



Gosford High School

2022

Year 11 FINAL YEAR EXAMINATION

Mathematics Extension 1

General Instructions

- Reading time – 5 minutes
- Working time – 1.5 hours
- Write using black pen
- Calculators approved by NESA may be used
- A reference sheet is provided at the back of this paper
- For all questions, show relevant mathematical reasoning and/or calculations
- Write your Student Number on each Question Writing Booklet provided

Total Marks: 56

Section I – 56 marks (pages 2 – 6)

- Attempt Questions 1 – 5
- Allow about 1 hour and 30 minutes for this section

Section I

56 marks

Attempt Questions 1 – 5.

Answer each question in the appropriate writing booklet. Extra writing booklets are available.

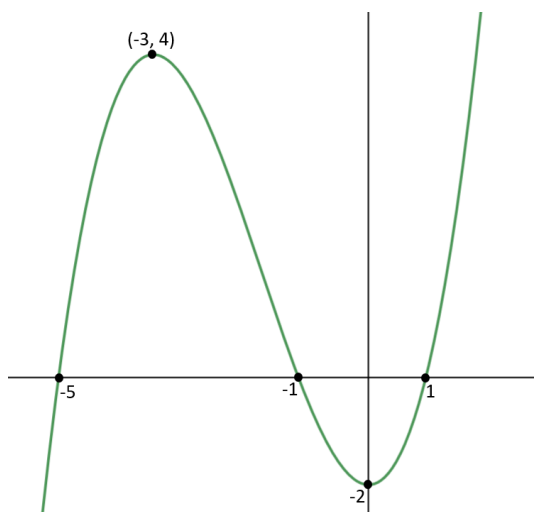
In Questions 1 – 5, your responses should include relevant mathematical reasoning and/or calculations.

Question 1 (11 marks) Use the Question 1 writing booklet.

- (a) The polynomial $P(x) = x^4 - 2x^3 - kx + 27$ has a factor of $(x - 2)$ as a factor. 2
What is the value of k ?

- (b) Solve the inequality $\frac{3x}{x-2} \geq 1$ 3

- (c) Given the graph of $y = f(x)$ below answer parts i, ii and iii:



Use a ruler for the Cartesian axes and sketch a $\frac{1}{3}$ page graph for the following, labelling any turning points, asymptotes and intercepts for the following:

- i. $y = |f(x)|$ 2
- ii. $y = f(|x|)$ 2
- iii. $y = \frac{1}{f(x)}$ 2

End of Question 1

Question 2 (12 marks) Use the Question 2 writing booklet.

- (a) Given that $2 \cos^2 x = 1 + \cos 2x$, prove that $8 \cos^4 x = 3 + 4 \cos 2x + \cos 4x$. **2**
- (b) Show that $\sin 75^\circ = \frac{1 + \sqrt{3}}{2\sqrt{2}}$. **2**
- (c) Sketch the graph of the function $y = \sin^{-1}(x + 2) - \frac{\pi}{2}$, showing all important features including any intercept(s). **3**
- (d) Find the coefficient of x^3 in the expansion of $\left(2x - \frac{1}{x}\right)^{11}$. **2**
- (e) If α, β and γ are the roots of $x^3 - 3x + 1 = 0$. Find:
- i. $\alpha + \beta + \gamma$ **1**
- ii. $\alpha\beta\gamma$ **1**
- iii. $\frac{1}{\alpha} + \frac{1}{\beta} + \frac{1}{\gamma}$ **1**

End of Question 2

Question 3 (11 marks) Use the Question 3 writing booklet.

- (a) Given that $0 < x < \frac{\pi}{4}$, prove that $\tan\left(\frac{\pi}{4} + x\right) = \frac{\cos x + \sin x}{\cos x - \sin x}$. **3**
- (b) i. Divide the polynomial $P(x) = 2x^4 - 10x^3 + 12x^2 + 2x - 3$ by $A(x) = x^2 - 3x + 1$. **2**
- ii. Hence write $P(x) = A(x)Q(x) + R(x)$, where $Q(x)$ and $R(x)$ are polynomials and $R(x)$ has degree less than 2. **1**
- iii. Hence explain why $P(x)$ and $A(x)$ have no zeros in common. **1**
- (c) A committee of 3 is to be elected from a club of 8 members:
- i. How many different committees can be formed? **1**
- ii. If there are 4 women in the club, what is the probability that a randomly selected committee of 3 contains only women? **2**
- (d) Find the Cartesian equation of the circle with parametric equations: **1**
 $x = 13 \cos t$
 $y = 13 \sin t$

End of Question 3

Question 4 (9 marks) Use the Question 4 writing booklet.

