	Class	Index Number
Candidate's Name ____________		

ST ANDREW'S SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2014
SECONDARY 4 EXPRESS/ 5 NORMAL ACADEMIC

MATHEMATICS 4016/01

Paper 1

TUESDAY 19 AUGUST 2014 2 hour

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer all questions.
If working is needed for any question it must be shown in the space below that question.
Omission of essential working will result in loss of marks.
You are expected to use an scientific calculator to evaluate explicit numerical expressions.
If the degree of accuracy is not specified in the question, and if the answer is not exact, give the answer to three significant figures. Give answers in degrees to one decimal place.
For π, use either your calculator value or 3.142, unless the question requires the answer in terms of π.

The number of marks is given in brackets [ ] at the end of each question or part question.
The total of the marks for this paper is 80.

FOR EXAMINER'S USE
/ 80

This question paper consists of 15 printed pages, including this cover page.

Compound interest

$$\text{Total amount} = P\left(1+\frac{r}{100}\right)^n$$

Mensuration

Curved surface area of a cone $= \pi rl$

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

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

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

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

Arc length $= r\theta$, where θ is in radians

$$\text{Sector area} = \frac{1}{2}r^2\theta, \text{ where } \theta \text{ is in radians}$$

Trigonometry

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

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

Statistics

$$\text{Mean} = \frac{\Sigma fx}{\Sigma f}$$

$$\text{Standard deviation} = \sqrt{\frac{\Sigma fx^2}{\Sigma f} - \left(\frac{\Sigma fx}{\Sigma f}\right)^2}$$

For Examiner's Use

For Examiner's Use

1 Einstein equation, $E = mc^2$, is used to determine the amount of energy E, in Joules, for a given mass m, in grams. Given that $c = 3\times10^8$ m/s, representing the speed of light, Calculate the value of E, in Joules and express your answer in standard form, when the mass is 0.08 nanograms.

Answer ..... Joules [2]

2 **(a)** Simplify $\dfrac{2^x \times 2^{x-2}}{\sqrt{4^x}}$.

(b) Simplify $\left(\dfrac{\sqrt[3]{a}}{-2a^2}\right)^{-2}$ and express your answer in positive index.

Answer *(a)* ..... [1]

(b) ..... [1]

3 Mr Wong wants to deposit \$10 000 in Bank A for 3 years which offers a simple interest rate of 3.8 % per annum, but Mrs Wong prefers to deposit it in Bank B which offers a 3.6 % per annum compound interest rate that is compounded monthly. Show by calculation, which bank offers better interest for a period of 3 years?

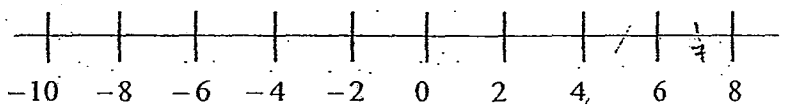
Answer Bank ..... [2]

For Examiner's Use

For Examiner's Use

4 Solve the inequality $\frac{x}{2} - 3 < \frac{2x-5}{3} \leq 10 - x$, and show your solution on the number line in the answer space below.

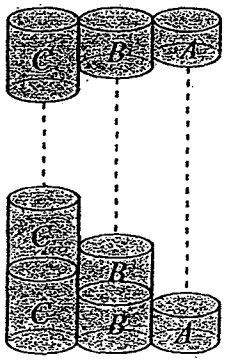
Answer



[3]

5 **(a)** 1050 and a number N have an LCM of 3150 and HCF of 42. Given that $1050 = 2 \times 3 \times 5^2 \times 7$ and $3150 = 2 \times 3^2 \times 5^2 \times 7$, find the number N.

(b) Three cylindrical cans, A, B and C, of the same radii have heights 0.08 m, 1 m and 1.5 m respectively. If all the cans are stacked to the same height as shown in the diagram, find the minimum number of cylinder B needed.

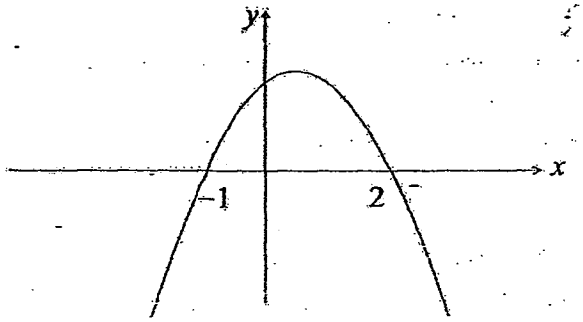


Answer (a) ..... [1]

(b) ..... cylinders [2]

For Examiner's Use

6 The diagram shows the graph of $y = ax^2 + bx + 6$. Find the value of a and of b.



Answer $a =$ ....., $b =$ ..... [3]

7 The temperature at the bottom of a mountain is x °C. The temperature at the top, at a height of 7 000 m, is $-y$ °C, where x and y are positive integers. Express in terms of x and y, find

(a) the difference between the two temperatures.

(b) the temperature at a height of 2 000 m, assuming that the temperature decreases at a constant rate.

Answer (a)..... °C [1]

(b)..... °C [2]

For Examiner's Use

For Examiner's Use

8 Express $\frac{1}{3x^2-10x+8}+\frac{2}{4-3x}$ as single fraction.

Answer ..... [3]

9 An area of 289 km^2 is represented on a map by an area of 25 cm^2. Find

(a) the scale of the map in the form 1 : n.

(b) the length of a road on the map with an actual distance of 84 km, leaving your answer correct to the nearest centimetres.

Answer (a) ..... [2]

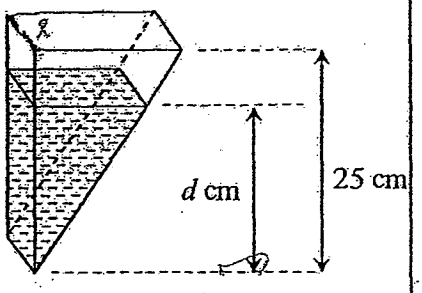
(b) ..... cm [1]

For Examiner's Use

10 A container is a prism with a triangular cross-section. The container has a height of 25 cm. Water is poured into the empty container at a constant rate. It takes 10 seconds to fill the container. After t seconds the depth of the water is d cm.

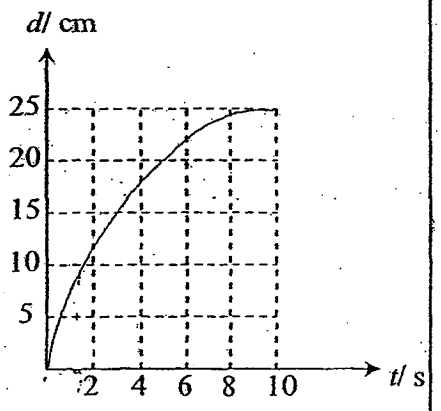
(a) Find the value of t when $d = 10$.

(b) On the axes in the answer space, sketch the graph showing how the depth varies during the 10 seconds.



Answer *(a)* ..... s [2]

(b) [1]



11 **(a)** Expand and simplify $p - \left(\frac{2}{3}p - 1\right)^2$.

(b) Solve the equation $27^x = 3^{2x+1} \times 9^x$.

Answer *(a)* ..... [2]

(b) ..... [2]

For Examiner's Use

For Examiner's Use

12 Factorise completely,

(a) $1-a^2b^2+a^2-b^2$,

(b) $2p^3-50p$.

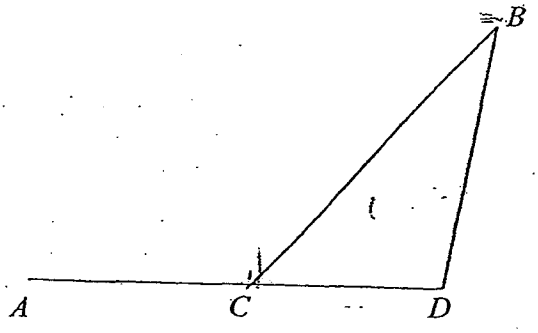
Answer (a)..... [2]

(b)..... [2]

13 In the diagram, ACD is a straight line, $CD = x$ cm, $BC = 2CD$ and the area of ΔBCD is $0.6x^2$ cm^2. Find the exact value of

(a) $\sin \angle ACB$,

(b) $\cos \angle ACB$.



Answer (a) ..... [2]

(b) ..... [2]

For Examiner's Use

14 **(a)** y is directly proportional to the cube of x. If x is increased by 1.5%, find the percentage increase in y.

(b) p varies inversely as $(3q-2)$ and the difference in the values of p when $q=-2$ and $q=4$ is 9. Express p in terms of q.

Answer *(a)*..... % [2]

(b) ..... [2]

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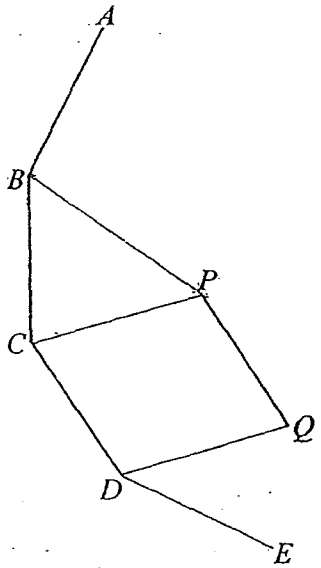
15 $ABCDE$ is part of a regular polygon which has an interior angle of 156°. $CPQD$ is a rhombus such that $\angle PCD = 80°$.

