Brick and stone masonry: study guide

Skilled trades and apprenticeships · suite apt-117-brick-and-stone-masonry · generated 2026-09-15T15:39:59.328Z

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> Answer keys and scoring logic stay server-side and are never included in any download or export.

How to use this guide

This file contains the whole study outline for this suite: every skill it draws on, the full lesson for each of those skills, worked examples, practice tips, a glossary, and where each piece of material comes from. Nothing here is a summary of a page you still have to visit.

1. Read the skills section end to end once, without timing yourself.
2. Work the guided practice mode for the suite, using the practice tips as a checklist.
3. Move to the mini-test only when guided practice feels unhurried.
4. Sit the full simulation last, once, in the conditions you expect on the day.

Practice attempts are stored on the device you used, never on an account. Exporting a result is the only way anything leaves that device.

Practice modes and durations

Practice modes for Brick and stone masonry

Mode	Duration	What it is for
Guided practice	15 minutes	Untimed, with feedback after every item.
Mini-test	18 minutes	A short timed set for checking pace.
Full simulation	45 minutes	Full length and full time, in one sitting.

- Start guided practice: https://learn.novusstreamsolutions.com/aptitude/practice/new?bank=apt-117-brick-and-stone-masonry&mode=guided
- Start mini-test: https://learn.novusstreamsolutions.com/aptitude/practice/new?bank=apt-117-brick-and-stone-masonry&mode=mini
- Start full simulation: https://learn.novusstreamsolutions.com/aptitude/practice/new?bank=apt-117-brick-and-stone-masonry&mode=full

Skills covered, in full

This suite draws on 5 skill constructs. Each one below carries its complete lesson.

Numerical reasoning

Arithmetic, fractions, percentages, ratios, rates, estimation, word problems, and number relationships.

Numerical reasoning is the ability to take a small set of supplied numbers (a price list, a staffing table, a fuel figure), and reach a defensible answer in around ninety seconds without a formula sheet. It is the most widely used quantitative section in graduate, management and public-sector screening, and it appears in banking, retail, armed forces and healthcare entry batteries alike. The arithmetic itself is deliberately ordinary: percentages, ratios, rates and averages. What is actually being measured is whether you pick the right operation quickly, keep the units straight, and answer the question that was asked rather than the one you started computing. Practice here is device-local: no account, and nothing leaves this device unless you export it.

What you should be able to do after this lesson:

1. Move between fractions, decimals, percentages and ratios on sight, and pick whichever form makes a given item fastest (12.5 percent as one eighth, 33.3 percent as one third).
2. Apply percentage change in both directions, including recovering an original figure from a post-increase total, and combine successive changes multiplicatively rather than by adding them.
3. Split a total in a stated ratio by counting parts first, and work backwards from a stated difference between two shares.
4. Solve rate problems (speed, unit price, consumption, combined work rates) by carrying units through every intermediate line so the units of the answer prove the method.
5. Produce a one-significant-figure estimate before computing, and use it to eliminate the distractors built from the common wrong operations.
6. Read a multi-step stem and name, in one sentence, the single quantity the final question asks for before touching the numbers.

Worked examples and pitfalls

Reverse percentages: the item most candidates get backwards: A subscription price rose by 15 percent and now stands at 57.50 pounds. What was it before? The correct move is to divide, not subtract: the new price is 115 percent of the old, so the old price is 57.50 / 1.15 = 50.00. Check it forwards: 15 percent of 50 is 7.50, and 50 + 7.50 = 57.50. The tempting wrong answer takes 15 percent of the NEW figure, 0.15 x 57.50 = 8.625, and reports 48.88. That distractor is always on the option list because it is what most people do under time pressure, and it is wrong by 2.25 percent, small enough to look plausible. The same asymmetry drives the successive-change item: a price that rises 20 percent and then falls 20 percent does not return to where it started. Multiply the factors: 1.20 x 0.80 = 0.96, a net fall of 4 percent. Starting at 500 pounds you get 600 then 480, not 500. Percentages compose by multiplication; they never add.

Ratio splits: count the parts before you divide: A 4,830 pound budget is split between three teams in the ratio 3:5:6. Add the parts first: 3 + 5 + 6 = 14. One part is 4,830 / 14 = 345. The shares are 3 x 345 = 1,035, 5 x 345 = 1,725 and 6 x 345 = 2,070, and they sum back to 4,830, which is the check you should always run. Two classic failures. The first is dividing by 3 because there are three teams. That gives 1,610 each and ignores the ratio entirely. The second is treating 5 as a fraction and computing five sixths or five fourteenths of something other than the total. The more interesting version of this item gives you a difference instead of the total: 'the second team receives 690 pounds more than the first, what is the whole budget?' The difference between the shares is 5 - 3 = 2 parts, so one part is 690 / 2 = 345, and the budget is 14 x 345 = 4,830. Same number, reached from the other end, and the arithmetic is trivial once you have made the parts

explicit.

Rates and units: 2 h 15 min is 2.25, not 2.15: A delivery van covers 174 km in 2 hours 15 minutes. Average speed is distance over time, and the time must be in hours: 15 minutes is 15/60 = 0.25 h, so 174 / 2.25 = 77.3 km/h. Type 2.15 into the calculator instead and you get 80.9 km/h: an error of roughly 4.7 percent that sits comfortably inside the plausible range and will match one of the options. Now extend it. The van consumes 8.6 litres per 100 km, so the trip needs 174 x 8.6 / 100 = 14.964 litres, and at 1.48 pounds per litre that is 14.964 x 1.48 = 22.15 pounds. Notice the units doing the work: (km) x (L / 100 km) leaves litres; (L) x (pounds / L) leaves pounds. If your intermediate line has km still attached at the end, you have divided when you should have multiplied. Write the unit next to every number and the method checks itself.

