FN1 Factors and Multiples

We want to look for factor pairs, i.e. pairs of numbers that multiply to make 54. We get

$$1\times 54 = 54,\ 2\times 27 = 54,\ 3\times 18 = 54,\ 6\times 9 = 54$$

Therefore, the full list of factors of 54 is: 1, 2, 3, 6, 9, 27, and 54.

FN2 BIDMAS

There are two sets of brackets, so our first step should be to evaluate them both. Which one we do first doesn't matter, so here we'll choose the left one first. It only contains one operation, so we get

$$13+2=15$$

Now, the bracket on the right contains two operations: an index/power, and a division. We do the index first followed by the division:

$$36\div 3^2 = 36\div 9 = 4$$

Therefore, we only have 1 operation left in our calculation (the multiplication between the two brackets), so we get the answer to be

$$15\times 4 = 60$$

FN3 Types of Numbers - Prime Numbers

Looking at the numbers on the card we can see the following numbers are prime

$$7,\ 29,\ 67,\ 89$$

FN4 Types of Numbers - Squares and Cubes

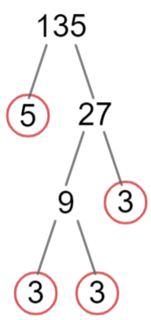
Firstly, $5^2 = 5\times 5 = 25$
Secondly, $2^3 = 2\times 2\times 2 = 8$
Finally, $25\times 8 = 200$
Final Answer = 200

FN5 Types of Numbers - Square and Cube Roots

First, $\sqrt[2]{49} = 7$
Next, $\sqrt[3]{27} = 3$
So finally, $7\times 3 = 21$
So our final answer = 21

FN6 Prime Factor Trees

We will use a prime factor tree, first splitting 135 into 5 and 27. 5 is prime, so we circle it, but 27 is not, so we split it into 9 and 3.



3 is prime, so we circle, but 9 is not, so we split it into 3 and 3. As we established, 3 is prime, so we circle both of these values, and so we have finished our tree. Therefore, the prime factorisation of 135 is

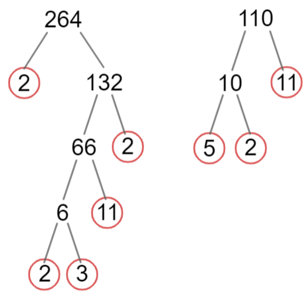
$$135 = 3\times 3\times 3\times 5$$

We can write $3\times 3\times 3$ as 3^3, the answer written using index notation is

$$135 = 3^3\times 5$$

FN7 HCF and LCM

Firstly, we need to find the prime factorisations of 264 and 110. Here, we will do this using prime factor trees.
So, we get that

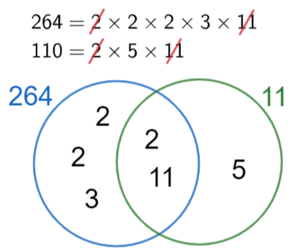


$$264 = 2\times 2\times 2\times 3\times 11$$

and

$$110 = 2\times 5\times 11$$

Then, we need to draw a Venn diagram with one circle for prime factors of 264 and another for prime factors of 110. Then, the first step to filling in this diagram is to look for any prime factors that 264 and 110 have in common. For each shared prime factor, we will cross it off both factor lists, and then write it once in the intersection of the two circles.
After all shared factors are crossed off, write the rest of the prime factors in their appropriate circles. The result should look something like the diagram below.



Then, we find the HCF by multiplying the numbers in the intersection:

$$\text{HCF } = 2\times 11 = 22$$

And find the LCM by multiplying all the numbers in the Venn diagram together:

$$\text{LCM } = 2\times 2\times 2\times 3\times 5\times 11 = 1{,}320$$

FN8 Fractions 1: Adding & Subtracting Fractions

To find a common denominator, multiply the denominators: $7 \times 5 = 35$. To make the denominator of the first fraction 35, we need to multiply its top and bottom by 5:

$$\frac{3}{7} = \frac{3 \times 5}{7 \times 5} = \frac{15}{35}$$

To make the denominator of the second fraction 35, we need to multiply its top and bottom by 7:

$$\frac{6}{5} = \frac{6 \times 7}{5 \times 7} = \frac{42}{35}$$

Now we can do the subtraction. We get:

$$\frac{15}{35} - \frac{42}{35} = -\frac{27}{35}$$

FN9 Fractions 2: Multiplying & Dividing Fractions

To divide these fractions, we need to keep the first fraction the same, change the ÷ to a ×, and flip the second fraction upside down. Doing so, we get

$$\frac{12}{7} \div \frac{9}{20} = \frac{12}{7} \times \frac{20}{9}$$

Then, we do the multiplication:

$$\frac{12}{7} \times \frac{20}{9} = \frac{12 \times 20}{7 \times 9} = \frac{240}{63}$$

240 and 63 both have 3 as a factor, so we can simplify our fraction to get

$$\frac{240}{63} = \frac{80}{21}$$

80 and 21 have no common factors, so we are done.

FN10 Fractions 3: Mixed Numbers and Fractions of Amounts

To find a fraction of an amount, first we need to divide by the denominator and then multiply by the numerator.
First we divide by 6

$$96 \div 6 = 16$$

Next we multiply by 5

$$16 \times 5 = 80$$

This gives our final answer as 80.

FN11 Fractions, Decimals, and Percentages

Firstly, we we know that $\frac{1}{4} = 25\%$, so $\frac{1}{8} = 12.5\%$
Now, $\frac{5}{8} = 12.5\% \times 5 = 62.5\%$
Last we need to convert 62.5% into a decimal. We do this by dividing by 100.

$$62.5 \div 100 = 0.625$$

Final answer

$$\frac{5}{8} = 62.5\% = 0.625$$

FN12 Rounding: Significant Figures & Decimal Places

i) In 7.789, the cut-off digit (the 1st decimal place) is the second 7. The digit after this is an 8, meaning we round the 7, and get the answer: 7.8

ii) In 0.0595, the cut-off digit (the 2nd significant figure) is the 9. The digit after this is a 5, meaning that we round the 9 up to 0, and add an extra 1 to the digit before the 9. Doing so, we get the answer: 0.060. (If you just got 0.06, this is correct)

FN13 Estimations

Firstly, recall that "distance = speed × time". Therefore, rounding both values to 1 significant figure, we get the estimated distance covered to be

$$50 \times 3 = 150 \text{ miles}$$

In this case, both the estimated values are bigger than the actual values. So, since we are multiplying together two bigger values, our result will be bigger. Therefore, this is an overestimate of the distance covered by Mateo during this journey.

