



BAULKHAM HILLS HIGH SCHOOL

YEAR 12 ASSESSMENT TASK 3 2022

Mathematics Advanced

General Instructions

- Reading time – 5 minutes
- Working time – 1 hour
- Write using black pen
- Calculators approved by NESA may be used
- For questions in Section II, show relevant mathematical reasoning and / or calculations
- Marks may be deducted for careless or badly arranged work
- A reference sheet is provided at the end of this paper

Total marks – 50

This paper consists of TWO sections.

Section I – 5 marks (pages 4 – 5)

- Attempt Questions 1 – 5
- Answer on answer sheet provided
- Allow about 5 minutes for this section

Section II – 45 marks (pages 6 – 18)

- Attempt Questions 6 – 15
- Allow about 55 minutes for this section

Section I

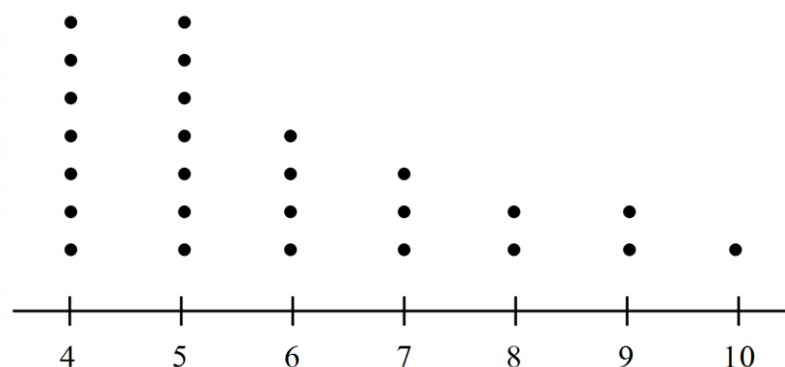
5 marks

Attempt Questions 1 – 5

Allow about 5 minutes for this section

Use the multiple choice answer sheet for Questions 1 – 5.

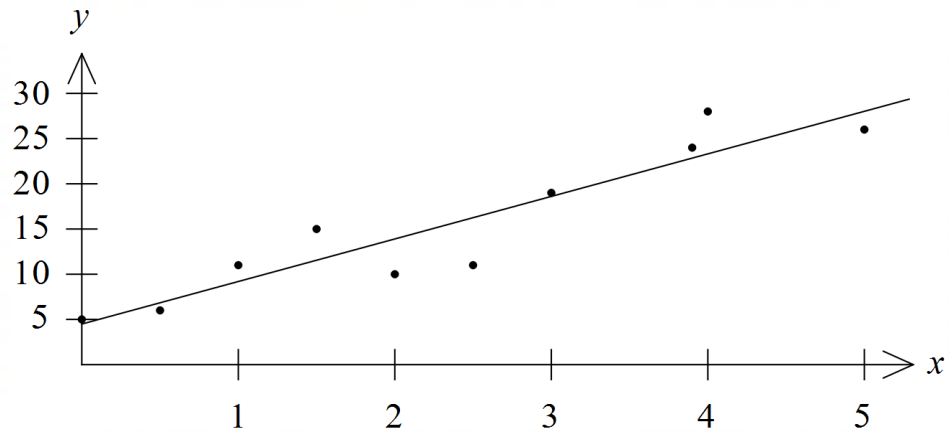
1. The population, N , of a colony of mice grows exponentially and is modelled by the formula $N = 550e^{0.232t}$, where t is the time in days. During which day will the population N reach 13750 mice?
 - A) 15th
 - B) 13th
 - C) 14th
 - D) 16th
2. Given that displacement of the particle, x , is increasing at decreasing rate with respect to time t . Which of the following pairs of inequalities best describe the given statement?
 - A) $\frac{dx}{dt} > 0, \frac{d^2x}{dt^2} > 0$
 - B) $\frac{dx}{dt} > 0, \frac{d^2x}{dt^2} < 0$
 - C) $\frac{dx}{dt} < 0, \frac{d^2x}{dt^2} < 0$
 - D) $\frac{dx}{dt} < 0, \frac{d^2x}{dt^2} > 0$
3. A set of results is displayed in the dot plot below.



Which of the following best describes the shape of this set of results?

- A) Symmetrical
- B) Positively skewed
- C) Negatively skewed
- D) Normally distributed

4. The following is a scatter plot with a line of best fit plotted.



Which of the following equations best models the line of best fit?

- A) $y = 6x + 5$
 - B) $y = 4x - 5$
 - C) $y = 6x - 5$
 - D) $y = 4x + 5$
5. A tree was planted when it was 1.2 metres tall. Every year its growth is $\frac{3}{8}$ of its growth in the previous year.

