

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2014

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.



SECTION A(1) (35 marks)

1. Simplify $\frac{(xy^{-2})^3}{y^4}$ and express your answer with positive indices. (3 marks)

$$\frac{(xy^{-2})^3}{y^4} = \frac{x^3 y^{-6}}{y^4}$$

$$= \frac{x^3 y^{-10}}{y^4}$$

$$= \frac{x^3}{y^{10}}$$

Answers written in the margins will not be marked.

2. Factorize

(a) $a^2 - 2a - 3$,

(b) $ab^2 + b^2 + a^2 - 2a - 3$.

(3 marks)

(a) $a^2 - 2a - 3$

$= (a-3)(a+1)$

(b) $ab^2 + b^2 + a^2 - 2a - 3$.

$= b^2(a+1) + (a-3)(a+1)$

$= (a+1)(b^2 + a - 3)$

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3. (a) Round up 123.45 to 1 significant figure.
(b) Round off 123.45 to the nearest integer.
(c) Round down 123.45 to 1 decimal place.

(3 marks)

a. 200

b. 123.

c. 123.4.

4. The table below shows the distribution of the numbers of calculators owned by some students.

Number of calculators	0	1	2	3
Number of students	7	14	15	4

Find the median, the mode and the standard deviation of the above distribution.

(3 marks)

median = 1.

mode = 2.

standard deviation: $\frac{\sqrt{79}}{10} \approx 0.889$

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5. Consider the formula $2(3m+n) = m+7$.

(a) Make n the subject of the above formula.

(b) If the value of m is increased by 2, write down the change in the value of n .

(4 marks)

$$a. 2(3m+n) = m+7$$

$$6m+2n = m+7$$

$$2n = -5m+7$$

$$n = \frac{-5m+7}{2}$$

$$b. -5$$

6. The marked price of a toy is \$255. The toy is now sold at a discount of 40% on its marked price.

(a) Find the selling price of the toy.

(b) If the percentage profit is 2%, find the cost of the toy.

(4 marks)

$$a. 255 \cdot (1-40\%) = \$153$$

b. Let \$C be the cost of the toy

$$\frac{153-C}{C} \cdot 100\% = 2\%$$

$$\frac{153-C}{C} = \frac{1}{50}$$

$$7650 - 50C - C = 0$$

$$C = 150$$

\therefore \$150 is the cost of the toy.

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7. Let $f(x) = 4x^3 - 5x^2 - 18x + c$, where c is a constant. When $f(x)$ is divided by $x - 2$, the remainder is -33 .

(a) Is $x + 1$ a factor of $f(x)$? Explain your answer.

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

(5 marks)

a. ~~$f(2) = 4(2)^3 - 5(2)^2 - 18(2) + c = -33$~~
 $f(2) = 4(2)^3 - 5(2)^2 - 18(2) + c = -33$
 $c = -9$

$$f(-1) = 4(-1)^3 - 5(-1)^2 - 18(-1) - 9 = 0$$

$\therefore x + 1$ is a factor of $f(x)$.

b. $4x^3 - 5x^2 - 18x - 9$
 $= (x + 1)(4x^2 - 9x - 9)$

\therefore the roots are $x = -1$ and $x = \frac{-(-9) \pm \sqrt{9^2 - 4(4)(-9)}}{2(4)}$

$$x = \frac{9 \pm 15}{8}$$

$$x = \frac{9}{8} \pm \frac{15}{8}$$

\therefore the roots are $x = -1, x = \frac{3}{4}, x = \frac{9}{4}$.

\therefore All are rational numbers

\therefore I agree.

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8. The coordinates of the points P and Q are $(-3, 5)$ and $(2, -7)$ respectively. P is rotated anticlockwise about the origin O through 270° to P' . Q is translated leftwards by 21 units to Q' .

- (a) Write down the coordinates of P' and Q' .
(b) Prove that PQ is perpendicular to $P'Q'$.

(5 marks)

a. $P': (5, 3)$.

