Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number

Candidate Number

Pearson Edexcel International GCSE

Time 2 hours

Paper reference **4MA1/1HR**

Mathematics A

PAPER 1HR

Higher Tier

You must have: Ruler graduated in centimetres and millimetres, protractor, pair of compasses, pen, HB pencil, eraser, calculator. Tracing paper may be used.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Without sufficient working, correct answers may be awarded no marks.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Calculators may be used.**
- You must **NOT** write anything on the formulae page.
  Anything you write on the formulae page will gain NO credit.

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Check your answers if you have time at the end.

Turn over

P72438A
P 7 2 4 3 8 A 0 1 2 8

J:1/1/1/

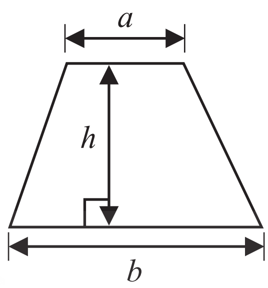
International GCSE Mathematics

Formulae sheet – Higher Tier

Arithmetic series

Sum to n terms, $S_n = \frac{n}{2}[2a + (n - 1)d]$

Area of trapezium $= \frac{1}{2}(a + b)h$

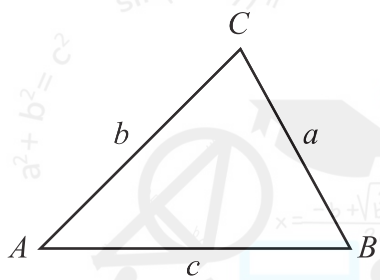


The quadratic equation

The solutions of $ax^2 + bx + c = 0$ where $a \neq 0$ are given by:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Trigonometry



In any triangle ABC

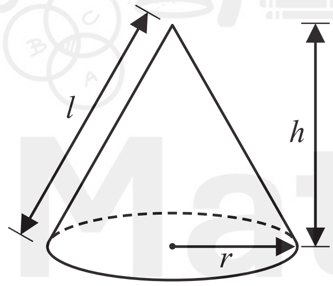
Sine Rule $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Cosine Rule $a^2 = b^2 + c^2 - 2bc\cos A$

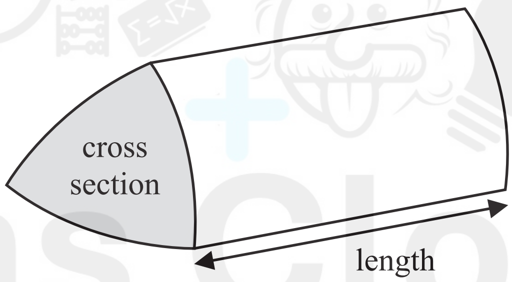
Area of triangle $= \frac{1}{2}ab\sin C$

Volume of cone $= \frac{1}{3}\pi r^2 h$

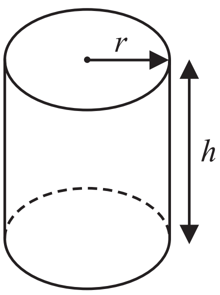
Curved surface area of cone $= \pi rl$



Volume of prism
$=$ area of cross section $\times$ length

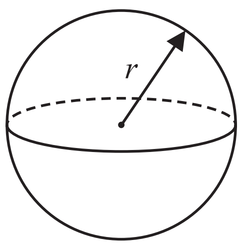


Volume of cylinder $= \pi r^2 h$
Curved surface area
of cylinder $= 2\pi rh$



Volume of sphere $= \frac{4}{3}\pi r^3$

Surface area of sphere $= 4\pi r^2$



Answer ALL TWENTY FOUR questions.

Write your answers in the spaces provided.

You must write down all the stages in your working.

1 The table shows information about the frame size, in cm, of 60 bicycles sold in a shop.

	Frame size (S cm)	Frequency
1	$30 < S \leqslant 36$	4
2	$36 < S \leqslant 42$	14
3	$42 < S \leqslant 48$	18
4	$48 < S \leqslant 54$	19
5	$54 < S \leqslant 60$	5

The modal class is the class where the highest frequency is located

(*a*) Write down the modal class.

$48 < S \leq 54$

(1)

(*b*) Work out an estimate for the mean frame size.

Method: take the midpoint of each frame size class and multiply it by the frequency
The mean is the sum of these values divided by the total number of bikes (60)

Midpoints:

1) $\frac{36-30}{2} + 30 = 3 + 30 = 33$

2) $\frac{42-36}{2} + 36 = 3 + 36 = 39$

3) $\frac{48-42}{2} + 42 = 3 + 42 = 45$

4) $\frac{54-48}{2} + 48 = 3 + 48 = 51$

5) $\frac{60-54}{2} + 54 = 3 + 54 = 57$

Multiplying by the frequency:

$33 \times 4 = 132$

$39 \times 14 = 546$

$45 \times 18 = 810$

$51 \times 19 = 969$

$57 \times 5 = 285$

Sum of the values:

$132 + 546 + 810 + 969 + 285 = 2742$

Dividing by total number of bikes:

$\frac{2742}{60} = 45.7$

45.7 cm

(4)

(Total for Question 1 is 5 marks)

2 The diagram shows a solid triangular prism.

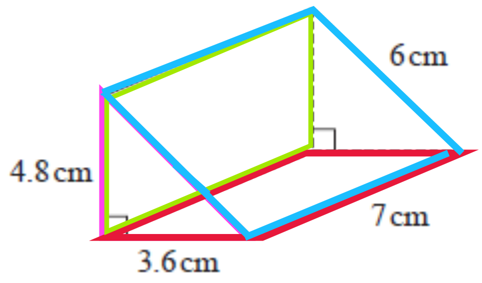


Diagram **NOT** accurately drawn

Work out the **total** surface area of the triangular prism.
Give your answer correct to 3 significant figures.

