



2019 YEAR 11 EXAMINATION

Mathematics Extension 1

**General
Instructions**

- Reading time – 5 minutes
- Working time – 1.5 hour
- Write using black pen
- Calculators approved by NESA may be used
- A reference sheet is provided with this question paper

For questions in Section II, show relevant mathematical reasoning and/or calculations

Total Marks: Section I – 10 Marks

55

- Attempt Questions 1 – 10
- Allow about 10 minutes for this section.

Section II – 45 Marks

- Attempt Questions 11 – 23
- Allow about 80 minutes for this section.

Multiple Choice	Short answer	Total
/10	/45	/55

DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM

Section I

10 marks

Attempt Questions 1–10

Allow about 10 minutes for this section

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

1 How many distinct arrangements are there of the letters of the word IONISATION?

- (A) 151 200
- (B) 604 800
- (C) 907 200
- (D) 3 628 800

2 What is the exact value of $\sin 15^\circ$

- (A) $\frac{2 - \sqrt{3}}{4}$
- (B) $\frac{\sqrt{3} - 1}{2\sqrt{2}}$
- (C) $\frac{1 - \sqrt{3}}{2\sqrt{2}}$
- (D) $\frac{1 + \sqrt{3}}{2\sqrt{2}}$

3 Given that $\cos^{-1}(\sqrt{1-t^2}) = \alpha$, which expression represents $\sin \alpha$.

(A) $\sqrt{1-t^2}$

(B) $\sqrt{1+t^2}$

(C) 1

(D) t

4 The velocity of a particle which is travelling along the x -axis is given by $v = 3t^2 + 4t + 5$, where t is the time in seconds.

Which of the following could be the function which gives the position of the particle with respect to time?

(A) $x = t^3 + 2t^2 + 5t + 10$

(B) $x = 3t^3 + 4t^2 + 5t + 10$

(C) $x = 6t + 4$

(D) $x = 3t + 4$

5 Which expression is equivalent to $\cos 3x \cos x + \sin 3x \sin x$?

(A) $2 \cos 4x \sin 4x$

(B) $\cos 4x + \sin 4x$

(C) $\cos 4x$

(D) $\cos 2x$

6 What is the inverse of the function $y = \frac{8x^3}{5} + 2$?

(A) $y = \frac{\sqrt[3]{5x - 10}}{8}$

(B) $y = \frac{\sqrt[3]{5x - 10}}{2}$

(C) $y = \frac{5\sqrt[3]{x - 2}}{2}$

(D) $y = \frac{\sqrt{5x - 10}}{2}$

7 Given the function $f(x) = -\frac{4}{\sqrt{x}}$, what is the solution to the equation $f'(x) = 128$?

(A) $\frac{1}{2}$

(B) 2

(C) $\frac{1}{4}$

(D) 4

8 Find the derivative of $\left(x + \frac{1}{x}\right)^2$ with respect to x .

(A) $2x - \frac{2}{x}$

(B) $2x + \frac{2}{x}$

(C) $2x - \frac{2}{x^3}$

(D) $2x + \frac{2}{x^3}$

9 Given $\sin \theta = \frac{1}{4}$ and $\tan \theta > 0$, what is the value of $\cos 2\theta$?

(A) $\frac{1}{2}$

(B) $\frac{3}{4}$

(C) $\frac{7}{8}$

(D) $\frac{2\sqrt{15}}{16}$

10 Solve $|3 - 2x| \leq 1$

(A) $1 \leq x \leq 2$

(B) $x \leq 1, x \geq 2$

(C) $-2 \leq x \leq -1$

(D) $x \leq -2, x \geq -1$

End of Section I

Section II

45 marks
Attempt Questions 11–23
Allow about 80 minutes for this section

Answer each question in the appropriate space.

In Questions 11–23, your responses should include relevant mathematical reasoning and/or calculations.

Question 11 (2 marks)

Solve the inequality $\frac{x-2}{x} > 0$

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Question 12 (4 marks)

Consider the function $y = \frac{1}{x} - 2$

- (a) State the equations of the vertical and horizontal asymptotes.