- (a) Let each different arrangement of all the letters of DELETED be called a word.
- i. How many different words will be possible? **1**
 - ii. In how many of these words will the D's be separated? **2**
- (b) It is given that $P(x) = (x-a)^3 + (x-b)^2$. The remainder when $P(x)$ is divided by $(x-b)$ is -8 .
- i. Show that when $P(x)$ is divided by $(x-a)$, the remainder is 4 . **2**
 - ii. Prove that $x = \frac{a+b}{2}$ is a zero of $P(x)$. **2**
- (c) Brett and Colin and eight other people go through a doorway at one time.
- i. In how many ways can the ten people go through the doorway if Brett and Colin go through the doorway with no-one between them? **1**
 - ii. Find the number of ways in which the ten people can go through the doorway if Colin goes through the doorway after Brett. **1**

End of Question 4

Question 5 (13 marks) Use the Question 5 writing booklet.

- (a) Let $f(x) = \frac{x}{x^2 - 1}$.
- i. For what values of x is $f(x)$ undefined? **1**
 - ii. Show that $y = f(x)$ is an odd function. **1**
 - iii. Show that $f'(x) < 0$ at all values of x for which the function is defined. **1**
 - iv. Hence, sketch $y = f(x)$. **2**
- (b) i. Sketch the parabola whose parametric equations are $x = t$ and $y = t^2$. On your diagram, mark the points P and Q which correspond to $t = -1$ and $t = 2$ respectively. **2**
- ii. Show that the tangents to the parabola at P and Q intersect at $R(\frac{1}{2}, -2)$. **3**
- iii. Let $T(t, t^2)$ be the point on the parabola between P and Q such that the tangent at T meets QR at the mid-point of QR. **3**

Show that the tangent at T is parallel to PQ

End of Question 5

Question	a	b	ci	cii	ciii
Mark					

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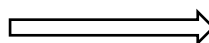
Mathematics Extension 1

Writing Booklet

Question 1

Instructions

- Use this booklet for Question 1



1

- Write the number of this booklet and the number of booklets that you have used for this question (e.g.

1

 of

3

)



of

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booklet

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booklets

- Write your name and Student Number at the top of this page.
- Write in a black pen
- You may ask for an extra writing booklet if you need more space
- If you have not attempted the question(s), you must still hand in the writing booklet with “NOT ATTEMPTED” written clearly on the front cover.
- You may not take any writing booklets, used or unused, from the examination room.

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Question Number 1

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Question	a	b	c	d	ei	eii	eiii
Mark							

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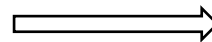
Mathematics Extension 1

Writing Booklet

Question 2

Instructions

- Use this booklet for Question 2



2

- Write the number of this booklet and the number of booklets that you have used for this question (e.g.

1

 of

3

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- Write your name and Student Number at the top of this page.
- Write in a black pen
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Question Number 2

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Question	a	bi	bii	biii	ci	cii	d
Mark							

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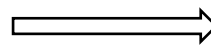
Mathematics Extension 1

Writing Booklet

Question 3

Instructions

- Use this booklet for Question 3



3

- Write the number of this booklet and the number of booklets that you have used for this question (e.g. 1 of 3)
- Write your name and Student Number at the top of this page.
- Write in a black pen
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Question Number 3

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Question	ai	aII	bi	bII	ci	cII
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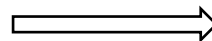
Mathematics Extension 1

Writing Booklet

Question 4

Instructions

- Use this booklet for Question 4



4

- Write the number of this booklet and the number of booklets that you have used for this question (e.g. 1 of 3)
- Write your name and Student Number at the top of this page.