4.8, 3.6

Surface area
$= \frac{3.6 \times 4.8}{2} = \frac{216}{25}$

Two present, so
$\frac{216}{25} \times 2 = \frac{432}{25}$

3.6, 7

surface area
$= 7 \times 3.6 = \frac{126}{5}$

4.8, 7

surface area
$7 \times 4.8 = \frac{168}{5}$

6, 7

surface area
$6 \times 7 = 42$

Total surface area $\frac{432}{25} + \frac{126}{5} + \frac{168}{5} + 42$

$= 118.08$

To 3 significant figures: 118 cm^2

118 cm^2

(Total for Question 2 is 3 marks)

3 Here is a list of six numbers written in order of size.

x 5 y z 10 12

The numbers have

a range of 9
a median of 8
a mode of 10

Find the value of x, the value of y and the value of z

Range = highest value − lowest value

$9 = 12 - x$
$-3 = -x$
$x = 3$

Mode = value which appears the most
So either y or z must be 10

But, median = middle point
In order for 8 to be the middle point, given y or z = 10, $y = 6$ and $z = 10$, as $\frac{(10-6)}{2} + 6 = 2 + 6$
$= 8$

So $y = 6$ and $z = 10$ for both the median and mode statements to hold

$x = $ 3

$y = $ 6

$z = $ 10

(Total for Question 3 is 3 marks)

4 Divya and Yuan each pay for a holiday at a special offer price.

Divya's holiday	Yuan's holiday
Normal price: \$1600	Normal price: \$1400
Special offer: 16% off the normal price	Special offer: k% off the normal price

The amount that Divya pays is the same as the amount that Yuan pays.

Work out the value of k

first, calculate how much Divya pays

16% can be expressed as 0.16

So, amount price is reduced by $= 1600 \times 0.16$

$= 256$

Amount Divya pays $= 1600 - 256$

$= \$1344$

or

$1 - 0.16 = 0.84$

$1600 \times 0.84 = 1344$

Yuan pays the same amount, so we can use 1400 and 1344 in the percentage change formula:

$$\left(\frac{\text{New} - \text{old}}{\text{old}}\right) \times 100$$

$$= \left(\frac{1344 - 1400}{1400}\right) \times 100$$

$= -4$

so: $k = 4$%

$k =$ 4

(Total for Question 4 is 4 marks)

5 C grams of chocolate is shared in the ratios 2 : 5 : 8
The difference between the largest share and the smallest share is 390 grams.

Work out the value of C

$8 - 2 = 6$

6 shares = 390g

1 share = $\frac{390}{6}$

1 share = 65g

Total number of shares: $2 + 5 + 8$
= 15 shares

$C = 15 \times 65$
$C = 975$g

C = 975

(Total for Question 5 is 3 marks)

---

6 Solve the simultaneous equations

×3 $x + 2y = 15$
$4x - 6y = 4$

Show clear algebraic working.

we want to manipulate the equations so the y values are the same. As the signs of the 2 equations are different, we will be adding them. By making the y values the same, we eliminate them, allowing us to first solve for x, and subsequently y.

$(x + 2y = 15) \times 3 = 3x + 6y = 45$

Now both of the y's have coefficients of, we can add the equations together:

$3x + 6y = 45$ +
$4x - 6y = 4$

$7x = 49$

$x = \frac{49}{7}$

$x = 7$

plug back into either equation to find y:

$3(7) + 6y = 45$
$21 + 6y = 45$
$6y = 24$
$y = \frac{24}{6}$
$y = 4$

So: $x = 7$, $y = 4$

x = 7

y = 4

(Total for Question 6 is 3 marks)

Note: Answers in standard form must always be between 1 and 10

$9.32 = 0.0000932$

-5, so decimal moves 5 places to the left

7 (*a*) Write 9.32×10^{-5} as an ordinary number.

0.0000932

(1)

(*b*) Work out $3 \times 10^5 - 6 \times 10^4$
Give your answer in standard form.

$(3 \times 10^5) - (6 \times 10^4)$

$= 300000 - 60000$

$= 240000$

converting back into standard form:

240000 : 5 places

$= 2.4 \times 10^5$

2.4×10^4

(2)

(*c*) Work out $(3 \times 10^{55}) \times (6 \times 10^{65})$
Give your answer in standard form.

This equation is too big to take out of standard form and convert it back (this method would be inefficient!)

Instead, lets split it up:

$3 \times 6 = 18$

Using indices rules:

$10^{55} \times 10^{65}$

$= 10^{55+65}$

$= 10^{120}$

equation becomes:

18×10^{120}

but, standard form values must always be between 1 and 10

moving the decimal point 1 place:

1.8×10^{121}

1.8×10^{121}

(2)

(Total for Question 7 is 5 marks)

recognise that the common term between the 2 values is $3c^2$

8 (*a*) Factorise fully $18c^3d^2 - 21c^2$

$3c^2(6cd^2 - 7)$

as $18 \div 3 = 6$

as $21 \div 3 = 7$

$3c^2(6dc^2 - 7)$

(2)

(*b*) (i) Factorise $y^2 - 3y - 18$

what multiplies to get -18, and adds to get -3?

recognise: $-6 \times 3 = -18$
and $-6 + 3 = -3$

So factorised:

$(y-6)(y+3)$

$(y-6)(y+3)$

(2)