Find

(a) $\angle QDE$,

(b) $\angle BPC$,

(c) the number of sides of the polygon.



Answer *(a)*..... [1]

(b)..... [2]

(c)..... sides [1]

For Examiner's Use

16 X, Y and Z are three vertices of a triangle on the flat ground. Z is located 21 km away from X, at a bearing of 050°. X and Y are shown in the diagram below.

(a) Using a scale of 1 cm to represent 2 km, construct ΔXYZ.

(b) Construct

(i) the perpendicular bisector of the line XY,

(ii) the angle bisector of $\angle XYZ$.

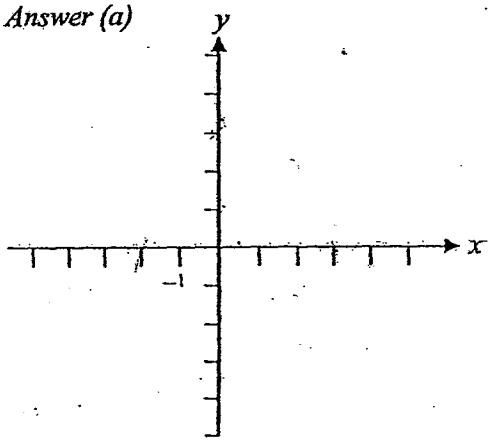
(c) The point M is equidistant from XY and YZ, but nearer to X than to Y. Indicate, in your diagram, a possible position of the point M.

[2], [1], [1], [1]

For Examiner's Use

17 **(a)** Sketch the graph of $y = (3-x)(x+2)$.

Answer (a)



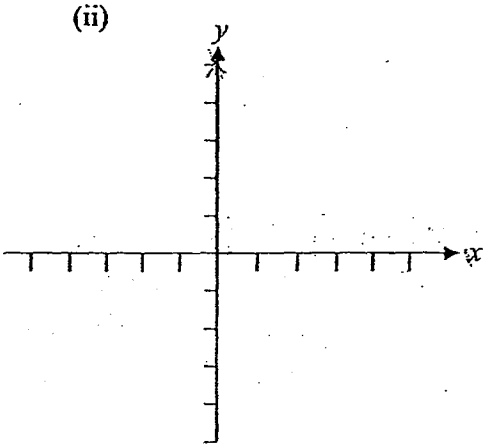
[2]

(b) **(i)** Express $x^2 - 2x + 5$ in the form $(x-a)^2 + b$.

(ii) Sketch the graph of $y = x^2 - 2x + 5$.

Answer (b)(i) $x^2 - 2x + 5 =$ ..... [1]

(ii)



[2]

For Examiner's Use

18 P is the point (1, 1), $\overrightarrow{PQ} = \begin{pmatrix} 8 \\ -4 \end{pmatrix}$ and $\overrightarrow{PR} = \begin{pmatrix} 14 \\ 0 \end{pmatrix}$.

(a) Find $|\overrightarrow{PQ}|$.

(b) Express $\overrightarrow{QR}$ as a column vector,

(c) It is given that $\overrightarrow{RS} = \begin{pmatrix} -11 \\ h \end{pmatrix}$. Find the two possible values of h which will make $PQRS$ a trapezium.

Answer (a) .....units [1]

(b) ..... [1]

(c) h = ... or..... [3]

For Examiner's Use

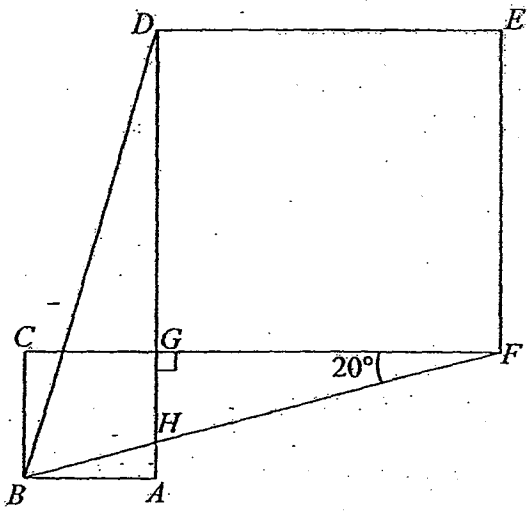
For Examiner's Use

19 In the diagram, $ABCG$ and $DEFG$ are squares and $\angle AGF = 90°$.

(a) **(i)** Prove that ΔBCF is congruent to ΔBAD.

(ii) Hence, prove that ΔFGH is similar to ΔDAB.

(b) If $\angle BFC = 20°$, find $\angle DBF$



Answer (a)(i) .....

.....

.....

.....

.....

..... [3]

(ii) .....

.....

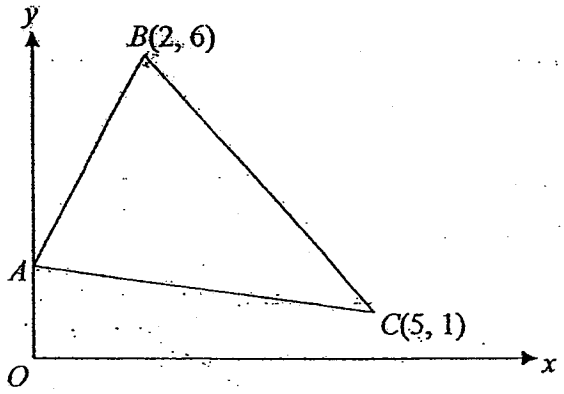
.....

..... [2]

(*b*)..... [1]

For Examiner's Use

20 In the diagram, the coordinates of B and C are (2, 6) and (5, 1) respectively. The line BA cuts the y-axis at A.



(a) Given that the gradient of AB is 2, find the coordinates of A.

(b) Find the equation of BC.

(c) Calculate the length of the line segment BC.

(d) $ABCD$ is a trapezium where BC is parallel to AD. The area of trapezium $ABCD$ is 5 times the area of triangle ABC. Find AD.

Answer *(a)* (....., ...) [1]

(b)..... [2]

(c)..... .....units [1]

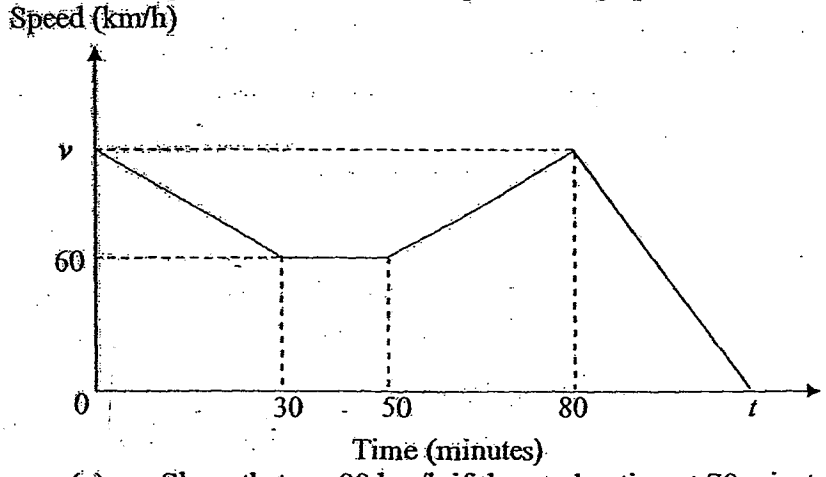
(d).....units [2]

For Examiner's Use

For Examiner's Use

For Examiner's Use

21 The diagram below shows the speed–time graph of a car.



(a) Show that $v = 90$ km/h if the acceleration at 70 minutes is 60 km/h^2

(b) Calculate the average speed for the first 50 minutes of the journey.

(c) Find the value of t, if the car decelerates at 270 km/h^2 after 80 minutes.

(d) Draw, on the answer space below, the distance-time graph of the car for the first 80 minutes of the journey.

Answer (a) .....

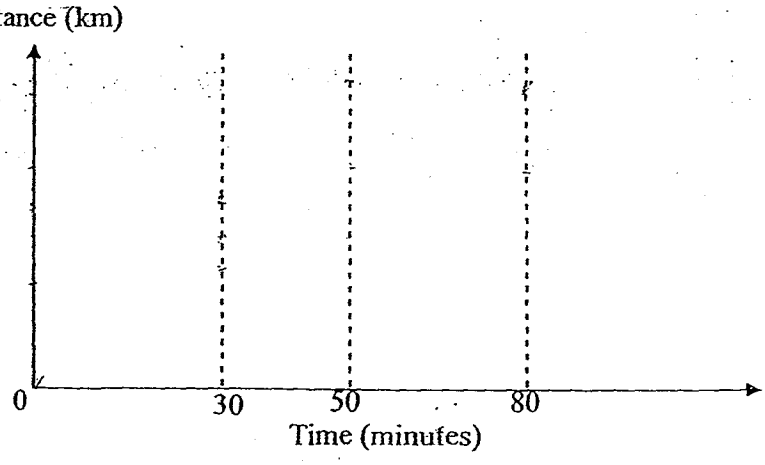
.....