Unit pricing: normalise before you compare: Three pack sizes of the same fluid. Pack A: 750 ml for 3.60 pounds. Pack B: 2 litres for 9.40. Pack C: 1.5 litres for 7.20. Convert all three to price per litre. A: 3.60 / 0.75 = 4.80 per litre. B: 9.40 / 2 = 4.70. C: 7.20 / 1.5 = 4.80. So B is cheapest by 10p a litre, and A and C are identical despite looking like different deals. The 'bigger pack is cheaper' heuristic happens to hold here but is not a rule, and test writers know it. Half of these items are built specifically so the largest pack loses. Now add the multibuy that these questions love: pack A is on three-for-two. Three packs give 2.25 litres for the price of two, 7.20 pounds, which is 7.20 / 2.25 = 3.20 per litre and beats everything. The trap in the multibuy version is dividing by the number of packs paid for rather than the volume received.

Combined work rates: add rates, never times: Printer A completes a 3,000-page run in 50 minutes; printer B completes the same run in 75 minutes. Running together, how long? Convert to rates: A prints 3,000 / 50 = 60 pages per minute, B prints 3,000 / 75 = 40 pages per minute, and together they print 100 pages per minute, so the job takes 3,000 / 100 = 30 minutes. Verify by counting output: in 30 minutes A produces 1,800 pages and B produces 1,200, which is 3,000 exactly. The two wrong answers you will see on the option list are 62.5 minutes (the average of 50 and 75) and 125 minutes (the sum). Both are impossible on inspection: two machines working together must finish faster than the faster machine alone, so any answer above 50 minutes is wrong before you compute anything. The general form is 1 / (1/50 + 1/75), and it is worth being able to write that line directly, but the sanity bound catches the error faster than the algebra does.

Estimate first, then compute: killing distractors in ten seconds: 'A department spent 847,300 pounds in 2024. In 2025 the budget fell by 12.5 percent. What was the 2025 spend?' Options: 741,387.50 / 953,212.50 / 105,912.50 / 762,570. Estimate before anything else: 12.5 percent is exactly one eighth, one eighth of roughly 850,000 is roughly 106,000, so the answer is roughly 744,000. That single line eliminates three options. 953,212.50 applied the change upwards. 105,912.50 is the size of the reduction, not the resulting spend: the 'answered the wrong question' distractor, and the most commonly selected wrong option on items of this shape. 762,570 is a 10 percent cut, planted for anyone who misread the rate. Exact working: 847,300 x 7/8 = 5,931,100 / 8 = 741,387.50. Doing it as a fraction avoids the decimal multiplication altogether. Learn the fraction equivalents cold (12.5 percent is 1/8, 16.7 percent is 1/6, 37.5 percent is 3/8, 62.5 percent is 5/8) because a fraction turns most percentage items into one division.

How to practise this skill

- Memorise the fraction-to-percentage table up to eighths and twelfths. Almost every 'nasty' percentage on these tests is a clean fraction in disguise, and the fraction route is two or three times faster than decimal multiplication.
- Write the unit beside every intermediate number, including the ones you keep in your head. Most numerical errors on timed sections are unit errors, not arithmetic errors, and units are the only cheap way to catch them.
- Rehearse reverse percentages as their own drill until dividing by 1.15 feels more natural than subtracting 15 percent. It is a single, identifiable technique that accounts for a disproportionate share of lost marks.
- Before selecting, re-read the last clause of the stem out loud. 'By how much did it fall' and 'what was it after the fall' have different answers, and both are always on the option list.

- Keep an error log with four columns (misread the question, wrong operation, unit slip, arithmetic slip), and tally which one you actually commit. Three sessions is usually enough to show that one column dominates, and that is the column to train.
- Work untimed until your method is stable, then add the clock in stages: generous, then realistic, then 20 percent tighter than the real test. Attempts stay on this device, so a slow first pass costs nothing.

Glossary

Percentage point: The arithmetic difference between two percentages. A rate moving from 4 percent to 5 percent rises by one percentage point but by 25 percent in relative terms; questions specify which they want and the two answers are both on the option list.

Reverse percentage: Recovering an original amount from a figure that already includes a percentage change, by dividing by the multiplier (1.15 for a 15 percent rise, 0.88 for a 12 percent fall) rather than subtracting the percentage from the new figure.

Multiplier (decimal factor): The single number a quantity is multiplied by to apply a percentage change: 1.20 for plus 20 percent, 0.80 for minus 20 percent. Successive changes are handled by multiplying the factors, which is why plus 20 then minus 20 gives 0.96, not 1.

Ratio part: One unit of a ratio split. Dividing the total by the sum of the ratio terms gives the value of one part; every share and every difference between shares is then a whole number of parts.

Unit rate: A quantity expressed per one of something: price per litre, pages per minute, litres per 100 km. Comparisons are only valid once every option has been converted to the same unit rate.

Combined rate: The sum of two or more individual rates working simultaneously. Times cannot be added or averaged; only rates add, and the combined time is the total work divided by the combined rate.

Significant figure estimate: Rounding every input to one meaningful digit to get an approximate answer in a few seconds. Its purpose is not accuracy but elimination: it removes any option that is off by a factor or has the sign of the change wrong.

Distractor: A wrong option written deliberately to match a specific predictable error: subtracting instead of dividing, reporting the change instead of the result, averaging instead of combining rates. Recognising the pattern is often faster than recomputing.

Study this next

- Numerical reasoning skill hub: https://learn.novusstreamsolutions.com/aptitude/skills/numerical-reasoning
- Numerical reasoning practice in the Cognitive Skills Lab: https://learn.novusstreamsolutions.com/cognitive-skills/numerical-reasoning
- Data interpretation lesson: https://learn.novusstreamsolutions.com/aptitude/skills/data-interpretation/lesson
- Office numeracy suite: https://learn.novusstreamsolutions.com/aptitude/tests/office-numeracy
- Finance, accounting and insurance careers: https://learn.novusstreamsolutions.com/careers/families/finance-accounting-and-insurance
- Numerical reasoning lesson on Novus Learn: https://learn.novusstreamsolutions.com/aptitude/skills/numerical-reasoning/lesson

Where this material comes from

- All worked figures above were written and checked for Novus Learn. Every division, ratio split and rate calculation in this lesson was verified by recomputing it in the reverse direction.
- Conventions only (percentage point, unit rate, significant figures) cross-checked against standard public references such as the Wikipedia articles 'Percentage', 'Ratio' and 'Rate (mathematics)'. No item text is

drawn from any published test.
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Spatial reasoning

Rotation, folding, views, orientation, maps, and three-dimensional visualization.

