Level 5 Paper 1
exemplar with comments

2015-DSE
MATH CP

PAPER 1

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2015

Please stick the barcode label here.

Candidate Number									

MATHEMATICS Compulsory Part

PAPER 1

Question-Answer Book

8.30 am – 10.45 am (2¼ hours)
This paper must be answered in English

INSTRUCTIONS

1. After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7, 9 and 11.

2. This paper consists of THREE sections, A(1), A(2) and B.

3. Attempt ALL questions in this paper. Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.

4. Graph paper and supplementary answer sheets will be supplied on request. Write your Candidate Number, mark the question number box and stick a barcode label on each sheet, and fasten them with string INSIDE this book.

5. Unless otherwise specified, all working must be clearly shown.

6. Unless otherwise specified, numerical answers should be either exact or correct to 3 significant figures.

7. The diagrams in this paper are not necessarily drawn to scale.

8. No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

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A030E001

SECTION A(1) (35 marks)

1. Simplify $\dfrac{m^9}{(m^3n^{-7})^5}$ and express your answer with positive indices. (3 marks)

1) $\dfrac{m^9}{(m^3n^{-7})^5}$

$= \dfrac{m^9}{m^{15}n^{-35}}$

$= \dfrac{n^{35}}{m^6}$ 1

2. Make b the subject of the formula $\dfrac{4a+5b-7}{b}=8$. (3 marks)

2) $\dfrac{4a+5b-7}{b}=8$

$4a+5b-7=8b$

$3b=4a-7$

$b=\dfrac{4a-7}{3}$ 1

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3. Bag A contains four cards numbered 1 , 3 , 5 and 7 respectively while bag B contains five cards numbered 2 , 4 , 6 , 8 and 10 respectively. If one card is randomly drawn from each bag, find the probability that the sum of the two numbers drawn is less than 9 . (3 marks)

3) The required probability

$= \frac{6}{4 \times 5}$

$= \frac{3}{10}$

4. Factorize

(a) $x^3 + x^2y - 7x^2$,

(b) $x^3 + x^2y - 7x^2 - x - y + 7$.

(4 marks)

4a) $x^3 + x^2y - 7x^2$

$= x^2(x + y - 7)$

4b) $x^3 + x^2y - 7x^2 - x - y + 7$

$= x^2(x+y-7) - (x+y-7)$

$= (x+y-7)(x^2-1)$

$= (x+y-7)(x+1)(x-1)$

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5. (a) Find the range of values of x which satisfy both $\frac{7-3x}{5} \leq 2(x+2)$ and $4x-13>0$.

(b) Write down the least integer which satisfies both inequalities in (a).

(4 marks)

5a) i) $\frac{7-3x}{5} \leq 2(x+2)$

$7-3x \leq 10x+20$

$13x \geq -13$

$x \geq -1$

ii) $4x-13>0$

$4x>13$

$x>\frac{13}{4}$

For i) and ii), the solution is $x>\frac{13}{4}$,

5b) The least integer which satisfies the inequalities is 4,

6. The cost of a book is \$250 . The book is now sold and the percentage profit is 20% .

(a) Find the selling price of the book.

(b) If the book is sold at a discount of 25% on its marked price, find the marked price of the book.

(4 marks)

6a) The selling price $= 250(1+20\%)$

$= \$300$,

6b) The marked price $= 300 \div (1-25\%)$

$= \$400$,

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7. The number of apples owned by Ada is 4 times that owned by Billy. If Ada gives 12 of her apples to Billy, they will have the same number of apples. Find the total number of apples owned by Ada and Billy. (4 marks)

7) Let a be the number of apples owned by Billy,

then $4a$ is the number of apples owned by Ada.

$4a - 12 = a + 12$

$3a = 24$

$a = 8$

$\therefore$ The total number of apples

$= 8 + 4(8)$

$= 40$,

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8. In Figure 1, $ABCD$ is a circle. E is a point lying on AC such that $BC = CE$. It is given that $AB = AD$, $\angle ADB = 58°$ and $\angle CBD = 25°$.