FN14 Error Bounds

The smallest value that, when rounded to 3sf, rounds up to 6.74 would be 6.735. The biggest value that, when rounded to 3sf, rounds down to 6.74 would be 6.745. Therefore, we get the error bound for m to be

$$6.735 \leq m < 6.745$$

FN15 Standard Form

i) We need to see how many times we must move the decimal point to make the number fall between 1 and 10. If we move it 8 times,

then it becomes 3.0095, which falls between 1 and 10. We are moving the decimal point 8 places to the left, so the power will be positive. (If we move to the right the power is negative)

$$300,950,000 = 3.0095 \times 10^8$$

ii) This is a negative power so want to end up with a small number - we must divide by 10 seven times. So, moving the decimal place 7 spaces to the left, we get

$$1.997 \times 10^{-7} = 0.0000001997$$

FA1 Algebra Basics & Collecting Like Terms

Firstly, collect the three like terms $3p, 3p,$ and $7p$ to get

$$3p+3p+7p=13p$$

Then, collect the like terms $3pt$ and $-6pt$ to get

$$3pt-6pt=-3pt$$

Therefore, the fully simplified expression is

$$13p-3pt$$

FA2 Simplifying & Solving Equations

We want the x terms on one side. So, adding $3x$ to both sides, we get

$$8x+18=2$$

Then, subtracting 18 from both sides, we get

$$8x=-16$$

Finally, dividing both sides by 8, we get

$$x=\frac{-16}{8}=-2$$

NOTE: it's possible to take a different route but get to the same answer. As long as your steps are mathematically correct, and your answer is -2, then you get full marks.

FA3 Forming & Solving Equations

a) Laline bought two tickets, so that's two lots of £x, and one large drink, which is one lot of £4. Adding these together, we get the expression

$$2x+4$$

b) The total cost of her trip was £26, and we know the expression above also represents the total cost of her trip, so we can set them equal to each other. Doing so, we get

$$2x+4=26$$

We can now solve this equation. Subtracting 4 from both sides, we get

$$2x=26-4=22$$

Then, dividing both sides by 2 gives us the answer

$$x=22\div 2=£11$$

FA4 Rules of Indices

First up, the numerator. The term has a power on top of another power, so they should be multiplied to get

$$\left(5^4\right)^4=5^{4\times 4}=5^{16}$$

Then, the denominator. The terms are being multiplied, so we add the powers. Note: we are going to add a positive number to a negative number in exactly the same we always add a positive number to a negative number. Doing so, we get

$$5^{24}\times 5^{-6}=5^{24+(-6)}=5^{18}$$

Next, we can treat the whole fraction as a division (meaning we will subtract the powers). So, after having simplified the top and bottom we get

$$\frac{5^{16}}{5^{18}}=5^{16-18}=5^{-2}$$

This is a negative power, so it becomes

$$5^{-2}=\frac{1}{5^2}=\frac{1}{25}$$

Thus, we have evaluated the expression to be $\frac{1}{25}$.

FA5 Rearranging Formulae

Firstly, we will multiply both sides by 2 to get

$$2v=at^2$$

Then, dividing both sides by a gives us

$$\frac{2v}{a}=t^2$$

We are almost there but not quite - we need to get rid of the power of 2. To do that, we must square root both sides to get

$$\sqrt{\frac{2v}{a}}=t$$

Flipped around (this step is not necessary, but is good practice), this looks like

$$t=\sqrt{\frac{2v}{a}}$$

FA6 Expanding Single Brackets

We must multiply the term on the outside, pqr, by all the terms on the inside. To do this, we must use the law of indices that says: when you multiply terms, their powers are added. So, multiplying the terms out, we get

$$=\left(pqr\times 5pr\right)+\left(pqr\times 5r^5\right)+\left(pqr\times\left(-25pqr\right)\right)$$
$$=5p^2qr^2+5pqr^6-25p^2q^2r^2$$

FA7 Factorising Single Brackets

We are looking for factors shared by all 3 terms. In this case, there is no number they are all divisible by, but they do share factors of f and g. So, taking these factors out in turn, we get

$$8fg+fgh-4f^3gh=f\left(8g+gh-4f^2gh\right)$$
$$=fg\left(8+h-4f^2h\right)$$

The terms in the bracket have no common factors, so we are done.

FA8 Expanding Double Brackets

We will apply FOIL, drawing red lines as we go, and then collect like terms once the expansion is done. So, we get

$$\begin{aligned}(y-2)(y-6) &= (y\times y)+(y\times(-6))+((-2)\times y)+((-2)\times(-6))\\ &= y^2-6y-2y+12\\ &= y^2-8y+12\end{aligned}$$

FA9 Factorising Quadratics

We want two numbers which multiply to make 10 and add to make -7. In order for them to multiply to make a positive number but add to make a negative one, we need them to both be negative. So, considering factors of 10,

$$10=(-1)\times(-10)=(-2)\times(-5)$$

We see that $(-2)\times(-5)=10$ and $-2+(-5)=-7$, so the two numbers we want are -2 and -5. Therefore, the quadratic factorises to

$$k^2-7k+10=(k-2)(k-5)$$

FA10 Solving Quadratics by Factorisation

We want two numbers which multiply to make -24 and add to make -2. So, considering factors of -24,

$$-24=1\times(-24)=2\times(-12)=3\times(-8)=4\times(-6)$$

We see that $4\times(-6)=-24$ and $4+(-6)=-2$, so the two numbers we want are 4 and -6. Therefore, the equation becomes

$$(z-6)(z+4)=0$$

Therefore, the two solutions are

$$z=6 \text{ and } z=-4$$

FA11 Linear Sequences & the nth Term

The formula must take the form $an+b$. To find a, find the common difference between the terms and confirm that they are the same.