(ii) Hence, solve $y^2 - 3y - 18 = 0$

$= (y-6)(y+3) = 0$

we need the y values when each bracket $= 0$ (as multiplying by $0 = 0$, the requirement)

$y - 6 = 0$ and $y + 3 = 0$

$y = 6$ $y = -3$

$y = 6$, $y = -3$

(1)

(Total for Question 8 is 5 marks)

9 The diagram shows an isosceles triangle ABC

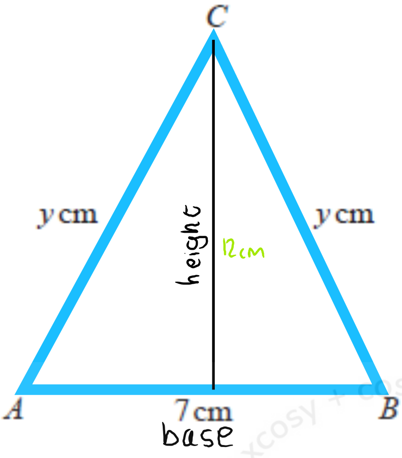


Diagram NOT accurately drawn

$AB = 7$ cm $AC = BC = y$ cm

The area of the triangle is 42 cm^2

Work out the value of y

area of triangle $= \frac{1}{2} \times$ base $\times$ height

$42 = \frac{1}{2} \times 7 \times$ Height

$\frac{\text{Height}}{2} = \frac{42}{7}$

Height $= \frac{42}{7} \times 2$

Height $= 12$ cm

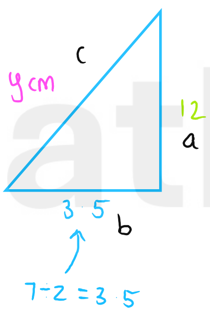
Applying pythagoras

$a^2 + b^2 = c^2$

$12^2 + 3.5^2 = y^2$

$y = \sqrt{12^2 + 3.5^2}$

$y = 12.5$ cm



$y =$ 12.5

(Total for Question 9 is 4 marks)

10 R and T are points on a circle, centre O

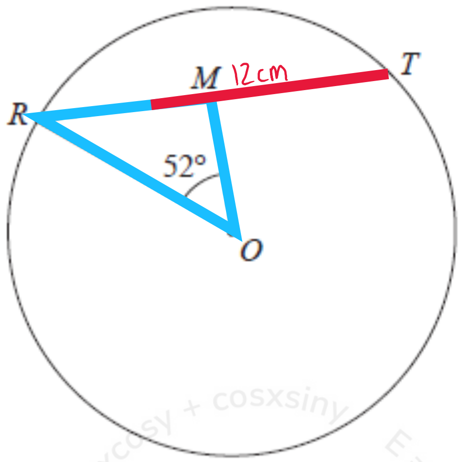


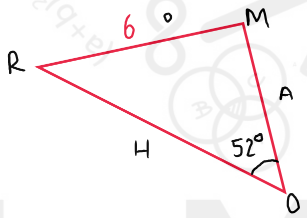
Diagram **NOT** accurately drawn

$RT = 12$ cm
M is the midpoint of RT
Angle $ROM = 52°$
Work out the area of the circle.
Give your answer correct to 3 significant figures.

Area $= \pi r^2$
where $r = RO$

$RM = \frac{RT}{2}$

$RM = 6$



using trig.

$\sin\theta = \frac{O}{H}$

$\sin 52 = \frac{6}{RO}$

$RO = \frac{6}{\sin 52}$

$RO = 7.614...$

$\therefore$ radius $= 7.614...$

Area $= \pi r^2$
Area $= \pi \times (7.614)^2$
Area $= 182.1327669$
rounded to 3 significant figures
Area $= 182$

.................................182 cm^2

(Total for Question 10 is 4 marks)

11 The table shows information about the times, in minutes, that 80 patients had to wait to see a doctor.

Time (W minutes)	**Frequency**
$0 < W \leq 10$	7
$10 < W \leq 20$	10
$20 < W \leq 30$	15
$30 < W \leq 40$	32
$40 < W \leq 50$	16

