
Student Number

2022 Glenwood High School
Year 12 - Trial HSC Examination

Mathematics Advanced

General Instructions

- Reading Time – 10 minutes
- Working time – 3 hours
- Write using black pen
- NESA approved calculators may be used
- A reference sheet will be provided
- For questions in Section II, show relevant mathematical reasoning and/or calculations

Total marks: 100

Section I – 10 marks (pages 2 – 7)

- Attempt Questions 1- 10
- Allow about 15 minutes for this section

Section II – 90 marks (pages 9 – 40)

- Attempt Questions 11 – 34
- Allow about 2 hours and 45 minutes for this section

Section I

10 marks
Attempt Questions 1–10
Allow about 15 minutes for this section

Use the multiple-choice answer sheet for Questions 1 – 10

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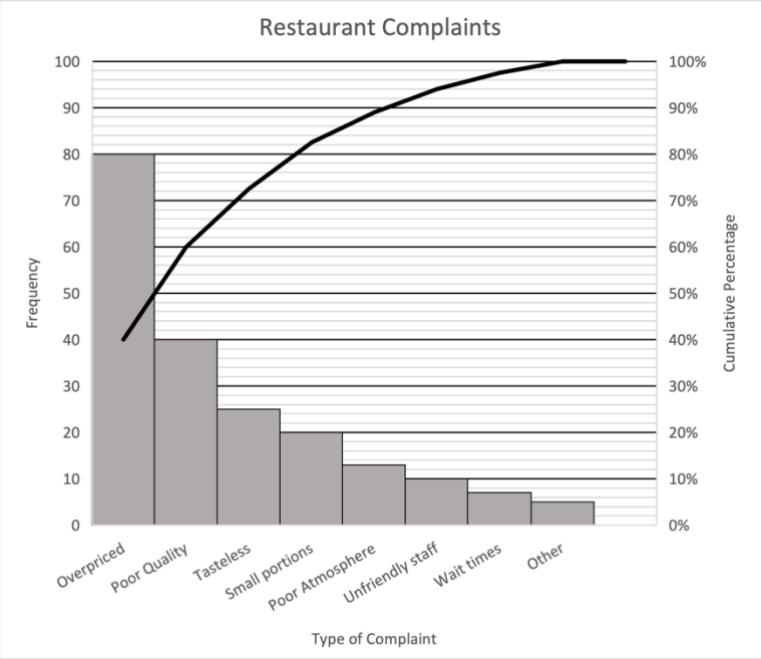
1. The Pareto chart below shows the frequency of types of complaints received by a restaurant.



What percentage of complaints were for poor quality?

A. 20%
B. 40%
C. 60%
D. 80%

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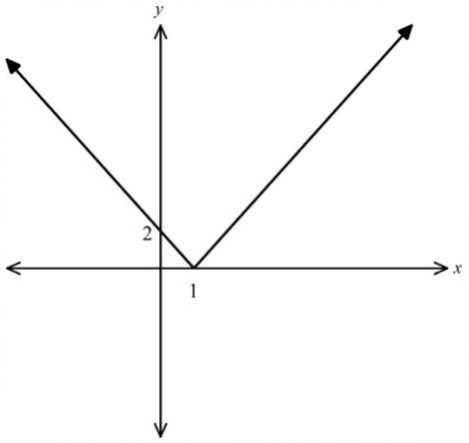
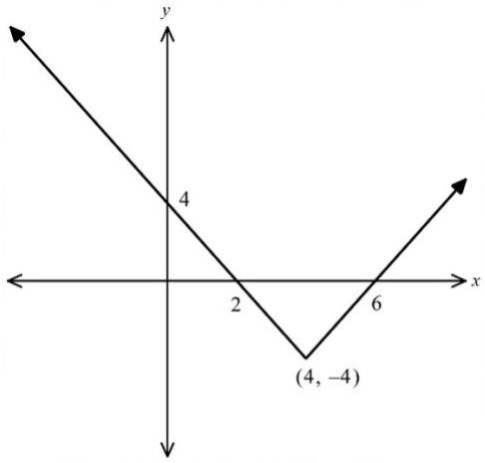
2. The graph of $y = f(x)$ is shown below.

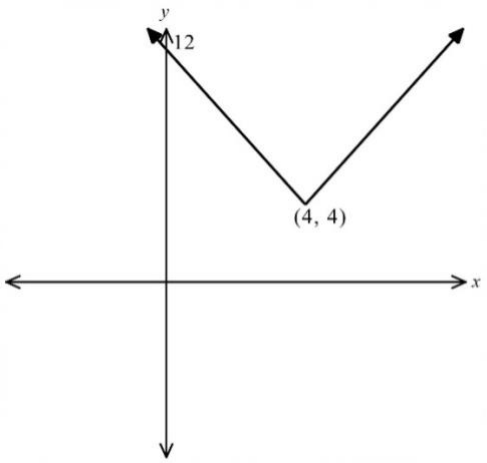


Which of the graphs below represents $y = f(x + 3) + 4$?

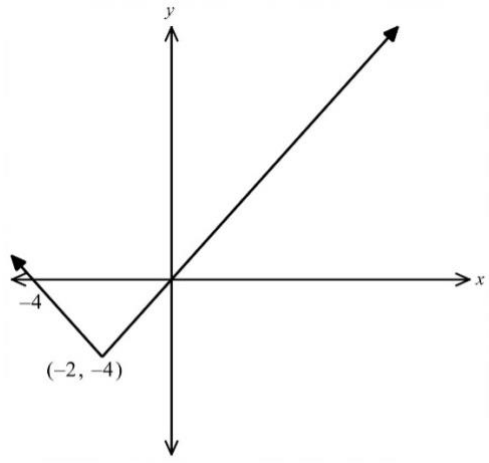
A.



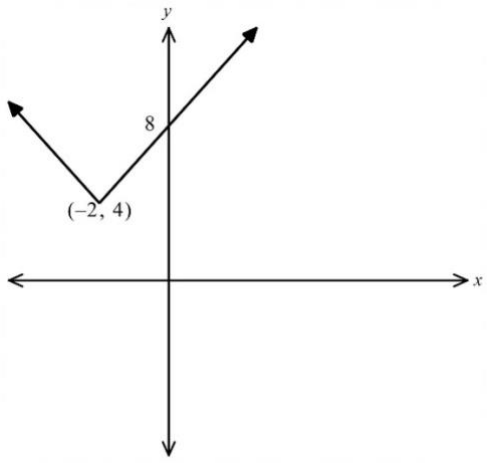
B.



C.



D.



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3. The stem and leaf plot shows the number of shots needed to complete a game of pool on two tables. Twenty games were played on each table.

Table A							Table B				
			7	6	4	**0**	6	8			
		8	4	4	1	**1**	2	6	7	7	
8	8	7	7	5	3	**2**	0	2	3	4	4
		6	5	5	4	**3**	1	3	5		
				2	1	**4**	5	5	6	8	9
						5					
					9	**6**	9				

Is the result of 69 shots an outlier for either of the tables?

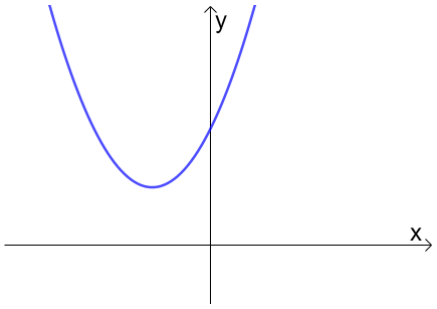
A. No, it isn't for either table.

B. Yes, for Table A only

C. Yes, for Table B only

D. Yes, for both tables

4. The diagram shows the graph of $y = x^2 + bx + 2$



Which of the following could be the value of b?

A. 2

B. -2

C. 3

D. -3

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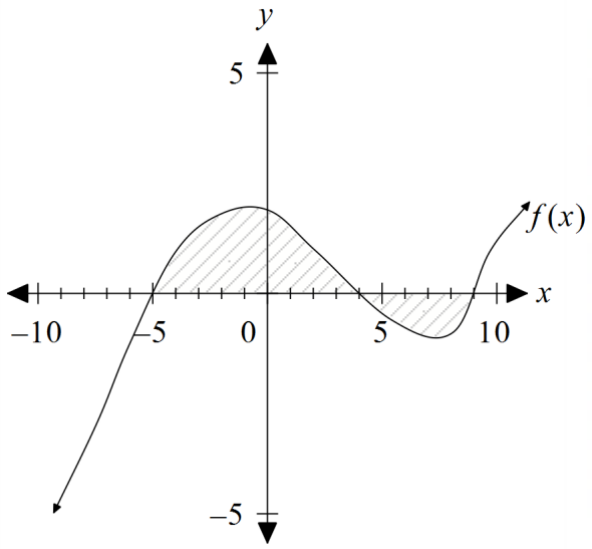
5. The curve shown in the graph has x-intercepts at -5, 4, and 9. Which of the following integrals would NOT give the shaded area under the curve?



A. $A = \int_{-5}^{4} f(x)\,dx + \left|\int_{4}^{9} f(x)\,dx\right|$

B. $A = \int_{-5}^{4} f(x)\,dx - \int_{4}^{9} f(x)\,dx$

C. $A = \left|\int_{-5}^{9} f(x)\,dx\right|$

D. $A = \int_{-5}^{4} f(x)\,dx + \int_{9}^{4} f(x)\,dx$

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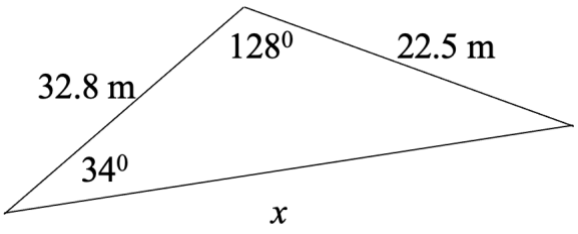
6. The correct value for x is:



NOT TO SCALE

A. $x = 22.5 \times \sin 34° \div \sin 128°$

B. $x = 22.5 \times \sin 128° \div \sin 34°$

C. $x = \sqrt{22.5^2 + 32.8^2 - 2 \times 22.5 \times 32.8 \times \cos 18°}$

D. $x = \sqrt{22.5^2 + 32.8^2 - 2 \times 22.5 \times 32.8 \times \cos 34°}$

7. What is the gradient of the tangent to the function $y = \cos^2 x$ at $x = \frac{\pi}{6}$?

A. -1

B. $\frac{1}{2}$

C. $\sqrt{3}$

D. $-\frac{\sqrt{3}}{2}$

8. Which of the following represents the domain of the function $f(x) = \frac{1}{\ln(x-2)}$?

A. $[2, \infty)$

B. $(2, \infty)$

C. $(2,3) \cup (3, \infty)$

D. $(3, \infty)$

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9. It is known that $f(x)$ is an odd function and $g(x)$ is an even function.

Given that $f(2) = 2$ and $g(2) = -2$, what is the value of $f\big(g(-2)\big) + g\big(f(-2)\big)$?