1, 5, 9, 13, 17

+4 +4 +4 +4

So, the formula must be $4n+b$. So, we now write out the sequence given by $4n$ (i.e., the 4 times table):

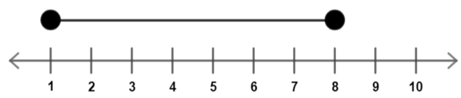
$$4,\ 8,\ 12,\ 16,\ 20$$

Each of these terms is 3 bigger than their respective terms in the original sequence, so we must subtract 3 from them all. Therefore, the nth term is

$$4n-3$$

FA12 Inequalities on a Number Line

There are boundaries at 1 and 8, so we will draw two circles there on the number. They are both inclusive inequalities, so we will draw closed (filled-in) circles. Then, since the only numbers included in the inequality are those in between the two boundaries, we connect the two circles with a line. This looks like



FA13 Solving Inequalities

We will rearrange to make z the subject. So, adding $4z$ to both sides, we get

$$2\le 5z-18$$

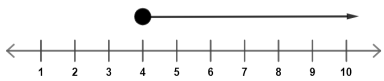
Then, adding 18 to both sides, we get

$$20\le 5z$$

Finally, dividing both sides by 5 gives us the solution

$$4\le z$$

So now we need to draw a closed circle at 4 on the number line (the inequality is inclusive), and draw an arrow going to the right, away from the circle. This looks like



FA14 Simultaneous Equations

To make the coefficients of a the same, we will multiply the first equation by 2. Doing so, we get

$$4a-8b=-2$$

Then, we will subtract the second equation from this new equation we just obtained. This looks like

$$\begin{aligned}4a-8b&=-2\\ 4a+6b&=12\\ \hline -14b&=-14\end{aligned}$$

Thus, we get the equation $-14b=-14$. If we divide both sides by -14, we get

$$b=\frac{-14}{-14}=1$$

Then, substituting $b=1$ into our very first equation, we get

$$2a-4=-1$$

Add 4 to both sides:

$$2a = 3$$

Then, divide both sides by 2 to get

$$a = \frac{3}{2}$$

We have found both a and b, so we're done.

NOTE: if your first step was to divide the second equation given in the question by 2, then that is perfectly valid. If you got the right answer, then that method (or any other way of multiply/dividing equations to make the elimination step work) is worth full marks.

FA15 Proof

We are going to expand the first expression, and the aim to factorise it to end up with the second expression. So, we get

$$m(m+4) + 3(2m+8) = m^2 + 4m + 6m + 24 = m^2 + 10m + 24$$

Then, we want two numbers that multiply to make 24 but add to make 10. Indeed, 6 and 4 satisfy these criteria, and so we get

$$m^2 + 10m + 24 = (m+4)(m+6)$$

So, we have shown that they are equivalent, and so we are done.

FG1 Gradient and $y = mx + c$

Remember we just need to find two numbers to describe our line: the gradient (m) and the y-axis intercept (c).
It's easier if we start with the gradient.

$$m = \frac{\text{change in y}}{\text{change in x}} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{8 - -7}{2 - -3} = \frac{15}{5} = 3$$

So our equation so far is $y = 3x + c$. To find c, we substitute any coordinates that the line passes through for x and y in this equation let's use the point (2,8).

$$8 = 3 \times 2 + c$$

Now we just rearrange this equation to find c.

$$8 = 6 + c$$
$$c = 2$$

So our completed equation is $y = 3x + 2$

FG2 Coordinates and Midpoints

Point A has coordinates $(-2, -2)$.
Point B has coordinates $(0, 3)$.
By taking the average of the x coordinates of A and B, the x coordinate of the midpoint is:

$$\frac{-2 + 0}{2} = -1$$

By taking the average of the y coordinates of A and B, the y coordinate of the midpoint is:

$$\frac{-2 + 3}{2} = \frac{1}{2}$$

Therefore, the coordinates of the midpoint are $\left(-1, \frac{1}{2}\right)$.

FG3 Drawing Linear Graphs

Let's rearrange this equation. Subtract 1 from both sides:

$$2y = 8x - 1$$

Then, divide both sides by 2:

$$y = 4x - \frac{1}{2}$$

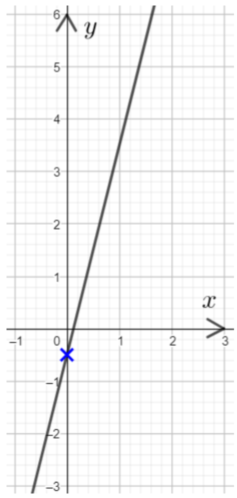
We can use this to find some coordinates. Since it's a straight line we only really need two points so we can pick any two sensible x coordinates. Let's use $x = 0$ and $x = 4$. We can then substitute these into the equation of the graph to give us the corresponding y coordinates.

$$y = 4 \times 0 - \frac{1}{2} = -\frac{1}{2}$$

$$y = 4 \times 4 - \frac{1}{2} = 15.5$$

So we have the coordinates $(0, -\frac{1}{2})$ and $(4, 15.5)$. Now we only need to plot these on a graph and join them with a straight line.
Another way to think about this is to think about what any $y = mx + c$ equation tells us. m is the gradient, and c is the y-axis intercept.

So, for our equation, the y-intercept is $-\frac{1}{2}$, and the gradient is 4. This means that for every step we take in the x direction, the y coordinate increases by 4. This is all the information we need to plot the graph. The result should look like this:

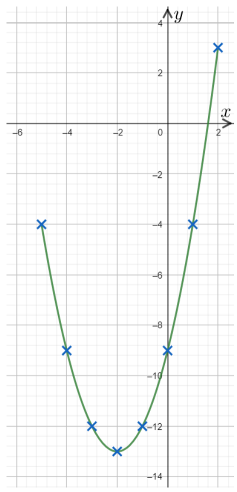


FG4 Quadratic Graphs

The coefficient of x^2 is positive, so the graph will be a U-shaped curve. To plot the graph, we need to make a table of coordinates. First, we pick some x coordinates (e.g. -5 to 2), then we use the equation of the graph to work out the y-coordinates. For example, when x is -5, the y coordinate is given by $y = (-5)^2 + 4 \times (-5) - 9 = 25 - 20 - 9 = -4$. We then do this with the other x coordinates until we have the following table:

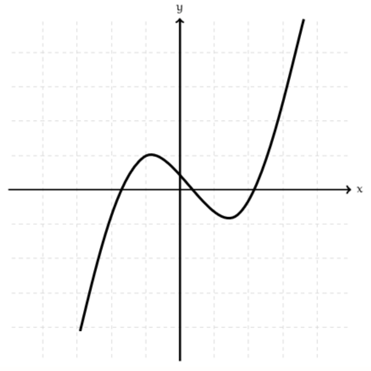
x	-5	-4	-3	-2	-1	0	1	2
y	-4	-9	-12	-13	-12	-9	-4	3

Then we plot the coordinates $(-5, -4), (-4, -9)$ etc. to get the following graph.