..... [1]

(b).....km/h [2]

(c).....minutes [1]

(d)



[2]

Sec 4E/5N 4016/01 and 4016/02 SASS Math Preliminary Exam 2014 [Answers]

Paper 1

1. Given $E = mc^2$

When $c = 3 \times 10^8$ m/s and

$m = 0.08$ nanogram $= 0.08 \times 10^{-9}$ g $= 8 \times 10^{-11}$ g

$E = 8 \times 10^{-11} \times 3^2 \times 10^{16}$

$= 72 \times 10^5$ J

$= 7.2 \times 10^6$ J

2.(a) $\dfrac{2^x \times 2^{x-2}}{\sqrt{4^x}} = 2^{x+x-2-x} = 2^{x-2}$

(b)

$$\left(\frac{\sqrt[3]{a}}{-2a^2}\right)^{-2} = \left(-\frac{1}{2}a^{\frac{1}{3}-2}\right)^{-2}$$

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

$$= 4a^{\frac{10}{3}}$$

3. Amount Mr Wong will get after 3 years from Bank A

$$= \$10000\left[1 + \frac{3.8}{100} \times 3\right]$$

$= \$111\ 40$

Amount Mr Wong will get after 3 years from Bank B

$$= \$10000\left[1 + \frac{3.6}{1200}\right]^{36}$$

$\approx \$111\ 38.676$

$= \$111\ 38.68$ [to the nearest cent]

Bank A will offer better interest for the period of 3 years.

4. Given $\dfrac{x}{2} - 3 < \dfrac{2x-5}{3} \le 10 - x$

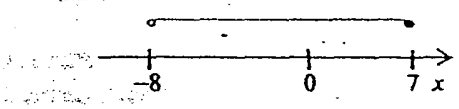
$3x - 18 < 4x - 10 \le 60 - 6x$

$3x - 18 < 4x - 10$ and $4x - 10 \le 60 - 6x$

$x > -8$ and $10x \le 70$

$x \le 7$

Thus, $-8 < x \le 7$



5.(a) $1050 = 2 \times 3 \times 5^2 \times 7$

$3150 = 2 \times 3^2 \times 5^2 \times 7$

LCM of 1050 and $N = 3150 = 2 \times 3^2 \times 5^2 \times 7$

HCF of 1050 and N $= 42 = 2 \times 3 \times 7$

$N = 2 \times 3^2 \times 7 = 126$

(b) $8 = 2^3$

$100 = 2^2 \times 5^2$

$150 = 2 \times 3 \times 5^2$

LCM of 8, 100, 150 $= 2^3 \times 3 \times 5^2$

Hence, the minimum number of cylinder B needed

$= 2 \times 3 = 6$

6. x-intercepts are -1 and 2.

So, the curve $y = a(x+1)(x-2)$

As $-2a = 6 \ \therefore a = -3$

$-3(-1) = b \ \therefore b = 3$

7.(a) The difference between the two temperatures

$= x\,°C - (-y\,°C)$

$= (x + y)\,°C$

(b) Rate of change of temperature $= -\dfrac{x+y}{7000}$ °C per metre

Temperature at 2000 m

$$= x - \frac{x+y}{7000} \times 2000$$

$$= \frac{1}{7}(5x - 2y)\,°C$$

8.

$$\frac{1}{3x^2 - 10x + 8} + \frac{2}{4 - 3x}$$

$$= \frac{1}{(3x-4)(x-2)} - \frac{2}{3x-4}$$

$$= \frac{1 - 2(x-2)}{(3x-4)(x-2)}$$

$$= \frac{5 - 2x}{(3x-4)(x-2)}$$

9.(a) Area scale $25\ cm^2 : 289\ km^2$

So, linear scale 5 cm : 17 km

$= 5$cm : $1\ 700\ 000$ cm

$= 1 : 340\ 000$

(b) The length of a road on the map

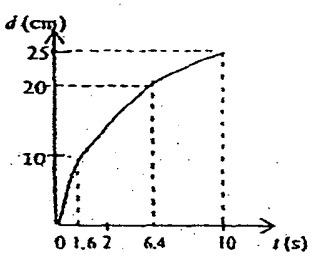
$$= \frac{84\ km}{17\ km} \times 5\ cm$$

≈ 24.7 cm

$= 25$ cm [to the nearest centimetres]

10.(a) $\dfrac{t}{10} = \left(\dfrac{10}{25}\right)^2$

$t = 1.6$ s



11.(a)

$$p-\left(\frac{2}{3}p-1\right)^2 = p-\frac{4}{9}p^2+\frac{4}{3}p-1$$

$$=\frac{7}{3}p-\frac{4}{9}p^2-1$$

(b) $27^x = 3^{2x+1}\times 9^x$

$3^{3x} = 3^{2x+1+2x}$

$3x = 4x+1$

$x=-1$

12.(a) $1-a^2b^2+a^2-b^2$

$=1-b^2+a^2-a^2b^2$

$=(1-b^2)+a^2(1-b^2)$

$=(1+a^2)(1-b)(1+b)$

(b) $2p^3-50p$

$=2p(p^2-25)$

$=2p(p+5)(p-5)$

13. (a) Area of $\Delta BCD = \frac{1}{2}\times x\times 2x\times \sin\angle BCD = 0.6x^2$

$$\sin\angle BCD = \frac{3}{5}$$

$$\sin\angle ACB = \sin\angle BCD = \frac{3}{5}$$

(b) $\cos\angle ACB = -\cos\angle BCD = -\frac{4}{5}$

14.(a) Given $y = kx^3$

Let $x_0 = a$, so $y_0 = ka^3$

When $x = 1.015a$, $y = k(1.015a)^3$

Percentage change in y

$$=\frac{k(1.015a)^3-ka^3}{ka^3}\times 100\%$$

$\approx 4.567\%$

$= 4.57\%$ [to 3 s. f.]

(b) Given $p=\frac{k}{3q-2}$

And

$$\frac{k}{12-2}-\frac{k}{-6-2}=9$$

$$\frac{k}{10}+\frac{k}{8}=9$$

$4k+5k=360$

$k=40$

$$\therefore p=\frac{40}{3q-2}$$

15.(a) Given interior angle = 156°

Given $CPQD$ is a rhombus and $\angle PCD = 80°$

$\angle QDC = 180°-80° = 100°$

Thus, $\angle QDE = 156°-100° = 56°$

15. (b) $\angle BCP = 156°-80° = 76°$

As $BC = CP$, so $\angle BPC = [180°-76°]\div 2$

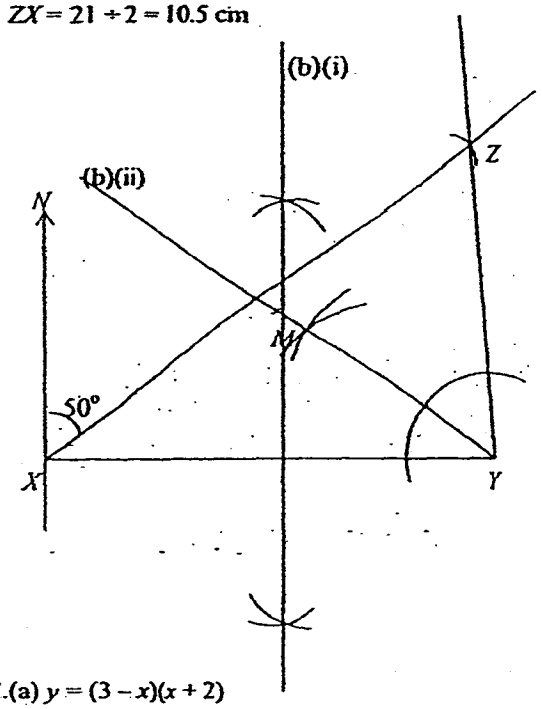
$= 52°$

(c) Exterior angle of the polygon $= 180°-156° = 24°$

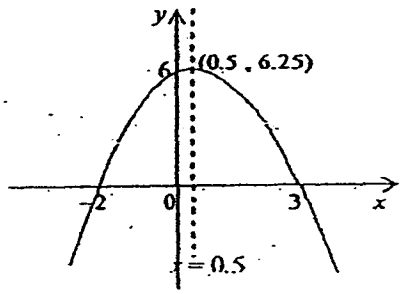
So, the number of sides $= 360°\div 24° = 15$

16. Scale 1 cm : 2 km

$ZX = 21\div 2 = 10.5$ cm



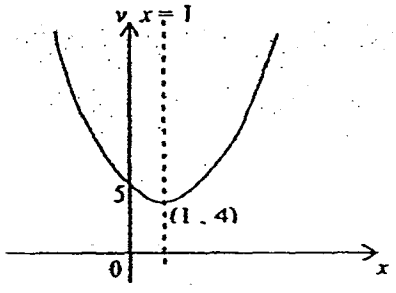
17.(a) $y = (3-x)(x+2)$



(b)(i) $x^2-2x+5 = (x-1)^2-1+5$

$= (x-1)+4$

(ii)



18. Given P is (1 , 1), so $\overrightarrow{OP} = \begin{pmatrix}1\\1\end{pmatrix}$

(a) $\left|\overrightarrow{PQ}\right| = \sqrt{8^2 + (-4)^2}$ units

≈ 8.944 units

$= 8.94$ units [to 3 s. f.]