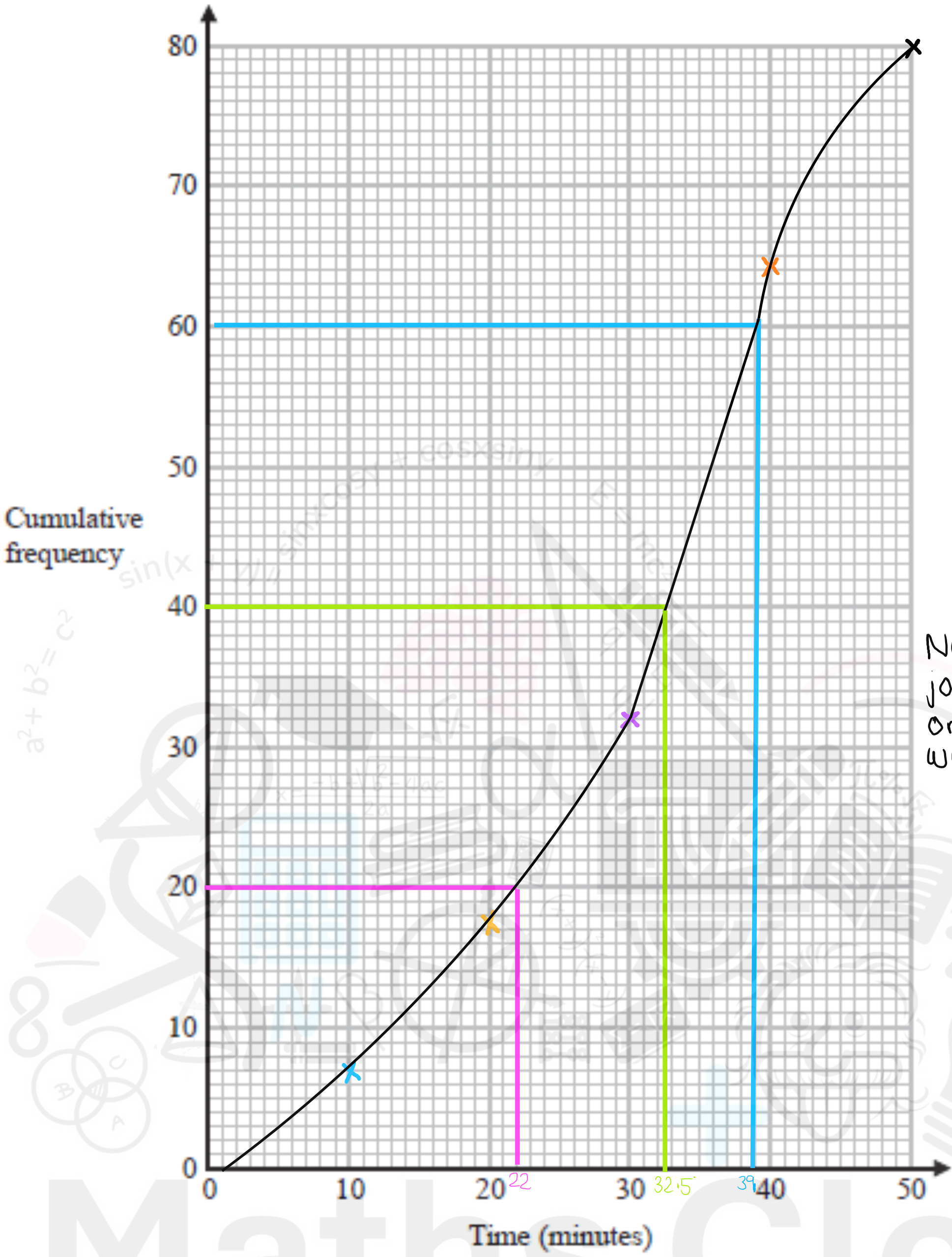
Note:
To find each value, add the current cumulative frequency to the value in the frequency table which aligns with the time bounds.

(*a*) Complete the cumulative frequency table below.

Time (W minutes)	**Cumulative frequency**	
$0 < W \leq 10$	7	
$10 < W \leq 20$	17	(7 + 10)
$20 < W \leq 30$	32	(17 + 15)
$30 < W \leq 40$	64	(32 + 32)
$40 < W \leq 50$	80	(64 + 16)

(1)

(*b*) On the grid on the next page, draw a cumulative frequency graph for your table.



Note: the points joined with a curve or line segments will be accepted

(2)

(*c*) Use your graph to find an estimate for the median.

32.5 minutes
(any value 32-34 will be accepted) **(1)**

(*d*) Use your graph to find an estimate for the interquartile range.

IQR = 75% value − 25% value
(80 × 0.75) − (80 × 0.25)
minutes at CF of 60 − minutes at CF of 20
39 − 22 = 17

17 minutes
(any value 15-17 will be accepted) **(2)**

(Total for Question 11 is 6 marks)

Note: median and range values sourced from a correctly drawn graph will be accepted

12 Solve $2^{-4x} = 32$

In order to get a value of 32, the power term must be a positive number.
So x must be a negative term, as $-ve \times -ve = +ve$.

Recognise: $2^5 = 32$

so $-4 \times x = 5$

$x = -\frac{5}{4}$

$x = -\frac{5}{4}$

(Total for Question 12 is 2 marks)

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13 Use algebra to show that $0.3\dot{8}\dot{1} = \frac{21}{55}$

$x = 0.38\dot{1}$

$10{,}000x = 3818.\boxed{18}...$
$100x = 38.\boxed{18}...$ $-$

$9900x = 3780$

$x = \frac{3780}{9900}$

$x = \frac{21}{55}$

or

$1000x = 381.8\boxed{18}...$
$10x = 3.8\boxed{18}...$ $-$

$990x = 378$

$x = \frac{378}{990}$

$x = \frac{21}{55}$

or

$100x = 38.\boxed{1818}$
$1x = 0.3\boxed{818}$ $-$

$99x = 37.8$

$x = \frac{37.8}{99}$

$x = \frac{21}{55}$

Note: there are multiple ways to answer this question, the key here is that we want to get x into a fraction. The easiest way to achieve this is by 'lining up' the decimal points through strategic multiplication before finding the difference to then lead us to the desired fraction.

(Total for Question 13 is 2 marks)

P72438A

14 $T = \dfrac{p}{r}$

$p = 0.51$ correct to 2 significant figures.
$r = 6.3$ correct to 2 significant figures.

Work out the upper bound for the value of T
Show your working clearly.

To find the upper bound of T, we want to create the biggest value possible. This is done by taking the upper bound of the numerator and the lower bound of the denominator.