Spatial reasoning is the ability to turn an object in your head and be right about the result: to tell a rotation from a mirror image, fold a flat net into a solid and know which faces meet, read plan and elevation views back into a three-dimensional shape, and hold your own orientation steady while a route turns underneath you. It is a heavily weighted construct in pilot and aircrew selection, firefighter and military technical batteries, architecture and design admissions, and trades screening where a drawing has to be built. Much of it can be trained by replacing imagination with a checkable procedure. Practice is device-local unless you export it.

What you should be able to do after this lesson:

1. Distinguish a rotation from a reflection by checking whether the clockwise order of three marked features is preserved or reversed.
2. Read a cube net and name which faces end up opposite, using the rule that squares two apart in a straight strip are opposite.
3. Reconstruct a solid from plan, front and side views, count its unit cubes, and identify when the views leave the count undetermined.
4. Predict the hole pattern produced by unfolding a punched sheet, treating each unfold as a reflection across the fold line rather than a rotation.
5. Work with bearings and relative direction, converting between a map frame and a traveller frame without losing track of which is which.
6. Name the cross-section produced by cutting a cylinder, cone or cube on a given plane, including the oblique cuts people default to calling circles.

Worked examples and pitfalls

Rotation preserves handedness; reflection reverses it: A figure carries three distinguishable marks (say a red band, a blue band and a yellow band), which read red, blue, yellow going clockwise around its centre. Rotating that figure in the plane, by any angle, never changes that clockwise order: it still reads red, blue, yellow clockwise from whatever mark you start at. Mirroring it reverses the order, so a reflected copy reads red, yellow, blue clockwise. That single check answers the whole is-this-a-rotation-or-a-reflection family without imagining any motion. It works on letters, which is why no in-plane rotation of the letter R produces a backwards R, and no rotation of a lower-case b produces a d: b and d are mirror images across a vertical line, and turning one will never give you the other. Contrast b and q, which are related by a half turn and therefore genuinely are rotations of each other. The distinction is exactly what the clockwise-order test measures. In three dimensions the equivalent is handedness at a corner: pick three edges meeting at a vertex, and a rotation preserves whether they form a right-handed or left-handed set while a reflection swaps it. This is exactly why most Western dice, viewed at the corner where the 1, 2 and 3 faces meet, show those numbers running anticlockwise, and a die showing them clockwise is a mirror-image die rather than a differently rotated one. The one honest limitation: a figure with its own mirror line looks identical after reflection, so the test decides nothing for symmetric shapes, which is precisely why item writers use asymmetric ones.

Cube nets: two apart in a strip means opposite: A net made of six squares. Four of them, call them A, B, C and D, sit in a horizontal strip left to right. Square E sits directly above B, and square F sits directly below B. Fold it. The strip of four wraps around the cube as a band, so squares two apart in that strip end up on opposite faces: A is opposite C, and B is opposite D. E and F are the remaining pair, and they become the top and bottom, opposite each other. The two rules that solve almost every net item are exactly these. Squares separated by one square in a straight line end up opposite. Squares sharing an edge on the net end up adjacent on the cube, and can never be opposite. Everything else is applying them carefully. A die adds one more constraint worth carrying: opposite faces of a standard die sum to seven, so 1 faces 6, 2 faces 5 and 3 faces 4, and a net showing 1 and 6 two apart in a strip is consistent while a net showing 1 and 2 two apart is not a standard die. The classic error on these items is trying to fold the net in your head all at once. Do not. Pick one square as the base, identify its opposite by the two-apart rule, then repeat for a second pair, and you have determined the cube in two cheap steps rather than one expensive act of visualisation.

Three views, one solid, and the cubes you cannot see: A solid is built from unit cubes on a base one cube deep and three cubes wide. The column heights, left to right, are 3, 1 and 2. The front view is therefore a staircase profile of heights 3, 1, 2. The side view, looking along the row from the right, is a single column three cubes tall, because the tallest column hides the others behind it. The plan view is a three-by-one rectangle. Total cubes: 3 plus 1 plus 2, which is 6, and here the three views pin it down exactly because the plan view tells you the solid is only one cube deep. Now change one thing. Suppose the plan view is three by two, so the solid is two cubes deep. The front view can still read 3, 1, 2 while the count is anything from 6, one row of cubes with a hollow back, up to 12, a solid block matching the front profile in both rows. The views constrain the shape but do not determine it, and a well-written item will either supply the count or ask for the minimum and maximum rather than a single figure. That is the trap in this family: candidates who assume every hidden position is filled will over-count, and candidates who assume nothing is hidden will under-count. Read the plan view first to establish the footprint, then use the elevations to cap each column, then ask explicitly whether the item wants the minimum, the maximum, or a determined value.

Punched and unfolded, with coordinates: Take a square sheet 8 units across, with the origin at its centre so the corners are at plus or minus 4 in each direction. Fold the right half onto the left half across the vertical centre line, then fold the bottom half up onto the top half across the horizontal centre line. What is left visible is one quarter, the region where x runs from minus 4 to 0 and y runs from 0 to 4. Punch a single hole at the point minus 3, 3. Now unfold, one step at a time, and treat every unfold as a reflection. Undoing the horizontal fold reflects across the line y equals 0 and adds a hole at minus 3, minus 3. Undoing the vertical fold reflects both existing holes across x equals 0 and adds holes at 3, 3 and 3, minus 3. The finished sheet has four holes, at all four combinations of plus or minus 3. Two rules generalise from this. The number of holes is one punch multiplied by two for each fold the punch passed through, so two folds give four holes and three folds give eight, provided the punch went through every layer, which it does when the folds are through the middle. And the positions are mirror images across each fold line, never rotations. That second point is where the marks go: candidates who place the fourth hole by rotational symmetry get three holes right and one wrong, which is exactly the answer option the item includes.