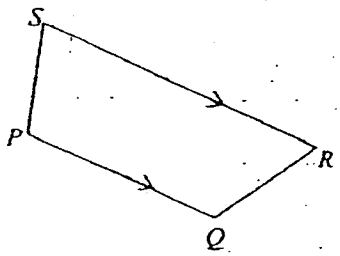
(b)

$\overrightarrow{QR} = \overrightarrow{QP} + \overrightarrow{PR}$

$= \begin{pmatrix}-8\\4\end{pmatrix} + \begin{pmatrix}14\\0\end{pmatrix}$

$= \begin{pmatrix}6\\4\end{pmatrix}$

(c)

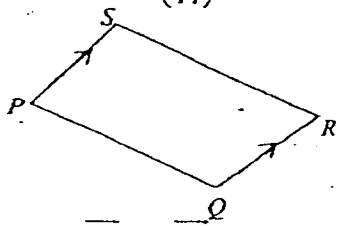


If $PQ \parallel SR$, $\overrightarrow{PQ} = k\overrightarrow{SR}$ where k is a scalar.

$\begin{pmatrix}8\\-4\end{pmatrix} = k\begin{pmatrix}11\\-h\end{pmatrix}$

$11k = 8 \quad \therefore k = \frac{8}{11}$

$kh = 4 \quad \therefore h = \frac{4}{\left(\frac{8}{11}\right)} = 5\frac{1}{2}$



If $PS \parallel QR$, $\overrightarrow{PS} = m\overrightarrow{QR}$

$\overrightarrow{PR} + \overrightarrow{RS} = m\begin{pmatrix}6\\4\end{pmatrix}$

$\begin{pmatrix}14\\0\end{pmatrix} + \begin{pmatrix}-11\\h\end{pmatrix} = m\begin{pmatrix}6\\4\end{pmatrix}$

$\begin{pmatrix}3\\h\end{pmatrix} = m\begin{pmatrix}6\\4\end{pmatrix}$

$6m = 3 \quad \therefore m = \frac{1}{2}$

$h = 2$

19.(a) **To Prove** $\Delta BCF \equiv \Delta BAD$

Proof

From the ΔBCF and ΔBAD,

$BC = BA$ [$ABCG$ is a square so equal sides]

$\angle BCF = \angle BAD = 90°$

[$ABCG$ is a square so int. $\angle$s = 90°]

$CF = CG + GF$

$= AG + GD$ [$ABCG$ and $DEFG$ are squares]

$= AD$

By SAS property, ΔBCF is congruent to ΔBAD.

(ii) To Prove ΔFGH and ΔDAB are similar

Proof

From ΔFGH and ΔDAB.

$\angle FGH = \angle DAB = 90°$ [given]

$\angle GFH = \angle BFC$ [same $\angle$]

$= \angle BDA$ [$\Delta BCF \equiv \Delta BAD$]

By AA property, ΔFGH and ΔDAB are similar.

(b) Given $\angle BFC = 20°$

So, $\angle GHB = 90° + 20° = 110°$

Thus, $\angle DBF = \angle DBH$

$= 180° - 110° - 20°$

$= 50°$

20.(a) Let A be $(0 , a)$

$m_{AB} = 2$

$\frac{6-a}{2-0} = 2$

$a = 2$

A is (0 , 2)

(b) $m_{BC} = \frac{5}{-3}$

Equation of BC:

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

$\therefore y = -\frac{5}{3}x + \frac{28}{3}$

(c) $BC = \sqrt{(-3)^2 + 5^2}$ units

≈ 5.830 units

$= 5.83$ units [to 3 s.f.]

(d) Area of trapezium $ABCD = 5 \times$ Area of ΔABC

$\frac{1}{2}(BC + AD) \times h = 5\left[\frac{1}{2} \times h \times BC\right]$

$\therefore AD = 4BC$

$= 4 \times 5.830$ units

$= 23.3$ units [to 3 s.f.]

21.(a) Given the acceleration at 70 minutes = 60 km/h^2

$\frac{v - 60}{\left(\frac{30}{60}\right)} = 60 \quad \therefore v = 30 + 60 = 90$ km/h

21.(b) Average speed for the first 50 minutes

$$= \frac{\frac{1}{2}[90+60]\times\frac{1}{2}+60\times\frac{1}{3}}{\left(\frac{5}{6}\right)} \text{ km/h}$$

= 69 km/h

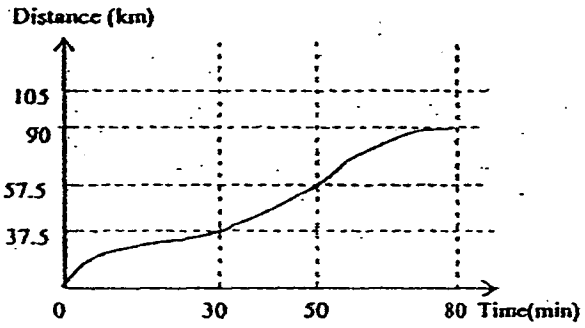
(c)

$$\frac{\frac{90}{t-80}}{60} = 270$$

$$\frac{1}{3} = \frac{t-80}{60}$$

$t = 80 + 20 = 100$

(d)



Paper 2

1.(a) $\xi = \{1, 2, 3, \ldots, 14\}$

$A = \{2, 4, 6, 8, 10, 12, 14\}$

$B = \{3, 6, 9, 12\}$

(i) $n(A') = 7$

(ii) $(A \cup B)' = \{1, 5, 7, 11, 13\}$

(iii) $A \cap B$: The elements that are multiples of 6.

(b)(i)(a) 2, 3, ..., 9, ..., 3, 2

The sum of the numbers

$= 9^2 - 2$

$= 79$

(b) $S = 2 + 3 + 4 + \ldots + (k-1) + k + (k-1) + \ldots + 3 + 2$

$= 98$

$k^2 = 98 + 2$

$\therefore k = 10$

(ii) When $S = 398$ then $S + 2 = 400 = 20^2$, a perfect square, so, it is possible for $S = 398$.

(iii) $S = n^2 - 2$

2.(a)(i) For English,

(a) the mean mark

$= [6 \times 5 + 8 \times 15 + 12 \times 25 + 8 \times 35 + 6 \times 45] \div 40$

= 25 marks

(b) The standard deviation

$$= \sqrt{\frac{6\times5^2+8\times15^2+12\times25^2+8\times35^2+6\times45^2}{40} - 25^2}$$

≈ 12.64 marks

= 12.6 mars [to 3 s. f.]

(ii) The mean mark for Mathematics

$= [13 \times 5 + 6 \times 15 + 2 \times 25 + 6 \times 35 + 13 \times 45] \div 40$

= 25 marks

The standard deviation mark for Mathematics

= 17.0 mark

As the mean mark for both English & Mathematics are the same, so we cannot conclude the measure of the central tendency, in fact, with the smaller deviation mark for English as compare to Mathematics, it shows that the spread of English marks for the students is smaller in Class A.

(iii) It is not an absolute or fair conclusion because there are many external factors affecting the performance of the students on the subjects. By comparing the performance on different subjects, it does not show how good will be the performance as the testing of the nature subjects are not the same and the abilities of students are different with respect to the different subjects.

(b) Class A Science Test

(i)(a) The estimated median mark = 20 mark

(b) The interquartile range = 24 – 16 = 8 marks

(c) Number of students who scored > 30 marks

= 38 – 35 = 3

Candidate's Name ______________________ | Class | Index Number |

ST ANDREW'S SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2014
SECONDARY 4 EXPRESS/ 5 NORMAL ACADEMIC

MATHEMATICS 4016/2
Paper 2

THURSDAY 21 AUGUST 2014 2 hours 30 minutes

Additional materials: Answer Paper
Electronic Calculator
Graph Paper (1 sheet)

READ THESE INSTRUCTIONS FIRST

Write your answers and working on the separate Answer Paper provided
Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a pencil for any diagrams or graphs
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
If working is needed for any question it must be shown with the answer
Omission of essential working will result in loss of marks.
Calculators should be used where appropriate.
If the degree of accuracy is not specified in the question, and if the answer is not exact, give the answer to three significant figures. Give answers in degrees to one decimal place.
For π, use either your calculator value or 3.142, unless the question requires the answer in terms of π.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total of the marks for this paper is 100.

This question paper consists of 10 printed pages, including this cover page

Mathematical Formulae

Compound interest

$$\text{Total amount} = P\left(1+\frac{r}{100}\right)^n$$

Mensuration

Curved surface area of a cone $= \pi rl$

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

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

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

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

Arc length $= r\theta$, where θ is in radians

$$\text{Sector area} = \frac{1}{2}r^2\theta, \text{ where } \theta \text{ is in radians}$$

Trigonometry

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

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

Statistics

$$\text{Mean} = \frac{\Sigma fx}{\Sigma f}$$

$$\text{Standard deviation} = \sqrt{\frac{\Sigma fx^2}{\Sigma f} - \left(\frac{\Sigma fx}{\Sigma f}\right)^2}$$

1 (a) $\xi = \{x : 1 \le x < 15$ and x is an integer$\}$, $A = \{x: x$ is divisible by $2\}$, $B = \{x: x$ is a multiple of $3\}$.

Find

(i) $n(A')$. [1]

(ii) $(A \cup B)'$. [1]

(iii) Describe, as simply as possible, in words, the elements contained in the set $A \cap B$. [1]

(b) Study the number pattern shown in the table below.

