NSW GOVERNMENT

NSW Education Standards Authority

Sample **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Mathematics Extension 1

General Instructions

- Reading time – 10 minutes
- Working time – 2 hours
- Write using black pen
- Calculators approved by NESA may be used
- A reference sheet is provided at the back of this paper
- In Questions 11–14, show relevant mathematical reasoning and/or calculations

Total marks: 70

Section I – 10 marks (pages 2–6)

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

Section II – 60 marks (pages 7–12)

- Attempt Questions 11–14
- Allow about 1 hour 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 What is the angle between the vectors $\begin{pmatrix} 7 \\ 1 \end{pmatrix}$ and $\begin{pmatrix} -1 \\ 1 \end{pmatrix}$?

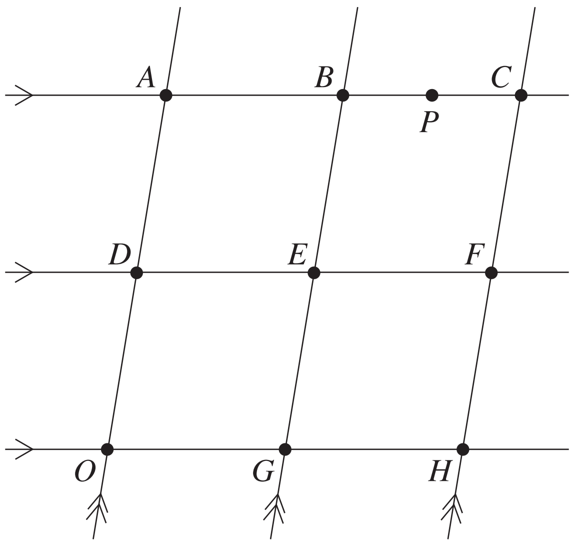
A. $\cos^{-1}(0.6)$

B. $\cos^{-1}(0.06)$

C. $\cos^{-1}(-0.06)$

D. $\cos^{-1}(-0.6)$

2 The diagram shows a grid of equally spaced lines. The vector $\overrightarrow{OH} = \underset{\sim}{h}$ and the vector $\overrightarrow{OA} = \underset{\sim}{a}$. The point P is halfway between B and C.



Which expression represents the vector $\overrightarrow{OP}$?

A. $-\frac{1}{2}\underset{\sim}{a} - \frac{1}{4}\underset{\sim}{h}$

B. $\frac{1}{4}\underset{\sim}{a} - \frac{1}{2}\underset{\sim}{h}$

C. $\underset{\sim}{a} + \frac{1}{4}\underset{\sim}{h}$

D. $\underset{\sim}{a} + \frac{3}{4}\underset{\sim}{h}$

3 Given that $\cos\theta - 2\sin\theta + 2 = 0$, which of the following shows the two possible values for $\tan\dfrac{\theta}{2}$?