Bearings, and the difference between the map and the walker: A walker leaves a gate, goes 300 m due north, then 400 m due east. The straight-line distance back to the gate is the hypotenuse of a 300 by 400 right triangle, which is 500 m: the 3-4-5 triangle, so no calculator is needed. The bearing from the gate to the walker is measured clockwise from north, and it is the angle whose tangent is 400 over 300, which is about 53 degrees, so the bearing is 053. The return bearing is that plus 180, which is 233. Bearings are always three digits and always clockwise from north, so 53 degrees is written 053 and a bearing of 350 is very slightly west of north, not south. Now the other half of this construct, which trips up more people than the trigonometry. You are facing south and you turn left. Which way are you now facing? East. Your left hand points east when you face south, and the standard wrong answer, west, comes from reading left as left-on-the-map while forgetting that the map is drawn north-up and you are not. The general fix is to state your heading before every turn and rotate your frame with the traveller: facing north, left is west; facing south,

left is east; facing east, left is north; facing west, left is south. On route items, physically rotate the page so the direction of travel points up before working out a turn, and rotate it back only to read off the final compass direction.

What a cut actually reveals: Cross-section items ask what shape a plane makes as it slices a solid, and the reflex answer of circle is wrong most of the time. A cylinder cut perpendicular to its axis gives a circle. Cut parallel to the axis, it gives a rectangle. Cut obliquely so the plane crosses only the curved surface, it gives an ellipse; cut obliquely so the plane also crosses one flat end, it gives an ellipse with one side sliced flat, a D-shape. A cone is richer, because its sections are the conic sections that give the family its name: perpendicular to the axis gives a circle; an oblique cut that crosses every side of the cone gives an ellipse; a cut parallel to one slanted side gives a parabola; a cut parallel to the axis gives a hyperbola branch; and a cut through the apex gives a triangle. A cube is the one that surprises people. A cut parallel to a face gives a square, obviously. A cut through three vertices that are mutually adjacent to one corner gives an equilateral triangle. And a cut through the midpoints of six edges, perpendicular to a long diagonal of the cube, gives a regular hexagon: a six-sided section from a six-faced solid with no curves anywhere. For a flat-faced solid, work these by counting faces rather than by visualising: the section of a convex polyhedron gains exactly one straight edge for every face the plane passes through, so a cut crossing six faces of a cube must close into a six-sided figure and a cut touching only three cannot have more than three sides. For curved solids the question becomes whether the plane meets the curved surface all the way round, which gives a closed circle or ellipse, or only partway, which leaves an open arc closed off by a straight chord.

How to practise this skill

- Replace visualisation with a rule wherever one exists. Two-apart-means-opposite on nets, and clockwise-order-preserved for rotations, both give a checkable answer in seconds and are reliable when mental imagery gets tired late in a section.
- Physically rotate the paper or the device on route and orientation items so the direction of travel points up, work out the turn, then rotate back to read the compass direction. Fighting the north-up convention in your head is the single largest source of left-right errors.
- On view and cube-count items, read the plan view first to fix the footprint, then use the elevations to cap each column, then decide explicitly whether the question wants a minimum, a maximum, or a determined count.
- Treat every unfold as a reflection across the fold line. Say the word reflection out loud as you draw each new hole; the rotational version of the pattern is a deliberately included wrong answer in almost every folding item.
- Build a physical reference once. Fold a paper cube net, mark the faces, and hold it: ten minutes with a real cube fixes the opposite-face rule more firmly than an hour of diagrams, and the memory transfers to items you have never seen.
- Practise untimed first and check whether your errors cluster in rotation, folding, views or orientation, because the four subskills train differently. Attempts are stored on this device only, so an honest error log costs nothing and is what tells you which drill to repeat.

Glossary

Chirality (handedness): The property that distinguishes a figure from its mirror image. Rotation preserves it and reflection reverses it, which is what makes the clockwise-order test decisive for asymmetric figures.

Net: A flat arrangement of faces that folds into a solid. On a cube net, squares two apart in a straight strip become opposite faces and squares sharing an edge become adjacent ones.

Plan view: The view looking straight down on an object. It fixes the footprint of a stacked-cube solid, which is why it is the first view to read.

Elevation: A view looking horizontally at an object, usually given as front and side. Each elevation caps the

heights it shows but hides anything directly behind.

Orthographic projection: A drawing convention showing an object through separate parallel views with no perspective. Together the views constrain a solid but do not always determine it.

Bearing: A direction measured clockwise from north and written with three digits, so due east is 090 and a heading slightly west of north is 350. The reverse bearing differs by 180 degrees.

Egocentric versus allocentric frame: The difference between directions relative to a traveller who is turning and directions relative to a fixed map. Left means different compass headings in the two frames, which is why headings must be restated before every turn.

Cross-section: The shape revealed where a plane cuts a solid. It gains one straight edge for each flat face the plane crosses and one curve for each curved surface, which turns the question into a count.

Study this next

- Spatial reasoning skill hub: https://learn.novusstreamsolutions.com/aptitude/skills/spatial-reasoning
- Spatial reasoning practice bank: https://learn.novusstreamsolutions.com/cognitive-skills/spatial-reasoning
- Mechanical comprehension lesson: https://learn.novusstreamsolutions.com/aptitude/skills/mechanical-comprehension/lesson
- Firefighter spatial reasoning suite: https://learn.novusstreamsolutions.com/aptitude/tests/firefighter-spatial-reasoning
- Architecture and design aptitude suite: https://learn.novusstreamsolutions.com/aptitude/tests/architecture-and-design-aptitude
- Spatial reasoning lesson on Novus Learn: https://learn.novusstreamsolutions.com/aptitude/skills/spatial-reasoning/lesson

Where this material comes from

- Worked items written for Novus Learn from standard introductory geometry: cube-net opposite-face rules, orthographic view reconstruction, reflection across fold lines, right-triangle distances and bearings, and the conic and polyhedral cross-sections. The 3-4-5 distance, the 053 and 233 bearings, and the four hole coordinates were each computed and checked.
- Terminology checked against the public Wikipedia articles 'Net (polyhedron)', 'Multiview orthographic projection', 'Chirality', 'Bearing (navigation)' and 'Conic section'. Definitions only; every figure described above is original.
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Technical reasoning

Applied technical principles, diagrams, tools, systems, measurements, and troubleshooting.