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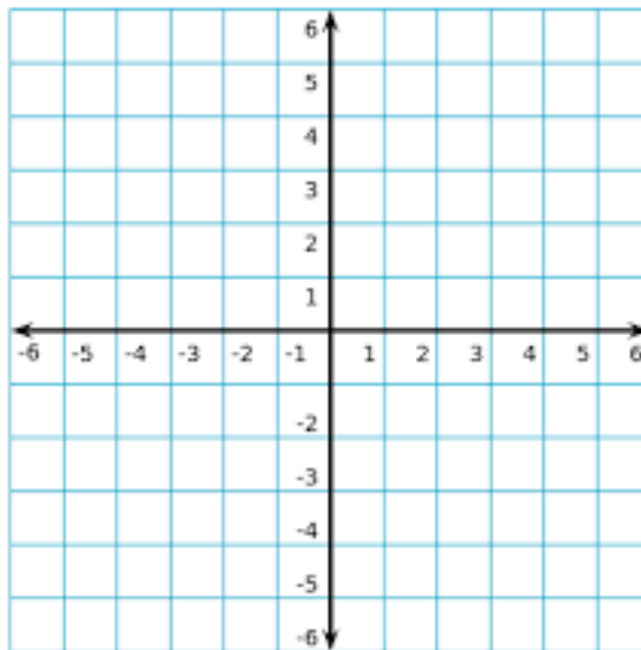
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- (b) Sketch the graph of the function, including all asymptotes and intercepts.

2



Question 13 (3 marks)

Fully factorise the polynomial $P(x) = x^3 - 7x^2 + 36$.

3

Question 14 (5 marks)

(a) Expand $(3 + x^2)^5$. **2**

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(b) Hence find the coefficient of x^4 in $(x + 2)^2(3 + x^2)^5$ **3**

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Question 15 (5 marks)

- (a) Show that $\sin 3A = 3\sin A - 4\sin^3 A$

3

[illegible]

- (b) Given that $t = \tan \frac{\theta}{2}$, show that $\frac{\sin \theta}{1 + \cos \theta} = t$

2

[illegible]

Question 16 (2 marks)

Find the exact value of $\cos^{-1}\left(\frac{\sqrt{3}}{2}\right) - \tan^{-1}(-\sqrt{3})$ in radians. Show full working. **2**

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Question 17 (3 marks)

Solve $\sin \theta + 6 \cos^2 \theta = 5$ for $0^\circ \leq \theta \leq 360^\circ$. **3**

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Question 18 (4 marks)

Find the number of ways in which a committee of 3 people can be chosen from 4 teachers and 5 students.

(a) Without restriction.

1

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(b) Exactly one student.

1

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(c) At least one teacher.

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Question 19 (4 marks)

A coin is dropped from a tall building. Its height h metres above the ground t seconds after it is dropped, is given by $h = 50 - 4.9t^2$

- (a) How tall is the building? 1

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- (b) What is the velocity of the coin when it hits the ground? 2

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- (c) Find the acceleration of the coin as it falls to the ground. 1

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Question 20 (3 marks)

Differentiate the following, expressing your answer as a single fraction:

$$\frac{2x^2 - 4x}{x\sqrt{x}}$$

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Question 21 (3 marks)

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Sketch the function $y = 2\sin^{-1}(\frac{x}{3})$ and state the domain and range.

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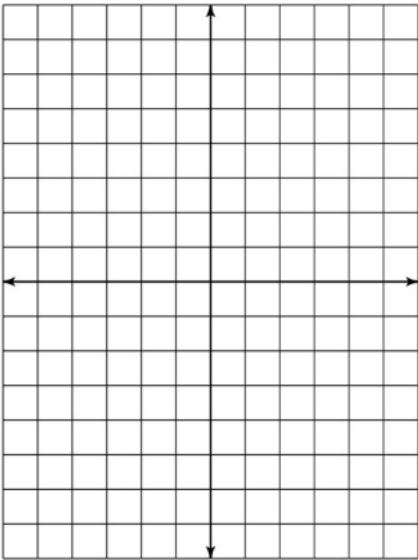
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Question 22 (3 marks)

Two of the roots of the cubic equation $x^3 + 7x^2 - 16x + d = 0$ are opposites.