FG5 Cubic and Reciprocal Graphs

The name of this function is cubic.
The sketch should be any general cubic sketch, like the one shown below.



FG6 Parallel Lines

Given that L_1 and L_2 are parallel, we know that they have same gradient. By comparing L_1 to $y = mx + c$, we can see that the gradient of L_1 is -2.
This means that the gradient of L_2 is -2 as well, so it has the equation $y = -2x + c$. Once again, we just need to find c and we'll have the complete equation! To find c, we substitute the coordinates of any point that the line passes through into the equation of the line. We're told that the line passes through $(1,5)$, so we substitute $x = 1$ and $y = 5$ into the equation and solve it to find c:

$$5 = -2 \times 1 + c$$
$$c = 7$$

So our complete equation for L_2 is $y = -2x + 7$

FG7 Distance-Time Graphs

a) We can see that the graph was flat for the duration of one big square. From the axis, we can see that two big squares total 15 minutes, therefore one big square is worth 7.5 minutes, so she was stationary for 7.5 minutes.

b) Valentina travelled away 25 km away from home, stopped briefly, and then travelled 25 km back home. Therefore, she travelled 50 km in total.

c) We need to calculate the gradient of the graph between 17:15 and 17:45. This period lasted for 30 minutes, which is equivalent to 0.5 hours - this is the "change in x". During this period, she increased her distance from home from 5 km up to 25 km, meaning she travelled 20 km in total - this is the "change in y". So, we get

$$\text{Gradient } = \frac{20}{0.5} = 40 \text{ km/h}$$

NOTE: if you are asked to calculate the average speed over a longer period of time which contains several lines of different graphs, you still want to do the same calculation: divide the change in distance by the change in time. Even though you aren't strictly calculating the gradient of one particular line, it's still as if you're looking at calculating an average gradient during that period.

FR1 Ratio

We know that difference between Deborah's and Kemah's ages is 21. Looking at the ratio, Kemah has 1 part and Deborah has 4, meaning that the difference between them (21 years) constitutes 3 parts in the ratio. Therefore, we get that

$$1 \text{ part } = 21 \div 3 = 7$$

Kemah, Bob, and Deborah have 1, 2, and 4 parts in the ratio respectively. So, we get that
Kemah's age $= 1 \times 7 = 7$
Bob's age $= 2 \times 7 = 14$
Deborah's age $= 4 \times 7 = 28$

FR2 Proportionality

This recipe makes 6 pancakes, but Wes wants to make 21.
$21 \div 6 = 3.5$
Therefore, he needs to 3.5 times as much of every ingredient. So, we get:
flour: $100 \times 3.5 = 350$ g
eggs: $2 \times 3.5 = 7$ eggs
milk: $300 \times 3.5 = 1{,}050$ ml

FR3 Percentage

This is a 32% decrease, so the multiplier for a 32% decrease is

$$1 - \frac{32}{100} = 0.68$$

Therefore, multiplying this by the original value Matt bought the TV for, we get the price that Dave purchased it for to be

$$550 \times 0.68 = £374$$

FR4 Reverse Percentage

We need to consider how we would calculate a 4% increase. We know that 4% = 0.04, so we get the multiplier for a 4% increase to be

$$1 + 0.04 = 1.04$$

Let H be Tom's height from two years ago. We know that the result of multiplying H by 1.04 must be 182. We can write this as an equation:

$$H \times 1.04 = 182$$

Then, if we divide both sides by 1.04 we get

$$H = 182 \div 1.04 = 175$$

So, Tom's height two years ago was 175 cm.

FR5 Growth & Decay

This is a case of compound growth. Firstly, the multiplier for a 40% increase is

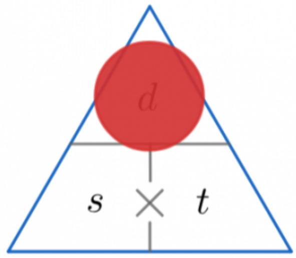
$$1 + 0.40 = 1.4$$

We are looking at the number of bacteria after one week, which means SEVEN 40% increases. Therefore, our calculation is

$$480 \times (1.4)^7 = 5{,}060 \text{ (to nearest whole number)}$$

5,060 is clearly bigger than 5,000, so the scientist's estimate is correct.

FR6 Speed, Distance, Time



If we cover up d in the triangle, we see that we will have to multiply s by t to get our answer. However, the units don't match up - we need to convert the minutes to hours, which we will do by dividing it by 60.

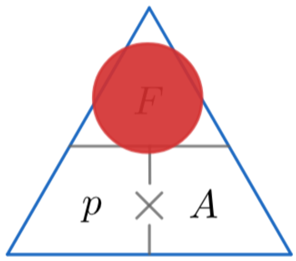
$$t = 414 \div 60 = 6.9 \text{ hours}$$

Now, we can do the multiplication:

$$\text{distance covered } = d = 230 \times 6.9 = 1{,}587 \text{ km}$$

FR7 Pressure & Density

Covering up F on the triangle,



we see that we need to multiply p (pressure) by A (area). To do this, we need to find the area of the triangle. Before that, however, notice that the sides of the triangle are measured in centimetres which doesn't match up with the "Newtons per metres squared" in the question. So, we will convert the dimensions of the triangle into metres by dividing by 100:

$$\text{height } = 80 \div 100 = 0.8 \text{ m}$$

$$\text{base } = 150 \div 100 = 1.5 \text{ m}$$

Now we can calculate the area of the triangle:

$$\text{area } = \frac{1}{2}bh = \frac{1}{2} \times 0.8 \times 1.5 = 0.6 \text{ m}^2$$

Therefore, we get that the force being applied is

$$F = p \times A = 40 \times 0.6 = 24 \text{ N}$$

FR8 Best Buys

We will work out the cost per drink for each brand.
Brand 1:
Each bottle is 600 ml and provides 3 drinks per 100 ml. $600 \div 100 = 6$, so we get

$$\text{drinks per bottle } = 3 \times 6 = 18$$

The cost of a bottle of Brand 1 squash is £1.89, therefore we get

$$\text{cost per drink } = 1.89 \div 18 = £0.105$$

Brand 2:
Each bottle is 1300 ml and provides 7 drinks per 200 ml.
$1300 \div 200 = 6.5$, so we get

$$\text{drinks per bottle } = 7 \times 6.5 = 45.5$$

The cost of a bottle of Brand 2 squash is £5.10, therefore we get

$$\text{cost per drink } = 5.10 \div 45.5 = £0.112...$$

The cost per drink is lower for Brand 2, therefore Brand 1 is better value.