Technical reasoning is what sits above any single trade: reading a system diagram for what it actually does, isolating a fault by measurement instead of by guesswork, and taking the governing number off a drawing or a nameplate without importing assumptions. It is assessed in HVAC, instrumentation, mechatronics, process-operator and engineering-technician selection, and it is the construct that best predicts whether someone can diagnose an unfamiliar machine. Employers care about it because part-swapping is expensive and half-splitting is not. Practice sessions here stay on your device unless you choose to export them.

What you should be able to do after this lesson:

1. Trace a process or signal diagram end to end and state, for a given symptom, which components could physically cause it and which could not.
2. Isolate a fault by half-splitting a chain of stages, and say how many measurements a chain of a given length should take.
3. Convert a dimension with asymmetric tolerance into an acceptance window and decide whether a measured part passes, can be reworked, or is scrap.
4. Match a measuring instrument to a required resolution, and distinguish an instrument's resolution from its accuracy.
5. Describe a closed control loop as sensor, controller, setpoint, actuator and feedback, then design the one measurement that separates a sensor fault from an actuator fault.
6. Read the qualifier attached to a rated number (duty cycle, working load limit, working pressure, nominal versus maximum), and apply it correctly.

Worked examples and pitfalls

Half-splitting beats swapping parts: A conveyor will not stop when its photo-eye is blocked. The chain is: sensor, field cable, junction box, PLC input card, PLC program, output card, interposing relay, contactor. Eight places the signal can die. Swapping parts one at a time means four or five attempts on average, since the culprit is equally likely to sit anywhere in the eight, and every attempt costs a part. Half-splitting starts in the middle instead: watch the PLC input LED while a colleague blocks the beam. If it toggles, the sensor, field cable, junction box and input card are all proven good in a single observation, and eight candidates become four. Force the output in the PLC and watch the contactor: if it pulls in, the output card, interposing relay and contactor are good as well, so the fault is in the program logic rather than the hardware. Three checks resolve eight stages, because each check halves the remaining suspects. The trap is starting at whichever end is easiest to reach, which resolves one stage per check instead of half of them. The second trap is the sentence 'I replaced the sensor and it still fails', that proves only that the sensor was not the fault, at the price of a part and an hour.

Tolerance: in spec, or scrap?: A drawing calls a shaft 25.00 mm with a tolerance of plus 0.05 and minus 0.10. That is an asymmetric tolerance, so the acceptance window runs from 24.90 mm to 25.05 mm and the nominal is not at its centre. A part measuring 24.92 mm is inside the window and passes, even though it is below nominal: the most common wrong rejection on this style of item, made by anyone who silently reads the tolerance as plus or minus 0.05. A part at 25.06 mm fails by 0.01 mm, but it fails oversize, so material can still be removed and it is rework rather than scrap. A part at 24.85 mm fails undersize and there is no recovering it. One more layer the better items include: if you took that 25.06 reading on a caliper with 0.02 mm resolution, the reading is at the very limit of what the instrument can resolve, and the honest next step is to re-measure with a micrometer before anyone scraps or reworks anything.

Reading a system diagram: what can actually cause this?: A tank fill line is drawn as supply, isolation valve V1, strainer, pump P1, check valve, control valve CV1, tank. A high-level switch LSH-1 is wired to close CV1. The reported symptom is that the tank overfilled. Work the path between the measurement and the element that stops flow: a CV1 that has stuck open, an LSH-1 that never actuated, and a broken wire in the LSH-1 loop are all consistent with the symptom. A blocked strainer is not: restricting the inlet reduces flow, and no amount of restriction causes an overfill. Nor is the check valve, whose function is to prevent reverse flow, not forward flow. Candidates pick the strainer because it is the component they know fouls in service, which is a memory of maintenance history rather than a reading of the diagram. The discipline that earns the mark is directional: a component can only be responsible if it lies on the causal path AND its failure mode pushes the system in the direction of the symptom.

Instrument choice: resolution is not accuracy: A steel rule resolves to roughly 0.5 mm. A vernier caliper marked 0.02 mm resolves to 0.02 mm. A 0 to 25 mm micrometer resolves 0.01 mm on the thimble, or 0.001 mm if it carries a vernier. A dial indicator reads 0.01 mm of relative movement but tells you nothing about

absolute size without a reference. Asked to verify a 25.00 mm shaft with a tolerance of plus or minus 0.02 mm, the tolerance band is 0.04 mm wide: two divisions on that caliper, which is not enough to judge anything reliably. The workshop convention is that the instrument should resolve to about a tenth of the tolerance band, here 0.004 mm, so even the micrometer is marginal and comparison against gauge blocks is the defensible answer. The trap the item is built around is a digital display: showing four decimal places is a statement about resolution, not accuracy. An uncalibrated digital caliper will report 25.0000 mm with total confidence and be 0.03 mm out.