A. -4

B. -2

C. 0

D. 4

10. If $y = log_2 4x$ then $\frac{dy}{dx} =$

A. $\dfrac{log_e 4x}{log_e 8}$

B. $\dfrac{1}{x log_e 2}$

C. $\dfrac{log_e 2x}{log_e 2}$

D. $\dfrac{log_e 4}{log_e 2x}$

END OF SECTION I

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2022 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Student Number

Mathematics Advanced

Section II Answer Booklet 1

90 marks
Attempt Questions 11 – 34
Allow about 2 hour and 45 minutes for this section

Booklet 1 — Attempt Questions 11–28 (62 marks)

Booklet 2 — Attempt Questions 29–34 (28 marks)

Instructions

- Write your Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of responses.
- Your responses should include relevant mathematical reasoning and/or calculations.
- Extra writing space is provided on pages 25-28 of Booklet 1. If you use this space, clearly indicate which question you are answering.

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Question 11 (2 marks)

Express $\frac{2x}{x^2-4} - \frac{x+1}{x^2-x-2}$ as a single algebraic fraction, in simplest form. **2**

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Question 12 (5 marks)

Find the following derivatives.

(a) $\frac{d}{dx}\left(3x^5 + \frac{2}{x^3} - 4\sqrt{x}\right)$ **2**

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Question 12 continues on page 11

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Question 12 (continued)

(b) $\frac{d}{dx}\left(\frac{e^x \cos(2x)}{x^2}\right)$ **3**

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Question 13 (2 marks)

Find the following integral **2**

$$\int \frac{6(x-4)}{x^2-8x}\,dx$$

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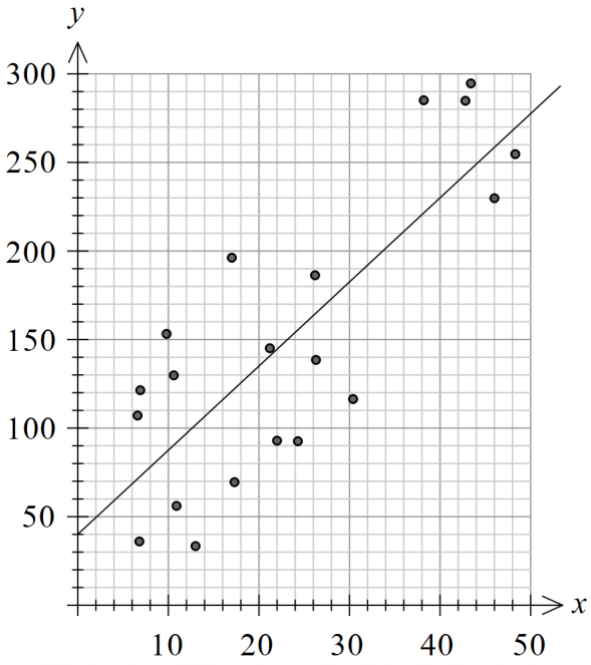
Question 14 (5 marks)

An environmental scientist is studying the results of bushland rehabilitation on native species. The scatterplot shows x, the number of native trees planted in various rehabilitated sites, and y, the number of native species present in that area. The least-squares regression line is shown on the scatterplot.



(a) Use the least squares regression line to estimate the number of the native species present in an area with 30 native trees planted. **1**

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(b) What is the equation of the least-squares regression line? **2**

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Question 14 continues on page 13

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Question 14 (continued)

(c) Hence or otherwise, predict the number of native trees that should be planted for approximately 410 native species to be present in the area. **2**

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Question 15 (3 marks)

The population of a seal colony varies according to the equation

$$P = 100 \sin\left(\frac{\pi t}{6}\right) + 300$$

where t is in months.

(a) Find the maximum and minimum populations of the colony. **1**

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(b) Find the number of months it takes for the population to vary from the maximum population to the minimum population. **2**

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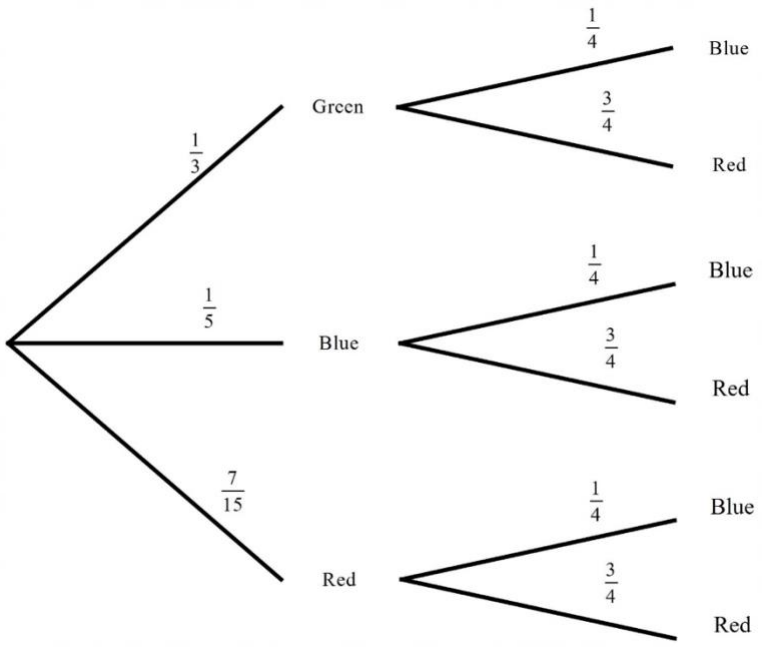
Question 16 (3 marks)

An artist has two boxes of paints beside his easel. The first box contains 15 tubes which contain green, red or blue paint and the second contains four tubes which have only red or blue paint.

The artist chooses one tube of paint from each box.

The tree diagram below shows the probabilities of him choosing a given colour.



(a) What is the probability that the two tubes he chooses are red and blue? **1**

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(b) What is the probability that the tubes he chooses are not the same colour? **2**

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Question 17 (4 marks)

The present value of an annuity of \$1 for various interest rates and periods is shown in the table.

Present Value of an Annuity of \$1

	Interest Rate per period					
Periods	0.25%	0.50%	0.75%	1.00%	2.00%	3.00%
3	2.9851	2.9702	2.9556	2.9410	2.8839	2.8286
6	5.9478	5.8964	5.8456	5.7955	5.6014	5.4172
9	8.8885	8.7791	8.6716	8.5660	8.1622	7.7861
12	11.8073	11.6189	11.4349	11.2551	10.5753	9.9540
24	23.2660	22.5629	21.8891	21.2434	18.9139	16.9355
36	34.3865	32.8710	31.4468	30.1075	25.4888	21.8323
48	45.1787	42.5803	40.1848	37.9740	30.6731	25.2667

(a) Find the amount, to the nearest cent, that must be invested quarterly at an interest rate of 3% p.a. compounded quarterly for 6 years, that would have a present value of \$20,000. **2**

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(b) Find the future value of an annuity of \$1,000 invested monthly at 0.5% interest compounded monthly for 1 year. **2**

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Question 18 (2 marks)

The function $f(x) = 4tan^3x$ is given. **2**

If $f'(x) = 12\tan^2 x\left(1+\tan^m x\right)$, find the value of m.

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Question 19 (3 marks)

The table below shows the probability distribution of a random variable X.

X	2	3	4	5
$P(X)$	0.4	0.1	0.27	0.23

(a) Calculate $E(X)$. **1**

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(b) Calculate $Var(X)$. **2**

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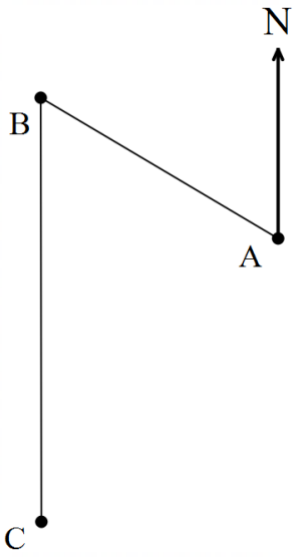
Question 20 (6 marks)

A plane flies 145 km from point A to point B on a bearing of 305°.
The plane then flies 208 km due south to point C before returning to point A.



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(a) Complete the diagram with the information provided and find $\angle ABC$. **2**

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(b) Find the distance the plane must travel from point C to return to point A, correct to the nearest kilometre. **2**

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(c) What is the three-figure bearing from point C to point A? **2**

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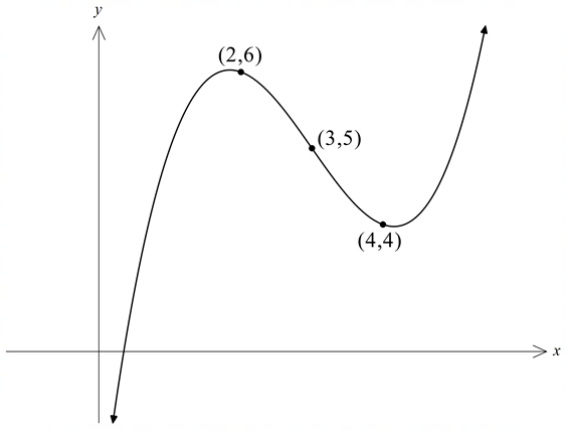
Question 21 (2 marks)

The graph of $y = f(x)$ is shown.



Use two applications of the trapezoidal rule to find an approximation for

$$\int_2^4 f(x)\,dx$$

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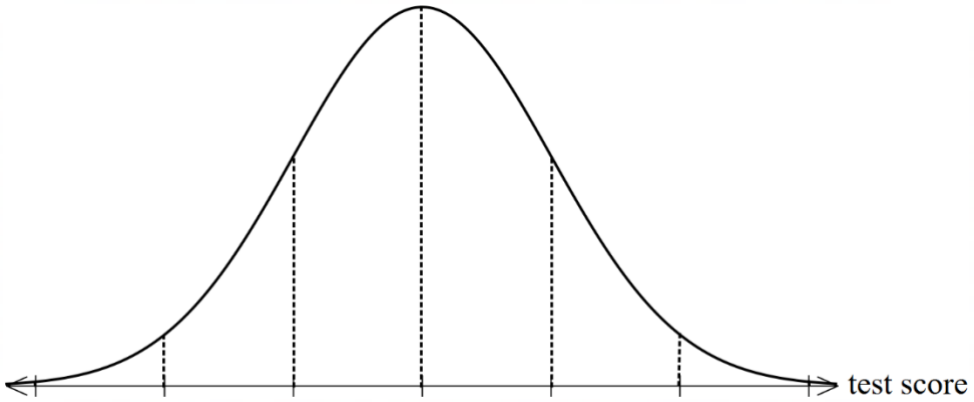
Question 22 (4 marks)

Marks on an aptitude test are normally distributed with a mean of 100 and a standard deviation of 15.

A normal distribution curve is shown below, where the vertical lines represent z-scores from -3 to 3.



