative time, or a triangle angle over 180°. **Every value the machine returns must be tested against the question's constraints** before you write it as a final answer. The markscheme explicitly refuses the final A mark for "inappropriate values" — a negative length, a probability above 1, a `sin θ = 1.5`.

6. Premature rounding in a chained question. Paper 2 questions feed part (a) into (b) into (c). Round `362.230...` to `362` early and your final answer drifts off the markscheme's accepted range. **Store the full value in memory, compute with it, and only round the value you write down.** Carrying full precision costs nothing and removes the risk.

7. Showing no method on a calculator question. "Once a correct answer is seen, ignore further working" cuts both ways — a *wrong* bare answer with no working scores zero, and earns no follow-through, because the examiner cannot see where you went wrong. Always write the equation you solved, the integral you set up, or the two curves you intersected. The M marks live in the set-up, not the number.

Paper 2 — Traps and Mark-Loss by Topic

A reference for students who can do the maths but keep dropping marks on the calculator paper. Paper 2 is the technology-permitted paper: 90 minutes, 80 marks, Section A (short questions) and Section B (extended questions), formula booklet provided, a GDC required throughout. The mark codes are the standard IB family: ***M*** *(method),* ***A*** *(answer / accuracy),* ***R*** *(reasoning),* ***AG*** *(answer given — must be shown convincingly), and the implied-mark, follow-through, and "from GDC" conventions described below. Paper 2 does not test different mathematics from Paper 1 — it tests the same mathematics with a machine in your hand, and the machine creates an entirely new family of traps. Almost every Paper-2-specific mark-loss is a presentation failure, an accuracy failure, or a mode failure, not a mathematics failure. This guide catalogues them, organised by topic, cross-referenced to the structure notes by §-number.*

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0. How Paper 2 mark schemes actually behave

Before the topic sections, four scheme conventions explain *why* the calculator-era traps cost what they cost. Internalising these is worth more than any single technique.

Method marks survive errors; answer marks do not. Within a question part, once you make an error, no further **A** marks are available for work that uses the error — but **M** marks still are, *if the method is visible*. This is the structural reason that "bare answers" are catastrophic on Paper 2: a wrong bare answer earns nothing, whereas a wrong answer with correct setup shown still banks the method marks and usually opens follow-through credit downstream.

Follow-through (FT) needs working present. An incorrect value from part (a) used correctly in part (c) earns FT marks — but the scheme is explicit that "to award FT marks, there must be working present." A student who carries an early slip silently through three parts, showing only final numbers, loses not just the original mark but every FT mark that visible working would have rescued.

"Do not accept final answers written using calculator notation." This is a verbatim scheme instruction. `normalcdf(...)`, `solve(...)`, an unevaluated `∫`-template — these can earn an intermediate **M** or **A** if "the evidence clearly reflects the demand of the mark," but they are **never** accepted as the *final* answer. The final answer must be an evaluated number.

Three significant figures unless told otherwise — and exact values used downstream. Where a value feeds later parts, the scheme uses the *exact* (full-precision) value, though it will also accept the correct 3 s.f. value and often prints the "from the use of 3 sf" alternative. The danger zone is using a value rounded to *fewer* than 3 s.f., or rounding at every step.

MR (misread) is not available on bare calculator answers. The scheme states plainly: "For calculator questions with no working and incorrect answers, examiners should not infer that values were read incorrectly." On Paper 1 a misread is penalised once; on Paper 2, a misread with no working shown is simply wrong, with no mitigation.

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1. Number & Algebra (including financial maths)

On Paper 2 this topic is dominated by financial mathematics, sequences with messy ratios, and "solve this equation" questions where the GDC does the solving. The arithmetic is trivial; the setup discipline is everything.