To 2 significant figures, so: $+0.005$ for upper bound (as 0.51 has 2 decimal places)
-0.05 for lower bound (as 6.3 has 1 decimal place)

$0.51 + 0.005 = 0.515$
$6.3 - 0.05 = 6.25$

$= \dfrac{0.515}{6.25}$

$= 0.0824$

0.0824

(Total for Question 14 is 2 marks)

$y = (-2)^3 - 3(-2) + 2$
$y = 0$

$y = (0)^3 - 3(0) + 2$
$y = 2$

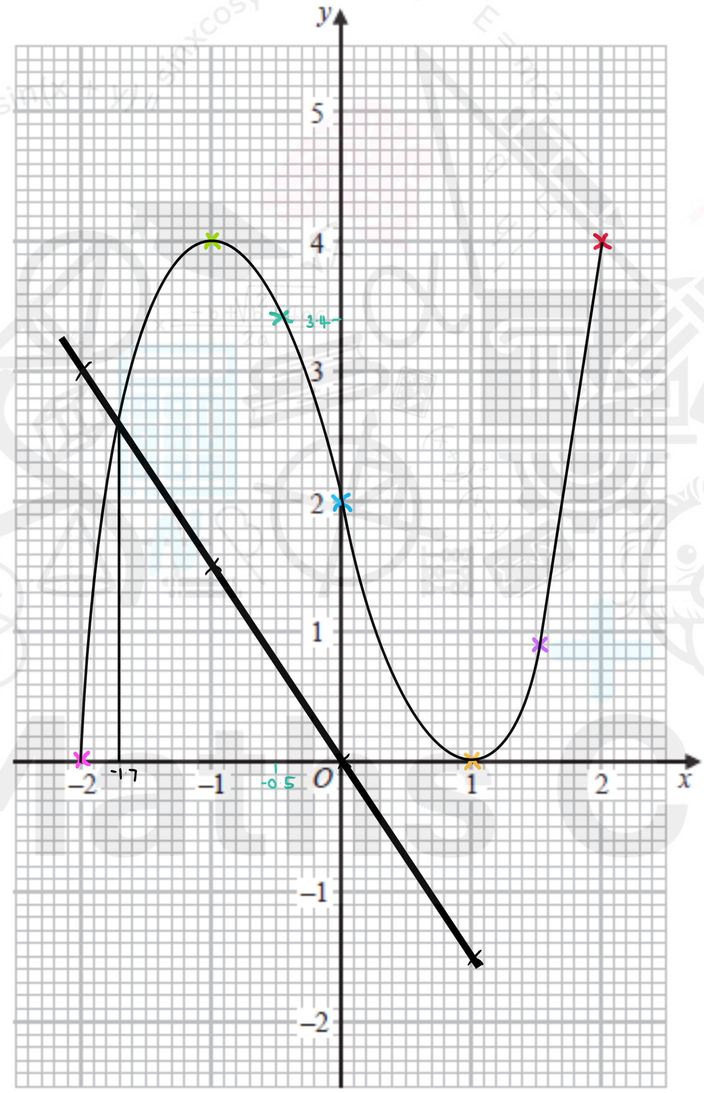
15 (*a*) Complete the table of values for $y = x^3 - 3x + 2$

$y = (2)^3 - 3(2) + 2$
$y = 4$

x	–2	–1	–0.5	0	1	1.5	2
y	0	4	3.4	2	0	0.9	4

(2)

(*b*) On the grid, draw the graph of $y = x^3 - 3x + 2$ for values of x from –2 to 2



(2)

(*c*) By drawing a suitable straight line on the grid, use your graph to find an estimate for the solution of

$$2x^3 - 3x + 4 = 0$$

Give your answer correct to one decimal place.

we have $x^3 - 3x + 2 = 0$ ①

and $2x^3 - 3x + 4 = 0$ ②

$\div 2$ to make ② have no coefficent infront of x like ①

$= x^3 \boxed{-\frac{3}{2}x} + 2 = 0$

Compairing them $x^3 \boxed{-3x} + 2 = 0$

The only different term is the $-\frac{3}{2}x$

so we need to draw on $y = -\frac{3}{2}x$

for $y = -\frac{3}{2}x$

x	-2	-1	0	1
y	3	$\frac{3}{2}$	0	$-\frac{3}{2}$

-1.7

(3)

(Total for Question 15 is 7 marks)

we can see from our sketch that the line intersects the graph at $x = -1.7$

(answers in the range of -1.6 to -1.7 are accepted, given a correct curve is drawn)

16 The function f is such that

$$f(x) = \frac{2}{3x-5} \quad \text{where } x \neq \frac{5}{3}$$

(*a*) Find $f\left(\frac{1}{3}\right)$

plug in $\frac{1}{3}$ for every x.

$= \frac{2}{3(\frac{1}{3})-5} = -\frac{1}{2}$

$-\frac{1}{2}$

(1)

(*b*) Find $f^{-1}(x)$

$y = \frac{2}{3x-5}$ $(\times 3x-5)$

we want to rearrange to make x the subject!

$y(3x-5) = 2$ (expand)

$3xy - 5y = 2$

$3xy = 2 + 5y$ $(+5y)$

$x = \frac{2+5y}{3y}$ $(\div 3y)$

Replace the y's with x's

$= \frac{2+5x}{3x}$

$f^{-1}(x) = \frac{2+5x}{3x}$

(2)

The function g is such that

$$g(x) = 5x^2 - 20x + 23$$

(*c*) Express g(*x*) in the form $a(x - b)^2 + c$

Recognise that this is completing the square

$5x^2 - 20x + 23$

$5[\underbrace{x^2 - 4x}_{\text{complete the square on this}}] + 23$

minus half the x coefficient

$5[(x-2)^2 - 4] + 23$

minus the square of the value in the brackets (in this case, 2)

multiply by the 5

$5(x-2)^2 - 20 + 23$

$5(x-2)^2 + 3$

$5(x-2)^2 + 3$

(3)

(Total for Question 16 is 6 marks)

17

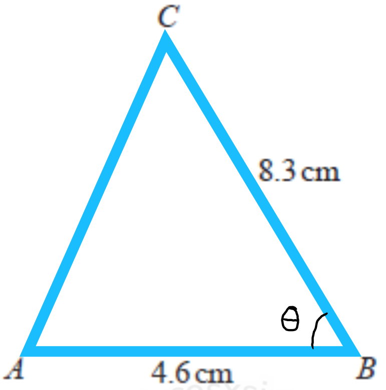


Diagram NOT accurately drawn

$AB = 4.6$ cm $\qquad BC = 8.3$ cm $\qquad$ angle ABC is acute

The area of triangle ABC is 12 cm²

Work out the perimeter of triangle ABC
Give your answer correct to 3 significant figures.