Closed loop: which element failed?: A room is meant to hold 21 degrees Celsius. A thermostat containing the sensor and the controller drives a valve on a radiator. The symptom: the room reaches 28 degrees Celsius and the valve stays open. Three explanations survive first inspection. The sensor reads low so the controller still believes the room is cold, the valve is mechanically jammed open, or the controller output has failed in the on state. One measurement separates them. Put an independent thermometer beside the thermostat. If the thermostat displays 17 degrees while the thermometer reads 28, the sensor is lying and everything downstream is behaving correctly. If the thermostat displays 28 and is still calling for heat, the sensor is fine and the fault is in the controller or the valve, which you then split by checking whether the valve actuator is being energised. The tempting non-answer is 'the room is too hot, so lower the setpoint'. That treats the symptom, and if the sensor reads seven degrees low the loop will simply settle seven degrees high again at the new setpoint.

Nameplates: read the qualifier, not just the number: A welding machine is rated 200 A at 40 percent duty cycle over a ten-minute period. That means four minutes of arc time and six minutes of cooling in every ten, at the full 200 A. It does not mean 40 percent of 200 A, and it does not mean 40 percent of an hour. Both wrong readings feel entirely natural, which is why they make good distractors. Run the machine continuously at 200 A and the thermal cut-out will open. The same discipline transfers across the whole trade: a hoist's working load limit is not its breaking load, a hose's working pressure is not its burst pressure, a motor's service factor describes a short-term overload allowance and not a continuous rating, and a pump curve's flow figure is quoted at a stated head. Whenever an item hands you a number in a table or on a plate, underline the qualifier printed next to it before you calculate anything; the wrong options are usually built by dropping exactly one qualifier.

How to practise this skill

- Trace every diagram with a pencil from input to output and name each block as you pass it. Technical items punish skimming far harder than they punish slow arithmetic.
- Rehearse half-splitting on systems you already know (a home network that has dropped out, a car that will not crank), and count the checks. The habit transfers to the test intact.
- Underline the qualifier beside every number a question supplies: per hour, at 20 degrees Celsius, at 40 percent duty, nominal, maximum. That single mark-up defuses most distractors.
- Convert the whole question to one unit system in one pass before calculating, rather than converting each intermediate result and accumulating rounding.
- Train yourself to state what a measurement PROVES rather than what it reads. '12 V present at the coil' proves the supply and the whole upstream path; it says nothing about whether the coil itself is good.
- Keep a running list of the schematic symbols and component names you personally keep getting wrong, and drill only those. Five focused minutes beats another full untargeted set, and your attempt history stays local to this device so the list is yours alone.

Glossary

Half-split fault finding: Testing at the midpoint of a chain of stages so that each measurement eliminates half the remaining suspects. A chain of eight stages resolves in about three checks rather than four swaps.

Tolerance band: The distance between the upper and lower acceptance limits of a dimension. A tolerance

written as plus 0.05 and minus 0.10 has a 0.15 mm band that is not centred on the nominal.

Resolution: The smallest change an instrument can display. A four-decimal readout has fine resolution and may still be inaccurate if the instrument is out of calibration.

Accuracy: How close a reading is to the true value, established by calibration against a traceable standard. Independent of resolution, and the property that decides whether a part passes.

Interlock: A condition wired or programmed to inhibit an action until it is satisfied, such as a guard-door switch that prevents a motor start while the door is open.

Closed-loop control: A control arrangement where a sensor measures the process, a controller compares that measurement to a setpoint, and an actuator drives the process until the difference closes.

Duty cycle: The proportion of a stated period during which equipment may operate at a stated output, for example 40 percent of a ten-minute period, after which it must cool.

Schematic versus pictorial diagram: A schematic shows function and connection logic with no regard to physical layout; a pictorial or exploded view shows physical arrangement and assembly order but hides the logic.

Root cause: The condition whose removal stops a failure recurring, as opposed to the symptom, which is only what became visible.

Study this next

- Technical reasoning skill hub: https://learn.novusstreamsolutions.com/aptitude/skills/technical-reasoning
- HVAC and refrigeration suite: https://learn.novusstreamsolutions.com/aptitude/tests/hvac-and-refrigeration
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- Encyclopedia search: troubleshooting: https://learn.novusstreamsolutions.com/search?q=Troubleshooting
- Technical reasoning lesson on Novus Learn: https://learn.novusstreamsolutions.com/aptitude/skills/technical-reasoning/lesson

Where this material comes from

- Diagnostic and metrology examples written for Novus Learn from general maintenance practice: binary-search fault isolation, asymmetric dimensional tolerance, and the ten-to-one instrument selection convention.
- Terminology checked against the public Wikipedia articles 'Troubleshooting', 'Engineering tolerance', 'Accuracy and precision' and 'Control loop'. Definitions only; every scenario above is original.
- Novus Learn aptitude construct registry (catalog seed) for the construct scope and related suite mapping.
- Public educational framing only: not affiliated with any official exam board, publisher or employer. Ratings and limits described here are illustrative and never override the equipment documentation in front of you.

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Mechanical comprehension

Forces, motion, gears, pulleys, levers, fluids, pressure, and basic machines.

Mechanical comprehension is the ability to predict what a physical system will do (which way a gear turns, how hard you have to pull, how far the load actually rises) from forces, moments and the simple machines, rather than from a memorised formula sheet. It carries real weight in apprenticeship entry batteries, military

technical selection, and screening for maintenance, machine operation and rigging roles. The same reasoning is daily work on site: sizing a jack, choosing a block-and-tackle arrangement, deciding why a belt slips under load but not at idle. Practice here is device-local: no account, and nothing leaves this device unless you export it.

What you should be able to do after this lesson:

1. Balance moments about a pivot (effort x effort arm = load x load arm) and name whether a given tool is a first-, second- or third-class lever.
2. Work out the speed, torque and rotation direction of a driven gear from tooth counts, including what an idler gear does and does not change.
3. Count the rope parts that support a moving block to get the mechanical advantage of a pulley system, then state how much rope must be pulled per metre of lift.
4. Apply pressure = force / area to a hydraulic jack and predict the piston-travel penalty that comes with the force gain.
5. Predict rpm across a belt or chain drive from pulley or sprocket diameters, and say when slip breaks the prediction.
6. State the trade-off that governs every simple machine: multiplied force always costs distance, and friction always makes the delivered advantage smaller than the ideal one.