Number Pattern	Sum of Number Pattern, S	$S+2$
2	2	4
2, 3, 2	7	9
2, 3, 4, 3, 2	14	16
2, 3, 4, 5, 4, 3, 2	23	25

(i) Find

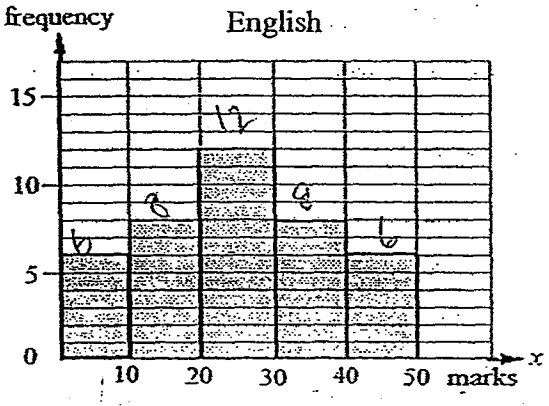
(a) the sum of the number pattern for which the middle term is 9. (i.e. 2, 3, …,9,…3, 2) [1]

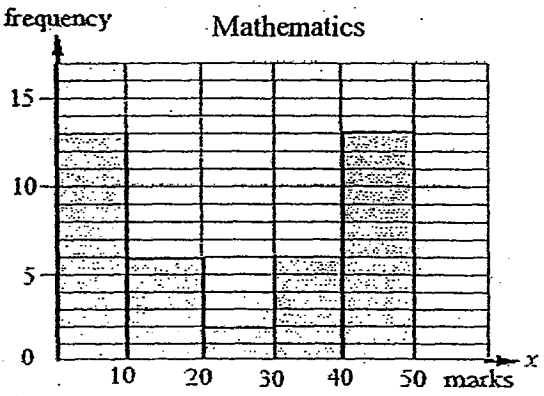
(b) the value of k, if
$S = 2+3+4+5+\ldots+(k-1)+k+(k-1)+\ldots+5+4+3+2 = 98$

(ii) Is it possible for $S = 398$? Explain your answer. [1]

(iii) Write a formula connecting S and n, for which the middle term is n. [1]

2 (a) The histograms show the test marks of English and Mathematics obtained by pupils in Class *A*.





(i) For English, calculate

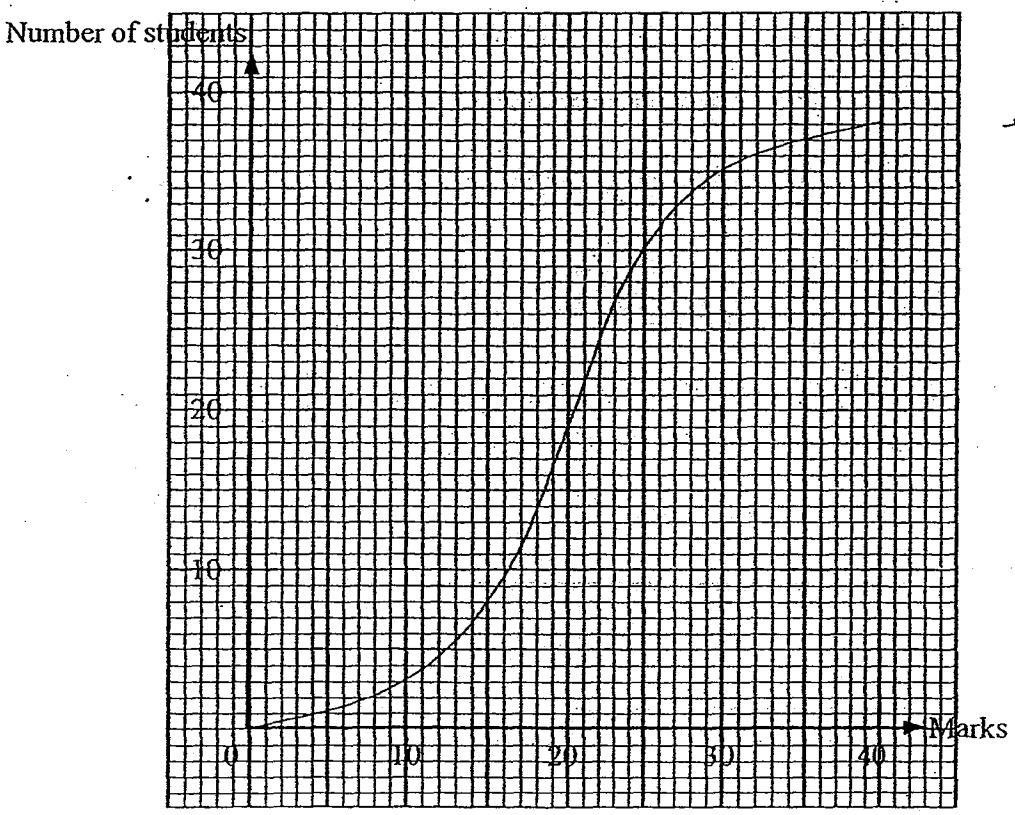
(a) the mean marks, [2]

(b) the standard deviation. [2]

(ii) Explain why by just calculating the two means of the two sets of marks is not a good measure of the central tendency. Justify your answer. [2]

(iii) Explain why, even if we use all kinds of statistical methods together, we still cannot get an absolute or fair conclusion on which subject was performing better. [1]

(b) The cumulative frequency curve below shows the test marks obtained by pupils in Class *A* in the Science test.



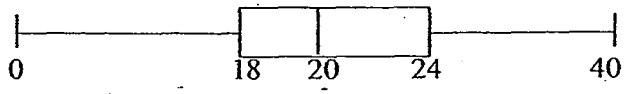
(i) Use your graph to find

(a) the median marks, [1]

(b) the interquartile range, [2]

(c) the number of students who scored more than 30 marks. [1]

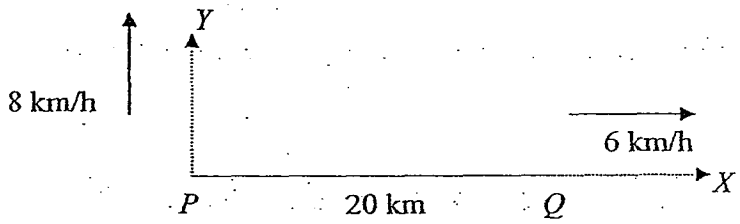
(ii) The box-and-whisker box below shows the test marks obtained by pupils in Class B in the same test.



Compare, in two different ways, the performance of the students of Class A and Class B in the test. [2]

---

3 Q is 20 km due east of P. Starting from P, a man Y walks at a constant speed of 8 km/h due north. Starting from Q, at the same time, a man X walks at a constant speed of 6 km/h due east.



(a) Write down, in terms of t,

(i) the distance of Y from P after t hours, [1]

(ii) the distance of X from P after t hours. [1]

(b) Show that after t hours, if the men are 30 km apart, $5t^2 + 12t - 25 = 0$. [3]

(c) Solve $5t^2 + 12t - 25 = 0$ correct to two decimal places. [3]

(d) Hence, find the value of t when the men are 30 km apart. Express your answer in hour and minutes, correct to the nearest minutes. [1]

---

4 The table below shows the number of tubs of ice cream of two brands: A and B, sold at 3 shops on Sunday and Monday to a customer.

	Sunday		Monday	
	Brand A	Brand B	Brand A	Brand B
Shop 1	5	3	1	1
Shop 2	11	6	8	5
Shop 3	8	5	4	3

(a) Given that $S = \begin{pmatrix} 5 & 3 \\ 11 & 6 \\ 8 & 5 \end{pmatrix} + \begin{pmatrix} 1 & 1 \\ 8 & 5 \\ 4 & 3 \end{pmatrix}$, evaluate S. [1]

(b) Explain what the elements in $\frac{1}{2}S$ represent. [1]

(c) A tub of ice cream was sold for \$15 for Brand A and \$10 for Brand B.

Evaluate $T = \begin{pmatrix} 5 & 3 \\ 11 & 6 \\ 8 & 5 \end{pmatrix} \begin{pmatrix} 15 \\ 10 \end{pmatrix}$. [1]

(d) Given that $U = \begin{pmatrix} 1 & 1 & 1 \end{pmatrix}$, evaluate UT. [1]

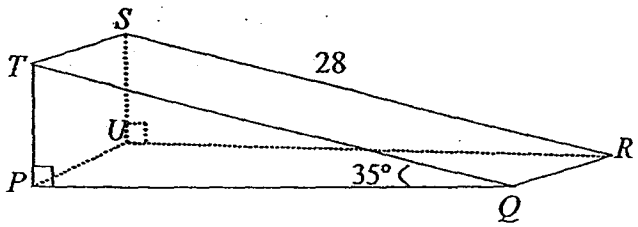
(e) Explain what the elements in **(d)** represent. [1]

(f) If one brand of ice cream is selected at random from the customer's purchase from Shop 1 and Shop 2 on Monday, find the probability that a Brand A and a Brand B ice cream are selected. [2]

(g) If one brand of ice cream is selected at random from the customer's purchase from the three shops on Monday, and it is given that a Brand B ice cream is selected, find the probability that it is from Shop 1 or Shop 2. [1]

(h) If two brands of ice cream are selected at random from the customer's purchase from the three shops on Monday, and it is given that two Brand A of ice cream are selected, find the probability that one is from Shop 1 and the other is from Shop 2. [2]

5 The diagram below shows a wedge $TPQRSU$ which consists of two rectangular planes $PQRU$ and $QRST$, a square plane $PUST$ as well as two triangular planes PQT and URS. It is given that $TQ = SR = 28$ cm, $\angle TQP = 35°$ and $\angle TPQ = \angle SUR = 90°$.