(a) For the normal distribution curve above, label the corresponding test marks (not z-scores) along the horizontal axis. **1**

(b) Shade under the normal distribution curve where (approximately) the top 20% of scores lie. **1**

(c) Hae-Won took the test and her z-score was 0.5. She needs to score in the top 20% in order to enrol in a training program. **2**

If she studies, retakes the test, and her test score increases by 10 marks, will she be able to enrol? Justify your answer with calculations.

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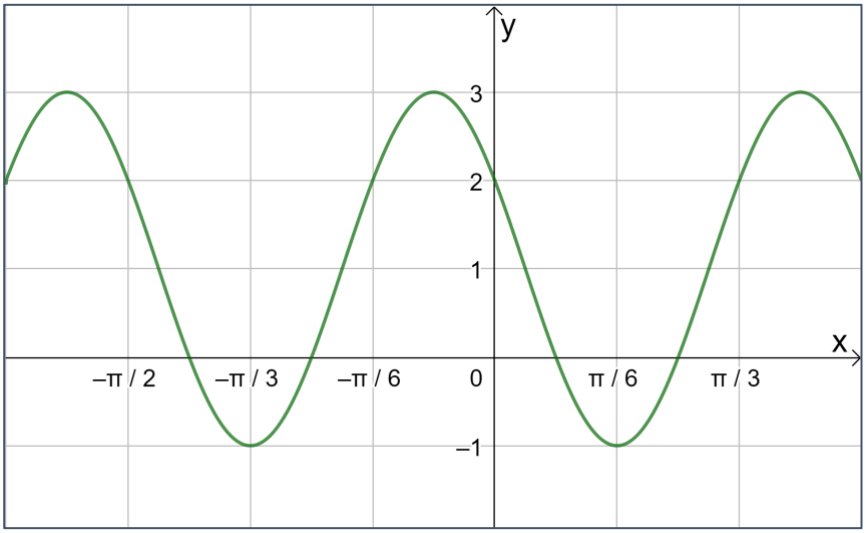
Question 23 (5 marks)

The diagram shows the graph of $y = a\cos(bx + c) + d$.



(a) State the range. **1**

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(b) State the period. **1**

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(c) Find the values of a, b, c and d. **3**

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Question 24 (3 marks)

Describe the three transformations which, when applied in order, transforms the graph of $y = 2\sin x$ to the graph with equation $y = \sin\left(\frac{x+\pi}{3}\right)$. **3**

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Question 25 (3 marks)

Prove that **3**

$$\frac{1+\tan^2 x}{1+\cot^2 x} = \tan^2 x$$

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Questions 11 – 25 are worth 52 marks in total

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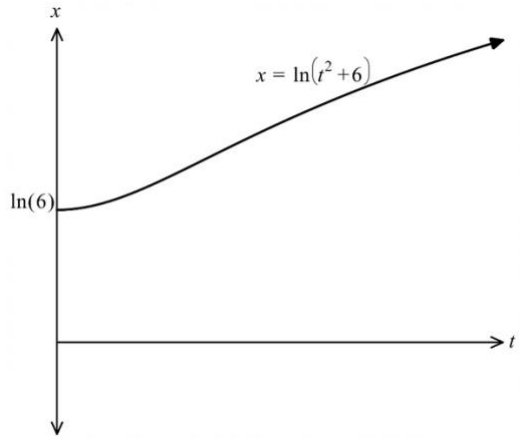
Question 26 (3 marks)

A particle moves on the *x*-axis so that it's displacement in metres from the origin at a time *t* second is given by the equation $x = \ln(t^2 + 6)$.

The particle starts from rest at the point $x = \ln(6)$ and accelerates in a positive direction as shown in the distance-time graph below.



Find the time when the acceleration of the particle is zero and the velocity at this time. **3**

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Question 27 (4 marks)

(a) Show that $\frac{d}{dx}(3x^2e^{2x+1}) = 6xe^{2x+1}\ (x+1)$ **2**

(b) Hence evaluate $\int_1^2 x(x+1)e^{2x+1}\ dx$. **2**

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Question 28 (3 marks)

A random variable Z is normally distributed with mean 0 and standard deviation 1. **3**

The table gives the probability of this random variable being greater than different values of z.

z	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2
$P(Z > z)$	0.5	0.4013	0.3085	0.2266	0.1587	0.1057	0.668	0.0401	0.0228

In a hospital of 3125 patients, it is found that 708 patients have a body temperature higher than $36.8℃$. The body temperatures are distributed normally with a mean μ and standard deviation $0.3℃$.

Using the given table, find the value of μ, correct to two decimal places.

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Proceed to Booklet 2 for Questions 29-34

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2022 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Student Number

Mathematics Advanced

Section II Answer Booklet 2

Booklet 2 — Attempt Questions 29–34 (28 marks)

Instructions

- Write your Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of responses.
- Your responses should include relevant mathematical reasoning and/or calculations.
- Extra writing space is provided on pages 39-40 of Booklet 2. If you use this space, clearly indicate which question you are answering.

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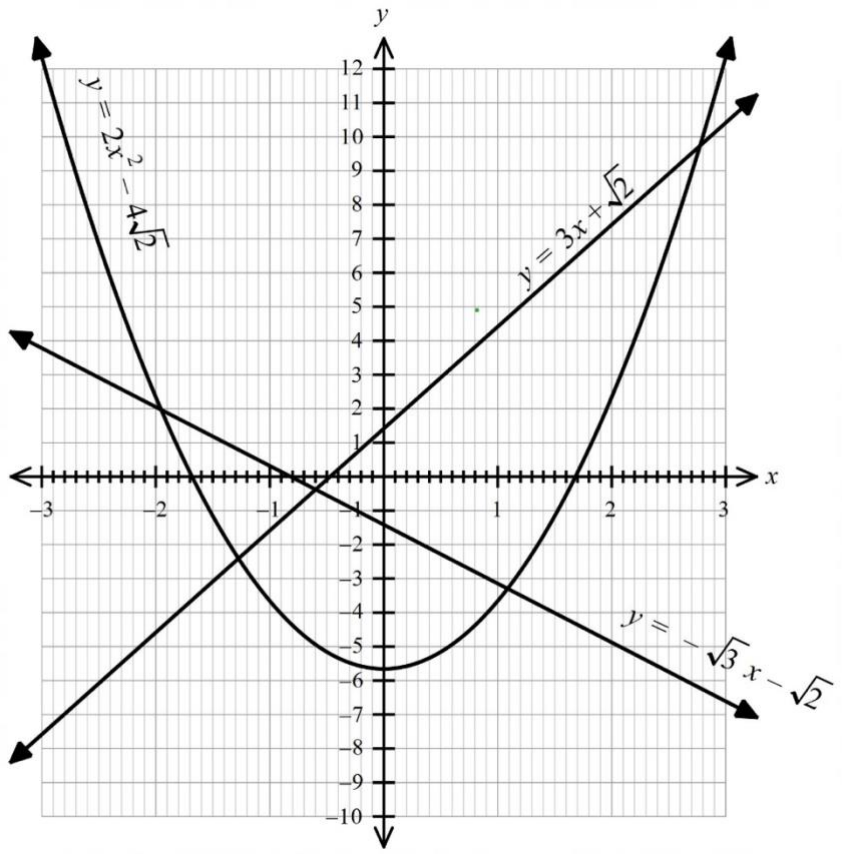
Question 29 (4 marks)

The diagram below shows the graphs of $y = 3x + \sqrt{2}$, $y = -\sqrt{3}\,x - \sqrt{2}$ and $y = 2x^2 - 4\sqrt{2}$.



Use the graph to find the solution to the following inequalities, giving your answer correct to the nearest tenth.

(a) $3x + \sqrt{2} > 2x^2 - 4\sqrt{2}$ **2**

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(b) $2x^2 + \sqrt{3}\,x - 3\sqrt{2} \geq 0$ **2**

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Question 30 (6 marks)

Find and classify the nature of any stationary points and points of inflection (horizontal or otherwise) for the function $y = 12x^5 - 15x^4 - 40x^3$. **6**

Hence, sketch the graph of the function, clearly labelling any stationary points, points of inflection and intercepts.

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Working space for Question 30 continues next page

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Question 30 (continued)

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Question 31 (4 marks)

The volume of a pond decreases during a period of no rain.

The volume in the pond, V, after t days can be modelled by the equation

$$V = V_0 e^{-kt}$$

where V_0 is the initial volume of the pond.

(a) Given that it takes 10 days for the volume of the pond to halve, show that $k \approx 0.0693$. **3**

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(b) If there is 30 megalitres (ML) in the pond after 7 days, calculate the initial volume of the pond, to the nearest ML. **1**

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Question 32 (4 marks)

A continuous random variable X has a probability density function $f(x)$ given by **4**

$$f(x) = \begin{cases} Ax + B, & 1 \leq x \leq 6 \\ 0, & otherwise \end{cases}$$

where A and B are constants.

The median of X is 3. Find the values of A and B.

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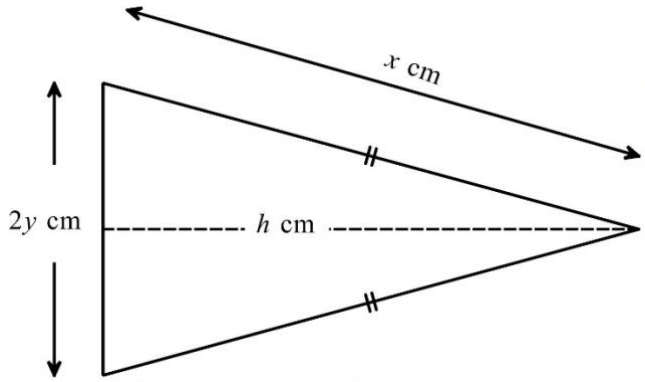
Question 33 (6 marks)

A banner is designed as an isosceles triangle, with equal sides of length x cm and base of length $2y$ cm, as shown.



The total perimeter of the triangle is 40 cm.

(a) Show that the area of the triangle in terms of x can written as: **2**

$$A = (20 - x)\,(40x - 400)^{\frac{1}{2}}$$

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Question 33 continues on page 36

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Question 33 (continued)

(b) Find the values of x and y which gives the largest possible area for the banner, showing why this is the maximum area. **4**

Hence, find this area.

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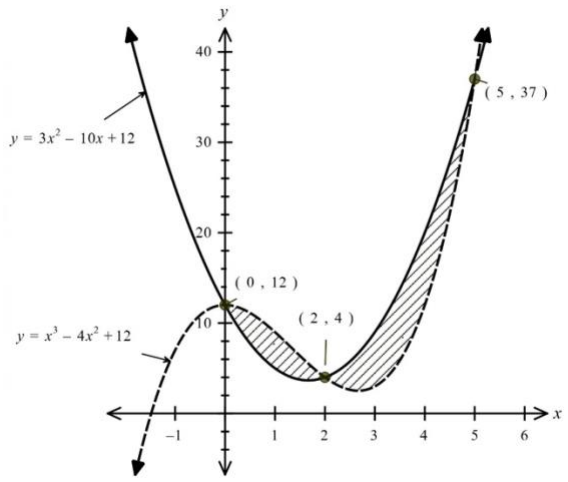
Question 34 (4 marks)

The curves $y = x^3 - 4x^2 + 12$ and $y = 3x^2 - 10x + 12$ intersect at the points $(0, 12)$, $(2, 4)$ and $(5, 37)$ as shown on the graph below. **4**



Calculate the total shaded area enclosed between the two curves.