Worked examples and pitfalls

Levers: balance the moments, then name the class: A wheelbarrow carries 60 kg whose centre of mass sits 0.4 m from the wheel axle, and you grip the handles 1.2 m from that same axle. Take moments about the axle: lift force x 1.2 m = 60 kgf x 0.4 m, so the lift force is 60 x 0.4 / 1.2 = 20 kgf, about 196 N. The mechanical advantage is simply the arm ratio, 1.2 / 0.4 = 3. Two traps live in this item. The first is measuring the load arm from your hands instead of from the fulcrum; the arm is always the perpendicular distance to the pivot, and the pivot here is the wheel contact, not the barrow body. The second is calling it a first-class lever because that is the one everyone pictures. A wheelbarrow is second class: fulcrum at one end, load in the middle, effort at the far end, which is why its mechanical advantage is always greater than one. Compare tweezers or a pair of tongs, where the effort sits between fulcrum and load: that is third class, mechanical advantage below one, and you are deliberately trading force away to buy speed and control at the tip. Your own forearm lifting a weight is the same arrangement, which is why a 5 kg dumbbell loads the biceps far more than 5 kg.

Gear trains: tooth counts set speed, meshes set direction: A 12-tooth driver turning at 300 rpm meshes directly with a 36-tooth gear. The ratio is driven teeth over driver teeth, 36/12 = 3:1, so the output turns at 300/3 = 100 rpm and, ignoring friction, carries about three times the torque. One external mesh reverses rotation, so the output turns opposite to the driver. Now drop a 20-tooth idler between them. Step it through: 300 x 12/20 = 180 rpm at the idler, then 180 x 20/36 = 100 rpm at the output. The overall ratio is unchanged at 3:1, the idler's tooth count cancels, but there are now two external meshes, two reversals, so the output turns the SAME way as the driver. That is the whole reason idlers are fitted. The tempting wrong answer treats the idler as another reduction stage and reports 180 rpm or some product of both ratios. The check that never fails: only the first and last gear in a simple train affect the ratio, and the direction depends on whether the number of external meshes is odd (reversed) or even (same). An internal or ring mesh, as in a planetary set, does not reverse at all.

Pulleys: count the rope parts that carry the load: A 200 kg load, about 1,962 N. Hung from a single pulley bolted to a beam, the pulley only changes the direction you pull; both rope parts still meet at a fixed axle, the mechanical advantage is 1, and you pull the full 200 kgf. Hang the pulley on the load instead, with one rope end anchored above and the other in your hands, and two rope parts now support the moving block: mechanical advantage 2, effort about 100 kgf or 981 N, but you must pull 2 m of rope for every 1 m the load rises. Build a tackle with four parts supporting the moving block and the effort falls to 200/4 = 50 kgf, about

490 N, at the cost of 4 m of rope pulled per metre of lift. The trap is counting sheaves instead of supporting parts. A three-sheave arrangement gives three parts if the dead end is made off to the fixed block and four if it is made off to the moving block, and the answer differs by 33 percent. The second trap is treating the figure as delivered force: real sheaves lose a few percent each to bearing and rope friction, so quoted mechanical advantage is the ideal velocity ratio, and the effort you actually feel is higher.

Hydraulics: pressure is shared, force and travel are traded: A jack has a 2 square centimetre input piston and a 50 square centimetre output ram. Push the small piston with 100 N and the pressure in the fluid is 100 / 2 = 50 N per square centimetre, which is 500 kPa. Pascal's principle says every part of the confined fluid sees that same 500 kPa, so the large ram feels 50 N/cm2 x 50 cm2 = 2,500 N. Mechanical advantage 25. Nothing is free: fluid is effectively incompressible, so volume in equals volume out. A 25 cm stroke on the small piston moves 2 x 25 = 50 cubic centimetres, and 50 cubic centimetres spread over a 50 square centimetre ram raises it 1 cm. Twenty-five centimetres of pumping buys one centimetre of lift: exactly the force-times-distance bargain a lever strikes. Candidates lose this item by assuming both pistons travel the same distance, or by concluding the jack manufactures energy. A related item asks about a tank: the pressure at the bottom depends on the height of fluid above and its density, not on the width of the vessel, so a narrow 3 m standpipe reads the same bottom pressure as a 3 m deep swimming pool.

Belts and chains: same belt speed, different rpm: A motor pulley 100 mm in diameter runs at 1,450 rpm and drives a 250 mm pulley through an open V-belt. The quantity that is genuinely shared is belt speed, not rpm, so the driven pulley turns at 1,450 x 100/250 = 580 rpm. Note the direction of the ratio: with gears you divide by driven teeth, with belts you divide by driven diameter, and the arithmetic looks the same only because both are proportional to circumference. An open belt drives both pulleys the same way; a crossed belt reverses the driven pulley, which is the entire point of the classic crossed-belt diagram item. The trap is slip. A flat or V-belt under an overload slips, so the driven speed falls below 580 rpm while the motor holds 1,450: the symptom of a glazed belt or a weak tensioner. A chain or a toothed timing belt physically cannot slip a tooth without damage, which is why camshaft and indexing drives use them and why a belt-driven answer and a chain-driven answer to the same question can legitimately differ.

Springs in series and parallel: the answer most people reverse: Two identical coil springs, each 20 N/mm. Mount them side by side, both carrying the same load, and they act in parallel: stiffness adds to 40 N/mm, so a 400 N load compresses the pair 400/40 = 10 mm. Now stack them end to end, in series. Each spring carries the whole 400 N, force is not split down a chain, so each deflects 400/20 = 20 mm and the total is 40 mm. The combined stiffness is 400/40 = 10 N/mm, half of one spring. Most candidates reverse the two because 'series' sounds like the case where things add. Two reliable checks: in parallel the arrangement is always stiffer than one spring, and in series it is always softer than the softest spring. That is also why suspension designers add a helper spring in parallel to raise rate under load, and why a long slender bolt clamps more forgivingly than a short stubby one carrying the same preload.