A. -3 or -1

B. -3 or 1

C. -1 or 3

D. 1 or 3

4 What is the derivative of $\tan^{-1}\dfrac{x}{2}$?

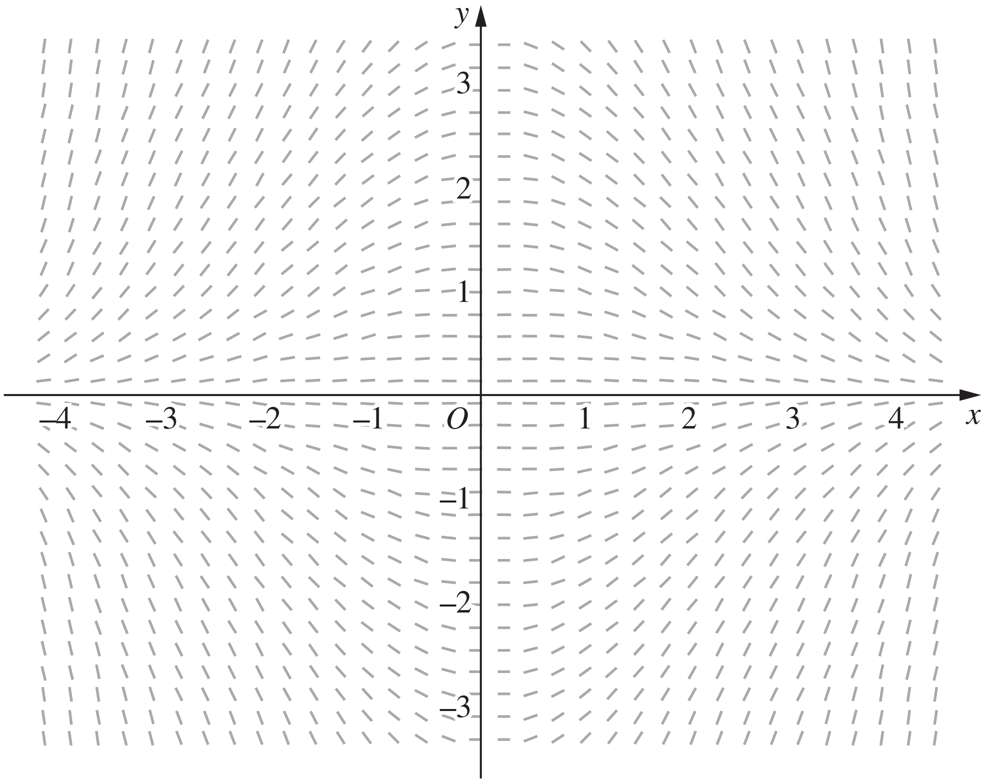
A. $\dfrac{1}{2\left(4+x^2\right)}$

B. $\dfrac{1}{4+x^2}$

C. $\dfrac{2}{4+x^2}$

D. $\dfrac{4}{4+x^2}$

5 The slope field for a first order differential equation is shown.



Which of the following could be the differential equation represented?

A. $\dfrac{dy}{dx} = \dfrac{x}{3y}$

B. $\dfrac{dy}{dx} = -\dfrac{x}{3y}$

C. $\dfrac{dy}{dx} = \dfrac{xy}{3}$

D. $\dfrac{dy}{dx} = -\dfrac{xy}{3}$

6 Let $P(x) = qx^3 + rx^2 + rx + q$ where q and r are constants, $q \neq 0$. One of the zeros of $P(x)$ is -1.

Given that α is a zero of $P(x)$, $\alpha \neq -1$, which of the following is also a zero?

A. $-\dfrac{1}{\alpha}$

B. $-\dfrac{q}{\alpha}$

C. $\dfrac{1}{\alpha}$

D. $\dfrac{q}{\alpha}$

7 Each of the students in an athletics team is randomly allocated their own locker from a row of 100 lockers.

What is the smallest number of students in the team that guarantees that two students are allocated consecutive lockers?

A. 26

B. 34

C. 50

D. 51

8 A team of 11 students is to be chosen from a group of 18 students. Among the 18 students are 3 students who are left-handed.

What is the number of possible teams containing at least 1 student who is left-handed?

A. 19 448

B. 30 459

C. 31 824

D. 58 344

9 A stone drops into a pond, creating a circular ripple. The radius of the ripple increases from 0 cm at a constant rate of 5 cm s^{-1}.

At what rate is the area enclosed within the ripple increasing when the radius is 15 cm?

A. 25π $cm^2\,s^{-1}$

B. 30π $cm^2\,s^{-1}$

C. 150π $cm^2\,s^{-1}$

D. 225π $cm^2\,s^{-1}$

10 The graph of the function $y = \sin^{-1}(x - 4)$ is transformed by being dilated horizontally with a scale factor of 2 and then translated to the right by 1.

What is the equation of the transformed graph?

A. $y = \sin^{-1}\left(\dfrac{x-9}{2}\right)$

B. $y = \sin^{-1}\left(\dfrac{x-10}{2}\right)$

C. $y = \sin^{-1}(2x - 6)$

D. $y = \sin^{-1}(2x - 5)$

Section II

60 marks
Attempt Questions 11–14
Allow about 1 hour and 45 minutes for this section

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

In Questions 11–14, your responses should include relevant mathematical reasoning and/or calculations.

Question 11 (15 marks) Use the Question 11 Writing Booklet.