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Question 34 (continued)

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Section II Extra writing space

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Section II Extra writing space

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Solution

Student Number

2022 Glenwood High School
Year 12 Trial HSC Examination
Assessment Task 4

Mathematics Advanced

General Instructions

- Reading Time – 10 minutes
- Working time – 3 hours
- Write using black pen
- NESA approved calculators may be used
- A reference sheet will be provided
- For questions in Section II, show relevant mathematical reasoning and/or calculations

Total marks: 100

Section I – 10 marks (pages 2 – 7)

- Attempt Questions 1- 10
- Allow about 15 minutes for this section

Section II – 90 marks (pages 9 – 40)

- Attempt Questions 11 – 34
- Allow about 2 hours and 45 minutes for this section

Section I

10 marks
Attempt Questions 1–10
Allow about 15 minutes for this section

Use the multiple-choice answer sheet for Questions 1 – 10

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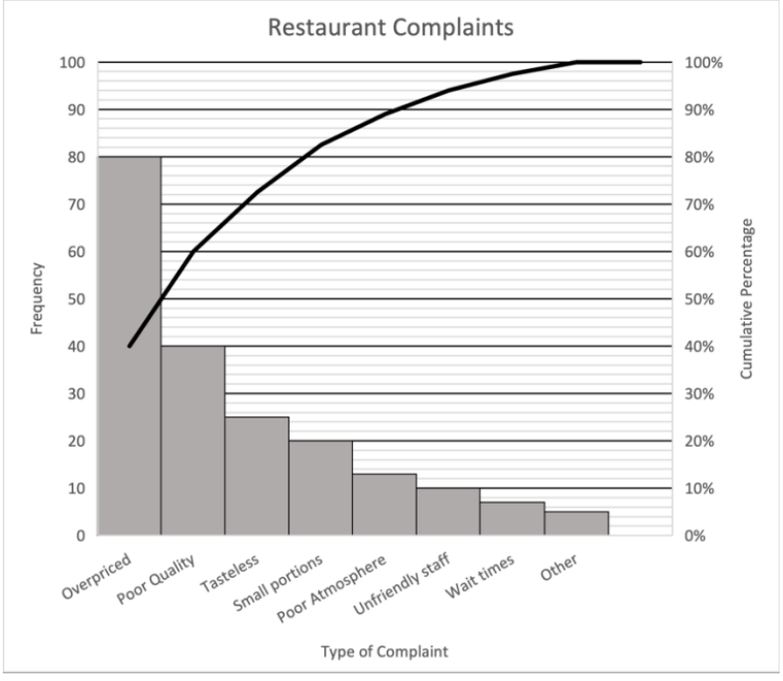
1. The pareto chart below shows the frequency of types of complaints received by a restaurant.



What percentage of complaints were for poor quality?

A. 20%
B. 40%
C. 60%
D. 80%

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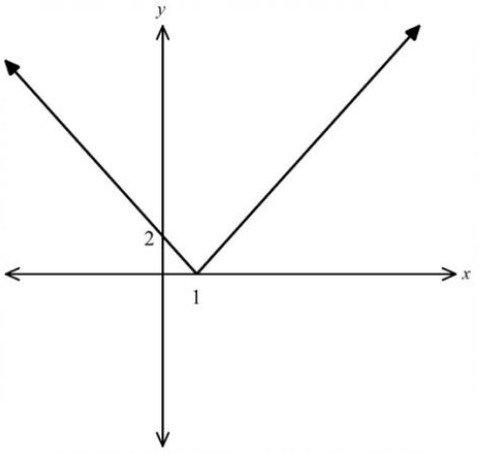
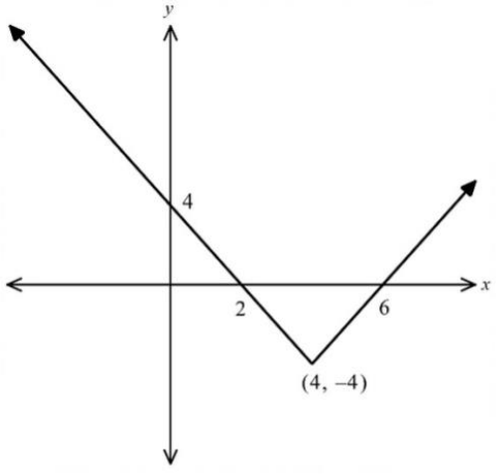
2. The graph of $y = f(x)$ is shown below.

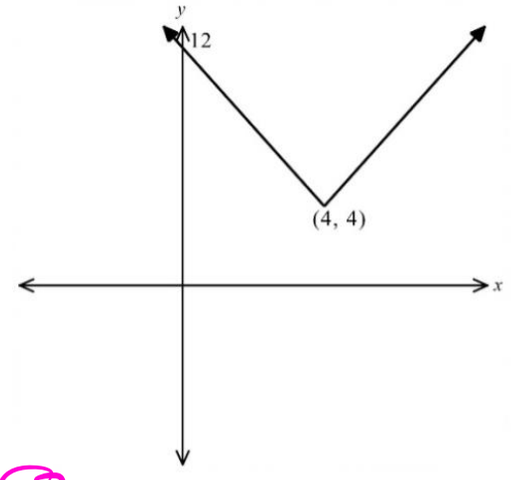


Which of the graphs below represents $y = f(x + 3) + 4$?

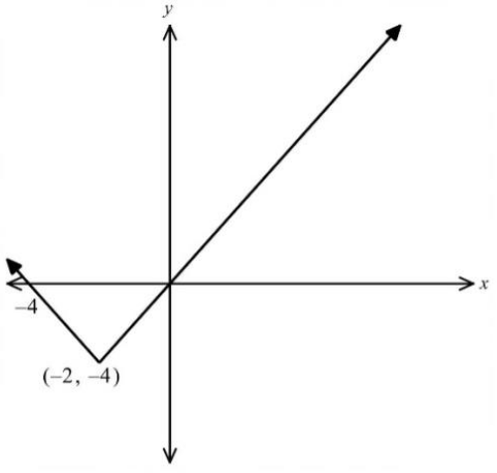
A.



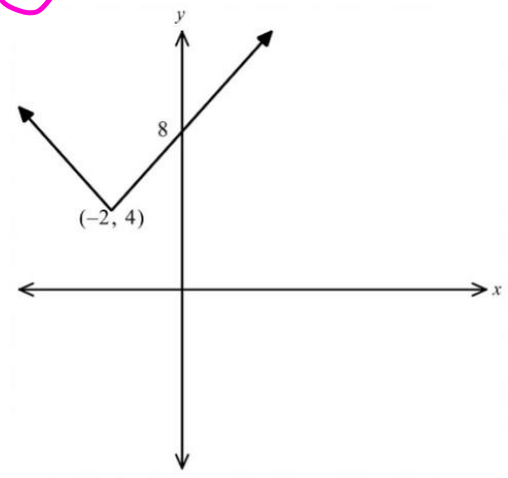
B.



C.



D.



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3. The stem and leaf plot shows the number of shots needed to complete a game of pool on two tables. Twenty games were played on each table.

Table A							Table B				
			7	6	4	**0**	6	8			
		8	4	4	1	**1**	2	6	7	7	
8	8	7	7	5	3	**2**	0	2	3	4	4
		6	5	5	4	**3**	1	3	5		
				2	1	**4**	5	5	6	8	9
						5					
					9	**6**	9				

Is the result of 69 shots an outlier for either of the tables?

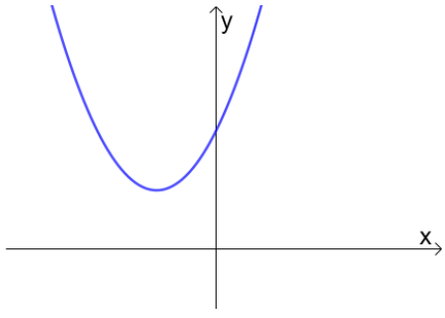
A. No, it isn't for either table.

B. Yes, for Table A only

C. Yes, for Table B only

D. Yes, for both tables

4. The diagram shows the graph of $y = x^2 + bx + 2$



Which of the following could be the value of b?

A. 2

B. -2

C. 3

D. -3

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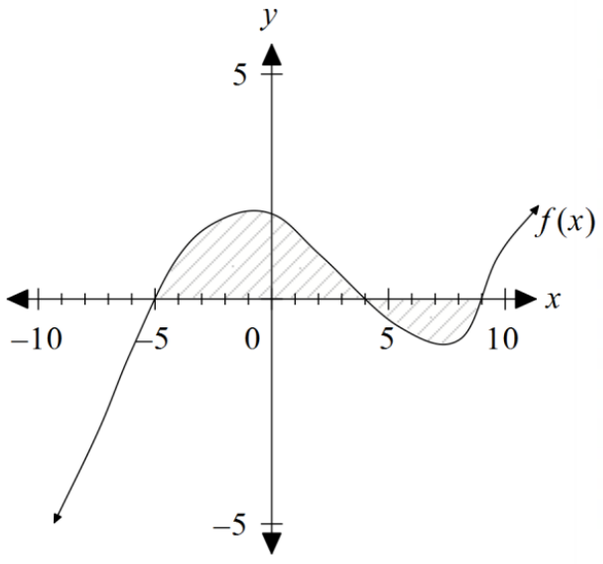
5. The curve shown in the graph has x-intercepts at -5, 4, and 9. Which of the following integrals would NOT give the shaded area under the curve?



A. $A = \int_{-5}^{4} f(x)\,dx + \left|\int_{4}^{9} f(x)\,dx\right|$

B. $A = \int_{-5}^{4} f(x)\,dx - \int_{4}^{9} f(x)\,dx$

C $A = \left|\int_{-5}^{9} f(x)\,dx\right|$

D. $A = \int_{-5}^{4} f(x)\,dx + \int_{9}^{4} f(x)\,dx$

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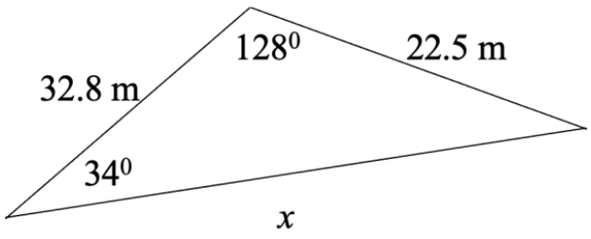
6. The correct value for x is:



NOT TO SCALE

A. $x = 22.5 \times \sin 34° \div \sin 128°$

B. $x = 22.5 \times \sin 128° \div \sin 34°$

C. $x = \sqrt{22.5^2 + 32.8^2 - 2 \times 22.5 \times 32.8 \times \cos 18°}$

D. $x = \sqrt{22.5^2 + 32.8^2 - 2 \times 22.5 \times 32.8 \times \cos 34°}$

7. What is the gradient of the tangent to the function $y = \cos^2 x$ at $x = \frac{\pi}{6}$?

A. -1

B. $\frac{1}{2}$

C. $\sqrt{3}$

D. $-\frac{\sqrt{3}}{2}$

8. Which of the following represents the domain of the function $f(x) = \frac{1}{\ln(x-2)}$?

A. $[2,\infty)$

B. $(2,\infty)$

C. $(2,3) \cup (3,\infty)$

D. $(3,\infty)$

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9. It is known that $f(x)$ is an odd function and $g(x)$ is an even function.