How to practise this skill

- Sketch the free body and mark the pivot before writing a single number. Mechanical items are lost by choosing the wrong fulcrum far more often than by mis-multiplying.
- Fix the three lever classes to a tool you can picture (pliers and a see-saw for first class, a wheelbarrow and a nutcracker for second, tweezers and your own forearm for third), and say the class out loud before answering.
- Sanity-check every answer against the work rule: if a machine multiplies force it must divide distance. An answer where the effort both moves less and is smaller than the load is wrong somewhere.
- Convert units before you multiply, not after. A moment computed with millimetres on one side and metres on the other is off by a thousand and looks perfectly plausible.
- For any direction question, walk the mesh or the belt with a finger: each external gear pair reverses, an internal or ring mesh does not, an open belt keeps direction and a crossed belt flips it.

- Work untimed until you can explain the reasoning aloud, then add the clock. Attempts are recorded on this device only, so a messy first pass through gear trains costs you nothing but time.

Glossary

Moment (torque): A force multiplied by the perpendicular distance from its line of action to the pivot, in newton-metres. A body is in rotational balance when clockwise moments equal anticlockwise moments about the same point.

Fulcrum: The pivot a lever turns about. Its position relative to the load and the effort defines the lever class and therefore whether the tool multiplies force or multiplies movement.

Mechanical advantage: Output force divided by input force. Ideal mechanical advantage is the geometric figure; actual mechanical advantage is what you get after friction, and it is always lower.

Velocity ratio: Distance moved by the effort divided by distance moved by the load. In a lossless machine it equals the ideal mechanical advantage, which is why force gain always costs travel.

Gear ratio: Driven teeth divided by driver teeth. A ratio above one reduces speed and multiplies torque; only the first and last gear of a simple train affect it.

Idler gear: A gear placed between driver and driven purely to add a mesh. It reverses the output direction and bridges a distance without altering the overall ratio.

Pascal's principle: Pressure applied to a confined fluid is transmitted undiminished to every part of it, which is what lets a small piston at high pressure produce a large force on a bigger ram.

Head: The height of a fluid column above a point. Pressure at depth is density x gravity x height and is independent of the vessel's width or shape.

Study this next

- Mechanical comprehension skill hub: https://learn.novusstreamsolutions.com/aptitude/skills/mechanical-comprehension
- Millwright and industrial mechanic suite: https://learn.novusstreamsolutions.com/aptitude/tests/millwright-and-industrial-mechanic
- Spatial reasoning lesson: https://learn.novusstreamsolutions.com/aptitude/skills/spatial-reasoning/lesson
- Skilled trades, maintenance and repair careers: https://learn.novusstreamsolutions.com/careers/families/skilled-trades-maintenance-and-repair
- Encyclopedia search: simple machine: https://learn.novusstreamsolutions.com/search?q=Simple%20machine
- Mechanical comprehension lesson on Novus Learn: https://learn.novusstreamsolutions.com/aptitude/skills/mechanical-comprehension/lesson

Where this material comes from

- Worked examples written for Novus Learn from standard introductory mechanics: moments about a pivot, gear ratios from tooth counts, rope-part counting for tackle, and Pascal's principle.
- Terminology checked against the public Wikipedia articles 'Simple machine', 'Lever', 'Gear train' and 'Pascal's law'. Definitions only; every number and item above is original.
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Safety judgment

Hazard recognition, safe sequencing, escalation, and risk controls.

Practise recognizing hazards and choosing a safe, proportionate response: protect people, control immediate exposure, use the correct reporting path, and verify that the control is effective.

What you should be able to do after this lesson:

1. Separate a hazard from the likelihood, severity, and exposure that shape its risk.
2. Choose an immediate control that stays within the person's training and authority.
3. Recognize when work should pause and when a supervisor, emergency process, or qualified specialist is needed.

Worked examples and pitfalls

Worked scenario: a damaged machine guard: A guard is loose before a scheduled run. Do not operate the machine or improvise a repair beyond your authorization. Keep people away, isolate or label the equipment only as procedure permits, report the defect to the responsible person, and wait for an approved inspection or repair. A deadline does not remove the hazard.

Risk-triage questions: Ask: what can cause harm, who is exposed now, how severe could the outcome be, what control is available, and who has authority to apply it? The safest answer is not always the most dramatic option; it is the option that controls the real exposure without creating a new hazard.

How to practise this skill

- Treat warnings, permits, isolation rules, and personal protective equipment as parts of a system, not interchangeable shortcuts.
- Do not ask an untrained person to investigate a hazard simply because they are nearby.
- In real work, site procedures and qualified safety direction override any general preparation heuristic.

Glossary

Hazard: A source or situation with the potential to cause harm.

Risk: A judgement about possible harm that considers likelihood, severity, and exposure.

Control: A measure that removes a hazard or reduces exposure to it under an approved process.

Study this next

- Occupational safety and health: https://learn.novusstreamsolutions.com/search?q=Occupational%20safety%20and%20health
- Hazard: https://learn.novusstreamsolutions.com/search?q=Hazard
- Risk assessment: https://learn.novusstreamsolutions.com/search?q=Risk%20assessment
- Safety judgment lesson on Novus Learn: https://learn.novusstreamsolutions.com/aptitude/skills/safety-judgement/lesson

Where this material comes from

- Novus Learn original safety-critical, hazard-recognition, and operational suite scenarios.
- Novus educational framework: identify the hazard, protect people, control exposure, report, and verify.

> Educational preparation only. Novus Learn does not administer official exams and does not guarantee scores or hiring outcomes.

Recommended preparation

- Practice numerical reasoning: https://learn.novusstreamsolutions.com/aptitude/skills/numerical-reasoning/lesson
- Learn spatial reasoning: https://learn.novusstreamsolutions.com/aptitude/skills/spatial-reasoning/lesson
- Practice safety judgement: https://learn.novusstreamsolutions.com/aptitude/skills/safety-judgement/lesson

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