$Q': (-19, -7)$.

b. Slope of $PQ = \frac{5 - (-7)}{-3 - 2}$
 $= \frac{12}{-5} = -\frac{12}{5}$

Slope of $P'Q' = \frac{3 - (-7)}{5 - (-19)}$
 $= \frac{10}{24} = \frac{5}{12}$

Slope of $PQ \times$ Slope of $P'Q' = -\frac{12}{5} \times \frac{5}{12}$
 $= -1$

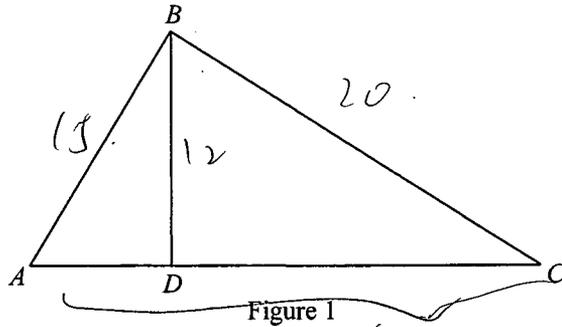
$\therefore PQ \perp P'Q'$

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9. In Figure 1, D is a point lying on AC such that $\angle BAC = \angle CBD$.



- (a) Prove that $\triangle ABC \sim \triangle BDC$.
- (b) Suppose that $AC = 25$ cm, $BC = 20$ cm and $BD = 12$ cm. Is $\triangle BCD$ a right-angled triangle? Explain your answer.

(5 marks)

$$\begin{aligned} 2. \quad \angle BAC &= \angle DBC \quad (\text{given}). \\ \angle ACB &= \angle BCD \quad (\text{common } \angle). \\ \angle ABC &= 180^\circ - \angle BAC - \angle ACB \quad (\text{sum of } \triangle) \\ \angle ABC &= 180^\circ - \angle DBC - \angle BCD \end{aligned}$$

$$\angle ABC = \angle BDC.$$

$$\therefore \triangle ABC \sim \triangle BDC \quad (\text{A.A.A}).$$

$$\therefore \frac{BD}{BC} = \frac{BC}{AC} \quad (\text{corr. sides, } \sim \triangle)$$

$$\frac{12}{20} = \frac{20}{AC}$$

$$AC = 16 \text{ cm.}$$

$$BC^2 = 20^2 = 400$$

$$BD^2 + DC^2 = 12^2 + 16^2 = 768.$$

$$\therefore BD^2 + DC^2 \neq BC^2$$

$\therefore \triangle BCD$ is NOT a right-angled triangle.

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SECTION A(2) (35 marks)

10. Town X and town Y are 80 km apart. Figure 2 shows the graphs for car A and car B travelling on the same straight road between town X and town Y during the period 7:30 to 9:30 in a morning. Car A travels at a constant speed during the period. Car B comes to rest at 8:15 in the morning.

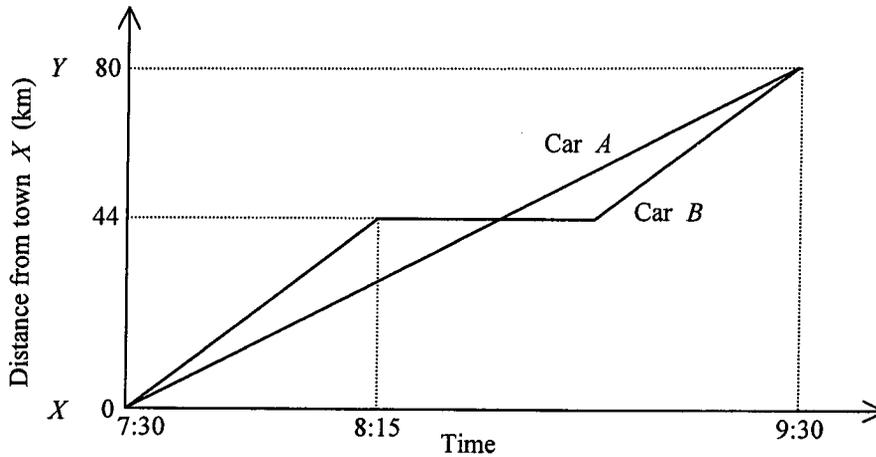


Figure 2

- (a) Find the distance of car A from town X at 8:15 in the morning. (2 marks)
- (b) At what time after 7:30 in the morning do car A and car B first meet? (2 marks)
- (c) The driver of car B claims that the average speed of car B is higher than that of car A during the period 8:15 to 9:30 in the morning. Do you agree? Explain your answer. (2 marks)

2. ~~$\frac{80 \text{ km}}{2 \text{ hr}}$~~ $\frac{80 \text{ km}}{2 \text{ hr}} \times \frac{3}{4} \text{ hr} = 30 \text{ km}$.