How tall will the tree eventually grow?

- A) 2.52 metres
- B) 2 metres
- C) 1.92 metres
- D) 2.5 metres

End of Section I

Mathematics Advanced Section II Answer Booklet

45 marks

Attempt Questions 6 – 15

Allow about 55 minutes for this section

Instructions:

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Your responses should include relevant mathematical reasoning and/or calculations.
- You may also ask for extra writing paper if you need extra space.

If you use extra writing paper proceed as follows:

- (a) At the end of the appropriate question, write “CONTINUED ON EXTRA SHEET”
- (b) On the extra page(s) clearly write your NESA#, the question number and the part of the question being answered.
- (c) At the conclusion of the exam staple ALL EXTRA SHEETS AT THE LAST PAGE OF THE APPROPRIATE QUESTION.

Question 6 (5 marks)**Marks**

The number of different jacket sizes in a shop is given in the table below.

Size	8	10	12	14	16	18
Number of jackets	12	23	20	21	13	11

- a) What percentage of jackets in the store were size 12?

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- b) Find the modal and median jacket size.

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- c) Find the upper and lower quartiles, and calculate the interquartile range for this set of data.

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Question 7 (3 marks)**Marks**

Bianca started a new job on 1st January 2022 with a salary of \$115 500. Her salary increases by 4.5% on January 1st each year thereafter.

- a) Calculate her salary in the eighth year.

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- b) In which year will her salary first exceed \$200 000?

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Question 8 (3 marks)

Marks

A set of bivariate data is given below:

x	3	7	4	8	12	2
y	15	11	9	8	7	18

For this set of data:

- a) Evaluate the correlation coefficient correct to two decimal places.

1

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- b) Find the equation of the least-squares regression line.

2

[illegible]

Question 9 (6 marks)**Marks**

The rate at which a certain compound is formed during a nuclear reaction, in R grams per minute, is given by the formula:

$$R = 20 + \frac{5}{t+1}$$

where t is time in minutes since the beginning of the reaction.

- a) At what rate is the compound being formed at the end of 4 minutes?

1

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- b) What value does R approach as t approaches infinity?

1

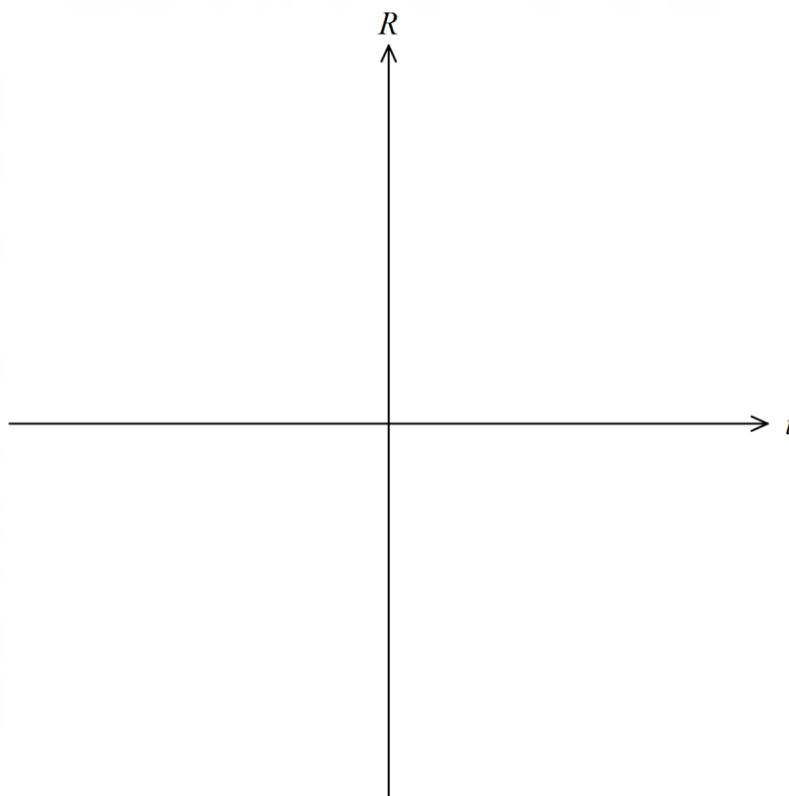
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- c) On the axes provided, draw the graph of R as a function of t .

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- d) How many grams of the compound are formed in the first 4 minutes? Express your answer in exact form.