FM1 Types of Angle and Angle Facts

The angles in the diagram go all the way around a point, so they must add up to 360°. One of the angles doesn't have a measurement, but it is marked with a square which means it's a right angle (90°)
We can write the following equation:

$$63+57+62+68+90+z=360$$

Then we just simplify it by adding together the number on the left hand side:

$$340+z=360$$

Then subtract 340 from both sides of the equation to give us the answer:

$$z=20^\circ$$

FM2 Angles in Parallel Lines

Firstly, because angles BEF and EHJ are corresponding angles, we get

$$\text{angle EHJ } = 39^\circ$$

Next, because angles EDH and DHG are alternate angles, we get

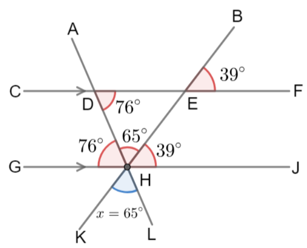
$$\text{angle DHG } = 76^\circ$$

Then, because angles DHG, DHE, and EHJ are angles on a straight line and angles on a straight line add to 180, we get

$$\text{angle DHE } = 180-76-39=65^\circ$$

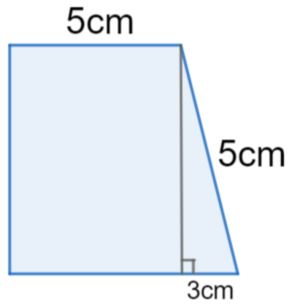
Finally, because angle DHE and angle x are vertically opposite angles, we get

$$x=65^\circ$$



FM3 Areas of Shapes

This is a bit of a weird-looking trapezium, but it is a trapezium nonetheless. To work out the area, we will, as the question states, need to find the perpendicular height. The word 'perpendicular' is key here, because it means that we can draw one line and form a right-angled triangle, as seen below. Because the top of a trapezium is always parallel to the base, we can find the base of the small right-angled triangle by subtracting the length of the top from the length of the base to get 3 cm.



Then, this is where Pythagoras comes in. The hypotenuse of the right-angled triangle is 5 cm and the base is 3 cm, so we get the other side (the perpendicular height of the trapezium) as such:

$$\text{Perpendicular height } = \sqrt{5^2-3^2}=\sqrt{16}=4 \text{ cm}$$

Now we know the perpendicular height, we can calculate the area.

$$\text{Area } = \frac{1}{2}(a+b)h = \frac{1}{2}(5+8)\times 4 = 26 \text{ cm}^2$$

FM4 Interior & Exterior Angles

This is a 4-sided shape, which we now know has interior angles that add up to $180\times 2=360$. So, if we know all the interior angles other than x, then we can find x.
Currently we don't know them all, however we do have an exterior angle, and we know that exterior angles form a straight line with their associated interior angles, we get the interior angle at D to be $180-121=59^\circ$.
Now we know all 4 interior angles, we get that

$$x=360-84-100-59=117^\circ$$

FM5 Parts of the Circle

The straight line passing through A and B intersects the circumference twice and doesn't pass through the centre, so it's a chord.
The straight line BC touches the circumference of the circle just once, so it's a tangent.
There are two curved lines joining A and B: the 'big part' of the circumference and the small part of the circumference. These are both arcs.

FM6 Area and Circumference of a Circle

When the question asks us for an "exact" answer, we have to make sure we're not rounding anything. So we will need to express our answer in terms of pi where appropriate.
For the first part of the question we want to find the radius of the circle. We know the formula that relates radius and area: $A=\pi r^2$. We need to rearrange this to make r the subject. First we divide both sides of the equation by pi:

$$\frac{A}{\pi}=r^2$$

Then we square root both sides to give us r:

$$\sqrt{\left(\frac{A}{\pi}\right)}=r$$

Substituting the given area for A:

$$\sqrt{\left(\frac{25\pi}{\pi}\right)} = r$$

The pi's cancel out:

$$\sqrt{25} = r$$

So we have $r = 5$.

Next, to find the circumference we just use the formula $c = 2\pi r$.
We could convert this answer into a decimal, which would be 31.4 to 1 dp. But the question asks for an exact answer, so we can't round it. The only way to represent the answer exactly is to leave it in terms of pi.

FM7 Perimeters of Shapes

We can see that the side lengths of the rectangle are 4cm and 6cm however it's not immediately clear how to get the length of the curved edge joining A and B!
We can work this out using the formula for the circumference of a circle, $c = \pi d$. We can see the diameter of the circle is 4 cm, the same as the length of the shortest edge of the rectangle. The circumference of a circle with a diameter of 4 cm would be 4π. However we only have half a circumference here, so the length of the curved edge is 2π. This means the total perimeter of the shape is:

$$6 + 4 + 6 + 2\pi = 22.3 \text{ (1 dp)}$$

FM8 Congruence

Let's check each shape individually.
Shape B: it has two angles in common with A, but the side is a different length.
Shape C: this has two angles and a side-length in common with A, but to pass the ASA test the side-length needs to be between the two angles, which in C's case it isn't.
Shape D: this does what shape C didn't - all the numbers match, and the side we know is between the two angles which means that shape D is congruent to A by the ASA criteria.

The real value in being able to spot when two triangles are congruent like this is that we suddenly know that all the other angles and side-lengths must also be the same. This is useful in making quick leaps towards solving bigger problems, for example in circle theorems, so keep the definition of congruence as well as the 4 tests for congruent triangles in mind when solving all kinds of geometry problems.