Finding θ using the area of a triangle:

$\text{Area} = \frac{1}{2}ab\sin C$

$12 = \frac{1}{2}(4.6)(8.3)\sin\theta$

$\frac{12}{\frac{1}{2}(4.6)(8.3)} = \sin\theta$

$\theta = \sin^{-1}\left(\frac{12}{\frac{1}{2}(4.6)(8.3)}\right)$

$\theta = 38.947\ldots$

Using cosine rule to find AC:

$A^2 = B^2 + C^2 - 2BC\cos A$

$AC^2 = AB^2 + BC^2 - 2(AB)(BC)\cos\theta$

$AC^2 = 4.6^2 + 8.3^2 - 2(4.6)(8.3)\cos(38.947\ldots)$

$AC^2 = 30.662\ldots$

$AC = \sqrt{30.662\ldots}$

$AC = 5.537\ldots$

perimeter $= AC + AB + BC$

$= 5.537\ldots + 4.6 + 8.3$

$= 18.437\ldots$

Rounded to 3 significant figures

perimeter $= 18.4$ cm

.......................18.4....... cm

(Total for Question 17 is 5 marks)

18 Solve $\sqrt{3}(x-2\sqrt{3}) = x+2\sqrt{3}$

Give your answer in the form $a+b\sqrt{3}$ where a and b are integers.
Show your working clearly.

$\sqrt{3}(x-2\sqrt{3}) = x+2\sqrt{3}$

expanding the brackets

Note: $\sqrt{3} \times \sqrt{3} = 3$

$x\sqrt{3} - 2(3) = x + 2\sqrt{3}$

$x\sqrt{3} - 6 = x + 2\sqrt{3}$

get all the x's on the same side

$x\sqrt{3} - x = 2\sqrt{3} + 6$

Factorising x

$x(\sqrt{3} - 1) = 2\sqrt{3} + 6$

$\div$ by $\sqrt{3} - 1$

$x = \dfrac{2\sqrt{3}+6}{\sqrt{3}-1}$

$x = 6 + 4\sqrt{3}$

$x =$ ....$6 + 4\sqrt{3}$....

(Total for Question 18 is 4 marks)

so we will be using a fraction

19 P is inversely proportional to y^2
When $y = 4$, $P = a$

(*a*) Find a formula for P in terms of y and a

$P = \frac{k}{y^2}$

$a = \frac{k}{4^2}$

$a = \frac{k}{16}$

$k = 16a$

$\therefore P = \frac{16a}{y^2}$

$P = \frac{16a}{y^2}$
....
(3)

Given also that y is directly proportional to $\sqrt{x}$
and when $x = a$, $P = 4a$

(*b*) find a formula for P in terms of x and a

First find y using what we just calculated above:

$P = \frac{16a}{y^2}$

$4a = \frac{16a}{y^2}$

$y^2 = \frac{16a}{4a}$

$y^2 = 4$

$y = \sqrt{4}$

$y = \pm 2$

$\therefore y = \pm 2$

given: $y = k\sqrt{x}$

$P = \frac{16a}{y^2}$

$P = \frac{16a}{(k\sqrt{x})^2}$

$P = \frac{16a}{k^2 x}$

where $x = a$

$P = \frac{16\cancel{x}}{k^2 \cancel{x}}$

$P = \frac{16}{k^2}$

$4a = \frac{16}{k^2}$

$k^2 = \frac{16}{4a}$

$k^2 = \frac{4}{a}$

$P = \frac{16a}{k^2 x}$

$P = \frac{16a}{\frac{4}{a}x}$

$P = \frac{16a}{1} \times \frac{a}{4x}$

$P = \frac{4a^2}{x}$

$P = \frac{4a^2}{x}$
....
(3)

(Total for Question 19 is 6 marks)

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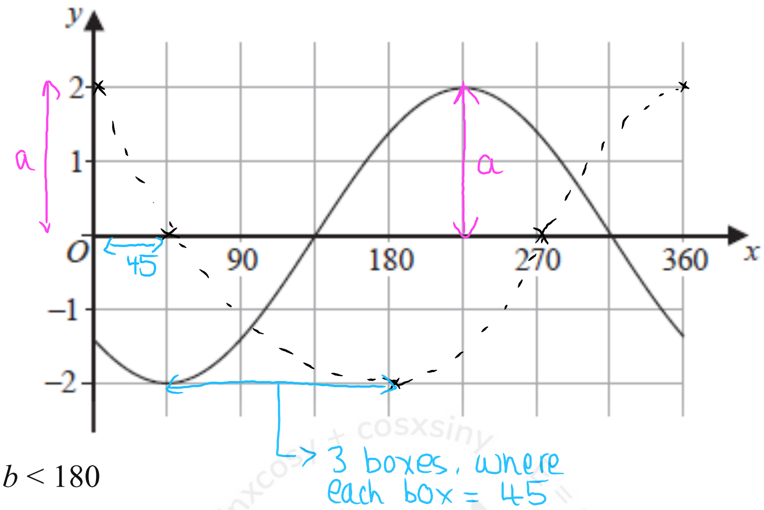
20 Here is a sketch of the curve $y = a\cos(x + b)°$ for $0 \leq x \leq 360$



Given that $0 < b < 180$

find the value of a and the value of b

Sketching $y = 2\cos x$ will help us compare to find B.