§1.1 The finance solver: P/Y and C/Y mismatched

The TVM / finance solver has separate fields for **P/Y** (payments per year) and **C/Y** (compounding periods per year). When a loan compounds monthly but is repaid monthly, both are 12; when interest compounds quarterly but the question is annual, they differ. Students leave both at the default (often 1) or set one and forget the other, and the solver returns a number that is internally consistent but answers a different question. The mark consequence: the **A** mark for the final value is lost, and because the solver output is a bare number, there is no visible method to rescue an **M** mark. The fix is mechanical — before touching the solver, write the five inputs (N, I%, PV, PMT, FV) and the P/Y, C/Y values on the page as a labelled list. That list *is* your method evidence and earns the **M** mark independently of whether the solver is configured correctly.

§1.2 Finance sign convention: money in vs money out

The solver treats cash flows as signed: money leaving you (an investment, a deposit) and money coming to you (a loan received, a withdrawal) must have opposite signs. The classic error is entering PV and FV with the same sign, which produces a negative interest rate or a nonsensical time. Examiner schemes show the expected entry explicitly — e.g. `PV = ∓29750`, `FV = ±3500` — precisely because the sign pairing is where candidates fail. Lost mark: the **A** mark, again with no method visible to recover. Fix: decide which direction is "out of pocket," make that negative, and keep it consistent for the whole question.

§1.3 Time units in finance — months vs years

If interest is quoted per annum but compounded monthly, N is the number of *months* and I% must be the *annual* rate with C/Y = 12, **not** the monthly rate with N in years. Mixing these produces answers off by orders of magnitude. The schemes condone "use of n or x" for the variable name but never condone the wrong unit. Lost mark: the **A** mark for the final value. Fix: write next to N what unit it is in ("N = 60 months") before solving.

§1.4 Geometric sequences: the GDC finds *a* root, the question wants the integer

"After how many years does the investment first exceed \$X" is an inequality, $a r^{n} > X$. The GDC solves the *equality* and returns a non-integer like 19.36. Students report 19.36, or round it to 19, when the answer is the next integer up, 20 — you must *exceed* the target, so you round **up** regardless of the decimal. Lost mark: the final **A** mark. The scheme explicitly prints both the non-integer solver output and the boundary check ($n=19 \Rightarrow$ below, $n=20 \Rightarrow$ above). Fix: after the GDC gives the boundary, test the integers on either side and state which one satisfies the inequality — that test is the **A**-mark-earning step.

§1.5 "Show that" inside a Number & Algebra question still needs algebra

Paper 2 sequence questions frequently embed an AG part — "show that $t_n = \tfrac{n}{2}(3n+1)$" — in the middle of an otherwise calculator-driven question. The GDC cannot earn an AG mark. The scheme wants the arithmetic-sequence sum formula written out, the substitution shown, and the simplification to the given form. A student who verifies the formula numerically for $n=4$ has produced a check, not a proof, and earns zero for that part. Lost marks: both the **M** for the method and the **AG**. Fix: treat any "show that" as a Paper-1 question — full algebra, every step, arriving *at* the printed expression.

§1.6 Binomial term selection on the calculator paper

Paper 2 binomial questions hide the index. Asked for the term containing a particular power when one bracket entry is itself a power (e.g. $\sqrt{x} = x^{1/2}$), students must first rewrite the radical as a fractional power, then solve for r so the power matches. The scheme awards a discrete **A** mark just for "rewriting $\sqrt{x}$ as $x^{1/2}$" and another for "evidence of correct term chosen ($r = 3$)." Skipping straight to a calculator-expanded polynomial and reading off a coefficient throws away those structured marks. Fix: show the general term, the power equation, and the value of r explicitly.

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2. Functions

The calculator turns most function questions into "type it in and read the graph." That is exactly where the traps live: the GDC will faithfully return *an* answer, including the wrong one.