[illegible]

Question 10 (3 marks)

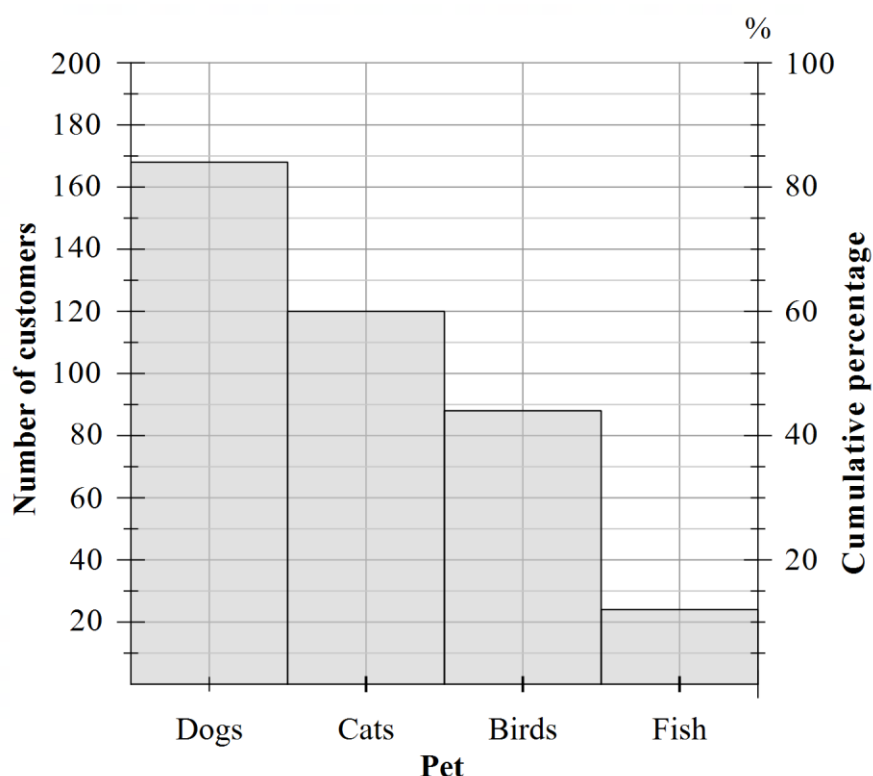
Marks

Customers of a pet store were surveyed asking them what pet they have. The table below shows the 400 responses collected.

Pets	Dogs	Cats	Birds	Fish
Number of customers	168	120	88	24
Cumulative Percentage				

- a) Complete the cumulative percentage row of the table above and hence complete the Pareto chart below, showing the cumulative percentages for the data collected.

2



- b) To maximise the profit, the management of the pet store decided to concentrate on more advertising for fish and birds. From your chart, comment on their decision and justify your comment.

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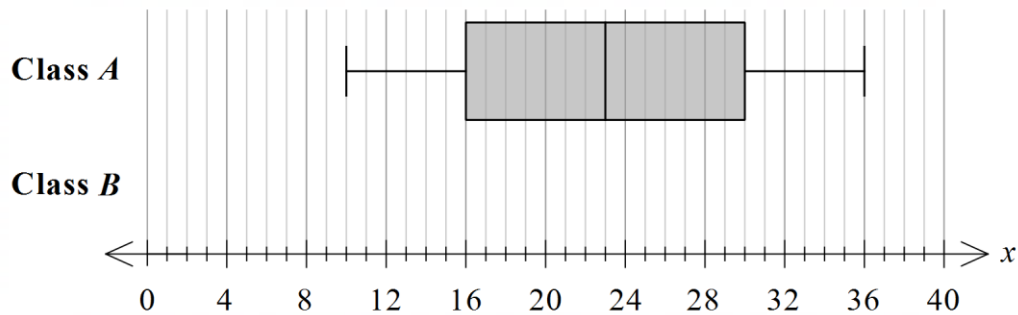
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Question 11 (4 marks)

Marks

Two classes, Class A and Class B, sat the same Mathematics Advanced task. The results for Class A is summarised in the box-and-whisker plot below.



The results for Class B are shown below:

10 , 16 , 18 , 20 , 22 , 27 , 30 , 32 , 33 , 34 , 34 , 35 , 38

- a) Complete the five-number summary for Class B and hence draw the box-and-whisker plot for this class in the space provided above.

2

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- b) Compare and contrast the results for these two classes by referring to measures of location and measures of spread.

2

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Question 12 (6 marks)**Marks**

The velocity of the particle is given by $\dot{x} = 3\sin\left(t - \frac{\pi}{3}\right)$ metres per second for $0 \leq t \leq 2\pi$.