$\therefore 30 \text{ km}$ is the distance of car A from town X at 8:15 in the morning.

b. Let $k \text{ hr}$ be the time after 7:30 in the morning
 ~~$\frac{80 \text{ km}}{2 \text{ hr}}$~~ $\frac{80 \text{ km}}{2 \text{ hr}} \cdot k = 44$.

$k = 1.1$

t.t. ~~60 min~~ $1.1 \text{ hr} \cdot 60 \text{ min} = 66$.

$\therefore 8:36$ is the time car A and car B first meet.

c. Average speed of Car B: ~~$\frac{80 \text{ km}}{2 \text{ hr}}$~~ $\frac{80 - 44}{1.25} = 28.8$

$\therefore 28 \text{ km/hr} < 40 \text{ km/hr}$

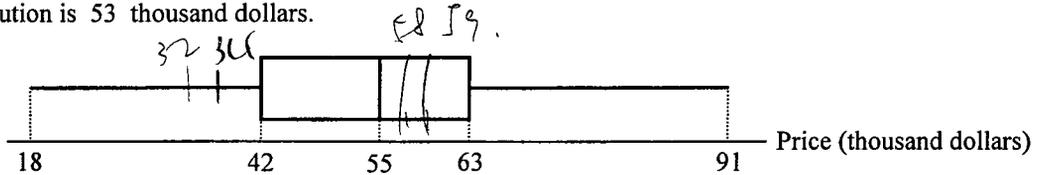
\therefore I do NOT agree

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11. There are 33 paintings in an art gallery. The box-and-whisker diagram below shows the distribution of the prices (in thousand dollars) of the paintings in the art gallery. It is given that the mean of this distribution is 53 thousand dollars.



- (a) Find the range and the inter-quartile range of the above distribution. (3 marks)
- (b) Four paintings of respective prices (in thousand dollars) 32, 34, 58 and 59 are now donated to a museum. Find the mean and the median of the prices of the remaining paintings in the art gallery. (3 marks)

a. range = $91 - 18 = 73$ (thousand dollars)
inter-quartile range = 21 (thousand dollars)

~~b. $\frac{33 \cdot 53 + 32 + 34 + 58 + 59}{33 + 4}$~~

~~b. new mean: $\frac{33 \cdot 53 + 32 + 34 + 58 + 59}{33 + 4} = 52.2$ (thousand dollars)
new median: 55 (thousand)~~

b. new mean = $\frac{33 \cdot 53 + 32 + 34 + 58 + 59}{33 + 4} = 54$ (thousand dollars)
new median = 55 (thousand dollars)

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12. The circle C passes through the point $A(6, 11)$ and the centre of C is the point $G(0, 3)$.

(a) Find the equation of C . (2 marks)

(b) P is a moving point in the rectangular coordinate plane such that $AP = GP$. Denote the locus of P by Γ .

(i) Find the equation of Γ .

(ii) Describe the geometric relationship between Γ and the line segment AG .

(iii) If Γ cuts C at Q and R , find the perimeter of the quadrilateral $AQGR$.

(5 marks)

$$a. (x-0)^2 + (y-3)^2 = (\sqrt{(0-6)^2 + (3-11)^2})^2$$

$$x^2 + (y-3)^2 = 100$$

$$x^2 + y^2 - 6y - 91 = 0.$$

b(i). Mid-point of $AG: (\frac{6+0}{2}, \frac{11+3}{2})$
 $= (3, 7).$

Slope of $AG: \frac{11-3}{6-0}$
 $= \frac{4}{3}.$

$\therefore \Gamma \perp$ ~~Slope~~ AG

~~Slope of AG~~

$\therefore \frac{4}{3} \times \text{slope of } \Gamma = -1.$

Slope of $\Gamma = -\frac{3}{4}.$

\therefore eq of $\Gamma: \frac{y-7}{x-3} = -\frac{3}{4}.$

$y = -\frac{3}{4}x + \frac{37}{4}.$

b(ii). Γ is a perpendicular bisector of AG .
 (line segment AG .)

b(iii). $\int x^2 + y^2 - 6y - 91 = 0.$
 $y = -\frac{3}{4}x + \frac{37}{4}.$

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$$\begin{cases} x^2 + y^2 - 6y - 9 = 0 & \text{--- ①} \\ 4y = -3x + 37 & \text{--- ②} \end{cases}$$