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- Write in a black pen
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Question Number 4

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Question	ai	aII	aiii	aiv	bi	bii	biii
Mark							

Student Number

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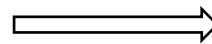
Mathematics Extension 1

Writing Booklet

Question 5

Instructions

- Use this booklet for Question 5
- Write the number of this booklet and the number of booklets that you have used for this question (e.g. 1 of 3)
- Write your name and Student Number at the top of this page.
- Write in a black pen
- You may ask for an extra writing booklet if you need more space
- If you have not attempted the question(s), you must still hand in the writing booklet with "NOT ATTEMPTED" written clearly on the front cover.
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Question Number 5

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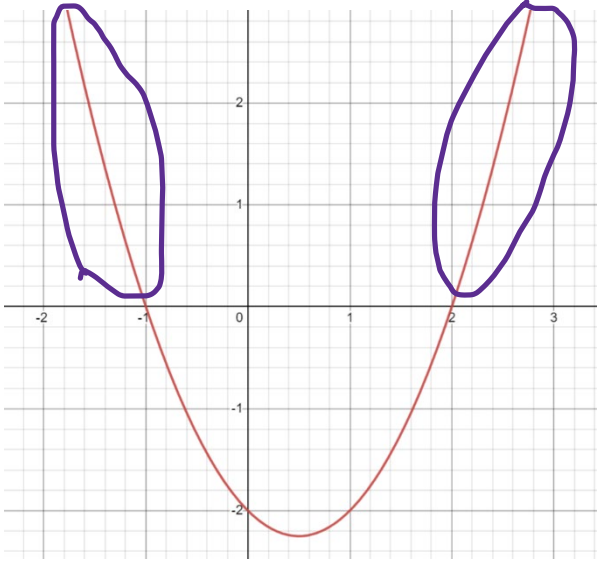
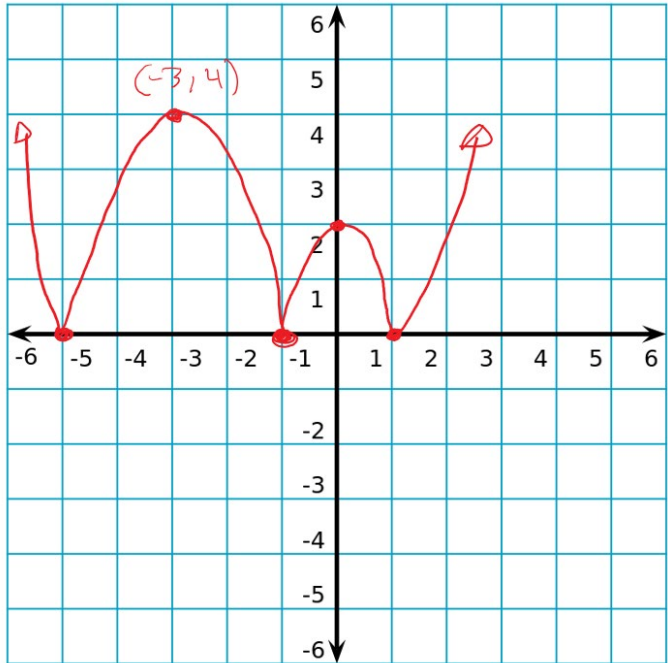
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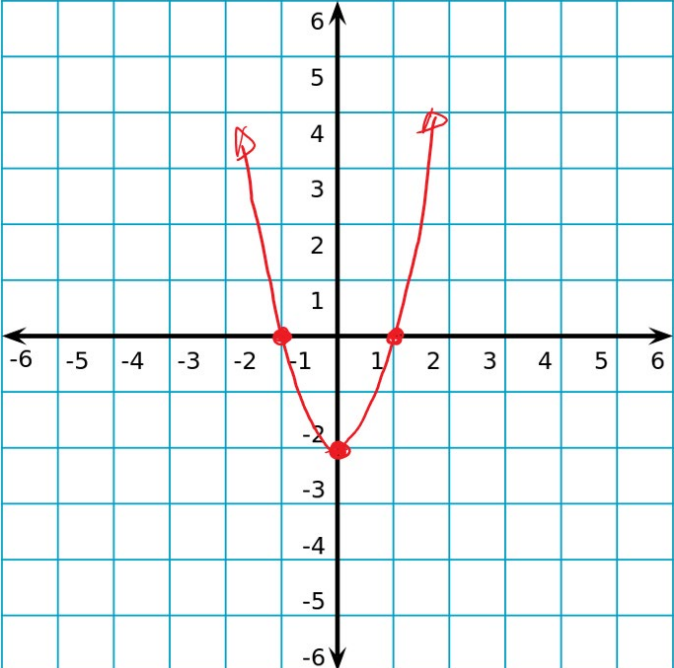
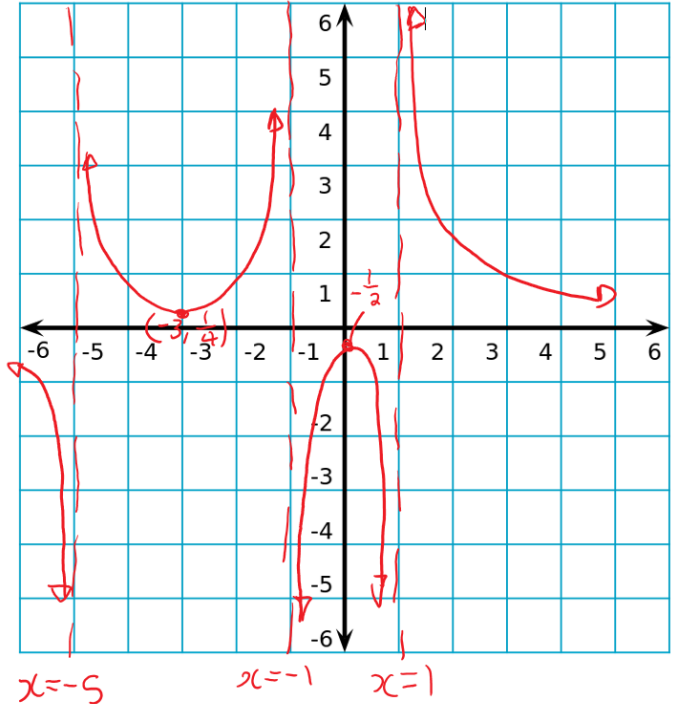
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Mathematics Extension 1