(a) Find

(i) PT, [2]

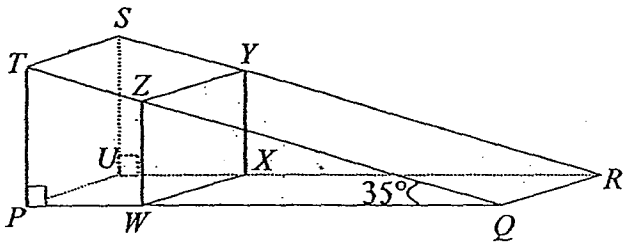
(ii) $\angle TQS$, [2]

(iii) the volume of the wedge. [3]

(b) The wedge is sliced vertically at ZY into 2 equal masses as shown. Find

(i) the ratio of the volumes of $ZWQRYX$ and $TPWZYXUS$. [1]

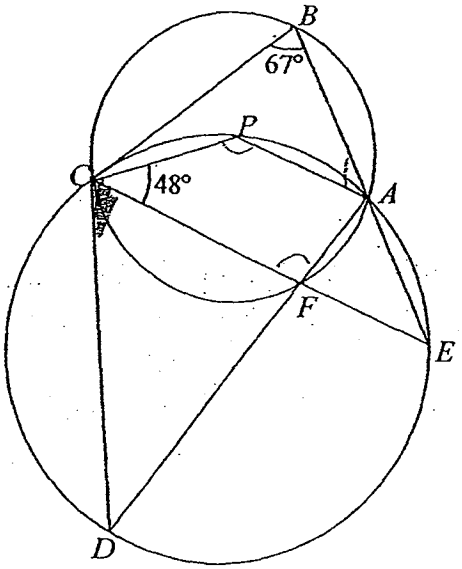
(ii) ZW. [2]



(c) $ZWQRYX$ is melted to form a solid cylinder. Given that the height, h cm, and the radius, r cm, of the cylinder is such that $2h = 3r$, find the value of r. [3]

---

6 In the diagram, P is the centre of the small circle $ABCF$, where $\angle ABC = 67°$ and $\angle PCE = 48°$. BAE, CFE and AFD are straight lines. A, C, D and E lie on the circumference of the large circle.



(a) Find, stating all your reasons clearly,

(i) $\angle CPA$, [1]

(ii) $\angle CDA$, [1]

(iii) $\angle PAB$, [2]

(iv) $\angle DCF$. [2]

(b) Prove that $CE = BE$. [2]

---

7 **Diagram 1** shows the cross-section of a roll of material that is wound onto a cylinder with diameter 20 cm. When the material is completely wounded, the diameter of the cross-section is 60 cm.
The rolls are packed in threes, touching one another as shown in **Diagram 2**. They are secured in position with a plastic sheet around the three rolls. The plastic sheet exactly covers the height of the rolls. Points A, B and C are the centres of the circular cross-section of each roll.

Diagram 1

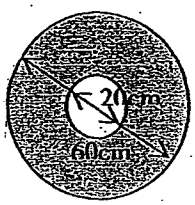
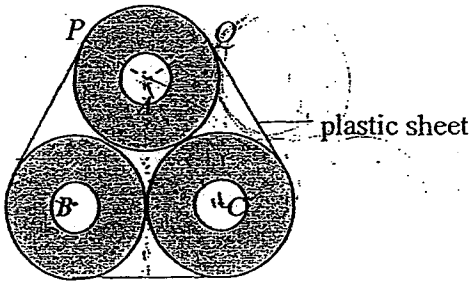


Diagram 2



(a) Show that $\angle PAQ$ is $\frac{2\pi}{3}$ radians. [1]

(b) Calculate the length of the plastic sheet used to wrap the pack once. [2]

(c) Once the rolls are being wrapped, a sticker $ABCDEF$, as shown in **Diagram 3**, is pasted to the plastic sheet. The sticker is formed by major arcs of two identical circles centered at P and Q, and the lines AB and AF which are tangents to the two circles at B and F respectively. AD is a common tangent to the circles at D. It is given that $AB = AF = 8$ mm and $\angle BAF = \frac{13\pi}{36}$ radians.

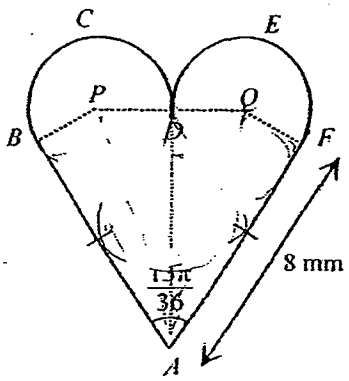
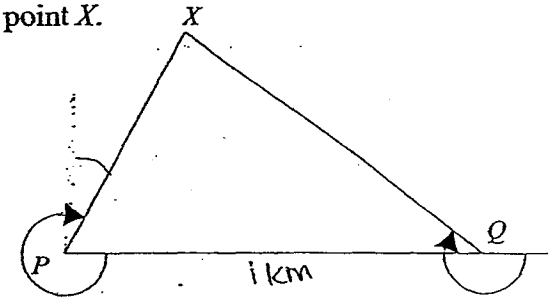


Diagram 3

(i) Find the radius of the circle. [2]

(ii) Find the area of the sticker. [3]

8 Two lighthouses, P and Q are 1 km apart with Q due east of P. Each lighthouse emits a narrow beam of light. Initially both beams are pointing due east and then at same instant they started to rotate in a clockwise direction. The beam, from P takes 6 seconds to make a complete revolution, while the beam from Q takes 8 seconds. 5 seconds after the beams start to rotate, they cross at a point X.



(a) Calculate the bearing of X from P. [1]

(b) Show that angle $PXQ = 75°$. [2]

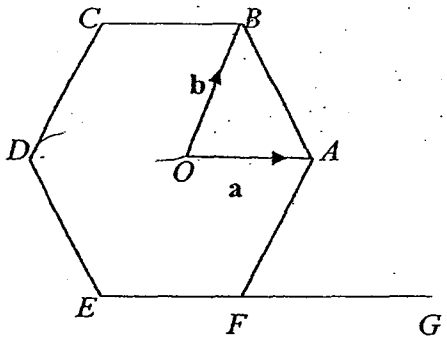
(c) Calculate the distance QX in m. [2]

(d) A ship sails from Q to a point R which is 900 m due east of Q. Calculate the distance XR in m. [2]

(e) Another ship sails from Q to X. The greatest angle of elevation of the top of lighthouse P when viewed from a point on the path QX is 10°. Calculate the height of the lighthouse in m. [3]

---

9 In the diagram, $ABCDEF$ is a regular hexagon. O is the centre of the regular hexagon. $\overrightarrow{OA} = \mathbf{a}$ and $\overrightarrow{OB} = \mathbf{b}$. EFG is a straight line such that $3EF = EG$.



(a) Express, as simply as possible, in terms of **a** and/ or **b**.

(i) $\overrightarrow{DO}$, [1]

(ii) $\overrightarrow{AB}$, [1]

(iii) $\overrightarrow{DB}$. [1]

(b) Explain why $|\mathbf{a}| = |\mathbf{b}| = |\mathbf{b} - \mathbf{a}|$. [1]

(c) The points X, Y and Z are such that $\overrightarrow{OX} = \mathbf{a} + \mathbf{b}$, $\overrightarrow{OY} = \mathbf{a} - 2\mathbf{b}$ and $\overrightarrow{OZ} = \mathbf{b} - 2\mathbf{a}$.

(i) Show, by a vector method, that AB and EZ are parallel. [2]

(ii) Express, as simply as possible, in terms of **a** and/ or **b**.

(a) $\overrightarrow{AX}$, [1]

(b) $\overrightarrow{YX}$. [1]

(iii) Write down two facts about about X, F and Y. [2]

(d) Find area of ΔOAF : area of ΔAFG. [1]

(e) Given that $\Delta AFC = 6\text{ cm}^2$, find the area of ΔEOF. [1]

---

10 Answer the whole of this question on a sheet of graph paper.

A particle was projected directly up a slope. Its distance, d m from the bottom of the slope, t s after it was projected, is given in the table below.

t	0	0.5	1	2	3	4	5	6	7
d	0	1.58	3.02	5.48	7.38	8.72	9.5	9.72	9.72

(a) Using a horizontal scale of 2 cm to represent 1 s, and a vertical scale of 1 cm to represent 1 m, draw a graph of d against t. [3]

(b) Use your graph to find the distance of the particle from the bottom of the slope when $t = 2.5$. [1]

(c) What happened to the particle after approximately 6 s? [1]

(d) (i) By drawing a tangent, find the gradient of your curve when $t = 4$. [2]

(ii) State briefly what this gradient represents. [1]

(e) Calculate the average speed of the particle during the first 6 s. [1]

(f) At the instant the particle was projected, another particle was projected down the slope from a point 10 m from the bottom. This particle moved directly down the slope at a constant speed of 2 m/s.