Given that $f(2) = 2$ and $g(2) = -2$, what is the value of $f\big(g(-2)\big) + g\big(f(-2)\big)$?

A. -4

B. -2

C. 0

D. 4

10. If $y = log_2 4x$ then $\frac{dy}{dx} =$

A. $\frac{log_e 4x}{log_e 8}$

B. $\frac{1}{x log_e 2}$

C. $\frac{log_e 2x}{log_e 2}$

D. $\frac{log_e 4}{log_e 2x}$

END OF SECTION I

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2022 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Student Number

Mathematics Advanced

Section II Answer Booklet 1

90 marks
Attempt Questions 11 – 34
Allow about 2 hour and 45 minutes for this section

Booklet 1 — Attempt Questions 11–28 (62 marks)

Booklet 2 — Attempt Questions 29–34 (28 marks)

Instructions

- Write your Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of responses.
- Your responses should include relevant mathematical reasoning and/or calculations.
- Extra writing space is provided on pages 25-28 of Booklet 1. If you use this space, clearly indicate which question you are answering.

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Question 11 (2 marks)

Express $\frac{2x}{x^2-4} - \frac{x+1}{x^2-x-2}$ as a single algebraic fraction, in simplest form. **2**

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

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

$= \frac{2x-(x+2)}{(x+2)(x-2)}$

$= \frac{(x-2)}{(x+2)(x-2)}$

$= \frac{1}{x+2}$

Question 12 (5 marks)

Find the following derivatives.

(a) $\frac{d}{dx}\left(3x^5 + \frac{2}{x^3} - 4\sqrt{x}\right)$ **2**

$= \frac{d}{dx}\left(3x^5 + 2x^{-3} - 4x^{1/2}\right)$

$= 15x^4 - 6x^{-4} - 2x^{-1/2}$

$= 15x^4 - \frac{6}{x^4} - \frac{2}{\sqrt{x}}$

Question 12 continues on page 11

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Question 12 (continued)

(b) $\frac{d}{dx}\left(\frac{e^x \cos(2x)}{x^2}\right)$ **3**

$u = e^x$
$u' = e^x$
$v = \cos 2x$
$v' = -2\sin 2x$

$\frac{d}{dx}(e^x \cos 2x)$
$= e^x \cos 2x - 2e^x \sin 2x.$

$u = e^x \cos 2x$
$u' = e^x \cos 2x - 2e^x \sin 2x$
$v = x^2$
$v' = 2x$

$\frac{d}{dx}\left(\frac{e^x \cos(2x)}{x^2}\right) = \frac{(e^x \cos 2x - 2e^x \sin 2x)x^2 - 2xe^x \cos 2x}{x^4}$

$= \frac{e^x(x\cos 2x - 2\sin 2x - 2\cos 2x)}{x^3}$

Question 13 (2 marks)

Find the following integral **2**

$$\int \frac{6(x-4)}{x^2-8x}\,dx$$

$= \int \frac{6x-24}{x^2-8x}\,dx$

$= \int \frac{3(2x-8)}{x^2-8x}\,dx$

$= 3\ln(x^2-8x) + C$

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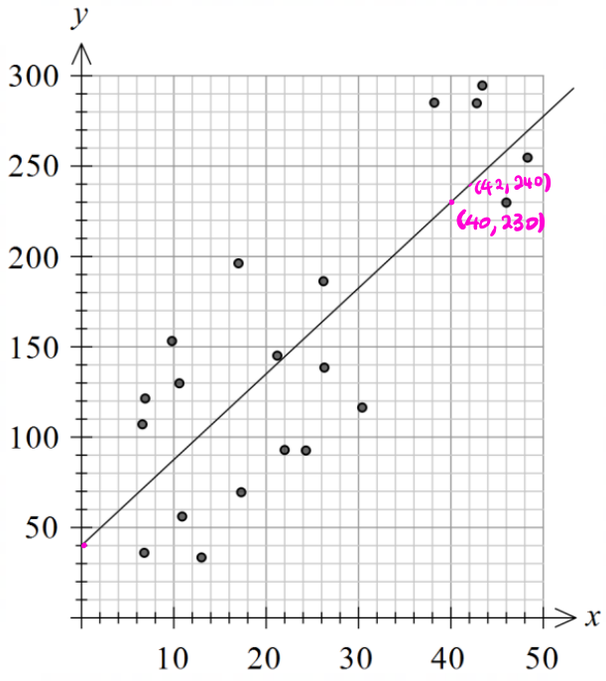
Question 14 (5 marks)

An environmental scientist is studying the results of bushland rehabilitation on native species. The scatterplot shows x, the number of native trees planted in various rehabilitated sites, and y, the number of native species present in that area. The least-squares regression line is shown on the scatterplot.



(a) Use the least squares regression line to estimate the number of the native species present in an area with 30 native trees planted. **1**

180

(b) What is the equation of the least-squares regression line? **2**

gradient $m = \frac{230-40}{40}$ y-intercept = 40

$m = \frac{19}{4}$ OR $m = \frac{240-230}{42-40}$

$m = \frac{10}{2}$

$y = \frac{19}{4}x + 40$ $= 5$

$y = 5x + 40$

Question 14 continues on page 13

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Question 14 (continued)

(c) Hence or otherwise, predict the number of native trees that should be planted for approximately 410 native species to be present in the area. **2**

$y = \frac{19}{4}x + 40$ OR $y = 5x + 40$

$410 = 5x + 40$

$410 = \frac{19}{4}x + 40$

$5x = 370$

$x = 74$

$\frac{19}{4}x = 370$

$x \approx 78$

Question 15 ~~(2~~ 3 marks)

The population of a seal colony varies according to the equation

$$P = 100\sin\left(\frac{\pi t}{6}\right) + 300$$

where t is in months.

(a) Find the maximum and minimum populations of the colony. **1**

Max = 400 max occurs when $\sin\theta = 1$

Min = 200 $\theta = \pi/2 \Rightarrow \frac{\pi t}{6} = \pi/2 \Rightarrow t = 3$

min occurs when $\sin\theta = -1$

$\theta = \frac{3\pi}{2} \Rightarrow \frac{\pi t}{6} = \frac{3\pi}{2} \Rightarrow t = 9$

(b) Find the number of months it takes for the population to vary from the maximum population to the minimum population. ~~1~~ 2.

$P = \frac{2\pi}{\pi/6} = 12$ From a) $t = 9 - 3$

$= 6$

6 months between maximum and minimum.

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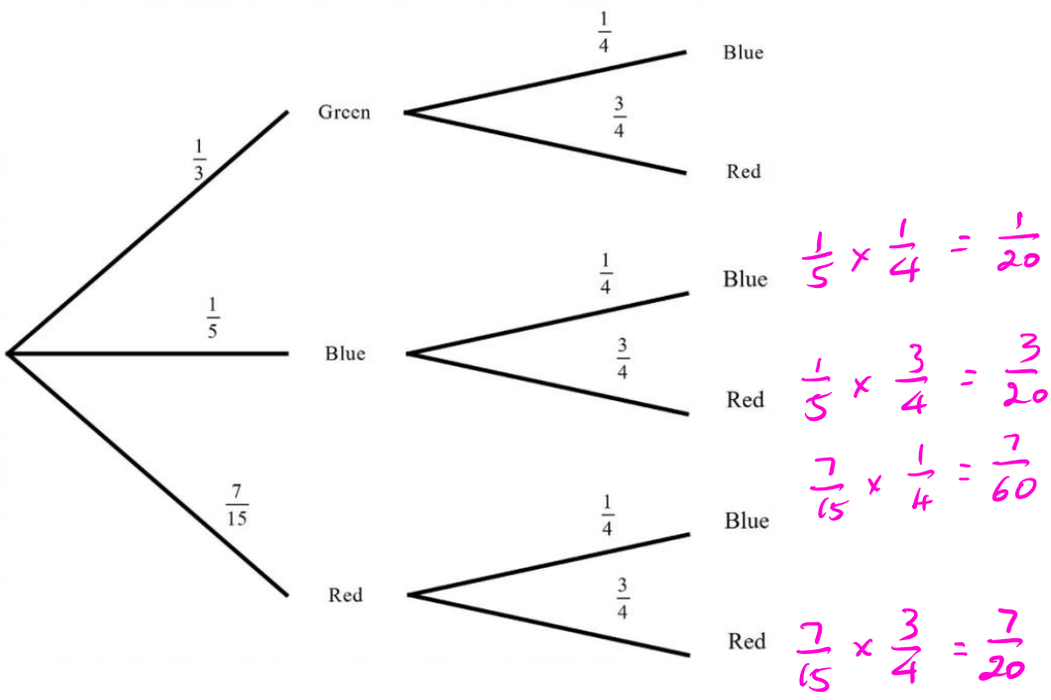
Question 16 (3 marks)

An artist has two boxes of paints beside his easel. The first box contains 15 tubes which contain green, red or blue paint and the second contains four tubes which have only red or blue paint.

The artist chooses one tube of paint from each box.

The tree diagram below shows the probabilities of him choosing a given colour.



(a) What is the probability that the tubes he chooses are red and blue? **1**

$P(R \text{ and } B) = P(RB) + P(BR)$

$= \frac{7}{60} + \frac{3}{20}$

$= \frac{16}{60} = \frac{4}{15}$

(b) What is the probability that the tubes he chooses are not the same colour? **2**

$P(\text{same}) = P(RR) + P(BB)$

$= \frac{7}{20} + \frac{1}{20}$

$= \frac{8}{20}$

$P(\text{not same}) = 1 - P(\text{same})$

$= 1 - \frac{8}{20}$

$= \frac{3}{5}$

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Question 17 (4 marks)

The present value of an annuity of $1 for various interest rates and periods is shown in the table.