(a) A particle is fired from the origin O with initial velocity 18 m s^{-1} at an angle 60° to the horizontal.

The equations of motion are $\dfrac{d^2x}{dt^2} = 0$ and $\dfrac{d^2y}{dt^2} = -10$.

(i) Show that $x = 9t$. **1**

(ii) Show that $y = 9\sqrt{3}t - 5t^2$. **2**

(iii) Hence find the Cartesian equation for the trajectory of the particle. **1**

(b) A function $f(x)$ is given by $x^2 + 4x + 7$.

(i) Explain why the domain of the function $f(x)$ must be restricted if $f(x)$ is to have an inverse function. **1**

(ii) Give the equation for $f^{-1}(x)$ if the domain of $f(x)$ is restricted to $x \geq -2$. **2**

(iii) State the domain and range of $f^{-1}(x)$, given the restriction in part (ii). **2**

(iv) Sketch the curve $y = f^{-1}(x)$. **2**

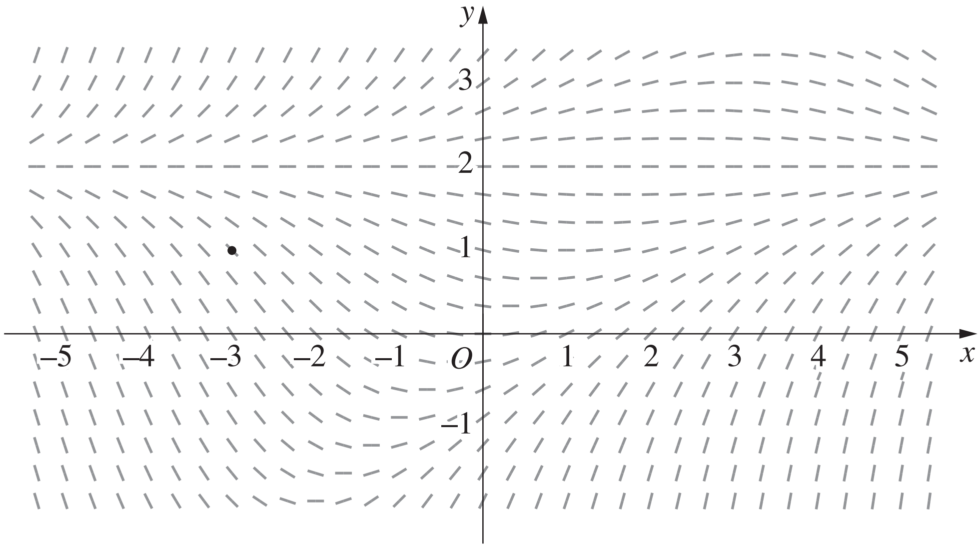
Question 11 continues on page 8

Question 11 (continued)

(c) The trajectories of particles in a fluid are described by the differential equation

$$\frac{dy}{dx} = \frac{1}{4}(y-2)(y-x).$$

The slope field for the differential equation is sketched below.



(i) Identify any solutions of the form $y = k$, where k is a constant. **1**

(ii) Draw a sketch of the trajectory of a particle in the fluid which passes through the point $(-3,1)$ and describe the trajectory as $x \longrightarrow \pm\infty$. **3**

End of Question 11

Question 12 (15 marks) Use the Question 12 Writing Booklet.

(a) A recent census showed that 20% of the adults in a city eat out regularly.

(i) A survey of 100 adults in this city is to be conducted to find the proportion who eat out regularly. Show that the mean and standard deviation for the distribution of sample proportions of such surveys are 0.2 and 0.04 respectively. **2**

(ii) Use the extract shown from a table giving values of $P(Z < z)$, where z has a standard normal distribution, to estimate the probability that a survey of 100 adults will find that at most 15 of those surveyed eat out regularly. **2**

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177

(b) A force described by the vector $\underset{\sim}{F} = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$ newtons is applied to an object lying on a line ℓ which is parallel to the vector $\begin{pmatrix} 3 \\ 4 \end{pmatrix}$.

(i) Find the component of the force $\underset{\sim}{F}$ in the direction of the line ℓ. **2**

(ii) What is the component of the force $\underset{\sim}{F}$ in the direction perpendicular to the line? **1**

(c) The points A and B are fixed points in a plane and have position vectors $\underset{\sim}{a}$ and $\underset{\sim}{b}$ respectively.