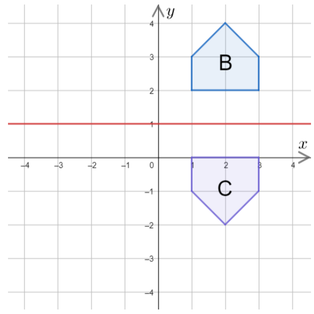
FM9 Similar Shapes

Firstly, we will determine the scale factor that relates the side-lengths by dividing the side-length of the bigger shape by that of the smaller shape: $SF = 28 \div 7 = 4$.
Now, if the scale factor for the side-lengths is 4, then that means that the scale factor for the areas is: $SF_A = 4^2 = 16$.
Therefore, to find the area of the smaller shape, we need to divide the area of the bigger shape by the area scale factor: 16. Doing so, we get

$$\text{Area of A } = 320 \div 16 = 20 \text{ cm}^2$$

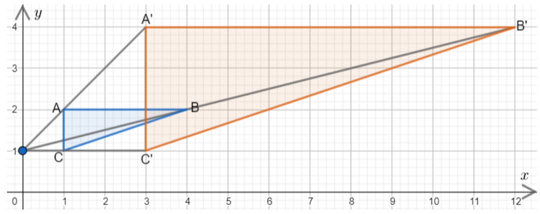
FM10 Translations and Reflections

Firstly, we must draw the line $y = 1$ onto the graph. Then, you can either choose to use tracing paper or, if you're confident without it, just go right into the reflection.
Then, the trace of the shape is the result of the reflection. Draw that shape onto the original axes, mark it with a C and you should get the resulting picture below.



FM11 Rotations and Enlargements

We need to draw lines from the point $(0, 1)$ to all corners of this shape. Then, since this is scale factor 3 enlargement, we need to extend these lines until they are 3 times longer. For example, the line from $(0, 1)$ to A goes 1 space to the right and 1 up. So, once we've extended it, the resulting line should go 3 spaces to right and 3 spaces up.
Then, once all these lines have been drawn, their ends will be the corners of the enlarged shape. Joining these corners up, we get the completed shape, as seen below.

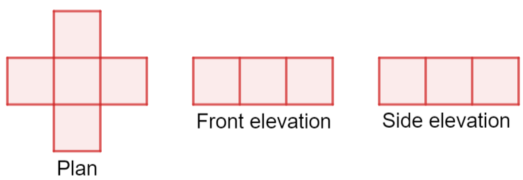


FM12 Edges, Faces and Vertices

There's no real "how-to" here we just need to count them up! Here we've been given a diagram, but it always helps to draw one if not so you don't forget any "hidden" features.
There are 5 faces (2 triangles and 3 rectangles), 9 edges, and 6 vertices.

FM13 Projections, Plans and Elevations

As we can see, the shape is one block high and is the shape of a cross, or letter x. As a result, the plan is going to be the shape of a cross, and both elevations will only be one block high. Furthermore, we can see that in looking both from the front and from the side, the shape in question is 3 blocks wide, so the resulting elevations will both be 3 blocks wide and 1 block high. All 3 projections are as seen below.



FM14 Volume of a Prism

A cylinder is a "circular prism". To find its volume, like with any other prism, we just need to multiply the cross-sectional area by the length. Because the cross-section of a cylinder is a circle, we can calculate its area using the formula for the area of a circle: $A = \pi r^2$.
So in this case, the cross-sectional area is:

$$A = \pi \times 3^2 = 28.274 \text{ cm}^2$$

Next we just multiply this by the length to get the volume:

$$V = 28.274 \times 8 = 226.19 \text{ cm}^3 \text{ (2 dp)}$$

FM15 Volume of a Cone and Sphere

Firstly, the cylinder is a type of prism, so we know we need to multiply the area of the cross section by its length. Here, the cross section is a circle with radius 4 mm, and the length of the cylinder is 3 mm, so we get

$$\text{Volume of cylinder} = \pi \times 4^2 \times 3 = 48\pi$$

We'll worry about the rounding at the end. Next, we have to work out the volume of the cone part, and fortunately the formula for this is given in exams!
h is the height of the cone, which we know to be 5.5, and r is the radius of the cone, which is the same as that of the base: 4mm. Therefore, we get

$$\text{Volume of cone } = \frac{1}{3}\pi \times 4^2 \times 5.5 = \frac{88}{3}\pi$$

Then, the volume of the shape is the sum of these two answers:

$$\text{Volume of whole shape } = 48\pi + \frac{88}{3}\pi = 242.9498... = 242.9 \text{ mm}^3 \text{ (1 dp)}$$

FM16 Surface Areas of 3D Shapes

We know the whole surface area is 120 cm^2 and we also know the radius. To work out the slant height, we need to first work out what the curved surface area is. In other words, we need to subtract the surface area of the base of the cone (since that's the only other face) from 120 to get the curved surface area. The base is a circle, so its area is

$$\pi \times 3^2 = 9\pi \text{ cm}^2$$

Subtracting this from the total we have $120 - 9\pi$.
Now, this must be the area of the curved face, and the formula for the area of the curved face is given to us: $\pi r l$. So, setting this formula equal to the value we worked out, we get

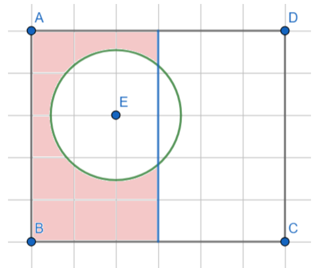
$$\pi r l = 120 - 9\pi$$

Then, to find the slant height, we will divide both sides by πr to get

$$l = \frac{120 - 9\pi}{3\pi} = 9.7 \text{ cm (1 dp)}$$

FM17 Loci and Constructions

For the fountain to be at least 3 m away from his house along CD, we need to only consider the area to the left of the straight line which is parallel to CD and 3 cm away from it.
Then, the locus of points which are 1.5 m away from the tree at E will be a circle of radius 1.5 cm - for the fountain to be at least 1.5 m away, it must be outside this circle.
So, the locus of points where he could place the fountain is to the left of the (blue) line 3 m away from the house, and outside the (green) circle which is 1.5 m away from the tree. The correct region is shaded red on the picture below.