Present Value of an Annuity of $1

	Interest Rate per period					
Periods	0.25%	0.50%	0.75%	1.00%	2.00%	3.00%
3	2.9851	2.9702	2.9556	2.9410	2.8839	2.8286
6	5.9478	5.8964	5.8456	5.7955	5.6014	5.4172
9	8.8885	8.7791	8.6716	8.5660	8.1622	7.7861
12	11.8073	11.6189	11.4349	11.2551	10.5753	9.9540
24	23.2660	22.5629	21.8891	21.2434	18.9139	16.9355
36	34.3865	32.8710	31.4468	30.1075	25.4888	21.8323
48	45.1787	42.5803	40.1848	37.9740	30.6731	25.2667

(a) Find the amount, to the nearest cent, that must be invested quarterly at an interest rate of 3% p.a. compounded quarterly for 6 years that would have a present value of $20,000. **2**

$r = 0.75\%$ $n = 24$

$IF = 21.8891$

$20000 = A \times 21.8891$

$A = \$913.70$

(b) Find the future value of an annuity of $1,000 invested monthly at 0.5% interest compounded monthly for 1 year. **2**

$r = 0.5\%$ $n = 12$

$IF = 11.6189$

$PV = 1000 \times 11.6189$

$= \$11618.90$

$FV = PV(1+r)^n$

$= 11618.90(1+0.005)^{12}$

$= \$12\,335.53$

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Question 18 (2 marks)

The function $f(x) = 4tan^3x$ is given. **2**

If $f'(x) = 12\tan^2 x\left(1+\tan^m x\right)$, find the value of m.

$f(x) = 4(\tan x)^3$

$f'(x) = 12\tan^2 x \sec^2 x$

$= 12\tan^2 x (1 + \tan^2 x)$

$m = 2$

Question 19 (3 marks)

The table below shows the probability distribution of a random variable X.

X	2	3	4	5
$P(X)$	0.4	0.1	0.27	0.23

(a) Calculate $E(X)$. **1**

$E(X) = 2\times0.4 + 3\times0.1 + 4\times0.27 + 5\times0.23$

$= 3.33$

(b) Calculate $Var(X)$. **2**

$Var(X) = E(X^2) - [E(X)]^2$

$= 2^2\times0.4 + 3^2\times0.1 + 4^2\times0.27 + 5^2\times0.23 - (3.33)^2$

$= 1.48$

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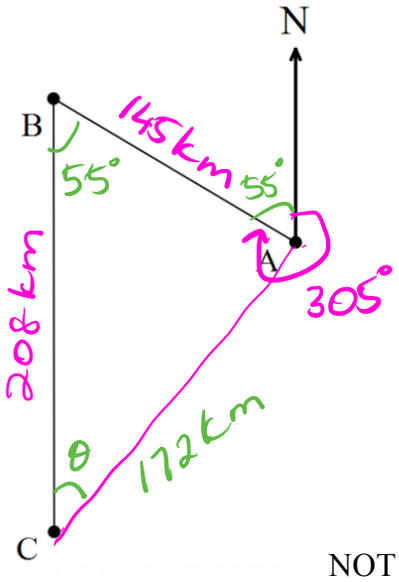
Question 20 (6 marks)

A plane flies 145 km from point A to point B on a bearing of 305°.
The plane then flies 208 km due south to point C before returning to point A.



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(a) Complete the diagram with the information provided and find $\angle ABC$. **2**

$\angle NAB = 360° - 305° = 55°$

$\angle ABC = 55°$ (alternate angles)

(b) Find the distance the plane must travel to return from point C to point A, correct to the nearest kilometre. **2**

$AC = \sqrt{145^2 + 208^2 - 2 \times 145 \times 208 \times \cos 55°}$

$= 172.310\ldots$

≈ 172 km

(c) What is the three-figure bearing from point C to point A? **2**

$\frac{\sin\theta}{145} = \frac{\sin 55°}{172}$

$\sin\theta = \frac{145 \sin 55°}{172}$

$\theta \approx 43.6°$

Bearing is 044° T

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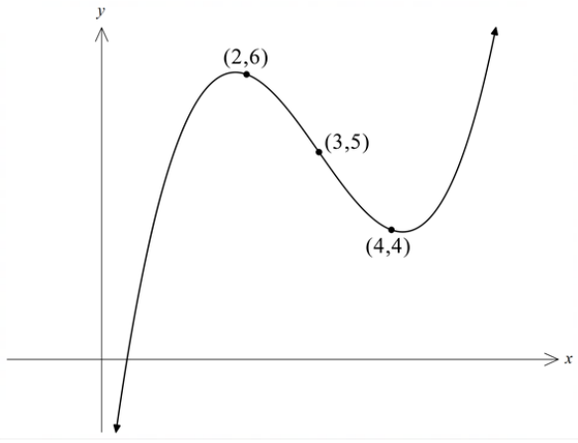
Question 21 (3 marks)

The graph of $y = f(x)$ is shown.



Use two applications of the trapezoidal rule to find an approximation for

$$\int_2^4 f(x)\,dx$$

2/3

x	2	3	4
$f(x)$	6	5	4

$h = 1$

$$\int_2^4 f(x)\,dx$$

$$= \frac{1}{2}\left[6 + 4 + 2\times 5\right]$$

$$= 10$$

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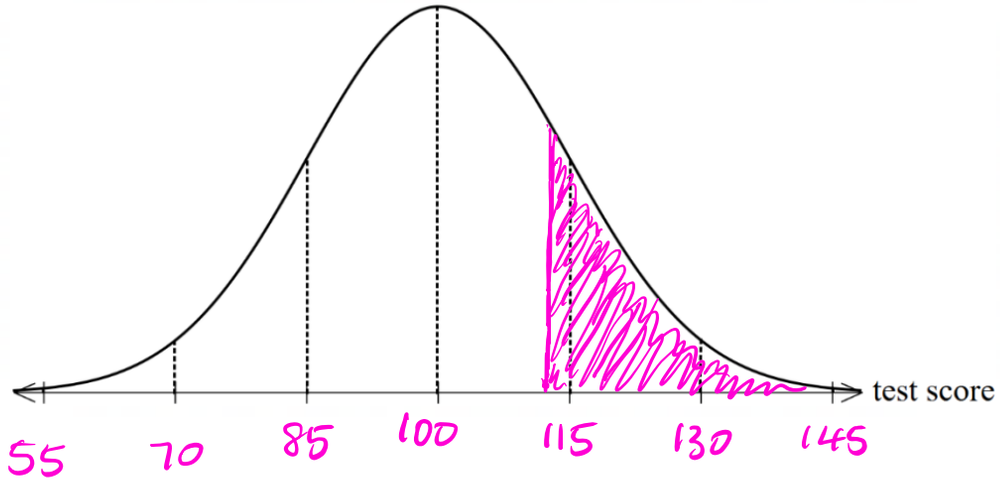
Question 22 (4 marks)

Marks on an aptitude test are normally distributed with a mean of 100 and a standard deviation of 15.

A normal distribution curve is shown below, where the vertical lines represent z-scores from -3 to 3.



(a) For the normal distribution curve above, label the corresponding test marks (not z-scores) along the horizontal axis. **1**

On diagram

(b) Shade under the normal distribution curve where (approximately) the top 20% of scores lie. **1**

On diagram

(c) Hae-Won took the test and her z-score was 0.5. She needs to score in the top 20% in order to enrol in a training program. **2**

If she studies, retakes the test, and her test score increases by 10 marks, will she be able to enrol? Justify your answer with calculations.

For $z = 0.5$, $0.5 = \frac{x - 100}{15}$ 2

$x = 107.5$

If $x = 107.5 + 10 = 117.5$

$z = \frac{117.5 - 100}{15}$

$= 1.17 > 1$

Yes she will be in the top 20%

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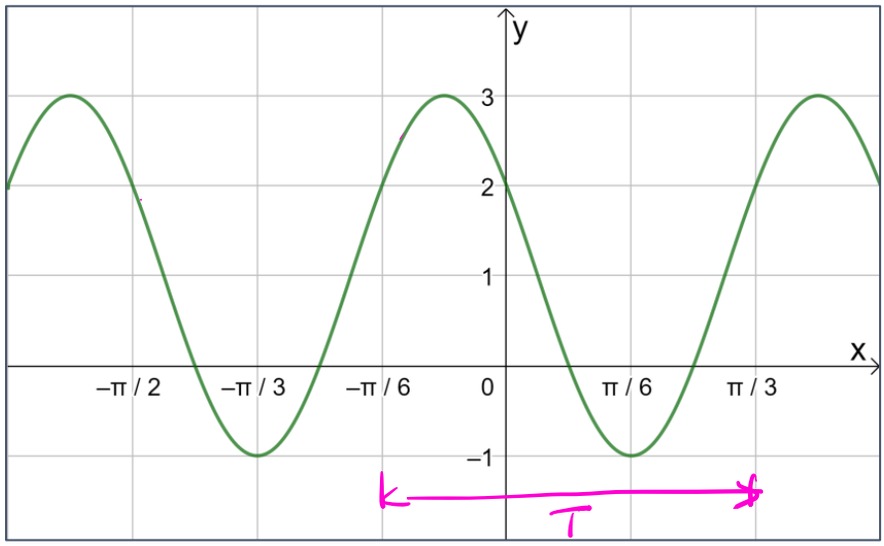
Question 23 (5 marks)

The diagram shows the graph of $y = a\cos(bx + c) + d$.



(a) State the range. **1**

[-1, 3]

(b) State the period. **1**

$T = \pi/6 + \pi/3$

$= \pi/2$

(c) Find the values of a, b, c and d. **3**

$a = 2$ $\quad d = 1$

$\frac{2\pi}{b} = \frac{\pi}{2}$, $\quad b = 4$

$y = 2\cos(4x + c) + 1$

$(0, 2)$ is on curve

$2 = 2\cos c + 1$

$2\cos c = 1$

$\cos c = 1/2$ $\quad c = \frac{\pi}{3}$

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Question 24 (3 marks)

Describe the three transformations which, when applied in order, transforms the graph of $y = 2\sin x$ to the graph with equation $y = \sin\left(\frac{x+\pi}{3}\right)$. **3**

$2\sin x$ to $\sin x$ Vertical dilation sf $\frac{1}{2}$

$\sin x$ to $\sin\left(\frac{x}{3}\right)$ Horizontal dilation sf 3

$\sin\left(\frac{x}{3}\right)$ to $\sin\left(\frac{x+\pi}{3}\right)$ Horizontal translation π units left.

Question 25 (3 marks)

Prove that ~~$\sin^2 x + \cot^2 x = \operatorname{cosec}^2 x - \cos^2 x$~~ $\dfrac{1+\tan^2 x}{1+\cot^2 x} = \tan^2 x$ **3**

$$\text{LHS} = \frac{1+\tan^2 x}{1+\cot^2 x}$$

$$= \frac{\sec^2 x}{\operatorname{cosec}^2 x}$$

$$= \frac{\frac{1}{\cos^2 x}}{\frac{1}{\sin^2 x}}$$

$$= \frac{1}{\cos^2 x} \times \frac{\sin^2 x}{1}$$

$$= \frac{\sin^2 x}{\cos^2 x}$$

$$= \tan^2 x = \text{RHS}$$

Questions 11 – 25 are worth 52 marks in total

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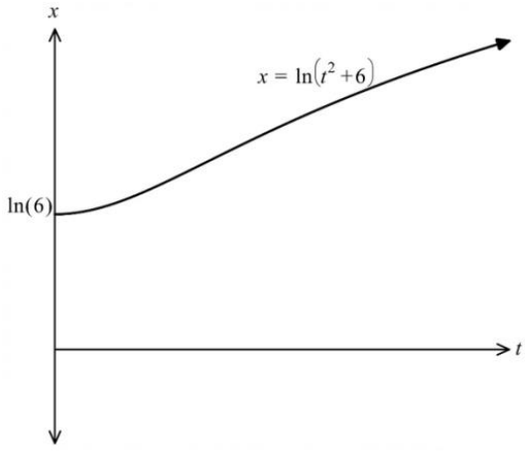
Question 26 (3 marks)

A particle moves on the x-axis so that it's displacement in metres from the origin at a time t second is given by the equation $x = \ln(t^2 + 6)$.