The point P with position vector $\underset{\sim}{p}$ also lies in the plane and is chosen so that $\angle APB = 90°$.

(i) Explain why $(\underset{\sim}{a} - \underset{\sim}{p}) \cdot (\underset{\sim}{b} - \underset{\sim}{p}) = 0$. **1**

(ii) Let $\underset{\sim}{m} = \frac{1}{2}(\underset{\sim}{a} + \underset{\sim}{b})$ denote the position vector of M, the midpoint of A and B. **3**

Using the properties of vectors, show that $\left|\underset{\sim}{p} - \underset{\sim}{m}\right|^2$ is independent of $\underset{\sim}{p}$ and find its value.

(iii) What does the result in part (ii) prove about the point P? **1**

(d) Use mathematical induction to prove that $2^{3n} - 3^n$ is divisible by 5 for $n \geq 1$. **3**

Question 13 (14 marks) Use the Question 13 Writing Booklet.

(a) Using the substitution $x = \sin^2\theta$, or otherwise, evaluate $\displaystyle\int_0^{\frac{1}{2}} \sqrt{\frac{x}{1-x}}\, dx$. **3**

(b) A device playing a signal given by $x = \sqrt{2}\sin t + \cos t$ produces distortion whenever $|x| \geq 1.5$. **4**

For what fraction of the time will the device produce distortion if the signal is played continuously?

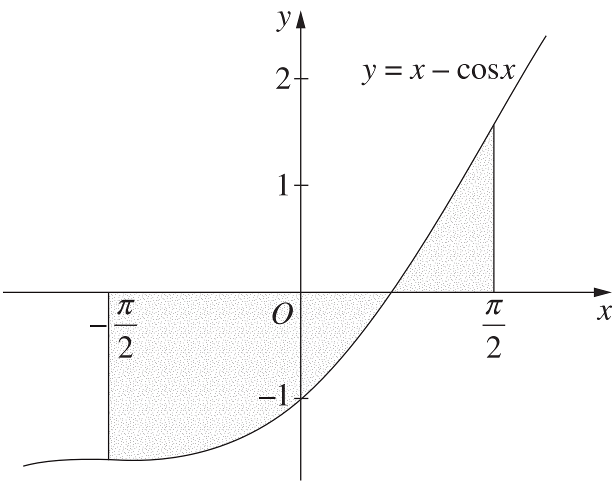
(c) (i) Prove the trigonometric identity $\cos 3\theta = 4\cos^3\theta - 3\cos\theta$. **3**

(ii) Hence find expressions for the exact values of the solutions to the equation $8x^3 - 6x = 1$. **4**

Question 14 (16 marks) Use the Question 14 Writing Booklet.

(a) (i) Sketch the graph of $y = x\cos x$ for $-\pi \le x \le \pi$ and hence explain why $\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} x\cos x \, dx = 0$. **3**

(ii) Consider the volume of the solid of revolution produced by rotating about the x-axis the shaded region between the graph of $y = x - \cos x$, the x-axis and the lines $x = -\frac{\pi}{2}$ and $x = \frac{\pi}{2}$. **3**



Using the results of part (i), or otherwise, find the volume of the solid.

(b) The population of foxes on an island is modelled by the logistic equation $\frac{dy}{dt} = y(1 - y)$, where y is the fraction of the island's carrying capacity reached after t years.

At time $t = 0$, the population of foxes is estimated to be one-quarter of the island's carrying capacity.