- a) Find the equation of the acceleration $\ddot{x}$ of the particle as a function of time. **1**

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- b) Calculate the maximum speed of the particle and the times at which it occurs in the given domain. **3**

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- c) Find the equation of the displacement of the particle, x , as a function of time if the particle was initially 3 metres to the left of the origin. **2**

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Question 13 (5 marks)**Marks**

The population of the suburb of Baulkham Hills has been growing over the last few years. At the beginning of January 2019, the population was 32500 and at the beginning of January 2022 it is estimated at 37700.

- a) Assume that the population P obeys the law of natural growth $\frac{dP}{dt} = kP$, for some positive constant k , where t is number of years since the beginning of January 2019. Show that $P = 32500e^{kt}$ satisfies the equation $\frac{dP}{dt} = kP$. **1**

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- b) Find the value of the positive constant k . Leave your answer in exact form. **2**

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- c) Calculate the size of the population at the beginning of January 2027. **1**

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- d) During which year will the population first exceed 55000? **1**

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Marks

Let A_n be the amount owing at the end of n months after the repayment has been made.

- 1**

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- 2

[illegible]

c) Hence find the value of M .

2

[illegible]

Question 15 (5 marks)**Marks**

Edric deposits \$1000 into a saving account at the beginning of each year. He makes his first deposit on January 1, 2000. The investment earns compound interest at a rate of 9% p.a., compounded yearly. He makes the last deposit of \$1000 on January 1, 2025 and he withdraws all his savings at the end of 2025.

- a) How much will the first \$1000 be worth at the end of 2025? **1**

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- b) Edric makes his final deposit on January 1, 2025. How much will this deposit of \$1000 be worth at the end of 2025? **1**

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- c) Show that the total amount in the account, in dollars, at the end of 2025 is given by: **2**

$$1000 \times \frac{1.09(1.09^{26} - 1)}{0.09}$$

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- d) Calculate the total interest that Edric will have earned by the end of 2025. **1**

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END OF EXAMINATION



BAULKHAM HILLS HIGH SCHOOL

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Solutions

Section I

5 marks

Attempt Questions 1 – 5

Allow about 5 minutes for this section

Use the multiple choice answer sheet for Questions 1 – 5.

1. The population, N , of a colony of mice grows exponentially and is modelled by the formula $N = 550e^{0.232t}$, where t is the time in days. During which day will the population N reach 13750 mice?

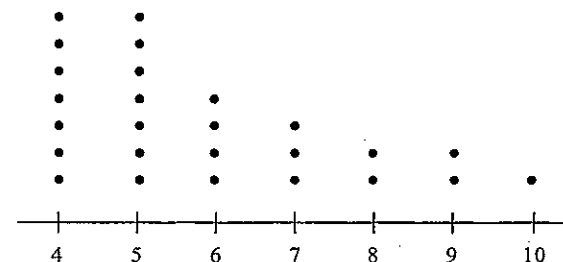
$$13750 = 550 e^{0.232t}$$

- A) 15th
B) 13th
☒ C) 14th
D) 16th

2. Given that displacement of the particle, x , is increasing at decreasing rate with respect to time t . Which of the following pairs of inequalities best describe the given statement?

- A) $\frac{dx}{dt} > 0, \frac{d^2x}{dt^2} > 0$
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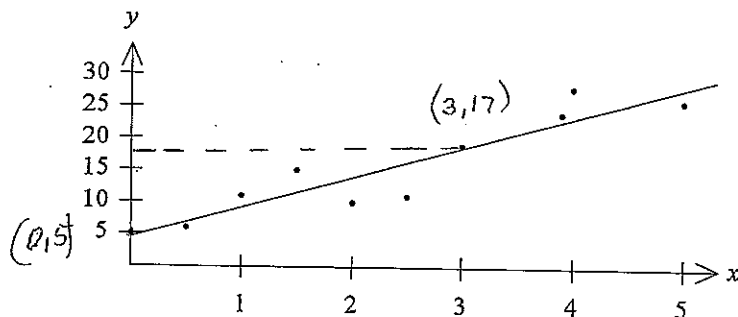
3. A set of results is displayed in the dot plot below.



Which of the following best describes the shape of this set of results?

- A) Symmetrical
☒ B) Positively skewed
C) Negatively skewed
D) Normally distributed

4. The following is a scatter plot with a line of best fit plotted.



Which of the following equations best models the line of best fit?

- A) $y = 6x + 5$
 B) $y = 4x - 5$
 C) $y = 6x - 5$
 D) $y = 4x + 5$

$$m = \frac{17-5}{3-0} = \frac{12}{3} = 4$$

5. A tree was planted when it was 1.2 metres tall. Every year its growth is $\frac{3}{8}$ of its growth in the previous year.