$\cos x$		$2\cos x$	
x	y	x	y
0	1	0	2
90	0	90	0
180	-1	180	-2
270	0	270	0
360	1	360	2

$b = 3 \times 45$

$b = 135$

$a =$ 2

$b =$ 135

(Total for Question 20 is 2 marks)

21 The diagram shows a triangular prism, *ABCDEF*, with a rectangular base *ABCD*

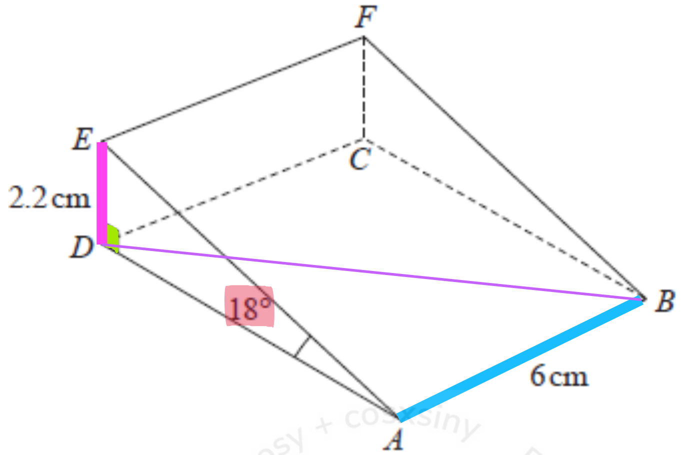


Diagram **NOT** accurately drawn

AB = 6 cm   *DE* = 2.2 cm angle   *DAE* = 18°   angle *ADE* = 90°

Work out the angle that *BE* makes with the plane *ABCD*
Give your answer correct to one decimal place.

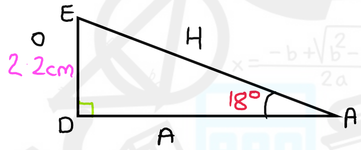
First, calculate length of AD:

$\tan\theta = \frac{O}{A}$

$\tan 18 = \frac{2.2}{AD}$

$AD = \frac{2.2}{\tan 18}$

$AD = 6.77...$



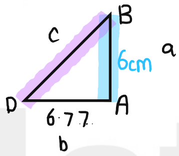
Next, calculate the length of DB:
Using pythagoras:

$a^2 + b^2 = c^2$

$DB^2 = 6^2 + 6.77...^2$

$DB = \sqrt{6^2 + 6.77...^2}$

$DB = 9.04...$ cm



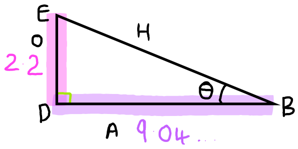
Finally, calculate θ:

$\tan\theta = \frac{O}{A}$

$\tan\theta = \frac{2.2}{9.04...}$

$\theta = \tan^{-1}\left(\frac{2.2}{9.04...}\right)$

$\theta = 13.7°$



.... 13.7°

(Total for Question 21 is 4 marks)

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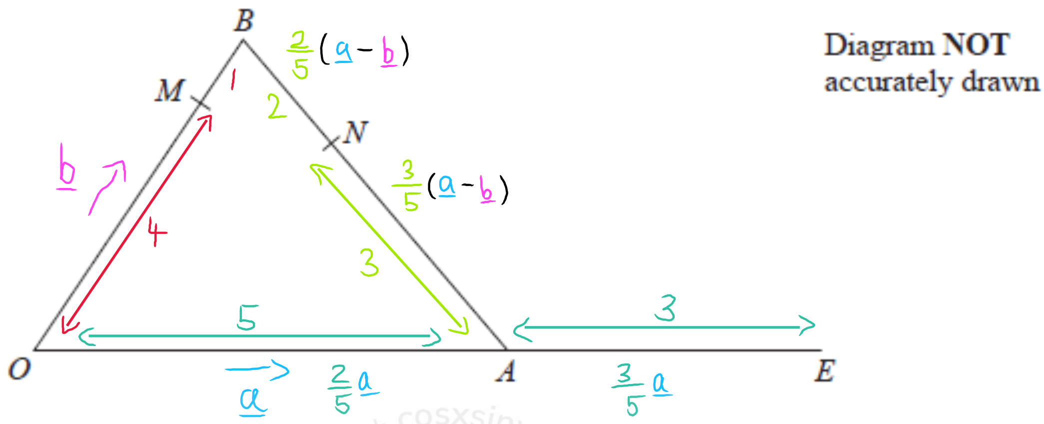
22 The diagram shows triangle OAB with OA extended to E



$\overrightarrow{OA} = \mathbf{a}$ $\overrightarrow{OB} = \mathbf{b}$

M is the point on OB such that $OM : MB = 4 : 1$
N is the point on AB such that $AN : NB = 3 : 2$
$OA : AE = 5 : 3$

(*a*) Find an expression for $\overrightarrow{ON}$ in terms of **a** and **b**
Give your answer in its simplest form.