SOLUTIONS

1	Outcome	GHS Ext 1 Year 11 Yearly 2022 Question 1 Worked Solutions	Marks	Allocation and Comments
(a)	7	$P(2) = 2^4 - 2(2)^3 - 2k + 27 = 0$ $-2k = -27$ $k = 13.5$	2	2 for correct solution 1 for substitution of 2 oem
Very mixed(b)	2	$\frac{3x}{x-2} \geq 1$ $x \neq 2$ $3x(x-2) \geq (x-2)^2$ $3x^2 - 6x \geq x^2 - 4x + 4$ $2x^2 - 2x - 4 \geq 0$ $x^2 - x - 2 \geq 0$ $(x-2)(x+1) \geq 0$  $\therefore x \leq -1, x > 2$	3	3 for correct solutions 2 for correct solutions but did not consider discontinuity 1 for work towards correct solution
(c) i	2	$y = f(x) $ 	2	2 marks for correct graph with relevant intercepts clear and peak labelled 1 mark for correct shape oem

(c) iii	2	$y = f(x)$ 	2 2 marks for correct graph with relevant intercepts clear 1 mark for correct shape oem
(c) iii	2	$y = \frac{1}{f(x)}$ 	2 2 marks for correct graph with relevant intercepts and asymptotes labelled 1 mark for correct shape oem

Markers Comments

1a – Mostly well done. Some students overcomplicated the question by doing polynomial division and often made an error in doing so.

1b – Mixed success with this question. Many students did not recognise that $x=2$ cannot be a solution and included this in their answer. Many students also did not answer the question or changed the inequality to an equation to find the critical points, but then did not solve the inequality or test any regions.

1ci and 1ciii – Students in this cohort need to learn to draw neat sketches of their graphs as many were messy and some almost illegible. Poorly done overall. Some students did not have the correct shape of the tails of the graph and lost a mark for this. Other students failed to label the peak which was required in the question. Many responses stated that their graph was $y = |f(x)|$ but they had drawn $y = f(|x|)$ instead.

1cii was the same but instead of drawing $y = f(|x|)$, they drew $y = |f(x)|$. It was clear that students did not have a sufficient understanding of the difference between these two functions or their graphs. You are poorly done.

1ciii – Mixed results for this question. Many students could successfully draw the graph but did not label the intercept or the asymptotes. Other students had the correct shape, but the wrong intercept or asymptotes.