The particle starts from rest at the point $x = \ln(6)$ and accelerates in a positive direction as shown in the distance-time graph below.



Find the time when the acceleration of the particle becomes zero and find the velocity at this time. **3**

$x = \ln(t^2+6)$ $\quad v = \dot{x} = \frac{2t}{t^2+6}$

$a = \ddot{x} = \frac{2(t^2+6) - 4t^2}{(t^2+6)^2}$

$u = 2t$, $u' = 2$, $v = t^2+6$, $v' = 2t$

$= \frac{12 - 2t^2}{(t^2+6)^2}$

$\ddot{x} = 0$ when $12 - 2t^2 = 0$

$2(6 - t^2) = 0$

$t = \sqrt{6}$ (positive value only)

at $t = \sqrt{6}$

$v = \frac{2\sqrt{6}}{(\sqrt{6})^2 + 6}$

$= \frac{2\sqrt{6}}{12}$

$v = \frac{\sqrt{6}}{6}$ m/s

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Question 27 (4 marks)

(a) Show that $\frac{d}{dx}(3x^2e^{2x+1}) = 6xe^{2x+1}\ (x+1)$ **2**

$u = 3x^2$
$u' = 6x$
$v = e^{2x+1}$
$v' = 2e^{2x+1}$

$\frac{d}{dx}(3x^2e^{2x+1})$

$= 6xe^{2x+1} + 6x^2e^{2x+1}$

$= 6xe^{2x+1}(1+x)$

as required

(b) Hence evaluate $\int_1^2 x(x+1)e^{2x+1}\ dx$. **2**

from a) $\int 6xe^{2x+1}(x+1)\,dx = 3x^2e^{2x+1}$

$\int_1^2 x(x+1)e^{2x+1}\,dx = \frac{1}{6}\left[3x^2e^{2x+1}\right]_1^2$

$= \frac{1}{6}\left[(3(4)e^5) - (3(1)e^3)\right]$

$= \frac{1}{6}\left[12e^5 - 3e^3\right]$

$= 2e^5 - \frac{1}{2}e^3$

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Question 28 (3 marks)

A random variable Z is normally distributed with mean 0 and standard deviation 1. **3**

The table gives the probability of this random variable being greater than different values of z.

z	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2
$P(Z > z)$	0.5	0.4013	0.3085	0.2266	0.1587	0.1057	0.668	0.0401	0.0228

In a hospital of 3125 patients, it is found that 708 patients have a body temperature higher than 36.8°C. The body temperatures are distributed normally with a mean μ and standard deviation 0.3°C.

Using the given table, find the value of μ, correct to two decimal places.

Let T be body temperature

$P(T > 36.8) = \frac{708}{3125} \approx 0.2266$

From the table, $P(Z > 0.75) = 0.2266$

$z = 0.75$ relates to temperature $36.8^\circ C$

$z = \frac{x - \mu}{\sigma}$

$0.75 = \frac{36.8 - \mu}{0.3}$

$36.8 - \mu = 0.225$

$\mu = 36.58^\circ C$

Proceed to Booklet 2 for Questions 29-34

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2022 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Student Number

Mathematics Advanced

Section II Answer Booklet 2

Booklet 2 — Attempt Questions 29–34 (28 marks)

Instructions

- Write your Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of responses.
- Your responses should include relevant mathematical reasoning and/or calculations.
- Extra writing space is provided on pages 39-40 of Booklet 2. If you use this space, clearly indicate which question you are answering.

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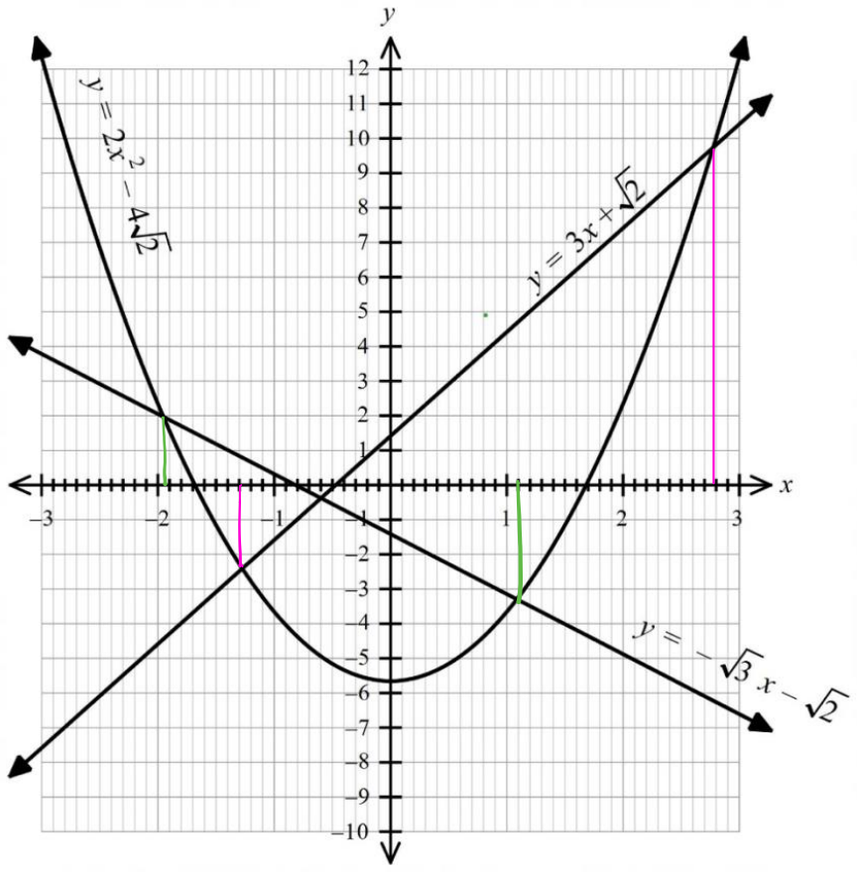
Question 29 (4 marks)

The diagram below shows the graphs of $y = 3x + \sqrt{2}$, $y = -\sqrt{3}\,x - \sqrt{2}$ and $y = 2x^2 - 4\sqrt{2}$.



Use the graph to find the solution to the following inequalities, giving your answer correct to the nearest tenth.

(a) $3x + \sqrt{2} > 2x^2 - 4\sqrt{2}$ **2**

From the graph, $-1.3 < x < 2.8$

(b) $2x^2 + \sqrt{3}\,x - 3\sqrt{2} \geq 0$ **2**

$2x^2 - 3\sqrt{2} \geq -\sqrt{3}x$ (Subtract $\sqrt{3}x$ both sides)

$2x^2 - 4\sqrt{2} \geq -\sqrt{3}x - \sqrt{2}$ (Subtract $\sqrt{2}$ both sides)

Find where $y = 2x^2 - 4\sqrt{2}$ is above $y = -\sqrt{3}\,x - \sqrt{2}$

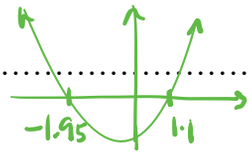
OR

$x \leq -1.95$ and $x \geq 1.1$

$x = \dfrac{-\sqrt{3} \pm \sqrt{(\sqrt{3})^2 - 4(2)(-3\sqrt{2})}}{4}$

$= \dfrac{-\sqrt{3} \pm \sqrt{3 + 24\sqrt{2}}}{4}$

$= 1.1, -1.95$



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Question 30 (6 marks)

Use calculus to determine and classifying the nature of stationary points and points of inflection (horizontal or otherwise) for the function $y = 12x^5 - 15x^4 - 40x^3$. **6**

Hence, sketch the graph of the function, clearly labelling all key features. Accurate values for x-intercepts are **not** required.