§2.1 The GDC returns one solution; the domain wants several

`solve` and the graph-intersection tool typically return the solution nearest the cursor or the first one found. Trig equations, polynomials of degree ≥ 3, and equations like $f(x) = g(x)$ over a stated interval frequently have multiple solutions. A student who reads off one root and moves on loses every **A** mark tied to the missing roots — and on a Section B question, the loss cascades, because later parts assume the full solution set. Fix: always graph the function over the *entire stated domain* first, count the intersections visually, then solve for each. The visible "I found N intersections" reasoning protects you.

§2.2 Trusting an intersection outside the valid domain

The GDC will happily give an intersection at $x = -4$ when the model is only defined for $x \ge 0$ (a population, a length, a time). The number is a real root of the equation; it is not a valid *answer*. The scheme's general rule — "if the error leads to an inappropriate value... do not award the mark(s) for the final answer" — bites here. Lost mark: the **A** mark, and an **R** mark if the question asked you to justify the solution. Fix: state the model's domain before solving, and explicitly discard out-of-domain roots in writing.

§2.3 Calculator notation as the final answer

Writing `solve(2^x = 7, x)` or leaving the answer as an unevaluated expression is not a final answer. The scheme accepts calculator notation for *intermediate* **M**/**A** credit but never for the final mark. Lost mark: the final **A**. Fix: evaluate to a 3 s.f. number and write that number as the answer line.

§2.4 "Hence" parts that still need algebra

"Hence find..." or "show that..." parts within a function question are command-term instructions that the GDC is not permitted to satisfy. If the command term is "Hence" (not "Hence or otherwise"), the scheme does not even allow alternative methods. A student who answers a "show that the asymptote is $x = 2$" part by reading a graph rather than analysing the function earns nothing. Fix: identify the command term first; "show that," "hence," "prove," "verify algebraically" all mean *pen, not machine*.

§2.5 Reading transformations off the GDC instead of solving for parameters

Section B function questions routinely ask for the parameters a, b, c, d of a sinusoidal or exponential model. Students who try to eyeball these from a calculator plot get approximate, wrong values. The scheme wants the period extracted ($b = 2\pi/\text{period}$), a known point substituted, the equation solved. Lost marks: the **M** for "correct substitution of a point" and the **A** for each parameter. Fix: use the GDC to *read coordinates of specific features* (a maximum, a zero, the period length), then do the parameter algebra by hand.

§2.6 Rational function asymptotes stated as inequalities or numbers

Asked for the asymptotes of a rational function, the answer must be an *equation* ($x = 2$, $y = \tfrac{3}{2}$). The scheme is explicit: "Award A1A0 for answers $x \ne 2$ and $y \ne \tfrac{3}{2}$." Stating the excluded value as an inequality, or as a bare number, loses the **A** mark even though the numerical content is right. Fix: write asymptotes as equations of lines, every time.

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3. Geometry & Trigonometry

This is the highest-density mode-error topic on Paper 2, because the calculator has a setting that silently changes every trig answer.

§3.1 Radian / degree mode — the single most destructive Paper 2 setting

The GDC is in radian or degree mode, and it stays there until you change it. Every trig evaluation, every `solve` involving trig, every intersection of a sinusoidal curve depends on it. A student whose calculator is in the wrong mode gets *every trig answer in the question wrong*, and often the whole of a Section B question, by a consistent but invisible factor. The scheme will sometimes accept work "where x values have been converted into degrees" — meaning consistency is what matters — but a mode mismatch between the question's units and the calculator's setting destroys the **A** marks wholesale, and the bare numbers leave no method to rescue. Fix: check the mode indicator at the start of the paper and again at the start of every trig question. If the question gives degrees, work in degree mode; if it gives radians or a period in terms of π, work in radian mode. State which you are using.

§3.2 Premature rounding in multi-step triangle problems

A triangle problem that finds a side, then an angle, then feeds both into an area or a volume is the canonical premature-rounding trap. Round the radius to 6.4 instead of carrying $6.37262...$, and the final volume drifts outside the accepted range. The scheme prints the consequence directly: it gives the answer from the exact value *and* a separate "Accept ... obtained from using [3 s.f. value]" note — but a value rounded to *two* s.f. mid-calculation falls outside even that tolerance. Lost mark: the final **A**. Fix: store intermediate results in calculator memory (ANS, or a variable); never re-type a rounded number.