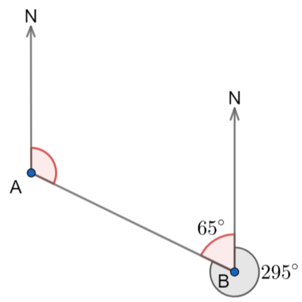


FM18 Bearings

We can't simply measure the angle, since the picture is not drawn accurately. Instead, we will use the fact that the two North lines are parallel to one another.
Firstly, recognise that we can find the other angle around the point B by subtracting 295 from 360.

$$360 - 295 = 65°$$

Then, because the two north lines are parallel, we can say that the bearing of B from A and the 65° angle we just found are interior (sometimes co-interior, or allied, depending on what your teacher likes). From our facts about angles in parallel lines, we know the two angles (marked with red below) must add to 180.



So, we get:

$$\text{Bearing of B from A } = 180 - 65 = 115°$$

FT1 Pythagoras

To do this we will need to use Pythagoras theorem $a^2 + b^2 = c^2$
We then add the numbers we know into the equation. This gives us

$$9^2 + x^2 = 13^2$$

Next, we need to rearrange to make x the subject.

$$x^2 = 13^2 - 9^2$$

Next if we then calculate the right-hand side:

$$x^2 = 169 - 81$$
$$x^2 = 88$$

Finally, we square root both sides

$$x = \sqrt{88} = 2\sqrt{22}$$

FT2 Trigonometry - Finding Lengths

Here we're dealing with the opposite and adjacent sides, so we need a formula with both of those in. This means we'll have to use $\tan(x) = \frac{O}{A}$.
First we rearrange the formula: we're after the adjacent so we want to make A the subject.

$$A \times \tan(x) = O$$
$$A = \frac{O}{\tan(x)}$$

Now we've made A the subject, we just need to plug in the values given.

$$z = \frac{3.6}{\tan(52)} = 2.81 \text{ km (2 dp)}$$

FT3 Trigonometry - Finding Angles

The two sides we're concerned with are the hypotenuse and the opposite (to the angle) - O and H. Therefore, we want the 'SOH' part of 'SOHCAHTOA', so will be using sin. We have $O = 13, H = 15$, and the angle is q, so we get

$$\sin(q) = \frac{O}{H} = \frac{13}{15}$$

Then, to get q, we have to apply the inverse sin function: $\sin^{-1}$ to both sides. It cancels out the sin on the left-hand side, and we get

$$q = \sin^{-1}\left(\frac{13}{15}\right)$$

Finally, putting this into the calculator we get

$$q = 60.0735... = 60.1° \text{ (1 dp)}$$

FT4 Trigonometry Common Values

This question requires a bit less work but a bit more thought.
Since two sides of this triangle are the same length, it must be an isosceles triangle. In an isosceles triangle, we must have two angles the same - specifically the two angles that aren't given to us (we can't have one angle be the same as the right-angle, because then the sum of the angles in the triangle would go above 180°).
If those two angles are the same, the other one must also be w. Then, because angles in a triangle sum to 180°, we get

$$w + w + 90 = 180$$

Subtract 90 from both sides to get

$$2w = 90$$

Then, dividing both sides by 2 gives us: $w = 45$. Now we know the size of w, from the values of sin that we memorised we get that

$$\sin(w) = \sin(45) = \frac{1}{\sqrt{2}}$$

ALTERNATIVE METHOD: According to SOHCAHTOA, the sin of w must be equal to the opposite side divided by the hypotenuse. The opposite side is given to us: 2, but the hypotenuse is not. However, we can find it using Pythagoras, since this is a right-angled triangle.
The hypotenuse is c, and then a and b are both 2, so the equation $a^2 + b^2 = c^2$ becomes

$$c^2 = 2^2 + 2^2 = 4 + 4 = 8$$

Square rooting both sides, we get

$$c = \sqrt{8}$$

At this point you can simplify the surd and make it into $2\sqrt{2}$, but you don't have to. Then, now we know the hypotenuse, we get

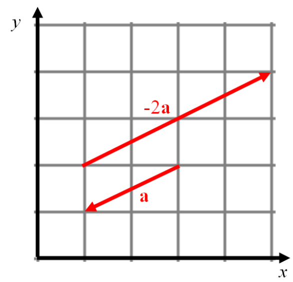
$$\sin(w) = \frac{2}{\sqrt{8}} = \frac{2}{2\sqrt{2}} = \frac{1}{\sqrt{2}}$$

FT5 Vectors

The vector shown in the diagram goes 2 steps to the left and 1 step downwards. That's the same as saying it goes 1 steps in the negative y direction and 2 step in the negative x direction. So the vertical part of the column vector is -1, and the horizontal part of its column vector is -2. We write the column vector with the horizontal part at the top, and the vertical part at the bottom.
Let

$$\mathbf{a} = \begin{pmatrix} -2 \\ -1 \end{pmatrix}$$

The vector -2a is what we get when we multiply a by -2. This doubles the size of it and switches its direction, so it looks like this on the grid:



FP1 Probability Basics

We know their probabilities must add up to 1 to make Amira's statement true. To add these values together, we must make them all share the same format. Here, we're going to convert them all to percentages. Firstly, we get that

$$0.35 = 35\%$$

Then, we get

$$\frac{1}{4} = 1 \div 4 = 0.25 = 25\%$$

Now, we can add the three probabilities together:

$$40\% + 25\% + 35\% = 100\% = 1$$

They all add to 1, so Amira's statement is correct.

FP2 Listing Outcomes

Let's consider the outcomes in which Joe comes first. We have:
JKL and JLK
Then, if Kiernan comes first, we have
KJL and KLJ
Next, if Lola comes first, we have
LJK and LKJ
Therefore, the total list of outcomes is
JKL, JLK, KJL, KLJ, LJK, and LKJ.

FP3 Fairness and Relative Frequency

To work out the probability of a random vehicle passing Arthur's house, we need to find the relative frequency of not-black cars. Doing this, we get

$$\frac{\text{number of not-black cars}}{\text{total number of vehicles}} = \frac{56}{20+56+12+32} = \frac{7}{15}$$

Putting it into a calculator, we see that $\frac{7}{15} = 0.4666... = 46.7\%$.
Given that 50% = 0.5, we can see that the relative frequency of not-black cars is close to 50% but not exactly 50%, therefore Arthur is not correct.