~~$$\begin{cases} x^2 + y^2 - 6y - 1 = 0 & \text{--- ①} \\ 4y = \frac{-3x + 37}{4} & \text{--- ②} \end{cases}$$~~

~~Put ② into ① $x^2 + \left(\frac{-3x+37}{4}\right)^2 - 6\left(\frac{-3x+37}{4}\right) - 1 = 0$

$$(6x^2 + (-3x+37)^2 - 9(-3x+37) - 4) = 0$$

$$25x^2 - 222x + 1369 + 270x - 3552 - 4 = 0$$

$$25x^2 + 66x - 2187 = 0$$~~

By solving,

13. It is given that $f(x)$ is the sum of two parts, one part varies as x^2 and the other part is a constant. Suppose that $f(2) = 59$ and $f(7) = -121$.

(a) Find $f(6)$. (4 marks)

(b) $A(6, a)$ and $B(-6, b)$ are points lying on the graph of $y = f(x)$. Find the area of $\triangle ABC$, where C is a point lying on the x -axis. (4 marks)

(a) Let $f(x) = k_1 x^2 + k_2$

~~$f(2) = 2^2 k_1 + k_2 = 59$~~

~~$f(7) = 7^2 k_1 + k_2 = -121$~~

$f(2) = 2^2 k_1 + k_2 = 59$ — (1)

$f(7) = 7^2 k_1 + k_2 = -121$ — (2)

(2) - (1), $45k_1 = -180$

$k_1 = -4$

$k_2 = 75$

$\therefore f(x) = -4x^2 + 75$

$f(6) = -4(6)^2 + 75$

$f(6) = -69$

(b) By (a), ~~$a = 69$~~ $A = (6, -69)$

$f(-6) = -4(-6)^2 + 75$

$= -69$

$\therefore B(-6, -69)$

\therefore Area of $\triangle ABC = 12 \cdot 69 \div 2 = 414$

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14. Figure 3 shows a vessel in the form of a frustum which is made by cutting off the lower part of an inverted right circular cone of base radius 72 cm and height 96 cm. The height of the vessel is 60 cm. The vessel is placed on a horizontal table. Some water is now poured into the vessel. John finds that the depth of water in the vessel is 28 cm.

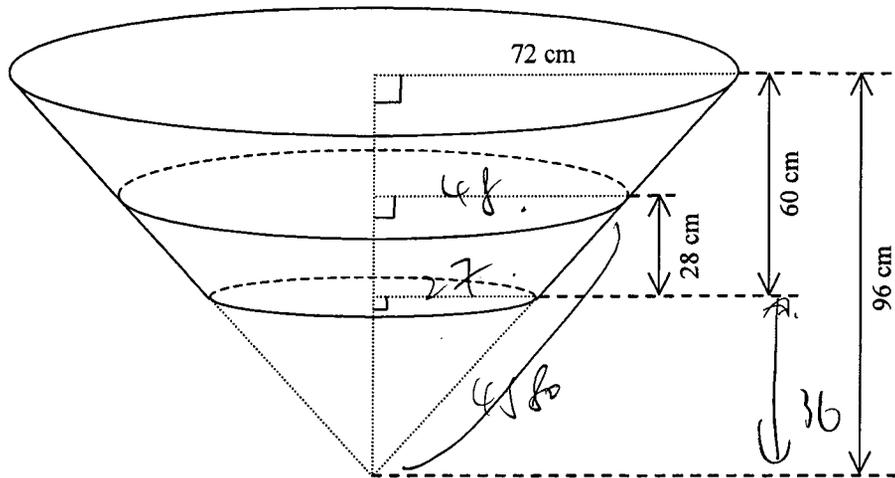


Figure 3

- (a) Find the area of the wet curved surface of the vessel in terms of π . (4 marks)
- (b) John claims that the volume of water in the vessel is greater than 0.1 m^3 . Do you agree? Explain your answer. (4 marks)

(a). Let r be the highest part of radii of the vessel.