- (a) Find the roots of the cubic equation. 2

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- (b) Find the value of d . 1

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Question 23 (4 marks)

A sphere is expanding so that its surface area is increasing at $24\text{cm}^2 / \text{s}$. When the radius is 12 cm, find the rate of increase, in exact form where appropriate, of its:

Surface area of a sphere: $4\pi r^2$

Volume of a sphere: $\frac{4}{3}\pi r^3$

(a) Radius **2**

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(b) Volume **2**

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End of examination

Section II extra writing space

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Section II extra writing space

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Section II extra writing space

If you use this space, clearly indicate which question you are answering.

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Section I Multiple-Choice Answer Sheet

- | | | | | |
|----|-------------------------|-------------------------|-------------------------|-------------------------|
| 1 | A ☐ | B ☐ | C ☐ | D ☐ |
| 2 | A ☐ | B ☐ | C ☐ | D ☐ |
| 3 | A ☐ | B ☐ | C ☐ | D ☐ |
| 4 | A ☐ | B ☐ | C ☐ | D ☐ |
| 5 | A ☐ | B ☐ | C ☐ | D ☐ |
| 6 | A ☐ | B ☐ | C ☐ | D ☐ |
| 7 | A ☐ | B ☐ | C ☐ | D ☐ |
| 8 | A ☐ | B ☐ | C ☐ | D ☐ |
| 9 | A ☐ | B ☐ | C ☐ | D ☐ |
| 10 | A ☐ | B ☐ | C ☐ | D ☐ |



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- (B) 604 800
- (C) 907 200
- (D) 3 628 800

$$\frac{10!}{3!2!2!}$$

2 What is the exact value of $\sin 15^\circ$?

(A) $\frac{2-\sqrt{3}}{4}$

(B) $\frac{\sqrt{3}-1}{2\sqrt{2}}$

(C) $\frac{1-\sqrt{3}}{2\sqrt{2}}$

(D) $\frac{1+\sqrt{3}}{2\sqrt{2}}$

$$\sin 15 = \sin (45 - 30)$$

$$= \sin 45 \cos 30 - \sin 30 \cos 45$$

$$= \frac{1}{\sqrt{2}} \times \frac{\sqrt{3}}{2} - \frac{1}{2} \times \frac{1}{\sqrt{2}}$$

$$= \frac{\sqrt{3}}{2\sqrt{2}} - \frac{1}{2\sqrt{2}}$$

$$= \frac{\sqrt{3}-1}{2\sqrt{2}}$$

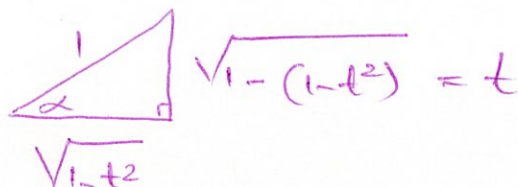
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(A) $\sqrt{1-t^2}$

(B) $\sqrt{1+t^2}$

(C) 1

(D) t



$$\sin \alpha = \frac{t}{1} = t.$$

4 The velocity of a particle which is travelling along the x -axis is given by $v = 3t^2 + 4t + 5$, where t is the time in seconds.

Which of the following could be the function which gives the position of the particle with respect to time?

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5 Which expression is equivalent to $\cos 3x \cos x + \sin 3x \sin x$?