§3.3 The sine rule ambiguous case is still ambiguous with a calculator

`arcsin` returns one angle. The second possible triangle angle, $180° - A$, is not produced by the calculator and must be considered by hand. Students assume the GDC "would have told them" if there were two — it would not. Lost marks: an **A** mark for the missing angle, often two or three across the question if it propagates. Fix: after any sine-rule angle, write "or $180° - A$" and check whether the second triangle is geometrically possible.

§3.4 Trig equations: the GDC misses solutions outside its default window

Solving $f(x) = k$ for a sinusoidal f over a stated interval, the GDC's graph window or `solve` may return only the solutions visible on screen. Tide and temperature models in Section B routinely have four or more solutions in the stated interval. The scheme lists them all (e.g. "$3.56...$ OR $6.70...$ OR $15.8...$ OR $18.9...$"). Missing any loses the corresponding **A** mark. Fix: set the graphing window to exactly the stated domain, count the intersections, solve for each.

§3.5 3D geometry: setup still earns the marks

Even with a calculator, a 3D box-diagonal or pyramid problem is marked on the *visible setup* — the right triangle identified, the relevant lengths labelled. A bare final number from a calculator earns the **A** mark only if correct, and nothing if wrong. Fix: sketch the relevant 2D right triangle, label it, then compute.

§3.6 Sector and arc formulas in the wrong angle measure

Even on the calculator paper, $s = r\theta$ and $A = \tfrac{1}{2}r^2\theta$ are radian-only. Schemes show both routes — the radian formula with θ converted, *or* the degree fraction $\tfrac{\theta}{360}$ form — but mixing a degree value into the radian formula loses the **M** and **A**. Fix: convert to radians explicitly (the conversion line earns credit) or use the degree-fraction form consistently.

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4. Statistics & Probability

This is the topic Paper 2 exists to test, because the heavy computation needs a machine. It is also where the most distinctive calculator-era traps live.

§4.1 normalcdf vs invNorm — solving the wrong direction

`normalcdf` takes bounds and returns a *probability*. `invNorm` takes a probability and returns a *boundary value*. Students reach for the wrong one constantly: asked "find the value k such that $P(X < k) = 0.9$," they use `normalcdf` and cannot proceed; asked "find $P(X > 13)$," they use `invNorm` and get a meaningless number. Lost marks: the **M** mark for "recognising the need to use inverse normal" (or for setting up the correct CDF), and the dependent **A**. Fix: read what the question gives you and what it wants. *Given a probability, wanting a value* → `invNorm`. *Given values, wanting a probability* → `normalcdf`.

§4.2 invNorm gives a value below the mean — watch the sign

When the target probability is below the mean, `invNorm` (or the standardised z) is negative. Students drop the minus sign when setting up $\tfrac{x - \mu}{\sigma} = z$, producing the wrong μ or σ. The scheme shows the negative explicitly ($\tfrac{153 - 163}{\sigma} = -1.55...$). Lost mark: the **A** for the parameter. Fix: sketch the normal curve, mark the mean, mark where the target value sits — if it is left of the mean, the z is negative.

§4.3 Symmetric-interval problems: the GDC won't spot the symmetry

"Find σ given that $P(a < X < b) = 0.88$ and the interval is symmetric about the mean" requires *recognising* the symmetry to convert it into a one-tailed probability ($P(X < b) = 0.94$). The scheme awards the **M** mark precisely for "recognition of symmetry of interval around mean (may be seen on a sketch)." The GDC cannot do this recognition. Fix: sketch the curve, mark the symmetry, and write the one-tailed probability before using `invNorm`.