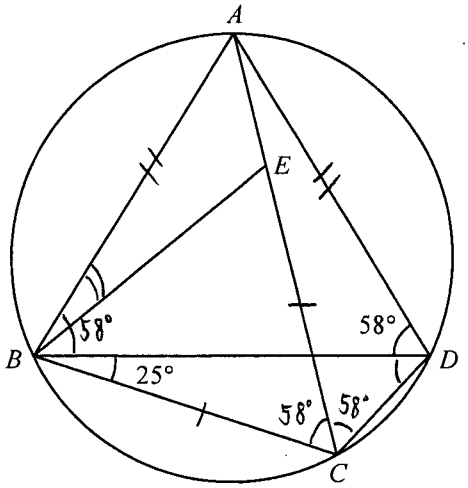

Figure 1

Find $\angle BDC$ and $\angle ABE$. (5 marks)

8) $\angle BCE = \angle ADB = 58°$ ($\angle$s in the same segment)

$\angle ABD = \angle ADB = 58°$ (base $\angle$s, isos. Δ)

$\angle ABD = \angle ACD = 58°$ ($\angle$s in the same segment)

$\angle BDC = 180° - 25° - 58° - 58°$ ($\angle$ sum of Δ)

$= 39°$,

$\angle BEC = \angle EBC$ (base $\angle$s, isos. Δ)

$2\angle EBC + 58° = 180°$ ($\angle$ sum of Δ)

$\angle EBC = 61°$

$\angle EBD = 61° - 25°$

$= 36°$

$\angle ABE = 58° - \angle EBD$

$= 58° - 36°$

$= 22°$,

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9. The radius and the area of a sector are 12 cm and 30π cm^2 respectively.

(a) Find the angle of the sector.

(b) Express the perimeter of the sector in terms of π.

(5 marks)

9a) Let θ be the angle of the sector.

$(\pi)(12)^2\left(\frac{\theta}{360^\circ}\right) = 30\pi$

$\theta = 75^\circ$

$\therefore$ The angle is 75°

9b) The perimeter of the sector

$= 12 + 12 + 2(\pi)(12)\left(\frac{75^\circ}{360^\circ}\right)$

$= (24 + 5\pi)$ (cm)

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SECTION A(2) (35 marks)

10. When Susan sells n handbags in a month, her income in that month is $\$S$. It is given that S is a sum of two parts, one part is a constant and the other part varies as n . When $n=10$, $S=10\,600$; when $n=6$, $S=9\,000$.

(a) When Susan sells 20 handbags in a month, find her income in that month. (4 marks)

(b) Is it possible that when Susan sells a certain number of handbags in a month, her income in that month is $\$18\,000$? Explain your answer. (2 marks)

10a) $S = k_1 + k_2 n$, where k_1, k_2 are non-zero constants

When $n = 10$, $S = 10600$,

$10600 = k_1 + 10k_2$ ——— ①

When $n = 6$, $S = 9000$,

$9000 = k_1 + 6k_2$ ——— ②

Subst. ① into ②, $10600 - 10k_2 + 6k_2 = 9000$

$4k_2 = 1600$

$k_2 = 400$

Subst. $k_2 = 400$ into ①, $10600 = k_1 + 10(400)$

$k_1 = 6600$

$\therefore S = 6600 + 400n$

When $n = 20$, $S = 6600 + 400(20)$

$= 14600$

$\therefore$ The income is \$14600,

10b) When $S = 18\,000$,

$6600 + 400n = 18000$

$n = 28.5$, which is not an integer

$\therefore$ It is impossible,

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11. Let $f(x)=(x-2)^2(x+h)+k$, where h and k are constants. When $f(x)$ is divided by $x-2$, the remainder is -5 . It is given that $f(x)$ is divisible by $x-3$.

(a) Find h and k. (3 marks)

(b) Someone claims that all the roots of the equation $f(x)=0$ are integers. Do you agree? Explain your answer. (3 marks)

11a) $f(2)=-5$

$(2-2)^2(2+h)+k=-5$

$k=-5$

$f(3)=0$

$(3-2)^2(3+h)+k=0$

$3+h-5=0$

$h=2$

$\therefore h=2,\ k=-5$

11b) When $f(x)=0$,

$(x-2)^2(x+2)-5=0$

$(x^2-4x+4)(x+2)-5=0$

$x^3+2x^2-4x^2-8x+4x+8-5=0$

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

$(x-3)(x^2+x-1)=0$

For $x^2+x-1=0$,

$x=\dfrac{-1\pm\sqrt{1-4(1)(-1)}}{2}$

$=\dfrac{-1\pm\sqrt{5}}{2}$, which are not integers

$\therefore$ I disagree.

$$\begin{array}{r|l} & 1+1-1 \\ \hline 1-3 & 1-2-4+3 \\ & 1-3 \\ \hline & 1-4 \\ & 1-3 \\ \hline & -1+3 \\ & -1+3 \\ \hline \end{array}$$

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12. The stem-and-leaf diagram below shows the distribution of the weights (in kg) of the students in a football club.