2	Outcome	GHS Ext 1 Year 11 Yearly 2022 Question 2 Worked Solutions	Marks	Allocation and Comments
(a)	3	$ \begin{aligned} LHS &= 8\cos^4 x \\ &= 8\cos^2 x \cos^2 x \\ &= 2\cos^2 x 2\cos^2 x \\ &= 2[1 + \cos 2x][1 + \cos 2x] \\ &= 2[1 + 2\cos 2x + \cos^2 2x] \\ &= 2 + 4\cos 2x + 2\cos^2 2x \\ &= 2 + 4\cos 2x + 1 + \cos 4x \\ &= 3 + 4\cos 2x + \cos 4x \\ &= RHS \end{aligned} $	2	2 for logical proof with all working 1 for work towards solution

Markers Comments

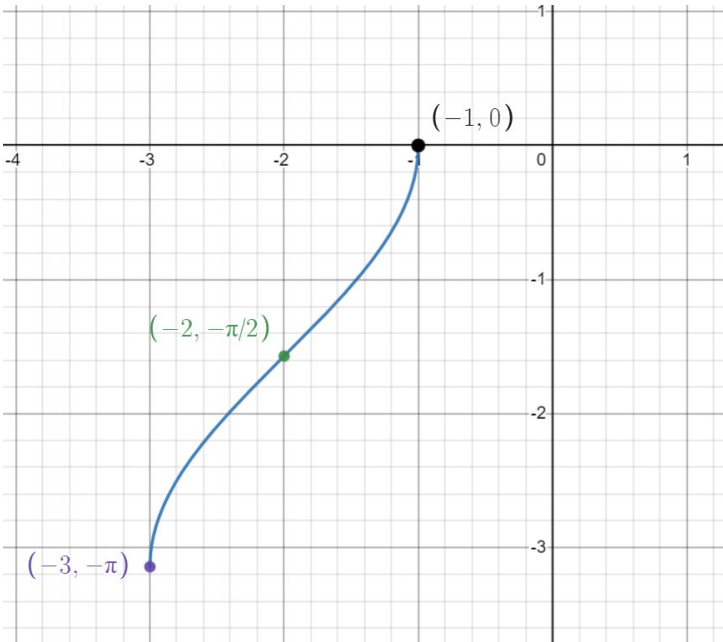
Done poorly in general. Students made this question quite difficult and long. Students who did well recognised the need to use the given identity and were able to recognise the ability to swap x for 2x and 2x for 4x in the angles of the given identity.

(b)	3	$ \begin{aligned} RTP : \sin 75^\circ &= \frac{1 + \sqrt{3}}{2\sqrt{2}} \\ LHS &= \sin(45^\circ + 30^\circ) \\ &= \sin 45^\circ \cos 30^\circ + \sin 30^\circ \cos 45^\circ \\ &= \frac{\sqrt{2}}{2} \cdot \frac{\sqrt{3}}{2} + \frac{1}{2} \cdot \frac{\sqrt{2}}{2} \\ &= \frac{\sqrt{3}}{2\sqrt{2}} + \frac{1}{2\sqrt{2}} \\ &= \frac{1 + \sqrt{3}}{2\sqrt{2}} \\ &= RHS \end{aligned} $	2	2 for logical proof with all working 1 for work towards solution
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Markers Comments

Students generally did this question very well, recognising the need to use the double angle formula. Students who got this question wrong wrote that $\sin 75 = \sin 30 + \sin 45$ without using the required formula.

Students should ensure they give answers in the form requested (eg in a show that question, the last line of work should be exactly what you were trying to show).

(c)	3	$y = \sin^{-1}(x+2) - \frac{\pi}{2}$ 	3	3 for correct graph 2 for correct graph with single error (eg, location, end points, etc) 1 for work towards solution
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Markers Comments

Students who did well recognised the shape and location of the original inverse sin graph and completed the transformation successfully.

Some incorrectly moved the domain or range or interpreted the end points as asymptotes.

(d)	5	$\left(2x - \frac{1}{x}\right)^{11}$ ${}^{11}C_4(2x)^7\left(\frac{-1}{x}\right)^4$ $= 330 \times 128x^7 \times \frac{1}{x^4}$ $= 42240x^3$ <i>Coefficient</i> = 42240	2	2 for correct coefficient found 1 for work towards solution
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Markers Comments

Students generally did well recognising the need to use the binomial expansion formula. Students who did well recognised or calculated the correct powers to create an x^3 term. They also recognised the elimination of the negative due to the even power.

(e) i	2	$\alpha + \beta + \gamma = \frac{-b}{a}$ $= 0$	1	1 for correct solution
(e) ii	2	$\alpha\beta\gamma = \frac{-d}{a}$ $= \frac{-1}{1}$ $= -1$	1	1 for correct solution

(e) iii	2	$\frac{1}{\alpha} + \frac{1}{\beta} + \frac{1}{\gamma} = \frac{\beta\gamma + \alpha\gamma + \alpha\beta}{\alpha\beta\gamma}$ $= \frac{c}{a} \div \frac{-d}{a}$ $= \frac{-3}{-1}$ $= 3$	1	1 for correct solution
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Markers Comments

These parts were all done very well. Students who made mistakes generally did so because they did not recognise that the b term was 0 or in part e did not correctly create a single fraction from the given reciprocals.