(A) $2 \cos 4x \sin 4x$

(B) $\cos 4x + \sin 4x$

(C) $\cos 4x$

(D) $\cos 2x$

$$\cos(3x - x) = \cos 2x$$

6 What is the inverse of the function $y = \frac{8x^3}{5} + 2$?

(A) $y = \frac{\sqrt[3]{5x-10}}{8}$

(B) $y = \frac{\sqrt[3]{5x-10}}{2}$

(C) $y = \frac{5\sqrt[3]{x-2}}{2}$

(D) $y = \frac{\sqrt{5x-10}}{2}$

$$x = \frac{8y^3}{5} + 2$$

$$x - 2 = \frac{8y^3}{5}$$

$$5x - 10 = 8y^3$$

$$y^3 = \frac{5x-10}{8}$$

$$y = \frac{\sqrt[3]{5x-10}}{2}$$

7 Given the function $f(x) = -\frac{4}{\sqrt{x}}$, what is the solution to the equation $f'(x) = 128$?

(A) $\frac{1}{2}$

(B) 2

(C) $\frac{1}{4}$

(D) 4

$$f(x) = -4x^{-1/2}$$

$$f'(x) = -4x^{-3/2} = 128$$

$$x^{-3/2} = 64$$

$$\sqrt{x^3} = \frac{1}{64}$$

$$x^3 = \left(\frac{1}{64}\right)^2$$

$$x^3 = \frac{1}{8}$$

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

$$x = \sqrt[3]{\frac{1}{64}}$$

$$x = \frac{1}{4}$$

8 Find the derivative of $\left(x + \frac{1}{x}\right)^2$ with respect to x .

(A) $2x - \frac{2}{x}$

(B) $2x + \frac{2}{x}$

(C) $2x - \frac{2}{x^3}$

(D) $2x + \frac{2}{x^3}$

$$y' = 2\left(x + \frac{1}{x}\right)\left(1 - \frac{1}{x^2}\right)$$

$$= 2\left(x - \frac{1}{x} + \frac{1}{x} - \frac{1}{x^3}\right)$$

$$= 2x - \frac{2}{x^3}$$

9 Given $\sin \theta = \frac{1}{4}$ and $\tan \theta > 0$, what is the value of $\cos 2\theta$?

(A) $\frac{1}{2}$

(B) $\frac{3}{4}$

(C) $\frac{7}{8}$

(D) $\frac{2\sqrt{15}}{16}$

$$\begin{aligned}\cos 2\theta &= 1 - 2\sin^2 \theta \\ &= 1 - 2\left(\frac{1}{4}\right)^2 \\ &= 1 - \frac{1}{8} \\ &= \frac{7}{8}\end{aligned}$$

10 Solve $|3 - 2x| \leq 1$

(A) $1 \leq x \leq 2$

(B) $x \leq 1, x \geq 2$

(C) $-2 \leq x \leq -1$

(D) $x \leq -2, x \geq -1$

$$\begin{aligned}3 - 2x &\leq 1 \\ -2x &\leq -2 \\ x &\geq 1\end{aligned}$$

$$\begin{aligned}-3 + 2x &\leq 1 \\ 2x &\leq 4 \\ x &\leq 2\end{aligned}$$

End of Section I

Section II

45 marks

Attempt Questions 11–23

Allow about 80 minutes for this section

Answer each question in the appropriate space.

In Questions 11–23, your responses should include relevant mathematical reasoning and/or calculations.

Question 11 (2 marks)

Solve the inequality $\frac{x-2}{x} > 0$

2

$$x \neq 0$$

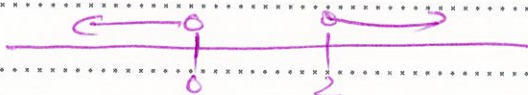
$$\frac{x-2}{x} \times x > 0$$

$$x^2 - 2x > 0$$

$$x(x-2) > 0$$

$$\text{Solve } x(x-2) = 0$$

$$x = 0, x = 2$$



$$x < 0, x > 2$$

Question 12 (4 marks)

Consider the function $y = \frac{1}{x} - 2$

- (a) State the equations of the vertical and horizontal asymptotes.