Stem (tens)	Leaf (units)
4	0 2 3 3 3 3 9
5	1 1 2 |2 3 7 9
6	3 5 8 9
7	8 9

(a) Find the mean, the median and the range of the above distribution. (3 marks)

(b) Two more students now join the club. It is found that both the mean and the range of the distribution of the weights are increased by 1 kg. Find the weight of each of these two students. (4 marks)

12a) The mean = 55 kg

The median $= \frac{52+52}{2}$

$= 52$ kg

The range $= 79 - 40$

$= 39$ kg

12b) Let x and y be the weight of these two students respectively and y is the heavier student.

$y - 40 = 39 + 1$

$y = 80$

$\frac{x + 80 + 55(20)}{22} = 55 + 1$

$x = 52$

$\therefore$ The weights of these two students are 52 kg and 80 kg respectively.

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13. In Figure 2, $ABCD$ is a square. E and F are points lying on BC and CD respectively such that $AE = BF$. AE and BF intersect at G .

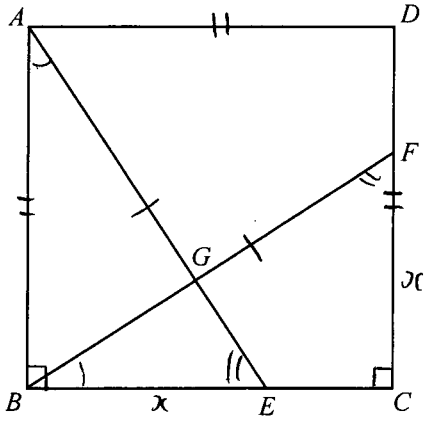

Figure 2

(a) Prove that $\Delta ABE \cong \Delta BCF$. (2 marks)

(b) Is ΔBGE a right-angled triangle? Explain your answer. (3 marks)

(c) If $CF = 15$ cm and $EG = 9$ cm , find BG . (2 marks)

13a) $AB = BC$ (prop. of square)

$\angle ABE = \angle BCF = 90°$ (prop. of square)

$AE = BF$ (given)

$\therefore \Delta ABE \cong \Delta BCF$ (R.H.S.)

13b) In ΔBGE and ΔBCF

$\angle GBE = \angle CBF$ (common $\angle$)

$\angle BEG = \angle BFC$ (corr. $\angle$s, $\cong \Delta$s)

$\angle BGE = \angle BCF$ ($\angle$ sum of Δ)

$\therefore \Delta BGE \sim \Delta BCF$ (A.A.A.)

$\therefore \angle BGE = \angle BCF = 90°$

$\therefore \Delta BGE$ is a right-angled triangle.

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13c) $CF = BE = 15$ cm (corr. sides, $\cong \Delta$s)

$BG^2 + 9^2 = 15^2$ (Py th. theorem)

$BG^2 = 144$

$BG = 12$ or -12 (rej.)

$\therefore BG = 12$ cm.

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14. The coordinates of the points P and Q are $(4,-1)$ and $(-14,23)$ respectively.

(a) Let L be the perpendicular bisector of PQ.

(i) Find the equation of L.

(ii) Suppose that G is a point lying on L. Denote the x-coordinate of G by h. Let C be the circle which is centred at G and passes through P and Q.
Prove that the equation of C is $2x^2+2y^2-4hx-(3h+59)y+13h-93=0$.

(6 marks)

(b) The coordinates of the point R are $(26,43)$. Using (a)(ii), or otherwise, find the diameter of the circle which passes through P, Q and R. (3 marks)

14a i) The coordinates of mid point of PQ

$= \left(\frac{-14+4}{2}, \frac{23-1}{2}\right)$

$= (-5, 11)$

Slope of PQ $= \frac{23+1}{-14-4}$

$= -\frac{4}{3}$

The equation of L is

$y-11 = \frac{-1}{-\frac{4}{3}}(x+5)$

$y-11 = \frac{3}{4}(x+5)$

$4y-44 = 3x+15$

$3x-4y+59=0$

14a ii) The coordinates of centre G

$= (h, \frac{3h+59}{4})$

The radius of circle $= \sqrt{h^2+\left(\frac{3h+59}{4}\right)^2-\left(\frac{13h-93}{2}\right)}$