3	Outcome	GHS Ext 1 Year 11 Yearly 2022 Question 3 Worked Solutions	Marks	Allocation and Comments
(a)	3	$RTP: \tan\left(\frac{\pi}{4} + x\right) = \frac{\cos x + \sin x}{\cos x - \sin x}$ $LHS = \tan\left(\frac{\pi}{4} + x\right)$ $= \frac{\tan \frac{\pi}{4} + \tan x}{1 - \tan \frac{\pi}{4} \tan x}$ $= \frac{1 + \tan x}{1 - \tan x}$ $= \frac{\frac{\cos x}{\cos x} + \frac{\sin x}{\cos x}}{\frac{\cos x}{\cos x} - \frac{\sin x}{\cos x}}$ $= \frac{\cos x + \sin x}{\cos x - \sin x}$ $= RHS$	3	3 for correct proof with logical steps 2 for correct steps with one error made 1 for work towards solution

Markers Comments

This question was generally well attempted. Better responses worked with each side independently to show equivalence between the two expressions. Students are encouraged to clearly show/explain all the relevant links that link successive lines of working and avoid skipping lines in a “show” question.

(b) i	2	$\begin{array}{r} 2x^2 - 4x - 2 \\ x^2 - 3x + 1 \overline{) 2x^4 - 10x^3 + 12x^2 + 2x - 3} \\ \underline{2x^4 - 6x^3 + 2x^2} \\ -4x^3 + 10x^2 + 2x - 3 \\ \underline{-4x^3 + 12x^2 - 4x} \\ -2x^2 + 6x - 3 \\ \underline{-2x^2 + 6x - 2} \\ -1 \end{array}$	2	2 for correct division 1 for work towards with one error
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Markers Comments

This question was generally well attempted. Most responses demonstrated knowledge of the process for division. Errors mostly involved subtraction involving negative numbers.

(b) ii	2	$2x^4 - 10x^3 + 12x^2 + 2x - 3 = (x^2 - 3x + 1)(2x^2 - 4x - 2) + -1$	1	1 for correct answer
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Markers Comments

This question was generally well attempted.

(b) iii	7	Any x value (zero) $x = \alpha$ that makes $A(x)=0$ $P(\alpha) = -1 \therefore$ no common zero.	1	1 for logical explanation or mathematical working to demonstrate
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Markers Comments

Generally, responses to this question did not adequately explain the link between factors of $A(x)$ and the remainder when $P(x)$ is divided by $A(x)$. 1 mark was awarded for acknowledgement of this link but students should be aware that in other instances, a more comprehensive explanation is required to show full understanding of the relationship of these facts.

(c) i	5	${}^8C_3 = 56$	1	1 for correct answer (left in notation form is acceptable)
Markers Comments Well answered by most students.				
(c) ii	5	Number of all women committee: ${}^4C_3 = 4$ $\therefore P(\text{all women}) = \frac{4}{56}$ $= \frac{1}{14}$	2	2 for correct answer 1 for correct calculation of women only committees oem
Markers Comments Well answered by most students				
(d)	2	$\cos t = \frac{x}{13} \quad \sin t = \frac{y}{13}$ $\sin^2 t + \cos^2 t = 1$ $\frac{y^2}{169} + \frac{x^2}{169} = 1$ $x^2 + y^2 = 169$	1	1 for correct equation
Markers Comments Students who were familiar with this style of parametric equation due to their diligent preparation were able to efficiently work towards a solution. Students who relied on making t the subject as per other parametric equations generally were not successful with this question.				

4	Outcome	GHS Ext 1 Year 11 Yearly 2022 Question 4 Worked Solutions	Marks	Allocation and Comments
(a) i	5	$\text{Number of ways} = \frac{7!}{3!2!}$ $= 420$	1	1 for correct solution
(a) ii	5	$D's \text{ grouped} = \frac{6!}{3!}$ $= 120$ $\therefore \text{Number of ways } D's \text{ separated} = 420 - 120$ $= 300$	2	2 for correct solution 1 for work towards solution

Markers Comments

a) i) Well done. Most students knew to divide by 3! For the 3 x E's and 2! For the 2 x D's.

ii) Not well done. Most knew to use the answer from part i) and subtract but still used 2! When the D's were grouped.