§4.4 Regressing the wrong variable — y-on-x vs x-on-y

There are two regression lines. To predict y from x, use y-on-x; to predict x from y, use x-on-y. Using the wrong one is a flat-out wrong answer. The scheme is unusually blunt: it prints "Award M0A0 for choosing the wrong regression line" — *both* marks gone, no follow-through. A separate scheme note flags "should not use line of y on x to predict x from y" as an **R**-mark reasoning point in its own right. Fix: identify which variable is the *unknown you want* — that variable goes on the left of the regression equation, and you regress it *on* the one you were given.

§4.5 Extrapolation — using a regression line outside the data range

Predicting a value for an x far outside the sampled range is unreliable, and Paper 2 explicitly tests whether you know this. The scheme awards an **R** mark for "should not extrapolate." A student who simply computes the prediction earns the arithmetic but loses the reasoning mark — and a question may award the **R** mark *instead of* a calculation mark, so the loss is total for that part. Fix: before predicting, check whether the input is within the data range; if not, state that the prediction is unreliable due to extrapolation.

§4.6 Calculator notation in normal / binomial answers

`normalcdf(153, 173, 163, σ) = 0.88` or `binompdf(...)` can earn intermediate credit — the scheme says so explicitly — but the *final* answer must be the evaluated number. A student whose answer line is a `normalcdf` expression loses the final **A**. Fix: evaluate, then write the number.

§4.7 Binomial: stating the distribution earns a mark; "np" does not

For binomial questions the scheme awards an **M** mark for "recognition of binomial distribution" — and notes you may state "binomial" or write $B(n, p)$, but "do not award the (M1) if candidates only state np." Students who jump straight to a `binompdf` number skip the recognition mark. Fix: write $X \sim B(n, p)$ with the parameters before computing.

§4.8 Discrete distributions and rounding to integers where integers are required

"Expected number of people," "number of months" — when the context demands an integer, a non-integer answer is wrong, and the scheme's "inappropriate value" rule removes the **A** mark. Conversely, expected value $E(X)$ as a *theoretical mean* is usually left exact or to 3 s.f., **not** rounded to an integer. Fix: ask whether the quantity is a count (integer) or an average (not necessarily integer).

§4.9 Conditional probability: the formula must be visible and in context

For $P(A \mid B)$ the scheme awards the **M** mark for "recognition of conditional probability" but adds: "recognition must be shown in context, either in words or symbols, not just $P(A \mid B)$." A bare ratio of two calculator numbers does not earn it. Fix: write the conditional-probability formula with the actual events named, then substitute.

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5. Calculus

Calculus on Paper 2 leans on `nDeriv` and `fnInt` — numerical derivative and numerical integral. These tools are reliable and that reliability is the trap: they encourage bare answers and they let students skip the setup that earns the method marks.

§5.1 The unevaluated integral as the final answer

Writing $\int_0^4 v(t)\, dt$ and stopping is not a final answer — it is, at best, the **M**-mark setup. The scheme accepts the integral *expression* for the method mark ("attempt to substitute into the total displacement formula, condone missing limits and absence of dt"), but the **A** mark requires the evaluated number. Fix: write the integral *and* its evaluated value on the next line.

§5.2 Premature rounding through a multi-step calculus chain — the #1 Paper 2 trap

This is the most frequent and most expensive Paper 2 mark-loss across every topic, and calculus is where it concentrates because calculus questions chain the most steps. A definite integral gives a population *change*; that change is added to an initial value; the total is rounded for a final answer. Round the integral to 3 s.f. too early — or worse, store a 2 s.f. version — and the final population drifts outside the accepted range. The scheme threads the *exact* value through ($-404165.8...$ then $6\,375\,834.1...$ then $6\,380\,000$) and accepts the 3 s.f. chain only within tolerance. Lost mark: the final **A**, and any FT marks downstream. Fix: never write a rounded number back into the calculator. Use ANS or stored variables for the entire chain; round **once**, at the very end.