FP4 Tree Diagrams

a) Firstly, we know she either wears a jumper or doesn't. Therefore, to fill in the gap at the top (after she has chosen trousers), we simply subtract the probability of her wearing a jumper from 1, to get

$$\text{P(N)} = 1 - \text{P(J)} = 1 - 0.85 = 0.15$$

Next, we know that the probability of her wearing shorts and a jumper is 0.144. This means that 0.144 must be the result of multiplying along the SJ branch, so in other words

$$0.45 \times x = 0.144$$

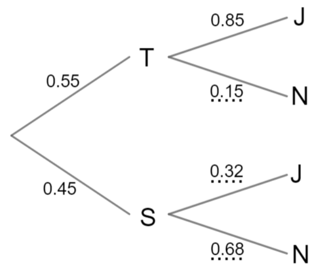
Thus, if we divide by 0.45, we get

$$x = 0.144 \div 0.45 = 0.32$$

Then, for the final gap, we subtract 0.32 from 1 to get

$$1 - 0.32 = 0.68$$

So, the completed tree diagram looks like



b) The two circumstances in which Heloise wears a jumper are: she wears trousers and a jumper, or she wears shorts and a jumper. Multiplying along the branch, we get

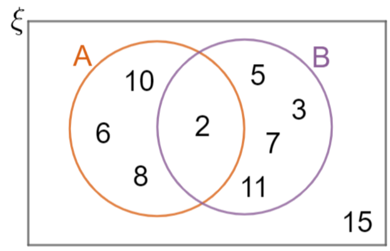
$$\text{P(T and J)} = 0.55 \times 0.85 = 0.4675$$

We already know the probability of her wearing shorts and a jumper: 0.144. This is an 'or' situation (since in either circumstance, she's wearing a jumper), so we must add these probabilities to get

$$\text{P(Jumper)} = 0.144 + 0.4675 = 0.6115$$

FP5 Venn Diagrams

a) Firstly, let's consider any number that are both even and prime. There is one: 2. This is the only number that will go in the section where the two circles cross over.
Then, the rest of the even numbers: 6, 8, and 10, will go in the section of the A circle that doesn't cross over with B. Next, the rest of the prime numbers: 3, 5, 7, and 11, will go in the section of the B circle that doesn't cross over with A.
Finally, the one number that is neither even nor prime is 15, so that goes outside the circles. The completed Venn diagram looks like the one below.



b) $A \cap B$ refers to "A and B". There is only one number in both A and B, so the answer is 1.

c) $A \cup B$ refers to "A or B". There are 8 numbers that are contained in circle A and/or circle B, and there are 9 numbers in total, so we get

$$P(A \cup B) = \frac{8}{9}$$

FP6 Averages and Spread

a) We must add up all the values and divide by 10.

$$\text{mean} = \frac{181+182+175+176+210+169+175+184+167+175}{10} = 179.4 \text{ cm}$$

b) To find the median, we must first put the values in ascending order:

$$167, 169, 175, 175, 175, 176, 181, 182, 184, 210$$

Then, if you cross off alternating biggest and smallest values, you'll be left with two numbers: 175 and 176. Therefore, the median is 175.5 cm, (the halfway point).

c) In this case, the man who is 210 cm tall is significantly taller than the other men. Therefore, when we calculate the mean, the 210 value is going to make the mean much higher than otherwise, and it might not be representative of the data (try calculating the mean without 210 and see what happens). The median, however, is not affected by the value of 210, so it might be a better measure of average in this case.

FP7 Mean from a Frequency Table

To calculate the mean, we must multiply each shoe size by its frequency, add up all of those values, and then divide the result by 60. Doing this, we get

$$\text{mean} = \frac{(1\times 2)+(2\times 0)+(3\times 12)+(4\times 22)+(5\times 14)+(6\times 7)+(7\times 3)}{60}$$
$$= \frac{259}{60} = 4.3 \text{ (1 dp)}$$

FP8 Scatter Graphs and Correlation

a) We can see that these points following a straight-line pattern fairly closely, and we can see that as the x value increases, so does the y value. Therefore, this graph displays moderate positive correlation.

b) There appears to be no relationship followed by the points on this graph. Therefore, it displays no correlation.

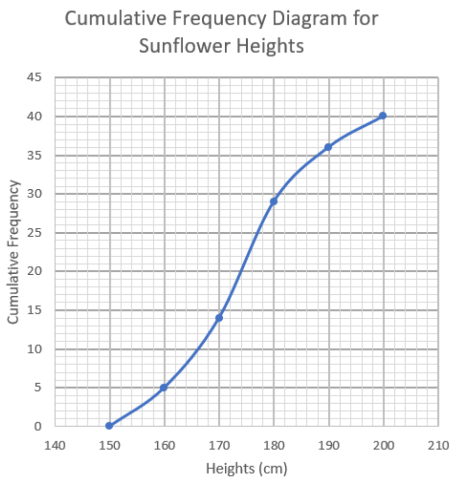
c) We can see that these points following a straight-line pattern very closely, and we can see that as the x value increases, the y value decreases. Therefore, this graph displays strong negative correlation.

FP9 Cumulative Frequency

Obtaining cumulative frequency from a frequency table amounts to adding up the values as we go along, using the upper limit of each class as our new upper limit at each step. So, the first value is 5, then the second is $5+9=14$, then the third is $5+9+15=29$. Continuing this, the completed table looks like

Height, h (cm)	Frequency	Cumulative Frequency
$150 < h \leq 160$	5	5
$160 < h \leq 170$	9	14
$170 < h \leq 180$	15	29
$180 < h \leq 190$	7	36
$190 < h \leq 200$	4	40

Then, plotting each of these cumulative frequency values against each of the upper limits of the classes, and joining them all together with a smooth curve, we get the graph shown below.



FP10 Pie Charts

We know that the formula for finding the angle is

$$\text{angle} = \frac{\text{number in one category}}{\text{sum of all categories}} \times 360$$

This time we know the angle (224), and the sum of all categories (1,260). So, the equation becomes

$$224° = \frac{\text{paperbacks sold}}{1,260} \times 360$$

Divide by 360 and then multiply by 1,260 to get

$$\text{paperbacks sold} = \frac{224}{360} \times 1,260 = 784$$

The number of paperbacks sold is 784, so the number of other books sold is $1,260 - 784 = 476$. The ratio of hardbacks:audiobooks is 3:1, so audiobooks constitute 1 part out of 4 in the ratio.
Therefore, we get

$$\text{audiobooks sold} = \frac{476}{4} = 119$$