$\overrightarrow{ON} = \overrightarrow{OB} + \overrightarrow{BN}$

$\overrightarrow{ON} = \overrightarrow{OB} + \frac{2}{5}\overrightarrow{BA}$

$\overrightarrow{ON} = b + \frac{2}{5}(a - b)$

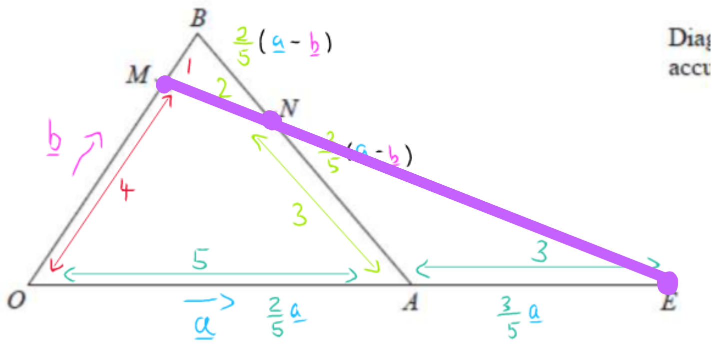
$= b + \frac{2}{5}a - \frac{2}{5}b$

$= \frac{2}{5}a + \frac{3}{5}b$

$\overrightarrow{ON} = \frac{2}{5}a + \frac{3}{5}b$

(2)

(*b*) Use a vector method to show that *MNE* is a straight line.



If on a straight line, then $\overrightarrow{MN}$ is parallel to $\overrightarrow{NE}$.

$\overrightarrow{MN} = \overrightarrow{MB} + \overrightarrow{BN}$
$= \frac{1}{5}b + \frac{2}{5}(a-b)$
$= \frac{1}{5}b + \frac{2}{5}a - \frac{2}{5}b$
$= \frac{2}{5}a - \frac{1}{5}b$ (1)

$\overrightarrow{NE} = \overrightarrow{NA} + \overrightarrow{AE}$
$= \frac{3}{5}(a+b) + \frac{3}{5}a$
$= \frac{3}{5}a + \frac{3}{5}b + \frac{3}{5}a$
$= \frac{6}{5}a - \frac{3}{5}b$ (2)

$3 \times (1) = (2)$

$3\times\left(\frac{2}{5}a - \frac{1}{5}b\right) = \frac{6}{5}a - \frac{3}{5}b$

$\frac{6}{5}a - \frac{3}{5}b = \frac{6}{5}a - \frac{3}{5}b$

So, $3\overrightarrow{ME} = \overrightarrow{NE}$
∴ They are parallel,
so MNE is a straight line.

(3)

(Total for Question 22 is 5 marks)

23 G is the point on the curve with equation $y = 8x^2 - 14x - 6$ where the gradient is 10
The straight line **Q** passes through the point G and is perpendicular to the tangent at G

Find an equation for **Q**
Give your answer in the form $ax + by + c = 0$ where a, b and c are integers.

First, find the values of x and y
gradient of $y = 8x^2 - 14x - 6$

$\frac{dy}{dx} = 16x - 14$ (times by the power, minus 1 from the power)

$\frac{dy}{dx} = 10$

$16x - 14 = 10$
$16x = 24$
$x_1 = 1.5$

Plugging back into $y = 8x^2 - 14x - 6$
$y = 8(1.5)^2 - 14(1.5) - 6$
$y_1 = -9$

The equation of a line
$y - y_1 = m(x - x_1)$
$y - (-9) = m(x - 1.5)$
m = gradient of Q
Q is perpendicular to the tangent
so $m_1 \times m_2 = -1$
$m_1 \times 10 = -1$
$m_1 = -\frac{1}{10}$

$y + 9 = -\frac{1}{10}(x - 1.5)$

$y + 9 = -\frac{1}{10}x + \frac{3}{20}$

$y + \frac{177}{20} = -\frac{1}{10}x$

$\frac{1}{10}x + y + \frac{177}{20} = 0$

$\times 20$ to simplify
$2x + 20y + 177 = 0$

$2x + 20y + 177 = 0$

(Total for Question 23 is 5 marks)

24 An arithmetic sequence has first term 8 and common difference 11
The sequence has k terms, where $k > 21$

The sum of the last 20 terms of the sequence is 10 170

Find the value of k
Show clear algebraic working.

Sum of last 20 terms $= S_k - S_{k-20}$ ← 'Sum of'

Sum of series formula

$S_n = \frac{n}{2}(2a + (n-1)d)$

$S_k = \frac{k}{2}(2(8) + (k-1)(11))$

$S_k = \frac{k}{2}(16 + 11k - 11)$

$S_k = \frac{k}{2}(5 + 11k)$

$S_{k-20} = \frac{k-20}{2}(2(8) + (k-20-1)(11))$

$S_{k-20} = \frac{k-20}{2}(16 + (k-21)(11))$

$S_{k-20} = \frac{k-20}{2}(16 + 11k - 231)$

$S_{k-20} = \frac{k-20}{2}(11k - 215)$

$10170 = S_k - S_{k-20}$

$10170 = \frac{k}{2}(5 + 11k) - \frac{k-20}{2}(11k - 215)$

Side workings of expansion

	$-k$	20
$11k$	$-11k^2$	$220k$
-215	$+215k$	-4300

$= -11k^2 + 435k - 4300$

×2 to remove the ÷2
expand the brackets

$20340 = 5k + \cancel{11}k^2 - \cancel{11}k^2 + 435k + 4300$

$20340 = 440k - 4300$

$24640 = 440k$

$k = 56$

$k =$ 56

(Total for Question 24 is 5 marks)

TOTAL FOR PAPER = 100 MARKS

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