~~The equation of circle is~~

$\cancel{(x-h)^2+\left(y-\frac{3h+59}{4}\right)^2=\left(\sqrt{h^2+\left(\frac{3h+59}{4}\right)^2-\left(\frac{13h-93}{2}\right)}\right)^2}$

$\cancel{x^2-2xh+h^2+y^2-2\left(\frac{3h+59}{4}\right)(y)+\left(\frac{3h+59}{4}\right)^2}$

Let $x^2+y^2+Dx+Ey+F=0$ be the equation of circle

$-\frac{D}{2}=h \qquad -\frac{E}{2}=\frac{3h+59}{4}$

$D=-2h \qquad E=-\frac{3h+59}{2}$

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$F = \frac{13h-93}{2}$

$\therefore$ The equation of circle is

$x^2 + y^2 - 2hx - \frac{3h+59}{2}y + \frac{13h-93}{2} = 0$

$2x^2 + 2y^2 - 4hx - (3h+59)y + 13h - 93 = 0$ //

14b) Subst. $(26, 43)$ into the equation of circle,

$2(26)^2 + 2(43)^2 - 4(h)(26) - (3h+59)(43) + 13h - 93 = 0$

$5050 - 104h - 129h - 2537 + 13h - 93 = 0$

$220h = 2420$

$h = 11$

The radius of circle

$= \sqrt{(11)^2 + \left(\frac{3(11)+59}{4}\right)^2 - \frac{13(11)-93}{2}}$

$= \sqrt{625}$

$= 25$

The diameter $= 25 \times 2$

$= 50$ //

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SECTION B (35 marks)

15. The table below shows the means and the standard deviations of the scores of a large group of students in a Mathematics examination and a Science examination:

Examination	Mean	Standard deviation
Mathematics	66 marks	12 marks
Science	52 marks	10 marks

The standard score of David in the Mathematics examination is -0.5 .

(a) Find the score of David in the Mathematics examination. (2 marks)

(b) Assume that the scores in each of the above examinations are normally distributed. David gets 49 marks in the Science examination. He claims that relative to other students, he performs better in the Science examination than in the Mathematics examination. Is the claim correct? Explain your answer. (2 marks)

15a) Let x be the score of David in the Maths exam.

$$\frac{x-66}{12} = -0.5$$

$$x = 60$$

$\therefore$ His Maths exam is 60 marks.

15b) The standard score of David in the Science exam

$$= \frac{49-52}{10}$$

$$= -0.3$$

$\because$ The scores of the above exams are normally distributed

$\therefore$ It can compare the standard scores of Maths and Science examinations.

$\because -0.3 > -0.5$

$\therefore$ The claim is correct.

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16. A box contains 5 red bowls, 6 yellow bowls and 3 white bowls. If 4 bowls are randomly drawn from the box at the same time,

(a) find the probability that exactly 2 red bowls are drawn; (2 marks)

(b) find the probability that at least 2 red bowls are drawn. (2 marks)

16a) The required probability

$= \dfrac{C^5_2 C^9_2}{C^{14}_4}$

$= \dfrac{360}{1001}$ //

16b) The required probability

$= 1 - \dfrac{C^9_4 C^5_0}{C^{14}_4} - \dfrac{C^9_3 C^5_1}{C^{14}_4}$

$= 1 - \dfrac{18}{143} - \dfrac{60}{143}$

$= \dfrac{5}{11}$ //

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17. For any positive integer n, let $A(n) = 4n - 5$ and $B(n) = 10^{4n-5}$.