How tall will the tree eventually grow?

- A) 2.52 metres
 B) 2 metres
 C) 1.92 metres
 D) 2.5 metres

$$a = 1.2$$

$$T_1 = ar = 0.45$$

$$T_2 = ar^2 = 0.16875$$

$$\vdots$$

$$T_\infty$$

$$\therefore S_\infty = \frac{a}{1-r} = 0.72$$

$$Total = 1.2 + 0.72$$

$$OR \quad S_\infty = \frac{1.2}{1-\frac{3}{8}} = 1.92$$

End of Section I

Mathematics Advanced Section II Answer Booklet

45 marks

Attempt Questions 6 – 15

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Question 6 (5 marks)

Marks

The number of different jacket sizes in a shop is given in the table below.

Size	8	10	12	14	16	18
Number of jackets	12	23	20	21	13	11

- a) What percentage of jackets in the store were size 12?

Total = 100 jackets
①

$$\% = \frac{20}{100} \% = 20\%$$

Marks
1 - correct answer

- b) Find the modal and median jacket size.

2

$$\text{modal size} = 10$$

2 - correct answers

1 - correct modal

$$\text{median} = \frac{50\text{th} + 51\text{th}}{2} = 12$$

OR median size

- c) Find the upper and lower quartiles, and calculate the interquartile range for this set of data.

2

$$\text{upper } Q_3 = 14$$

2 - all three

$$\text{lower } Q_1 = 10$$

answers correct

1 - 2 out of 3

$$\text{IQR} = 14 - 10 = 4$$

answers correct

Question 7 (3 marks)

Marks

Bianca started a new job on 1st January 2022 with a salary of \$115 500. Her salary increases by 4.5% on January 1st each year thereafter.

- a) Calculate her salary in the eighth year.

1

$$T_8 = 115500 \left(1 + \frac{4.5}{100}\right)^{8-1}$$

(7-increments)

$$= \$157\,179.54$$

Marks
1 - correct answer

- b) In which year will her salary first exceed \$200 000?

2

$$115\,500 (1.045)^{n-1} > 200\,000$$

$$1.045^{n-1} > \frac{200\,000}{115\,500} = \frac{400}{231}$$

$$\ln 1.045^{n-1} > \ln \frac{400}{231}$$

$$(n-1) \ln 1.045 > \ln \frac{400}{231}$$

$$(n-1) > \frac{\ln \frac{400}{231}}{\ln 1.045} = 12.47$$

$$n-1 > 12.47$$

$$\therefore n-1 = 13$$

$$\therefore 2022 + 13 = 2035$$

Question 8 (3 marks)

Marks

A set of bivariate data is given below:

x	3	7	4	8	12	2
y	15	11	9	8	7	18

For this set of data:

- a) Evaluate the correlation coefficient correct to two decimal places.

1

$$r = -0.816 = -0.82$$

Marks

1 - correct answer

- b) Find the equation of the least-squares regression line.

2

from calculator

$$A = 16.99$$

$$B = -0.9429$$

2 - correct solns.

1 - correct

A and B

$\therefore$ equation

$$y = A + Bx$$

$$y = 16.99 - 0.9429x$$

Question 9 (6 marks)

Marks

The rate at which a certain compound is formed during a nuclear reaction, in R grams per minute, is given by the formula:

$$R = 20 + \frac{5}{t+1}$$

where t is time in minutes since the beginning of the reaction.

- a) At what rate is the compound being formed at the end of 4 minutes?

Marks

1

$$t = 4, R = 20 + \frac{5}{4+1} = 21 \text{ g/min}$$

1 - correct soln.

- b) What value does R approach as t approaches infinity?

1

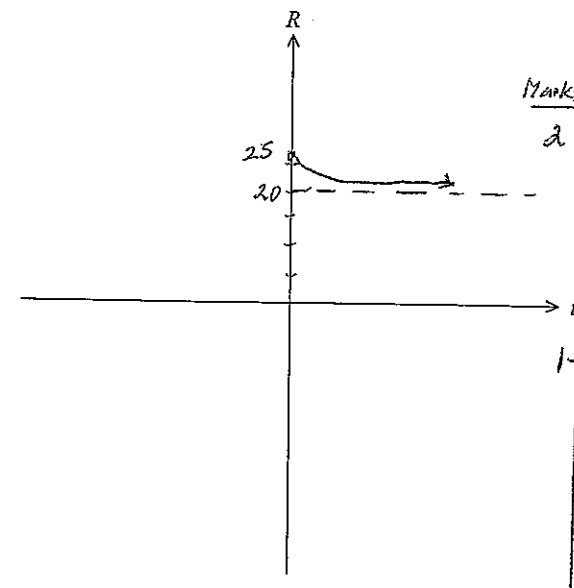
$$t \rightarrow \infty, R \rightarrow 20 + 0$$

$$R \rightarrow 20 \text{ g/min.}$$

1 - correct solns.