§5.3 Bare answers on `nDeriv` / `fnInt` — no setup, no method mark

A student who computes $f'(15)$ on the GDC and writes only the number earns the **A** mark *if and only if* it is correct, and *nothing* if it is wrong — no **M** mark survives, because none was shown. The scheme awards an explicit **M** for "recognition that $f'(15)$ is required" or "recognising the need to find F'." That recognition is a written line, not a calculator keystroke. Fix: write what you are about to compute — "$f'(15) =$", "area $= \int_a^b ...$" — *before* the number.

§5.4 "Show that" in calculus — the GDC cannot earn an AG mark

Section B calculus questions embed AG parts: "show that $f'(x) = \tfrac{-14}{(2x-4)^2}$." `nDeriv` produces a number, not a derivation. The scheme wants the quotient or product rule named, the substitution shown, the algebra simplified to the printed expression. A numerical check at one point is not a proof. Lost marks: the **M** and the **AG**. Fix: differentiate by hand, showing the rule and every step.

§5.5 Finding limits of integration with the GDC — but using the wrong ones

Area-between-curves and "distance travelled" questions need the intersection points or the times when $v = 0$ as the limits. The GDC finds them — but students then integrate over the *stated* interval instead of splitting at those points, or integrate v instead of $|v|$ for distance. The scheme separates "recognition that $v = 0$" (an **M** mark) from the interval and the final value. Lost marks: the **M** for finding the correct split points, the **A** for the value. Fix: solve for the intersection / rest points first, mark them, then split the integral there. For *distance*, integrate $|v|$ or sum the absolute values of the signed pieces.

§5.6 Displacement vs distance — the calculator computes whichever you ask for

$\int v\, dt$ gives signed *displacement*. *Distance travelled* needs $\int |v|\, dt$. The GDC will compute either; it does not know which the question wants. The scheme prints the warning directly — "Award (M1)A0 if -2.13 is followed by 2.13" — i.e. even taking the absolute value of a displacement answer when displacement was asked is wrong. Lost mark: the **A**. Fix: match the command word — *displacement* is signed, *distance* is not — and set up the integral accordingly.

§5.7 Optimisation with the GDC: justify, and substitute back

The GDC finds where $f'(x) = 0$ and even classifies via the graph. Two mark-losses persist. First, the question wants the optimum *value* (the minimum distance, the maximum volume), not the input x that produces it — students stop at the x-coordinate and lose the final **A**. Second, when the question wants a *coordinate*, both the x and the y must appear; the scheme awards **A1A1**, one for each. Fix: after finding the critical x, substitute back into the original function and report what was actually asked for.

§5.8 `e^{kt}` vs `a^t` models: exact k cannot come from an approximate base

When a question gives a model as a^t and a later part needs it as e^{kt}, $k = \ln a$ *exactly*. The scheme warns: "Do not award any marks if the candidate substitutes an approximate value... as this will not lead to an exact value for k." A student who computes $k \approx 0.0998$ from a rounded base, rather than writing $k = \ln 1.105$, loses both marks. Fix: when the question wants an exact constant, keep it symbolic — $\ln a$, not its decimal.

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6. Cross-Cutting Traps

These apply to every topic on Paper 2 and are, collectively, where most calculator-paper marks are lost.

Premature rounding (the headline trap). Round only once, at the end. Every intermediate value should be carried at full calculator precision via ANS or a stored variable. The scheme defends a tolerance band around the 3 s.f. chain, but rounding to fewer than 3 s.f. mid-calculation, or rounding repeatedly, pushes the final answer outside it. This single habit costs more Paper 2 marks than any topic-specific error.

Bare answers with no setup. Because **M** marks survive errors and **A** marks do not, a wrong bare answer scores zero while a wrong answer with visible setup banks the method and opens follow-through. Always write the expression, the equation, or the named quantity *before* the calculator's number. On Paper 2, "show your method" is not a stylistic nicety — it is the difference between 0 and partial credit on every part you get wrong.