$$\frac{72}{r} = \frac{96}{36}$$

$$r = 27.$$

~~\therefore The curved surface = $\pi(48)$~~

\therefore The wet curved surface =

$$\pi \left(\frac{72-64}{46} \right) (\sqrt{48^2 + 64^2}) - \pi (27) (\sqrt{27^2 + 36^2})$$

$$= 2625 \pi \text{ cm}^2 //$$

$$b. \pi (48)^2 \cdot 64 \cdot \frac{1}{3} - \frac{1}{3} \pi (27)^2 \cdot 36.$$

$$= 121212 \text{ cm}^3 \pi //$$

$$= 380791.7287 \text{ cm}^3$$

$$= 0.380798728 \text{ m}^3 > 0.1 \text{ m}^3.$$

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SECTION B (35 marks)

15. The graph in Figure 4 shows the linear relation between $\log_4 x$ and $\log_8 y$. The slope and the intercept on the horizontal axis of the graph are $-\frac{1}{3}$ and 3 respectively. Express the relation between x and y in the form $y = Ax^k$, where A and k are constants. (3 marks)

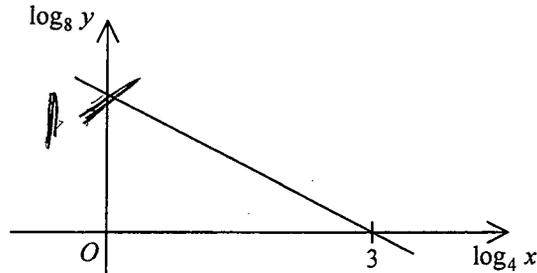


Figure 4

~~$$\log_8 y = -\frac{1}{3} \log_4 x + 3$$~~

let $(k, 0)$ be the y -intercept

$$\frac{k-0}{0-3} = -\frac{1}{3}$$

$$k = 1$$

$$\therefore \log_8 y = -\frac{1}{3} \log_4 x + 1$$

$$\log_8 y = -\frac{1}{3} \log_4 x + \log_8 4$$

$$\log_8 y = \log_4 x^{-\frac{1}{3}} + \log_8 4$$

$$\log y = \log (x^{-\frac{1}{3}} \cdot 4)$$

$$\log_8 y = \log_8 4$$

$$\log y = \frac{3}{2} \log (x^{-\frac{1}{3}} \cdot 4)$$

$$\log y = \log (x^{-\frac{1}{3}} \cdot 4)^{\frac{3}{2}}$$

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

$$y = x^{-\frac{1}{2}} \cdot 8$$

$$y = 8x^{-\frac{1}{2}}$$

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16. In Figure 5, the 1st pattern consists of 3 dots. For any positive integer n , the $(n+1)$ th pattern is formed by adding 2 dots to the n th pattern. Find the least value of m such that the total number of dots in the first m patterns exceeds 6888. (4 marks)

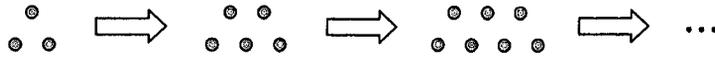


Figure 5

$$\frac{m}{2} [2(3) + (m-1)(2)] > 6888.$$

$$m(6 + 2m - 2) > 13776.$$

$$m(4 + 2m) > 13776.$$

$$2m^2 + 4m - 13776 > 0.$$

$$m^2 + 2m - 6888 > 0.$$

$$(m - 82)(m + 84) > 0.$$

$$m < -84 \text{ (rej.) or } m > 82.$$

$\therefore 83$ is the least value of m such that the total number of dots exceeds 6888.

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17. Figure 6(a) shows a solid pyramid $VABCD$ with a rectangular base, where $AB=18$ cm, $BC=10$ cm, $VB=VC=30$ cm and $\angle VAB = \angle VDC = 110^\circ$.

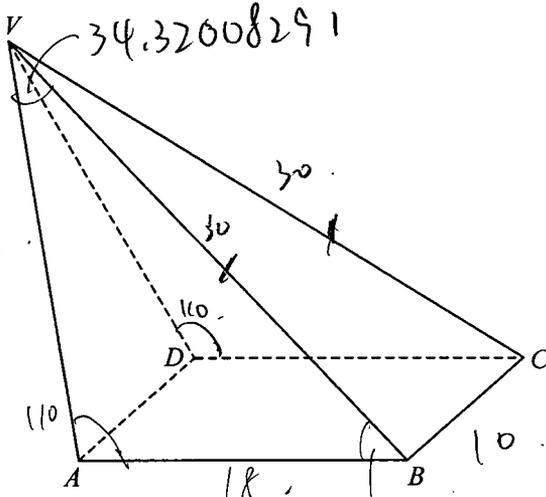


Figure 6(a)