- c) On the axes provided, draw the graph of R as a function of t .

(2)



Marks

2 - correct solns.

1 - correct shape with correct y-intercept

- d) How many grams of the compound are formed in the first 4 minutes? Express your answer in exact form. 2

$$\text{Total grams} = \int_0^4 20 + \frac{5}{t+1} dt$$

$$= \left[20t + 5 \ln|t+1| \right]_0^4$$

$$= 80 + 5 \ln 5 - (0 + 5 \ln 1)$$

$$= 80 + 5 \ln 5 - 0$$

$$= 80 + 5 \ln 5$$

Marks

2 - correct

solns.

1 - correct

integration

1 - significant

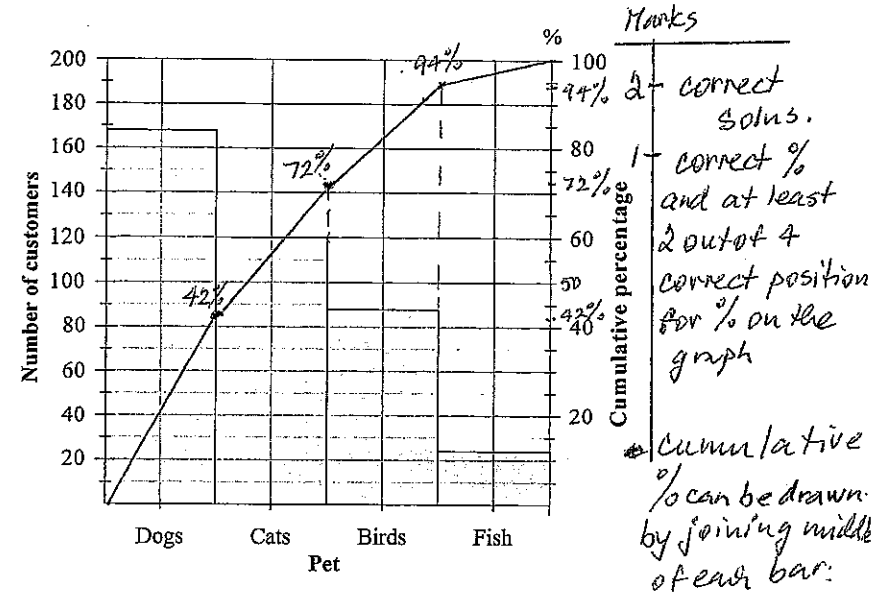
progress to

find answer

Customers of a pet store were surveyed asking them what pet they have. The table below shows the 400 responses collected.

Pets	Dogs	Cats	Birds	Fish
Number of customers	168	120	88	24
Cumulative Percentage	$\frac{168}{400} = 42\%$	$\frac{288}{400} = 72\%$	$\frac{376}{400} = 94\%$	100%

- a) Complete the cumulative percentage row of the table above and hence complete the Pareto chart below, showing the cumulative percentages for the data collected. 2



- b) To maximise the profit, the management of the pet store decided to concentrate on more advertising for fish and birds. From your chart, comment on their decision and justify your comment. 1

Marks

1 - either one of these two reasons

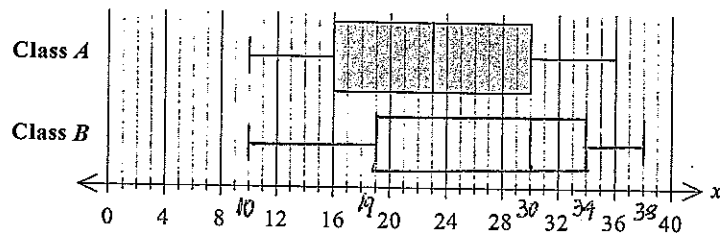
• That's not the best decision, because they are focusing on the least % profit.

OR • Since birds & fish representing the smallest % (not cumulative %) they want to increase it.

Question 11 (4 marks)

Marks

Two classes, Class A and Class B, sat the same Mathematics Advanced task. The results for Class A is summarised in the box-and-whisker plot below.