(b) i	2	$P(x) = (x-a)^3 + (x-b)^2$ $P(b) = (b-a)^3 + (b-b)^2 = -8$ $\therefore (b-a)^3 = -8$ $b-a = -2$ $a-b = 2$ $P(a) = (a-a)^3 + (a-b)^2$ $= (a-b)^2$ $= (2)^2$ $= 4$	2	2 for correct solution 1 for substitution of a or b into P(x) oem
(b) ii	2	$P\left(\frac{a+b}{2}\right) = \left(\frac{a+b}{2} - a\right)^3 + \left(\frac{a+b}{2} - b\right)^2$ $= \left(\frac{b-a}{2}\right)^3 + \left(\frac{a-b}{2}\right)^2$ $= \left(\frac{-2}{2}\right)^3 + \left(\frac{2}{2}\right)^2$ $= -1 + 1$ $= 0$ $\therefore \frac{a+b}{2} \text{ is a factor}$	2	2 for correct proof with logical steps 1 for substitution of root oem

Markers Comments

b) i) Many students used $P(a) = 4$ as a part of their proof. You cannot use what you have been asked to prove, as a part of your proof.

ii) You needed to simplify the substitution to earn your first mark. Many students forgot about the denominators of 2 when simplifying so could not get the result of 0.

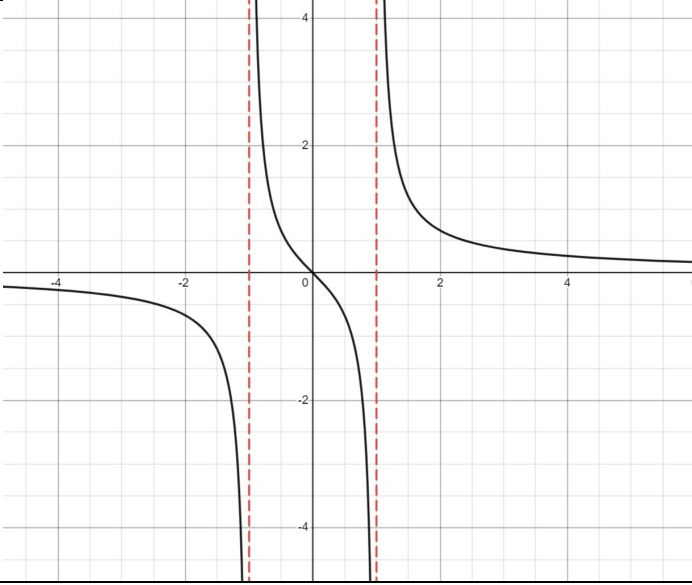
(c) i	5	$9! \times 2 = 725760$	1	1 for correct solution
(c) ii	5	Easy method: Colin will walk through the door after Brett half of the time so: $\frac{10!}{2} = 1,814,400$ Hard method: Using cases: Set Brett to position 1: Colin has 9 locations to stand, everyone else has 8! Set Brett to position 2: Colin has 8 locations to stand, everyone else has 8! Set Brett to position 3: Colin has 7 locations to stand, everyone else has 8! Set Brett to position 4: Colin has 6 locations to stand, everyone else has 8! Continue on in this manner and add the results to get: $Total = 8! \times (9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1)$ $= 1814400$	1	1 for correct answer

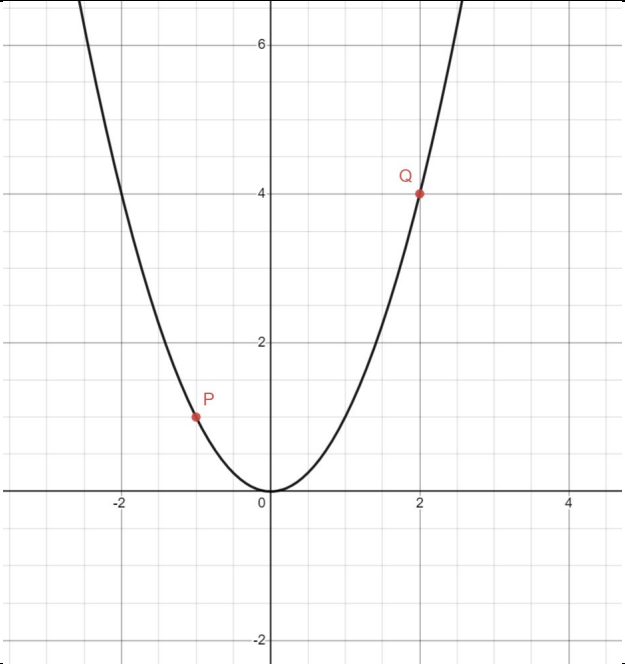
Markers Comments

c) i) Generally well done. Most students knew to group Brett and Colin together, making 9 objects then multiply by 2! for the 2 different ways they could stand.

ii) Better students knew the Easy method.