(i) On the same axes, draw the graph which shows the position of this particle. [1]

(ii) Use your graph to find when the particles passed each other. [1]

21.(b) Average speed for the first 50 minutes

$$= \frac{\frac{1}{2}[90+60]\times\frac{1}{2}+60\times\frac{1}{3}}{\left(\frac{5}{6}\right)} \text{ km/h}$$

$= 69$ km/h

(c)

$$\frac{\frac{90}{t-80}}{60} = 270$$

$$\frac{1}{3} = \frac{t-80}{60}$$

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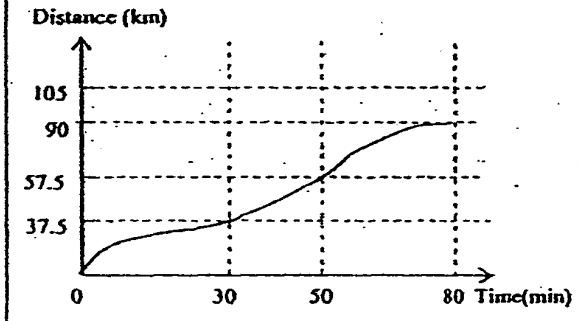

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(a) the mean mark

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≈ 12.64 marks

$= 12.6$ mars [to 3 s. f.]

(ii) The mean mark for Mathematics

$= [13 \times 5 + 6 \times 15 + 2 \times 25 + 6 \times 35 + 13 \times 45] \div 40$

$= 25$ marks

The standard deviation mark for Mathematics

$= 17.0$ mark

As the mean mark for both English & Mathematics are the same, so we cannot conclude the measure of the central tendency, in fact, with the smaller deviation mark for English as compare to Mathematics, it shows that the spread of English marks for the students is smaller in Class A.

(iii) It is not an absolute or fair conclusion because there are many external factors affecting the performance of the students on the subjects. By comparing the performance on different subjects, it does not show how good will be the performance as the testing of the nature subjects are not the same and the abilities of students are different with respect to the different subjects.

(b) Class A Science Test

(i)(a) The estimated median mark = 20 mark

(b) The interquartile range = 24 – 16 = 8 marks

(c) Number of students who scored > 30 marks

= 38 – 35 = 3

2.(b)(ii) Class B Science Test
Both Class A and B have the same median mark, 20. Class B has a smaller interquartile range of mark, 6 as compare to that of class A. So the marks of Class B students are more consistent.

3.(a)(i) Distance of Y from P after t hours
$= 8t$ km
(ii) Distance of X from P after t hours
$= (6t + 20)$ km

(b) Given $(8t)^2 + (6t + 20)^2 = 30^2$
$64t^2 + 36t^2 + 240t + 400 - 900 = 0$
$100t^2 + 240t - 500 = 0$
$\Rightarrow 5t^2 + 12t - 25 = 0.$

(c) $t = \dfrac{-12 \pm \sqrt{12^2 - 4 \times 5 \times (-25)}}{10}$
≈ 1.337 or -3.737
$= 1.34$ of -3.74 [to 2 d. p.]

(d) As $t > 0$, so $t = 1.337$ hr
$= 1$ hour 20 min [to the nearest minute]

4.(a) $S = \begin{pmatrix} 5 & 3 \\ 11 & 6 \\ 8 & 5 \end{pmatrix} + \begin{pmatrix} 1 & 1 \\ 8 & 5 \\ 4 & 3 \end{pmatrix} = \begin{pmatrix} 6 & 4 \\ 19 & 11 \\ 12 & 8 \end{pmatrix}$.

(b) The elements in $\frac{1}{2}S$ represent the average numbers of tubs of ice cream of Brand A and B respectively sold at each of the 3 shops over Sunday and Monday to the customer.

(c)
$$T = \begin{pmatrix} 5 & 3 \\ 11 & 6 \\ 8 & 5 \end{pmatrix} \begin{pmatrix} 15 \\ 10 \end{pmatrix} = \begin{pmatrix} 75 + 30 \\ 165 + 60 \\ 120 + 50 \end{pmatrix}$$
$$= \begin{pmatrix} 105 \\ 225 \\ 170 \end{pmatrix}$$

(d) $UT = \begin{pmatrix} 1 & 1 & 1 \end{pmatrix} \begin{pmatrix} 105 \\ 225 \\ 170 \end{pmatrix} = (500)$

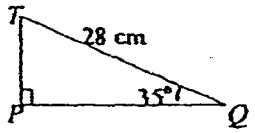
(e) The element represent the total amount of money collected from the sale of ice cream on Sunday from the 3 shops is \$500.

(f) P(a Brand A and a Brand B ice cream are selected on Monday) = P(A_1 & B_2) + P(B_1 & A_2)
$= \frac{1}{2} \times \frac{5}{13} + \frac{1}{2} \times \frac{8}{13} = \frac{1}{2}$

4. (g) P(Brand B is selected and is from Shop 1 or 2)
$= \dfrac{1+5}{1+5+3} = \dfrac{2}{3}$

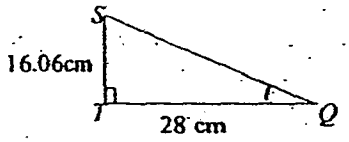
(h) P(Brand A from Shop 1 and Shop 2)
$= \dfrac{1}{13} \times \dfrac{8}{12} + \dfrac{8}{13} \times \dfrac{1}{12} = \dfrac{4}{39}$

5.(a)(i)



From ΔPQT, $\sin 35^\circ = \dfrac{PT}{28}$
$PT = 28 \sin 35^\circ$ cm
≈ 16.06 cm
$= 16.1$ cm [to 3 s. f.]

(ii)



From ΔSTQ, $\tan \angle TQS = \dfrac{16.06}{28}$
$\angle TQS \approx 29.83^\circ$
$= 29.8^\circ$ [to 1 d. p.]

(ii) The volume of the wedge
$= \frac{1}{2} \times 28 \cos 35^\circ \times 16.06 \times 16.06$ cm^3
≈ 2957.9 cm^3
$= 2960$ cm^3 [to 3 s.f.]

(b)(i) $M_1 : (M_1 + M_2) = 1 : 2$
the ratio of the volumes of $ZWQRYX$ and $TPWZYXUS$
$= 1 : 1$
$$\frac{\text{Volume of } ZWQRYX}{\text{Volume of } TPWZYXUS} = \frac{WZ \times WQ \times ZY}{TP \times PQ \times TS}$$
$$\left(\frac{WZ}{TP}\right)^2 = \frac{1}{2}$$
$$\frac{ZW}{TP} = \sqrt{\frac{1}{2}}$$
$$ZW = 16.06 \times \sqrt{\frac{1}{2}}$$
≈ 11.35 cm
$= 11.4$ cm [to 3 s. f.]

$ZY = TS$
ΔWZQ is similar to ΔPTQ

(c)
$$\pi r^2 \times \frac{3r}{2} = \frac{1}{2} \times 2957.9$$
$$\therefore r = \sqrt[3]{\frac{1}{3\pi} \times 2957.9}$$
≈ 6.795 cm
$= 6.80$ cm [to 3 s. f.]

6.(a)(i) $\angle CPA = 2(67^\circ)$ [$\angle$ at centre $= 2 \times \angle$ at $\odot^{ce}$]
$= 134^\circ$

(ii) $\angle CDA = 180^\circ - 134^\circ$ [$\angle$s in opp. segment]
$= 46^\circ$

(iii) $\angle CEA = 46^\circ$ [$\angle$s in the same segment]
$\angle BCE = 180^\circ - 67^\circ - 46^\circ$ [$\angle$s sum of Δ]
$= 67^\circ$
$\therefore \angle BCP = 67^\circ - 48^\circ = 19^\circ$
$\angle PAB = 67^\circ - 19^\circ = 48^\circ$ [base $\angle$s of isos. Δs]

(iv) $\angle AFE = 67^\circ$ [ext. $\angle$ of cyclic quad.]
$\angle CFD = 67^\circ$ [vert. opp. $\angle$s]
$\therefore \angle DCF = 180^\circ - 67^\circ - 46^\circ$ [$\angle$s sum of Δ]
$= 67^\circ$

(b) To Prove $CE = BE$
Proof
As $\angle BCE = 67^\circ$ [from (a)(iii)]
and $\angle EBC = 67^\circ$ [given]
by base $\angle$s of isos. Δ, so, $CE = BE$

7.(a) To show $\angle PAQ = \frac{2\pi}{3}$

Proof As $AB = AC = BC$, so ΔABC is an equilateral Δ.