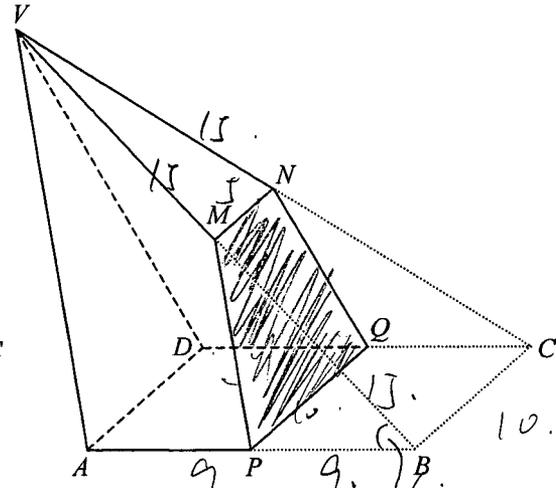


Figure 6(b)

- (a) Find $\angle VBA$. (2 marks)

- (b) P, Q, M and N are the mid-points of AB, CD, VB and VC respectively. A geometric model is made by cutting off $PBCQNM$ from $VABCD$ as shown in Figure 6(b). A craftsman claims that the area of the trapezium $PQNM$ is less than 70 cm². Do you agree? Explain your answer. (5 marks)

answer. $\frac{\sin \angle AVB}{18} = \frac{\sin 110^\circ}{30}$

$\angle AVB = 34.32008291$

$\angle VBA = 180^\circ - \angle AVB - 110^\circ$
 $= 35.67991709^\circ$
 $\approx 35.7^\circ$

(b.) $BC = PQ = 10$.

$\therefore PM = MB = 15$ (given)

$\therefore MN = BC$ (mid-pt theorem)

$MN = 5$.

In $\triangle MPB$, $\cos \angle VBA = \frac{MB^2 + PB^2 - MP^2}{2(PB)(MB)}$

$MP = 9.310329519$.

$\therefore MP = NQ = 9.310329519$.

the height of trapezium: 8.968402074 .
 \wedge PQNM

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∴ The area of trapezium P & NM:

$$(5+10) (8.968402074)$$

↓

$$= 67.26301555 \text{ cm}^2 < 70 \text{ cm}^2$$

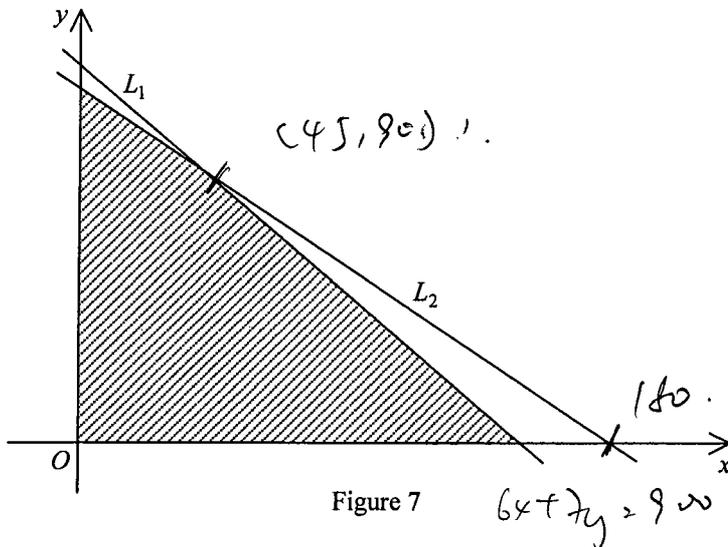
∴ I agree.

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18. (a) In Figure 7, the equation of the straight line L_1 is $6x + 7y = 900$ and the x -intercept of the straight line L_2 is 180. L_1 and L_2 intersect at the point $(45, 90)$. The shaded region (including the boundary) represents the solution of a system of inequalities. Find the system of inequalities. (4 marks)



- (b) A factory produces two types of wardrobes, X and Y . Each wardrobe X requires 6 man-hours for assembly and 2 man-hours for packing while each wardrobe Y requires 7 man-hours for assembly and 3 man-hours for packing. In a certain month, the factory has 900 man-hours available for assembly and 360 man-hours available for packing. The profits for producing a wardrobe X and a wardrobe Y are \$440 and \$665 respectively. A worker claims that the total profit can exceed \$80 000 that month. Do you agree? Explain your answer. (4 marks)

∴ eq. of $L_2 : \frac{y-0}{x-180} = \frac{90-0}{45-180}$

$$y = -\frac{2}{3}x + 120.$$

$$2x + 3y = 360.$$

∴ The system of inequalities are.

$$\begin{cases} x \geq 0. \\ y \geq 0. \\ 6x + 7y \leq 900. \\ 2x + 3y \leq 360. \end{cases}$$

∴ b. ∵ \$440 is the profit of wardrobe X and \$665 is the profit of wardrobe Y .
∴ By adding, $440x + 665y$ line.