2

VA: $x = 0$

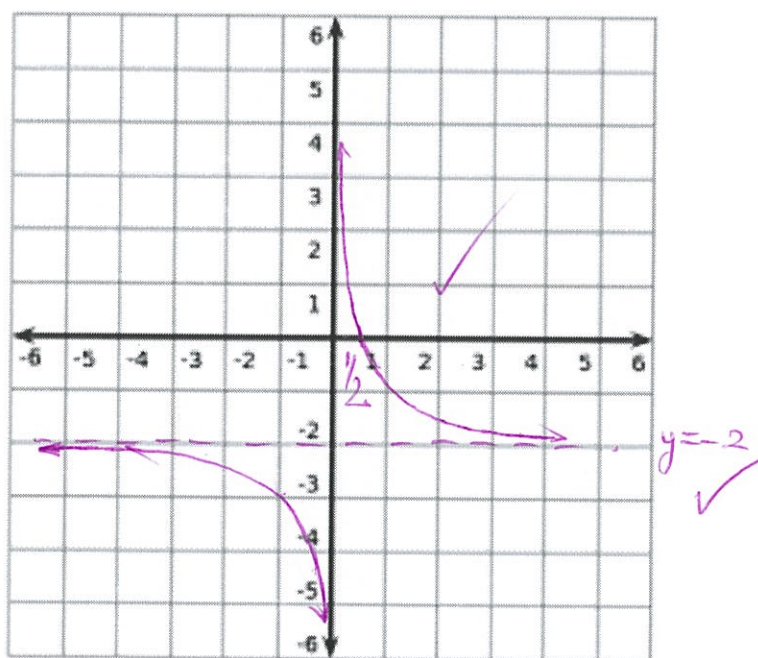
✓

HA: $y = -2$

✓

- (b) Sketch the graph of the function, including all asymptotes and intercepts.

2



Question 13 (3 marks)Fully factorise the polynomial $P(x) = x^3 - 7x^2 + 36$.

3

Test factor $(x-6)$

$$P(6) = 6^3 - 7(6)^2 + 36$$
$$= 0$$

 $\therefore (x-6)$ is a factor ✓

$$\begin{array}{r} x^2 - x - 6 \\ x-6 \overline{) x^3 - 7x^2 + 36} \\ \underline{x^3 - 6x^2} \\ -x^2 + 36 \\ \underline{-x^2 + 6x} \\ -6x + 36 \\ \underline{-6x + 36} \\ 0 \end{array}$$

$$\therefore P(x) = (x-6)(x^2 - x - 6)$$
 ✓

$$= (x-6)(x-3)(x+2)$$
 ✓

Question 14 (5 marks)

(a) Expand $(3 + x^2)^5$.

2

$$\begin{aligned} &= {}^5C_0 3^5 + {}^5C_1 3^4 x^2 + {}^5C_2 3^3 (x^2)^2 + {}^5C_3 3^2 (x^2)^3 + {}^5C_4 3 (x^2)^4 + {}^5C_5 (x^2)^5 \quad \checkmark \\ &= 243 + 405x^2 + 270x^4 + 90x^6 + 15x^8 + x^{10} \quad \checkmark \end{aligned}$$

(b) Hence find the coefficient of x^4 in $(x + 2)^2(3 + x^2)^5$

3

$$(x+2)^2 = x^2 + 4x + 4 \quad \checkmark$$

$$\Rightarrow (405x^2 \times x^2) + 4 \times 270x^4 \quad \checkmark$$

$$= 1485x^4$$

$$\therefore \text{coefficient is } 1485 \quad \checkmark$$

Question 15 (5 marks)

(a) Show that $\sin 3A = 3\sin A - 4\sin^3 A$

3

$$\sin 3A = \sin(2A + A)$$

$$= \sin 2A \cos A + \sin A \cos 2A$$

$$= 2\sin A \cos A \cos A + \sin A(1 - 2\sin^2 A)$$

$$= 2\sin A \cos^2 A + \sin A - 2\sin^3 A$$

$$= 2\sin A(1 - \sin^2 A) + \sin A - 2\sin^3 A$$

$$= 2\sin A - 2\sin^3 A + \sin A - 2\sin^3 A$$

$$= 3\sin A - 4\sin^3 A$$

(b) Given that $t = \tan \frac{\theta}{2}$, show that $\frac{\sin \theta}{1 + \cos \theta} = t$

2

$$\text{LHS } \frac{\sin \theta}{1 + \cos \theta} = \frac{2t}{1 + t^2} \div \left(1 + \frac{1 - t^2}{1 + t^2}\right)$$

$$= \frac{2t}{1 + t^2} \div \left(\frac{1 + t^2 + 1 - t^2}{1 + t^2}\right)$$

$$= \frac{2t}{1 + t^2} \times \frac{1 + t^2}{2}$$

$$= \frac{2t}{2}$$

$$= t$$

$$= \text{RHS}$$

Question 16 (2 marks)

Find the exact value of $\cos^{-1}\left(\frac{\sqrt{3}}{2}\right) - \tan^{-1}(-\sqrt{3})$ in radians. Show full working.