Calculator notation as a final answer. `normalcdf(...)`, `solve(...)`, `nDeriv(...)`, an unevaluated `∫` — fine for intermediate **M/A** credit, never accepted as the final answer. Always finish with an evaluated number.

Radian / degree mode. Check the mode at the start of the paper and at the start of every trig question. A mode mismatch silently corrupts every trig answer in a question with no warning and no recoverable method.

3 s.f. accuracy, and "exact" when demanded. The default is 3 s.f. unless the question states otherwise. When a question says "exact" or asks to "show that" a value, a decimal — however accurate — is a wrong answer; keep $\ln a$, $\pi/6$, fractions, and surds symbolic. When the question gives a required accuracy ("to the nearest dollar," "to the nearest integer"), a mark is tied to hitting it.

Inappropriate values. A probability above 1, a negative length, a non-integer count, a root outside the model's domain — the scheme's standing rule removes the final **A** mark for any answer the context forbids. Sanity-check every calculator output against what the quantity physically can be.

"Show that" and "Hence" defeat the calculator. Any AG part, and any part whose command term is "Hence" (not "Hence or otherwise"), must be done with algebra. The GDC earns intermediate credit elsewhere but never an AG mark, and "Hence" forbids alternative methods entirely. Identify the command term before deciding pen or machine.

Follow-through needs visible working. An early slip is survivable — FT marks reinstate most of the downstream credit — *but only if working is present*. Silent chains of bare numbers forfeit the FT safety net. This is the same point as "bare answers," seen from the multi-part angle: on a Section B question, visible working in part (a) is what keeps parts (c), (d), (e) scoring after an error.

Misreads are not inferred on bare answers. With no working shown, an examiner will not assume you misread a value — the answer is simply marked wrong. Copying the question's numbers onto your page as your first step both prevents misreads and creates the working that would mitigate one.

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7. Top 15 Paper 2 Mark-Losses — Priority Order

Read this list once before the paper and once after, to audit your script.

1. **Premature rounding propagating through a multi-step calculation.** The #1 Paper 2 trap. Final **A** mark plus downstream FT, on any chained question. Carry full precision; round once.
2. **Bare answers with no setup shown.** Wrong bare answer = zero; wrong answer with method = partial credit. Affects every part you get wrong.
3. **Radian / degree mode error.** Silently corrupts every trig answer in a question. Multiple **A** marks, no recoverable method.
4. **Calculator notation written as the final answer.** Final **A** mark, repeatedly across the paper.
5. **normalcdf vs invNorm confusion.** **M** and dependent **A** — given a probability use invNorm, given values use normalcdf.
6. **Regressing the wrong variable (y-on-x vs x-on-y).** Explicit **M0A0**, no follow-through.
7. **GDC returns one solution when the domain wants several.** One **A** mark per missing root, cascading in Section B.
8. **Trusting an intersection / root outside the valid domain.** Final **A**, plus **R** if justification was asked.
9. **Finance solver: P/Y vs C/Y, or sign convention, or time units.** Final **A** mark, no visible method to rescue it.
10. **"Show that" / "Hence" answered with the calculator.** Both the **M** and the **AG**.
11. **Displacement vs distance — integrating v when $|v|$ was needed (or vice versa).** Final **A** mark.
12. **Optimisation: stopping at the input x, not substituting back for the value.** Final **A** mark.
13. **Sequence inequality: reporting the GDC's non-integer instead of rounding to the correct integer.** Final **A** mark.
14. **Extrapolation not flagged when predicting outside the data range.** A whole **R** mark, sometimes the whole part.
15. **Exact value demanded but a decimal given (e.g. $k = \ln a$ left as 0.0998).** **A** mark, sometimes two.

The pattern most students see is that three or four of these recur across their practice papers. Those are personal habits, and on the calculator paper the habits are almost never mathematical — they are *mode, rounding, and showing setup*. Fixing those three is worth more than any new technique. On Paper 2, the marks are sitting in your method and your precision, not in your maths.