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$$\text{For } (0, 120), 440(0) + 665(120) = \$79800$$

$$\text{For } (45, 90), 440(45) + 665(90) = \$79650.$$

$$\text{For } (150, 0), 440(150) + 665(0) = \$66000$$

$\therefore (0, 120)$ attain the maximum

$\therefore \$79800$ is maximum profit where smaller than $\$80000$

\therefore I do NOT agree.

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19. Ada and Billy play a game consisting of two rounds. In the first round, Ada and Billy take turns to throw a fair die. The player who first gets a number '3' wins the first round. Ada and Billy play the first round until one of them wins. Ada throws the die first.

(a) Find the probability that Ada wins the first round of the game. (3 marks)

(b) In the second round of the game, balls are dropped one by one into a device containing eight tubes arranged side by side (see Figure 8). When a ball is dropped into the device, it falls randomly into one of the tubes. Each tube can hold at most three balls.

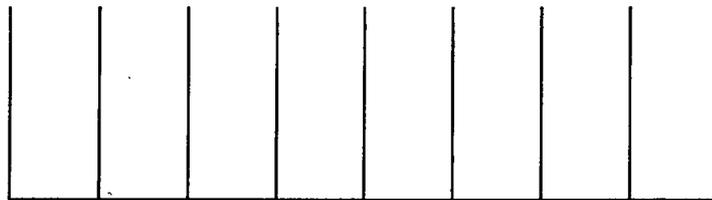


Figure 8

The player of this round adopts one of the following two options.

Option 1: Two balls are dropped one by one into the device. If the two balls fall into the same tube, then the player gets 10 tokens. If the two balls fall into two adjacent tubes, then the player gets 5 tokens. Otherwise, the player gets no tokens.

Option 2: Three balls are dropped one by one into the device. If the three balls fall into the same tube, then the player gets 50 tokens. If the three balls fall into three adjacent tubes, then the player gets 10 tokens. If the three balls fall into two adjacent tubes, then the player gets 5 tokens. Otherwise, the player gets no tokens.

- (i) If the player of the second round adopts Option 1, find the expected number of tokens got.
- (ii) Which option should the player of the second round adopt in order to maximise the expected number of tokens got? Explain your answer.
- (iii) Only the winner of the first round plays the second round. It is given that the player of the second round adopts the option which can maximise the expected number of tokens got. Billy claims that the probability of Ada getting no tokens in the game exceeds 0.9. Is the claim correct? Explain your answer.

(10 marks)

$$\begin{aligned}
 & \frac{1}{6} + \left(\frac{5}{6}\right)^2 \cdot \frac{1}{6} + \left(\frac{5}{6}\right)^4 \cdot \frac{1}{6} + \left(\frac{5}{6}\right)^6 \cdot \frac{1}{6} \dots \\
 & = \frac{1}{6} \left(1 + \left(\frac{5}{6}\right)^2 + \left(\frac{5}{6}\right)^4 + \left(\frac{5}{6}\right)^6 \dots \right) \\
 & = \frac{1}{6} \left[\frac{1}{1 - \left(\frac{5}{6}\right)^2} \right] \\
 & = \frac{6}{11}
 \end{aligned}$$

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$$\begin{aligned} \text{b. (i)} & \cdot 10 \left(\frac{2}{8} \cdot \frac{1}{8} \right) + 5 \left(\frac{2}{8} \times \frac{1}{8} \right) + \\ & 10 \left(\frac{6}{8} \times \frac{1}{8} \right) + 5 \left(\frac{6}{8} \times \frac{2}{8} \right) \\ & = 2.34375 \text{ tokens.} \end{aligned}$$

b. (ii) .

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Answers written in the margins will not be marked.

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 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 7, 13, 17 and 18 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.