Students need to understand when to use factorial (!) notation and when not to use nPr or nCr.

5	Outcome	GHS Ext 1 Year 11 Yearly 2022 Question 5 Worked Solutions	Marks	Allocation and Comments
(a) i	7	When $x = 1, x = -1$ $f(x)$ is undefined	1	1 for correct solutions
(a) ii	7	$f(-x) = \frac{(-x)}{(-x)^2 - 1}$ $= -\frac{x}{x^2 - 1}$ $= -f(x)$ $\therefore f(x) \text{ is odd}$	1	1 for valid solution
(a) iii	7	$f'(x) = \frac{vu' - uv'}{v^2}$ $= \frac{(x^2 - 1) - x(2x)}{(x^2 - 1)^2}$ $= \frac{x^2 - 1 - 2x^2}{(x^2 - 1)^2}$ $= -\left(\frac{x^2 + 1}{(x^2 - 1)^2}\right) < 0$ Since the term in the brackets is always positive, the whole expression must always be negative	1	1 for correct differentiation and logical conclusion
(a) iv	7		2	2 for correct graph with correct intercepts 1 for a section of correct graph

(b) i	7		2	2 for correct graph with points P and Q correctly labelled 1 for points or graph correct
(b) ii	7	$\frac{dy}{dx} = 2x$ $x = -1, m = -2$ At $x = 2, m = 4$ Tangent at P: $y - 1 = -2(x + 1)$ $y = -2x - 1$ Tangent at Q: $y - 4 = 4(x - 2)$ $y = 4x - 4$ Solve Simultaneously: $4x - 4 = -2x - 1$ $6x = 3$ $x = \frac{1}{2}$ $y = 4 \times \frac{1}{2} - 4$ $= 2 - 4$ $= -2$ $\therefore$ Tangents intersect at $R\left(\frac{1}{2}, -2\right)$	3	3 for finding correct equations for tangents and solving simultaneously to find R 2 for finding equations for tangents and attempting to solve simultaneously oem 1 for work towards solution
(b) iii	7	$Q(2, 4) \quad R\left(\frac{1}{2}, -2\right)$ $\text{Midpoint} = \left(\frac{2 + \frac{1}{2}}{2}, \frac{4 + (-2)}{2} \right)$ $= \left(\frac{5}{4}, 1 \right)$ Equation of tangent at T:	3	3 for finding midpoint, finding the gradient of PQ, finding the tangent at T and solving to show the lines are parallel. 2 for finding the midpoint, gradient of PQ and the equation of the tangent at T but being unable to solve for m oem

	$y - 1 = m\left(x - \frac{5}{4}\right)$ $t^2 - 1 = m\left(t - \frac{5}{4}\right)$ $t^2 - mt + \frac{5}{4}m - 1 = 0$ One solution means $\Delta = 0$ $b^2 - 4ac = 0$ $(-m)^2 - 4(1)\left(\frac{5}{4}m - 1\right) = 0$ $m^2 - 5m + 4 = 0$ $(m - 4)(m - 1) = 0$ $m = 4, m = 1$ m=4 is the tangent at Q, not at a point between P and Q m=1 is the gradient of the tangent at T $m_{PQ} = \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{4 - 1}{2 - -1}$ $= \frac{3}{3}$ $= 1$ $\therefore m_{PQ} = m_T$ the lines must be parallel		1 for finding the midpoint of QR and gradient of PQ oem
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Markers Comments

- a i) Very well done. Some students also included $x = 0$ as undefined.
- a ii) Mostly well done although many students thought that a function was odd if $f(-x) \neq f(x)$.
- a iii) Generally well done. Some students used $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{uv' - vu'}{v^2}$
- a iv) Very poorly done. Most student managed to get the curve correct for $x > 1$ but got the rest of the domain wrong.
- b i) Very well done.
- b ii) Mostly well done. Some errors in finding the tangents, mostly silly arithmetic errors.
- b iii) Very poorly done. Many student assumed that the lines were parallel and then went on to prove that they were parallel.