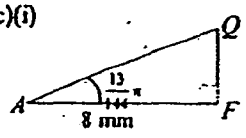
$$\angle BAC = \frac{\pi}{3}$$

$$\angle PAQ = 2\pi - \frac{\pi}{2} - \frac{\pi}{2} - \frac{\pi}{3} = \frac{2\pi}{3}$$

(b)The length of the plastic sheet

$$= 60 \times 3 + \frac{2\pi}{3} \times 30 \times 3 \text{ cm}$$
$$\approx 368.4 \text{ cm}$$
$$= 368 \text{ cm [to 3 s. f.]}$$

(c)(i)



From ΔAFQ,

$$\angle QAF = \frac{13\pi}{36} \times \frac{1}{4} = \frac{13\pi}{144}$$

$$\tan\frac{13\pi}{144} = \frac{QF}{8}$$

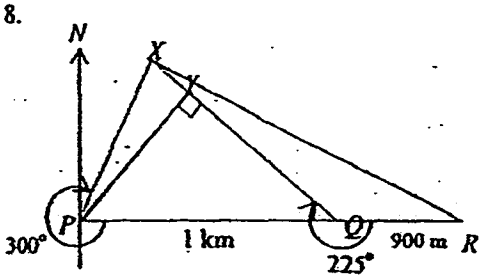
Radius, $QF \approx 2.331$ mm
$= 2.33$ mm [to 3 s. f.]

(ii) $\angle DQF = \pi - \frac{13\pi}{72} = \frac{59\pi}{72}$

Area of the sticker

$$= 2 \times \left[\frac{1}{2} \times \left(2\pi - \frac{59\pi}{72} \right) \times 2.331^2 + 2 \times \frac{1}{2} \times 2.331 \times 8 \right] \text{mm}^2$$
$$\approx 57.44 \text{ mm}^2$$
$= 57.4 \text{ mm}^2$ [to 3 s. f.] [if use 2.3317 then 57.5 mm^2]

8.



(a)Beam at P takes 6 seconds to make one revolution, so after 5s, angle turns thro' $= \frac{5}{6} \times 360^\circ = 300^\circ$

Bearing of X from $P = 030^\circ$

(b) To Show $\angle PXQ = 75^\circ$
After 5s, angle the beam from Q turns thro'

$$= \frac{5}{8} \times 360^\circ = 225^\circ$$

$\angle XPQ = 60^\circ$ and $\angle XQP = 45^\circ$
$\therefore \angle PXQ = 180^\circ - 60^\circ - 45^\circ$
$= 75^\circ$ [shown]

(c) By Sine Rule

$$\frac{QX}{\sin 60^\circ} = \frac{1000}{\sin 75^\circ}$$

$$QX = \frac{1000 \sin 60^\circ}{\sin 75^\circ}$$
$$\approx 896.5 \text{ m}$$
$$= 897 \text{ m [to 3 s. f.]}$$

(d) From ΔQRX, by Cosine Rule,

$$XR = \sqrt{896.5^2 + 900^2 - 2 \times 896.5 \times 900 \cos 135^\circ} \text{ m}$$
$$\approx 1659.75 \text{ m}$$
$$= 1660 \text{ m [to 3 s. f.]}$$

(e) From ΔPQY, $\sin 45^\circ = \frac{PY}{1000}$

$$PY = 1000 \sin 45^\circ \text{ m}$$

$$\tan 10^\circ = \frac{\text{ht. of lighthouse}}{1000 \sin 45^\circ}$$

Ht. of lighthouse $= 1000 \sin 45^\circ \tan 10^\circ$ m
≈ 124.6 m
$= 125$ m [to 3 s. f]

9.(a)(i) $\overrightarrow{DO} = \underline{a}$

(ii) $\overrightarrow{AB} = \overrightarrow{AO} + \overrightarrow{OB} = -\underline{a} + \underline{b}$

(iii) $\overrightarrow{DB} = \overrightarrow{DO} + \overrightarrow{OB} = \underline{a} + \underline{b}$

(b) As $ABCDEF$ is a regular hexagon, so $OA = OB = AB$.
Thus, $|\underline{a}| = |\underline{b}| = |\underline{b} - \underline{a}|$

(c) (i)

$$\overrightarrow{EZ} = \overrightarrow{EO} + \overrightarrow{OZ}$$
$$= \underline{b} + \underline{b} - 2\underline{a}$$
$$= 2(\underline{b} - \underline{a})$$
$$\therefore \overrightarrow{EZ} = 2\overrightarrow{AB}$$

Thus, AB and EZ are parallel.

(ii)(a)

$$\overrightarrow{AX} = \overrightarrow{AO} + \overrightarrow{OX}$$
$$= -\underline{a} + \underline{a} + \underline{b}$$
$$= \underline{b}$$

(b)

$$\overrightarrow{YX} = \overrightarrow{YO} + \overrightarrow{OX}$$
$$= 2\underline{b} - \underline{a} + \underline{a} + \underline{b}$$
$$= 3\underline{b}$$

(iii)

$$\overrightarrow{XF} = \overrightarrow{XO} + \overrightarrow{OF}$$
$$= -\underline{a} - \underline{b} + \underline{a} - \underline{b}$$
$$= -2\underline{b}$$

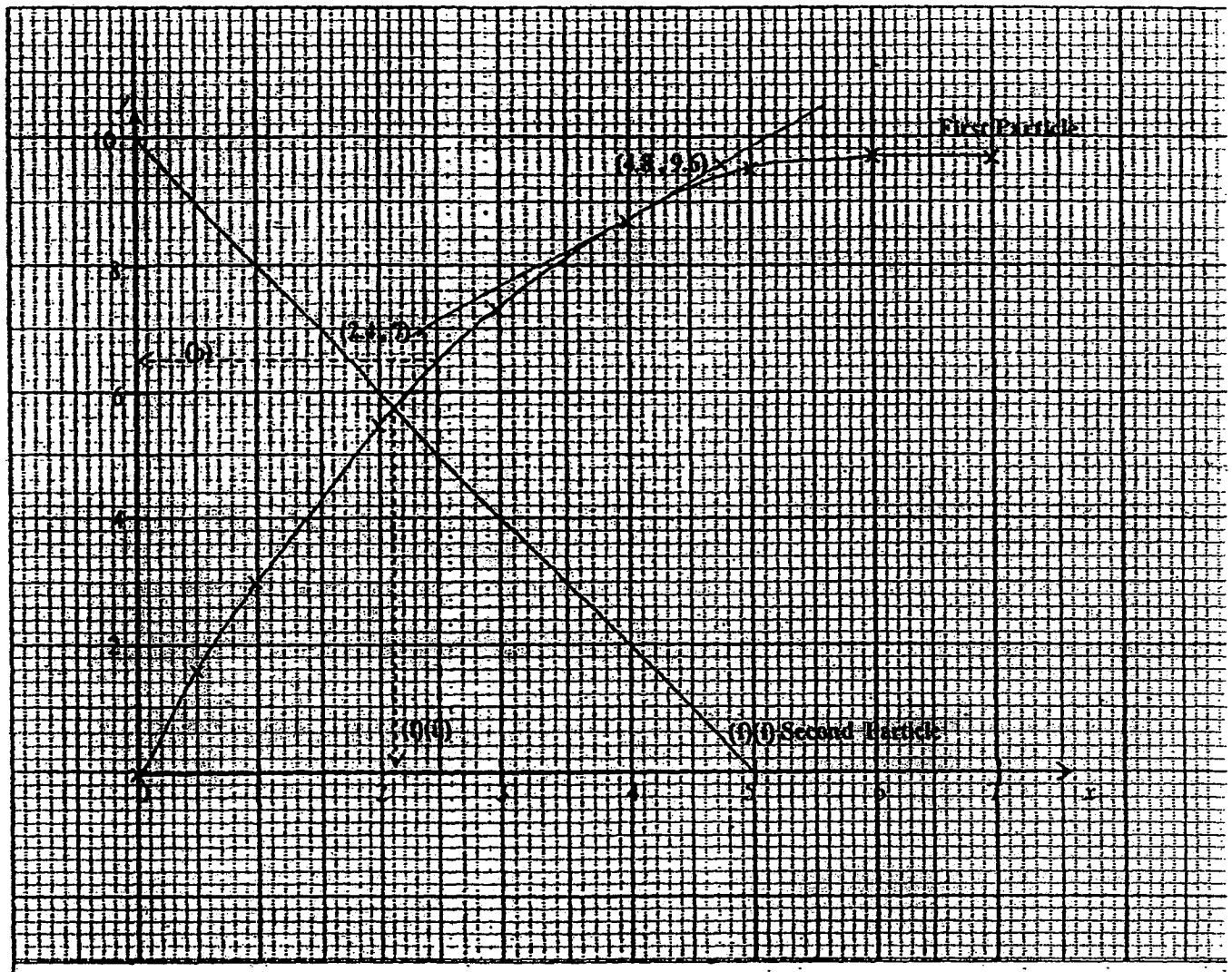
As $\overrightarrow{XF} = \frac{3}{2}\overrightarrow{XY}$, so

X, F and Y are collinear points and

$$XF = \frac{2}{3}XY$$

(d) Area of ΔOAF : Area of ΔAFG
$= EF : FG$
$= 1 : 2$

(e) Give area of $\Delta AFC = 6\ cm^2$
Area of $\Delta EOF = 3\ cm^2$



(b) When $t = 2.5$s, $d = 6.5$ m.

(c) Approximately after 6s, the particle reached the height of the slope at 9.72 m and stopped there.

(d)(i) Gradient of curve when $t = 4$s $= \dfrac{9.6-7}{4.8-2.4} = 1.08$ m/s [to 3 s. f.]

(ii) The gradient represents the speed of the stoned at 4 s which is 1.08 m/s.

(e) The average speed of the particle during the first 6 s = 9.72 ÷ 6 m/s = 1.62 m/s

(f) (ii) The particles passed each other approximately at 2.1 s.