(a) Express $A(1) + A(2) + A(3) + \cdots + A(n)$ in terms of n. (2 marks)

(b) Find the greatest value of n such that $\log(B(1)B(2)B(3)\cdots B(n)) \leq 8\,000$. (3 marks)

17a) $A(1) = 4(1) - 5$

$= -1$

$A(2) = 4(2) - 5$

$= 3$

$A(3) = 4(3) - 5$

$= 7$

$A(2) - A(1) = 3 - (-1)$

$\therefore$ The common difference of the terms is 4

$A(1) + A(2) + A(3) + \ldots + A(n)$

$= \frac{n}{2}[2(-1) + (n-1)(4)]$

$= -n + (4)(\frac{n}{2})(n-1)$

$= -n + 2n(n-1)$

$= -n + 2n^2 - 2n$

$= 2n^2 - 3n$

17b) $B(1) = 10^{4(1)-5}$

$= 0.1$

$B(2) = 10^{4(2)-5}$

$= 1000$

$B(3) = 10^{4(3)-5}$

$= 10\,000\,000$

$[B(1)][B(3)] = 0.1 \times 10\,000\,000$

$= 1\,000\,000$

$[B(2)]^2 = 1000^2$

$= 1\,000\,000$

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$\therefore B(n)$ forms a geometric sequence with the common ratio 10000.

$\log(B(1)B(2)B(3)\ldots B(n)) \leq 8000$

$\log B(1) + \log B(2) + \log B(3) + \ldots + \log B(n) \leq 8000$

$\log(0.1) + \log(1000) + \log(10000000) + \ldots + \log B(n) \leq 8000$

$-1 + 3 + 7 + \ldots + \log B(n) \leq 8000$

$A(1) + A(2) + A(3) + \ldots + A(n) \leq 8000$

$2n^2 - 3n \leq 8000$ (by (a))

$2n^2 - 3n - 8000 \leq 0$

$(n-64)(2n+125) \leq 0$

$-\frac{125}{2} \leq n \leq 64$

$\therefore$ The greatest value of n is 64.

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18. Let $f(x) = 2x^2 - 4kx + 3k^2 + 5$, where k is a real constant.

(a) Does the graph of $y = f(x)$ cut the x-axis? Explain your answer. (2 marks)

(b) Using the method of completing the square, express, in terms of k, the coordinates of the vertex of the graph of $y = f(x)$. (3 marks)

(c) In the same rectangular coordinate system, let S and T be moving points on the graph of $y = f(x)$ and the graph of $y = 2 - f(x)$ respectively. Denote the origin by O. Someone claims that when S and T are nearest to each other, the circumcentre of ΔOST lies on the x-axis. Is the claim correct? Explain your answer. (4 marks)

18a) When $f(x) = 0$,

$2x^2 - 4kx + 3k^2 + 5 = 0$

$\Delta = (-4k)^2 - 4(2)(3k^2+5)$

$= 16k^2 - 24k^2 - 40$

$= -8k^2 - 40$

For k equals to any real number, $\Delta < 0$

$\therefore$ The graph does not cut the x-axis.

18b) $f(x) = 2x^2 - 4kx + 3k^2 + 5$

$= 2(x^2 - 2kx + \frac{3k^2+5}{2})$

$= 2(x^2 - 2kx + k^2 - k^2 + \frac{3k^2+5}{2})$

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

$= 2(x-k)^2 + k^2 + 5$

$\therefore$ The coordinates of vertex are (k, k^2+5).

18c) The coordinates of vertex of S are (k, k^2+5)

The coordinates of vertex of T are $(k, -(k^2+5)+2)$

$= (k, -k^2-7)$

Slope of $SO = \frac{k^2+5}{k}$

Slope of $TO = \frac{-k^2-7}{k}$

Mid-pt. of ST

$= \left(\frac{k+k}{2}, \frac{k^2+5-k^2-7}{2}\right)$

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$= (k, k^2 - 1)$

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19. In Figure 3(a), $ABCDB'$ is a pentagonal paper card. It is given that $AB = AB' = 40$ cm, $BC = B'D = 24$ cm and $\angle ABC = \angle AB'D = 80°$.

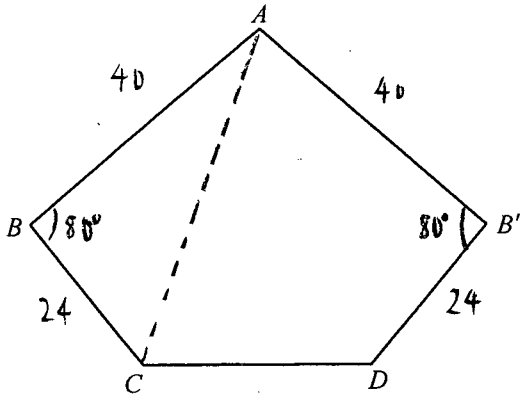

Figure 3(a)

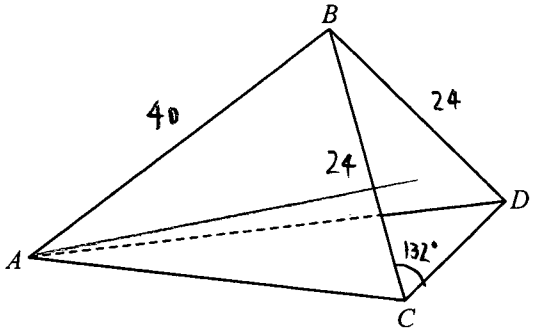

Figure 3(b)

(a) Suppose that $105° \le \angle BCD \le 145°$.