The results for Class B are shown below:

10, 16, 18, 20, 22, 27, 30, 32, 33, 34, 34, 35, 38

- a) Complete the five-number summary for Class B and hence draw the box-and-whisker plot for this class in the space provided above. 2

$Q_1 = \frac{18+20}{2} = 19$	2 - correct solns.
$Q_2 = 30$ Lowest score = 10	1 - correct five-number summary
$Q_3 = 34$ Highest score = 38	1 - correct graph

- b) Compare and contrast the results for these two classes by referring to measures of location and measures of spread. 2

* Results of class B are better	2 - correct
* Median Class B > Median of Class A	comments
* The middle 50% of scores are located higher, between 19-34	1 - at least one of the reasons
comp. to class A, which are only between 16-30.	is stated correctly
* The lowest score is the same but the highest for class B is better too.	

Question 12 (6 marks)

Marks

The velocity of the particle is given by $\dot{x} = 3 \sin\left(t - \frac{\pi}{3}\right)$ metres per second for $0 \leq t \leq 2\pi$.

- a) Find the equation of the acceleration $\ddot{x}$ of the particle as a function of time. 1

$$\ddot{x} = 3 \cos\left(t - \frac{\pi}{3}\right)$$

1 - correct solns

- b) Calculate the maximum speed of the particle and the times at which it occurs in the given domain. 3

Max. speed = 3 m/s (amplitude of $\dot{x}$) 3 - correct solns. for speed x times

$$\dot{x} = 3 \cos\left(t - \frac{\pi}{3}\right) = 0$$

2 - correct speed

$$\cos\left(t - \frac{\pi}{3}\right) = 0$$

2 - one correct time

$$t - \frac{\pi}{3} = \frac{\pi}{2} \text{ or } \frac{3\pi}{2}$$

1 - correct speed

$$t = \frac{5\pi}{6} \text{ or } \frac{11\pi}{6}$$

1 - for one correct time

Speed = $|\dot{x}| \therefore \pm 3 = 3 \sin\left(t - \frac{\pi}{3}\right)$

- c) Find the equation of the displacement of the particle, x , as a function of time if the particle was initially 3 metres to the left of the origin. 2

$$x = \int v dt = \int \dot{x} dt$$

2 - correct solns.

$$x = \int 3 \sin\left(t - \frac{\pi}{3}\right) dt$$

1 - correct integration

$$x = -3 \cos\left(t - \frac{\pi}{3}\right) + C$$

1 - finding constant

at $t = 0$ $x = -3$ (to the left)

$\therefore -3 = -3 \cos\left(0 - \frac{\pi}{3}\right) + C$

$C = -1.5$

$\therefore x = -3 \cos\left(t - \frac{\pi}{3}\right) - 1.5$

1 - correctly from incorrect integration

Question 13 (5 marks)

Marks

The population of the suburb of Baulkham Hills has been growing over the last few years. At the beginning of January 2019, the population was 32500 and at the beginning of January 2022 it is estimated at 37700.

- a) Assume that the population P obeys the law of natural growth $\frac{dP}{dt} = kP$, for some positive constant k , where t is number of years since the beginning of January 2019. Show that

$$P = 32500e^{kt} \text{ satisfies the equation } \frac{dP}{dt} = kP.$$

Marks

assume $P = 32500e^{kt}$ satisfies $\frac{dP}{dt} = kP$ 1 - correct solns.

$$\therefore \frac{dP}{dt} = k \times 32500e^{kt}$$

but $P = 32500e^{kt} \therefore \frac{dP}{dt} = kP$

- b) Find the value of the positive constant k . Leave your answer in exact form.

2

$$t = 0 \text{ (Jan. 2019)} \quad P = 32500$$

$$t = 3 \text{ (Jan. 2022)} \quad P = 37700$$

2 - correct solns.

$$\therefore 37700 = 32500e^{k(3)}$$

1 - significant

$$\frac{37700}{32500} = e^{3k} \quad \therefore k = \frac{1}{3} \ln \frac{377}{325}$$

progress towards full log. eqn.

$$\ln \frac{37700}{32500} = 3k \quad \text{or } k = \frac{1}{3} \ln 1.16$$

- c) Calculate the size of the population at the beginning of January 2027.

1

$$\text{Jan. 2027: } t = 8$$

$$\therefore P = 32500e^{\frac{1}{3} \ln 1.16 \times 8}$$

1 - correct

$$P = 48280.45$$

answer

$$\therefore 48280 \text{ (ignore rounding)}$$

- d) During which year will the population first exceed 55000?