$y = 12x^5 - 15x^4 - 40x^3$

$y' = 60x^4 - 60x^3 - 120x^2$

$= 60x^2(x^2 - x - 2)$

$y' = 60x^2(x-2)(x+1)$

Stationary points, $y' = 0$

$x = 0, \quad x = 2, \quad x = -1$

$y'' = 240x^3 - 180x^2 - 240x$

$= 60x(4x^2 - 3x - 4)$

at $x = 0$, $y'' = 0$ May be horizontal point of inflection

$y = 0$ at $(0,0)$

Test concavity change at $x = -0.5$, $y'' = 45$

at $x = 0.5$, $y'' = -135$

$\therefore$ $(0,0)$ is a horizontal point of inflection

at $x = 2$, $y'' = 720 > 0$ Minimum turning point at $(2, -176)$

$y = -176$

at $x = -1$, $y'' = -180 < 0$ maximum turning point at $(-1, 13)$

$y = 13$

Points of inflection, $y'' = 0$

$x = 0, \quad x = \frac{3 \pm \sqrt{73}}{8} \approx -0.69, 1.44$

Working space for Question 30 continues next page

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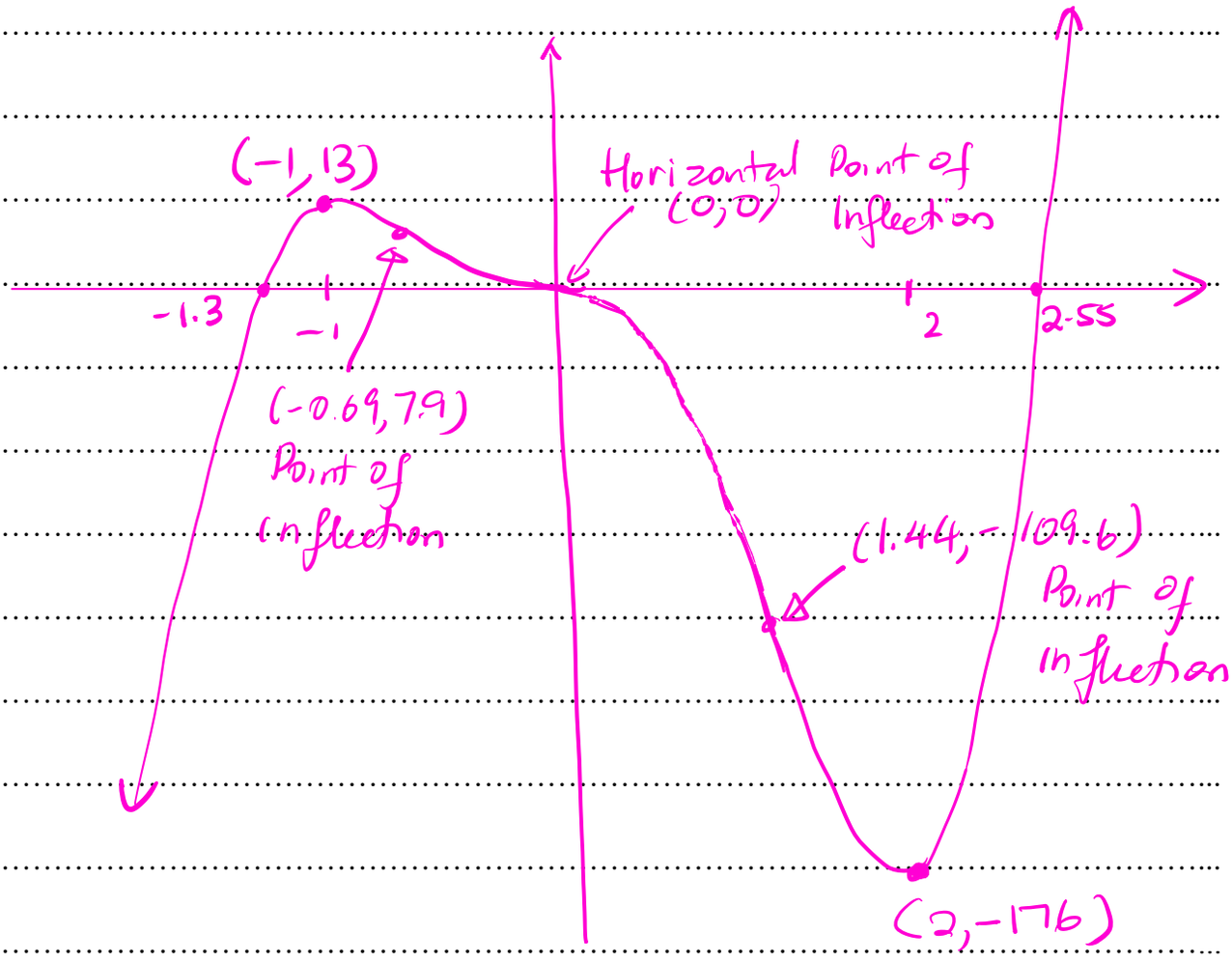
Question 30 (continued)

Check concavity changes at inflection points

x	-1	-0.69	-0.5	1	1.44	2
y''	-180	0	45	-180	0	720
y	13	7.9			-109.6	-176

Points of inflection at $(-0.69, 7.9)$ and $(1.44, -109.6)$



x-intercepts $\quad 12x^5 - 15x^4 - 40x^3 = 0$

$12x^2 - 15x - 40 = 0 \qquad x^3(12x^2 - 15x - 40) = 0$

$x = \dfrac{15 \pm \sqrt{2145}}{24} \qquad x = 0, \; x = 2.55, -1.3$

$x = 2.55, -1.3$

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Question 31 (4 marks)

The volume of a pond decreases during a period of no rain.

The volume in the pond, V, after t days can be modelled by the equation

$$V = V_0 e^{-kt}$$

where V_0 is the initial volume of the pond.

(a) Given that it takes 10 days for the volume of the pond to halve, show that $k \approx 0.0693$. **3**

$V = 0.5V_0$, $t = 10$

$0.5V_0 = V_0 e^{-10k}$

$e^{-10k} = 0.5$

$-10k = \ln 0.5$

$k = \dfrac{\ln 0.5}{-10}$

$= 0.0693147...$

$k \approx 0.0693$

(b) If there is 30 megalitres (ML) in the pond after 7 days, calculate the initial volume of the pond, to the nearest ML. **1**

at $t = 7$, $V = 30$ ML

$30 = V_0 e^{-7k}$ $\qquad k = \dfrac{\ln 0.5}{-10}$

$V_0 = \dfrac{30}{e^{-7k}}$

$= 48.735 \approx 49$ ML

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Question 32 (4 marks)

A continuous random variable X has a probability density function f given by **4**

$$f(x) = \begin{cases} Ax + B, & 1 \leq x \leq 6 \\ 0, & otherwise \end{cases}$$

where A and B are constants.

The median of X is 3. Find the values of A and B.

$\int_1^6 Ax + B\,dx = 1$

$\left[\frac{Ax^2}{2} + Bx\right]_1^6 = 1$

$18A + 6B - \frac{A}{2} - B = 1$

$\frac{35A}{2} + 5B = 1$

$35A + 10B = 2$ — (1)

Median $= 3$ $\int_1^3 Ax + B\,dx = 0.5$

$\left[\frac{Ax^2}{2} + Bx\right]_1^3 = 0.5$

$\frac{9A}{2} + 3B - \frac{A}{2} - B = 0.5$

$4A + 2B = 0.5$

$8A + 4B = 1$ — (2)

(1) x 4 $140A + 40B = 8$ — (3)

(2) x 10 $80A + 40B = 10$ — (4)

(3) − (4) $60A = -2$

$A = -\frac{1}{30}$

From (1) $35\left(-\frac{1}{30}\right) + 10B = 2$

$B = \frac{19}{60}$

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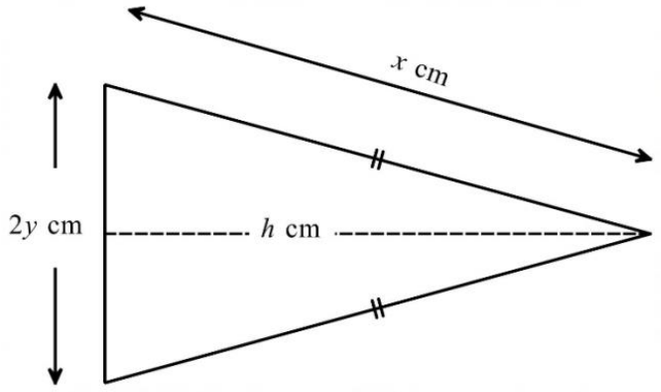
Question 33 (6 marks)

A banner is designed as an isosceles triangle, with equal sides of length x cm and base of length $2y$ cm, as shown.



The total perimeter of the triangle is 40 cm.

(a) Show that the area of the triangle in terms of x can written as: **2**

$$A = (20 - x)\,(40x - 400)^{\frac{1}{2}}$$

$2x + 2y = 40$

$2y = 40 - 2x$

$y = 20 - x$

Pythagoras' $y^2 + h^2 = x^2$

$h^2 = x^2 - y^2$

$h = \sqrt{x^2 - y^2}$

$= \sqrt{x^2 - (20-x)^2}$

$= \sqrt{x^2 - 400 + 40x - x^2}$

$h = \sqrt{40x - 400} = (40x - 400)^{1/2}$

Area $= \frac{1}{2} \times 2y \times h$

$= y \times h$

$= (20 - x)(40x - 400)^{1/2}$ as required

Question 33 continues on page 36

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Question 33 (continued)

(b) Use calculus to find the values of x and y which give a maximum area, showing why this gives the maximum area. **4**

Find this area.

$\frac{dA}{dx} = -(40x-400)^{1/2} + \frac{1}{2}(20-x)(40x-400)^{-1/2}(40)$ $u = 20-x$

$= -(40x-400)^{1/2} + \frac{20(20-x)}{(40x-400)^{1/2}}$ $u' = -1$

$v = (40x-400)^{1/2}$

$= \frac{20(20-x) - (40x-400)}{(40x-400)^{1/2}}$ $v' = \frac{1}{2}(40x-400)^{-1/2} \cdot 40$

$= \frac{400 - 20x - 40x + 400}{(40x-400)^{1/2}}$

$\frac{dA}{dx} = \frac{800-60x}{(40x-400)^{1/2}}$

$A'' = \frac{-60}{\sqrt{40x-400}} - (800-60x)\left[\frac{20}{(40x-400)^{3/2}}\right]$

For maximum area, $\frac{dA}{dx} = 0$ at $x = \frac{40}{3}$

$800 - 60x = 0$ $A'' = -5.2 < 0$

$x = \frac{40}{3} = 13\frac{1}{3}$ hence maximum area.

Test using 1st derivative to show $x = \frac{40}{3}$ gives maximum

When $x = 13$, $\frac{dA}{dx} \approx 1.82$

$x = 14$, $\frac{dA}{dx} \approx -3.16$

$\therefore$ Max area at $\boxed{x = \frac{40}{3}}$ and $y = 20 - x$

$= 20 - \frac{40}{3}$

$\boxed{y = \frac{20}{3}}$

Maximum area

$A = (20 - \frac{40}{3})(40(\frac{40}{3}) - 400)^{1/2} = \frac{400\sqrt{3}}{9}$

$A = 76.98\,cm^2$

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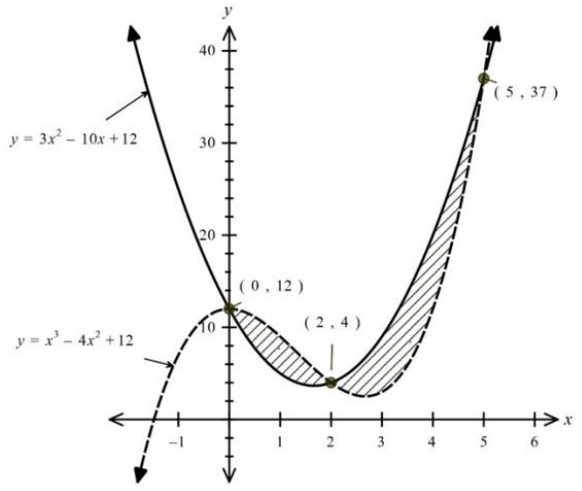
Question 34 (4 marks)

The curves $y = x^3 - 4x^2 + 12$ and $y = 3x^2 - 10x + 12$ intersect at the points $(0, 12)$, $(2, 4)$ and $(5, 37)$ as shown on the graph below. **4**



Calculate the total shaded area enclosed between the two curves.

$$\text{Area} = \int_0^2 x^3 - 4x^2 + 12 - (3x^2 - 10x + 12)\,dx + \int_2^5 3x^2 - 10x + 12 - (x^3 - 4x^2 + 12)\,dx$$

$$= \int_0^2 x^3 - 7x^2 + 10x\,dx + \int_2^5 -x^3 + 7x^2 - 10x\,dx$$

$$= \left[\frac{x^4}{4} - \frac{7x^3}{3} + 5x^2\right]_0^2 + \left[-\frac{x^4}{4} + \frac{7x^3}{3} - 5x^2\right]_2^5$$

$$= \left[\left(\frac{2^4}{4} - \frac{56}{3} + 20\right) - 0\right] + \left[\left(\frac{-(5^4)}{4} + \frac{875}{3} - 125\right) - \left(\frac{-2^4}{4} + \frac{56}{3} - 20\right)\right]$$

$$= \frac{16}{3} + \frac{125}{12} + \frac{16}{3}$$

$$= 16/3 + 63/4$$

$$\text{Area} = \frac{253}{12} \text{ units}^2$$

$$= 21\,1/12 \text{ units}^2$$

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Question 34 (continued)

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END OF EXAMINATION

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