(i) Find the distance between A and C.

(ii) Find $\angle ACB$.

(iii) Describe how the area of the paper card varies when $\angle BCD$ increases from $105°$ to $145°$. Explain your answer.

(7 marks)

(b) Suppose that $\angle BCD = 132°$. The paper card in Figure 3(a) is folded along AC and AD such that AB and AB' join together to form a pyramid $ABCD$ as shown in Figure 3(b). Find the volume of the pyramid $ABCD$. (6 marks)

19a i) $AC^2 = 40^2 + 24^2 - 2(40)(24)\cos 80°$

$AC \approx 42.9$ cm ($\because AC > 0$)

$\therefore$ The req'd distance is 42.9 cm.

19a ii) $\cos \angle ACB = \dfrac{24^2 + AC^2 - 40^2}{2(24)(AC)}$

$= \dfrac{24^2 + (42.92546446)^2 - 40^2}{2(24)(42.92546446)}$

$\angle ACB \approx 66.6°$.

19a iii) When $\angle BCD = 105°$

Area of $\triangle BCA = \frac{1}{2}(BC)(AC)\sin \angle ACB$

≈ 472.7077 cm^2

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When $\angle BCD = 145°$,

Area of $\Delta BCA = \frac{1}{2}(24)(42.92546446)\sin(\angle ACB + 45°)$

$\approx 478.9634 \text{ cm}^2$

$\therefore$ The area of ΔBCA increases when $\angle BCD$ increases from $105°$ to $145°$

$\therefore$ The area of paper increases when $\angle BCD$ increases from $105°$ to $145°$,

(In the paper card,

19b) $\Delta ABC \cong \Delta AB'D$ (S.A.S.)

$\therefore AC = AD \approx 42.92546446$ cm (Corr. sides, $\cong \Delta$s)

$\angle ACD = 132° - \angle ACB$

$\approx 65.409185°$

$CD^2 + AC^2 - 2(CD)(AC)\cos\angle ACD = AD^2$

$CD^2 - 35.72557859\,CD = 0$

$CD \approx 35.72557859$ cm ($\because CD > 0$)

In the pyramid ABCD

Area of $\Delta BCD = \frac{1}{2}(24)(CD)\sin 132°$

$\approx 318.5913464 \text{ cm}^2$

Volume of pyramid ABCD

$= \frac{1}{3}$(Area of ΔBCD)(Height)

$= \frac{1}{3}(318.5913464)(42.92546446)$

$\approx 4460 \text{ cm}^3$,

Answers written in the margins will not be marked.

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END OF PAPER

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Comments

The candidate has an excellent mastery of algebraic manipulation skills, which enables him/her to solve the questions in Section A accurately and precisely. He/She finds the required statistical measures accurately by applying relevant formulas. He/She solves questions involving geometric figures proficiently by using concepts in deductive geometry, coordinate geometry, mensuration and trigonometry. This demonstrates that the candidate has a comprehensive knowledge and understanding of the mathematical concepts in all three strands of the curriculum.

In addition, the candidate is capable of presenting proofs and solutions for the questions logically and precisely using relevant symbols and mathematical language, including equations and inequalities, to express his/her views and ideas.

His/Her performance in Questions 12, 13, 15 and 17 demonstrates that the candidate recognizes the meaning and significance of the results obtained in the first few parts of the questions, which allows him/her to make further deductions and thus come to the correct conclusion. This demonstrates that the candidate has the ability to trace the links between different parts of the harder questions and to draw conclusions through logical deduction.

It can be concluded that the candidate demonstrates comprehensive knowledge and understanding of the mathematical concepts in the Compulsory Part and is capable of expressing views precisely and logically using mathematical language and notations. Also, the candidate has the ability to apply and integrate knowledge and skills from different areas of the Compulsory Part to handle complex tasks.