1

$$\text{Trial \& error: } t = 11 \therefore P = 56005$$

$$t = 10 \therefore P = 53301$$

1 - correct

$$\text{OR: } 32500e^{\frac{1}{3} \ln 1.16} > 55000$$

solns.

$$\frac{55000}{32500} < e^{\frac{1}{3} \ln 1.16} \therefore (t > 10.63)$$

$$\therefore \text{During 2029 (2019 + 10 years)}$$

Question 14 (5 marks)

Marks

Peter borrows \$480 000 from a bank. The loan is to be repaid over 20 years in equal monthly instalments of \$ M at the end of each month, after the interest has been added. Reducible interest is charged at 4.8% p.a., calculated monthly.

Let A_n be the amount owing at the end of n months after the repayment has been made.

- a) Show that the expression of the amount owing at the end of second month, A_2 , after the repayment has been made is:

1

$$A_2 = 480000 \times 1.004^2 - 1.004M - M$$

Marks

$$A_1 = 480000 \left(1 + \frac{4.8 \div 12}{100}\right) - M$$

$$= 480000(1.004) - M$$

1 - correct solns.

$$A_2 = A_1(1.004) - M = [480000(1.004) - M] \times 1.004 - M$$

$$A_2 = 480000(1.004)^2 - 1.004M - M$$

- b) Show that $A_n = 480000 \times 1.004^n - M \left(\frac{1.004^n - 1}{0.004} \right)$.

2

$$A_3 = 480000(1.004)^3 - M(1.004)^2 - M(1.004) - M$$

2 - correct solns.

$$A_n = 480000(1.004)^n - M(1.004)^{n-1} - \dots - M(1.004) - M$$

$$A_n = 480000(1.004)^n - M[1.004^{n-1} + \dots + 1.004 + 1]$$

establishes

$$\text{G.P. } a = 1, \quad n = n, \quad r = 1.004$$

correctly the sum of G.P.

$$\therefore A_n = 480000(1.004)^n - M \times \left[\frac{1.004^n - 1}{1.004 - 1} \right]$$

$$A_n = 480000(1.004)^n - M \left[1 \times \frac{1.004^n - 1}{1.004 - 1} \right]$$

$$\therefore A_n = 480000 \times 1.004^n - M \left[\frac{1.004^n - 1}{0.004} \right]$$

c) Hence find the value of M .

2

after $n = 20 \text{ years} \times 12 \text{ months} = 240 \text{ repayments}$

$$0 = A_{240} = 480000 (1.004)^{240} - M \left[\frac{1.004^{240} - 1}{0.004} \right]$$

$$M \left[\frac{1.004^{240} - 1}{0.004} \right] = 480000 (1.004)^{240}$$

$$M = \frac{480000 (1.004)^{240}}{\left[\frac{1.004^{240} - 1}{0.004} \right]}$$

$$M = \$3114.9958...$$

$$M = \$3115$$

(ignore
rounding)

Marks

2 - correct solns.

1 - establishes

$A_{240} = 0$ as $n = 240$
and significant
progress towards
finding M

Edric deposits \$1000 into a saving account at the beginning of each year. He makes his first deposit on January 1, 2000. The investment earns compound interest at a rate of 9% p.a., compounded yearly. He makes the last deposit of \$1000 on January 1, 2025 and he withdraws all his savings at the end of 2025.

a) How much will the first \$1000 be worth at the end of 2025?

1

Marks

$$A_1 = 1000 \left(1 + \frac{9}{100}\right)^{26} = \$9399.16$$

1 - correct answer

b) Edric makes his final deposit on January 1, 2025. How much will this deposit of \$1000 be worth at the end of 2025?

1

$$A_{26} = 1000 (1.09)^1 = \$1090$$

1 - correct answer

c) Show that the total amount in the account, in dollars, at the end of 2025 is given by:

2

$$1000 \times \frac{1.09(1.09^{26} - 1)}{0.09}$$

$$\begin{aligned} \text{Total} &= A_1 + A_2 + \dots + A_{26} \\ &= 1000 (1.09)^1 + 1000 (1.09)^2 + \dots + 1000 (1.09)^{26} \\ &= 1000 [1.09^1 + 1.09^2 + \dots + 1.09^{26}] \end{aligned}$$

Sum of G.P. $n = 26$

$$\begin{aligned} \text{Total} &= 1000 \times a \frac{r^n - 1}{r - 1} \\ &= 1000 \times 1.09 \frac{(1.09)^{26} - 1}{1.09 - 1} = 1000 \frac{1.09(1.09^{26} - 1)}{0.09} \end{aligned}$$

2 - correct soln.
1 - correctly establishes G.P.

d) Calculate the total interest that Edric will have earned by the end of 2025.

1

$$\text{Total} = \$101723.13$$

$$\text{He invested} = \$1000 \times 26 = 26000$$

$$\therefore \text{interest} = \text{Total} - \text{invested money} = \$75723.13$$

1 - correct solns