2

$$\frac{\pi}{6} - \left(-\frac{\pi}{3}\right) \quad \checkmark$$

$$= \frac{\pi}{6} + \frac{\pi}{3}$$

$$= \frac{\pi}{2} \quad \checkmark$$

Question 17 (3 marks)

Solve $\sin \theta + 6 \cos^2 \theta = 5$ for $0^\circ \leq \theta \leq 360^\circ$.

3

$$\sin \theta + 6(1 - \sin^2 \theta) = 5$$

$$\sin \theta + 6 - 6\sin^2 \theta - 5 = 0$$

$$6\sin^2 \theta - \sin \theta - 1 = 0 \quad \checkmark$$

$$P = -6$$

$$Q = -1 \quad (-3, 2)$$

$$6\sin^2 \theta - 3\sin \theta + 2\sin \theta - 1 = 0$$

$$3\sin \theta (2\sin \theta - 1) + (2\sin \theta - 1) = 0$$

$$(2\sin \theta - 1)(3\sin \theta + 1) = 0$$

$$2\sin \theta - 1 = 0 \rightarrow \sin \theta = \frac{1}{2}$$

$$\theta = 30^\circ, 150^\circ \quad \checkmark$$

$$3\sin \theta + 1 = 0 \rightarrow \sin \theta = -\frac{1}{3}$$

$$\theta = 199^\circ, 341^\circ \quad \checkmark$$

Question 18 (4 marks)

Find the number of ways in which a committee of 3 people can be chosen from 4 teachers and 5 students.

(a) Without restriction.

1

$${}^9C_3 = 84$$

(b) Exactly one student.

1

$${}^4C_2 \times {}^5C_1 = 30$$

(c) At least one teacher.

2

$$\text{No teacher } {}^5C_3 = 10 \checkmark$$

$${}^9C_3 - 10$$

$$= 84 - 10$$

$$= 74 \checkmark$$

Question 19 (4 marks)

A coin is dropped from a tall building. Its height h metres above the ground t seconds after it is dropped, is given by $h = 50 - 4.9t^2$

(a) How tall is the building?

1

At $t=0$ $h = 50 - 4.9 \times 0$

$h = 50 \text{ m.}$

Building is 50m tall

(b) What is the velocity of the coin when it hits the ground?

2

when coin hits the ground $h=0$

$0 = 50 - 4.9t^2$

$4.9t^2 = 50$

$t = \frac{\sqrt{50}}{4.9} = 3.2 \text{ seconds.}$

$v = \frac{dh}{dt} = -9.8t$

At $t = 3.2 \text{ second.}$

$v = -9.8 \times 3.2$

$= -31.4 \text{ m/s.}$

(c) Find the acceleration of the coin as it falls to the ground.

1

$a = v' = -9.8 \text{ m/s}^2$

Question 20 (3 marks)

Differentiate the following, expressing your answer as a single fraction:

$$\frac{2x^2 - 4x}{x\sqrt{x}}$$

3

$$u = 2x^2 - 4x \rightarrow u' = 4x - 4$$

$$v = x\sqrt{x} \rightarrow v' = \frac{3}{2}\sqrt{x}$$

$$y' = \frac{u'v - v'u}{v^2}$$

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

$$= \frac{4x^2\sqrt{x} - 4x\sqrt{x} - 3x^2\sqrt{x} + 6x\sqrt{x}}{x^3}$$

$$= \frac{x^2\sqrt{x} + 2x\sqrt{x}}{x^3}$$

$$= \frac{x\sqrt{x} + 2\sqrt{x}}{x^2}$$

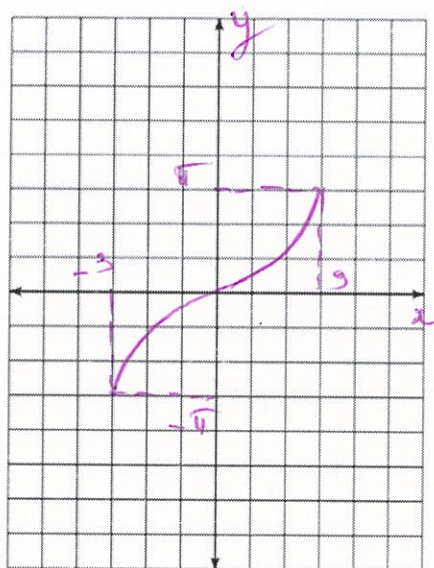
Question 21 (3 marks)

Sketch the function $y = 2\sin^{-1}\left(\frac{x}{3}\right)$ and state the domain and range.

3

Domain $[-3, 3]$

Range $[-\pi, \pi]$



Question 22 (3 marks)

Two of the roots of the cubic equation $x^3 + 7x^2 - 16x + d = 0$ are opposites.

- (a) Find the roots of the cubic equation.

2

Let the roots be: $\alpha, -\alpha, \beta$

$$\alpha - \alpha + \beta = -\frac{b}{a}$$

$$\beta = -7$$

$$\alpha(-\alpha) + \alpha(\beta) + \beta(-\alpha) = \frac{c}{a}$$

$$-\alpha^2 + 7\alpha + 7\alpha = -16$$

$$\alpha^2 = 16$$

$$\alpha = \pm 4$$

Roots are: 4, -4, -7

- (b) Find the value of d .

1

$$\alpha(-\alpha)\beta = -\frac{d}{a}$$

$$4(-4)(-7) = -d$$

$$-d = 112$$

$$d = -112$$

Question 23 (4 marks)

A sphere is expanding so that its surface area is increasing at $24\text{cm}^2/\text{s}$. When the radius is 12 cm, find the rate of increase, in exact form where appropriate, of its:

Surface area of a sphere: $4\pi r^2$

Volume of a sphere: $\frac{4}{3}\pi r^3$

(a) Radius

2

$$A = 4\pi r^2 \Rightarrow \frac{dA}{dr} = 8\pi r$$

$$\frac{dA}{dt} = 24$$

$$\frac{dr}{dt} = \frac{dA}{dt} \times \frac{dr}{dA}$$

$$= 24 \times \frac{1}{8\pi r}$$

$$= \frac{3}{\pi r}$$

$$\text{When } r=12, \frac{dr}{dt} = \frac{3}{12\pi} = \frac{1}{4\pi} \text{ cm/s}$$

(b) Volume

2

$$V = \frac{4}{3}\pi r^3$$

$$\frac{dV}{dr} = 4\pi r^2$$

$$\frac{dV}{dt} = \frac{dV}{dr} \times \frac{dr}{dt}$$

$$= 4\pi r^2 \times \frac{3}{\pi r}$$

$$= 12r$$

$$\text{When } r=12, \frac{dV}{dt} = 12 \times 12 = 144 \text{ cm}^3/\text{s}$$

End of examination

Section I Multiple-Choice Answer Sheet

- | | | | | |
|----|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| 1 | A ☒ | B ☐ | C ☐ | D ☐ |
| 2 | A ☐ | B ☒ | C ☐ | D ☐ |
| 3 | A ☐ | B ☐ | C ☐ | D ☒ |
| 4 | A ☒ | B ☐ | C ☐ | D ☐ |
| 5 | A ☐ | B ☐ | C ☐ | D ☒ |
| 6 | A ☐ | B ☒ | C ☐ | D ☐ |
| 7 | A ☒ | B ☐ | C ☐ | D ☐ |
| 8 | A ☐ | B ☐ | C ☒ | D ☐ |
| 9 | A ☐ | B ☐ | C ☒ | D ☐ |
| 10 | A ☒ | B ☐ | C ☐ | D ☐ |