(i) Use the substitution $y = \frac{1}{1 - w}$ to transform the logistic equation to $\frac{dw}{dt} = -w$. **2**

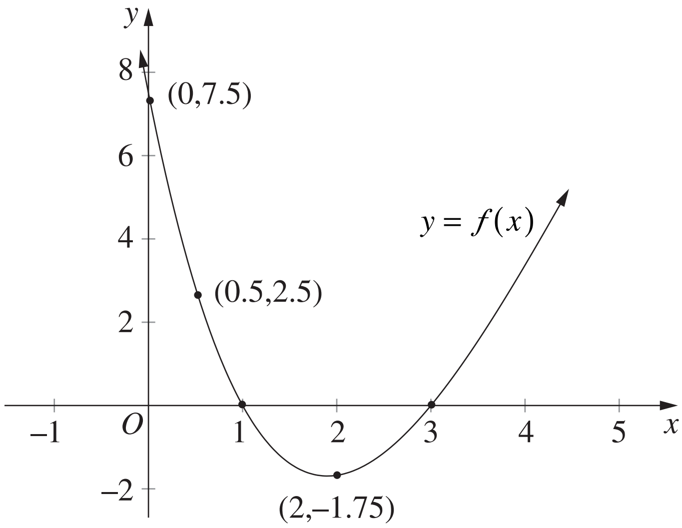
(ii) Using the solution of $\frac{dw}{dt} = -w$, find the solution of the logistic equation for y satisfying the initial conditions. **2**

(iii) How long will it take for the fox population to reach three-quarters of the island's carrying capacity? **2**

Question 14 continues on page 12

Question 14 (continued)

(c) The diagram below is a sketch of the graph of the function $y = f(x)$.



(i) Sketch the graph of $y = \dfrac{1}{|f(x)|}$. **3**

Your sketch should show any asymptotes and intercepts, together with the location of the points corresponding to the labelled points on the original sketch.

(ii) How many solutions does the equation $\dfrac{1}{|f(x)|} = x$ have? **1**

End of paper

NSW Education Standards Authority

2020 HIGHER SCHOOL CERTIFICATE EXAMINATION

Mathematics Advanced
Mathematics Extension 1
Mathematics Extension 2

REFERENCE SHEET

Measurement

Length

$$l = \frac{\theta}{360} \times 2\pi r$$

Area

$$A = \frac{\theta}{360} \times \pi r^2$$

$$A = \frac{h}{2}(a + b)$$

Surface area

$$A = 2\pi r^2 + 2\pi rh$$

$$A = 4\pi r^2$$

Volume

$$V = \frac{1}{3}Ah$$

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

Functions

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

For $ax^3 + bx^2 + cx + d = 0$:

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

$$\alpha\beta + \alpha\gamma + \beta\gamma = \frac{c}{a}$$

and $\alpha\beta\gamma = -\frac{d}{a}$

Relations

$$(x - h)^2 + (y - k)^2 = r^2$$

Financial Mathematics

$$A = P(1 + r)^n$$

Sequences and series

$$T_n = a + (n - 1)d$$

$$S_n = \frac{n}{2}[2a + (n - 1)d] = \frac{n}{2}(a + l)$$

$$T_n = ar^{n-1}$$

$$S_n = \frac{a(1 - r^n)}{1 - r} = \frac{a(r^n - 1)}{r - 1}, \ r \neq 1$$

$$S = \frac{a}{1 - r}, \ |r| < 1$$

Logarithmic and Exponential Functions

$$\log_a a^x = x = a^{\log_a x}$$

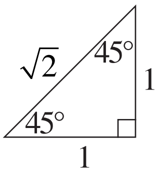
$$\log_a x = \frac{\log_b x}{\log_b a}$$

$$a^x = e^{x \ln a}$$

Trigonometric Functions

$$\sin A = \frac{\text{opp}}{\text{hyp}}, \quad \cos A = \frac{\text{adj}}{\text{hyp}}, \quad \tan A = \frac{\text{opp}}{\text{adj}}$$

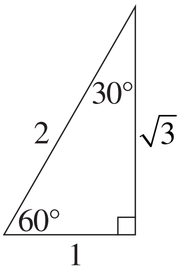
$$A = \frac{1}{2}ab\sin C$$



$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

$$\cos C = \frac{a^2 + b^2 - c^2}{2ab}$$



$$l = r\theta$$

$$A = \frac{1}{2}r^2\theta$$

Trigonometric identities

$$\sec A = \frac{1}{\cos A}, \ \cos A \neq 0$$

$$\operatorname{cosec} A = \frac{1}{\sin A}, \ \sin A \neq 0$$

$$\cot A = \frac{\cos A}{\sin A}, \ \sin A \neq 0$$

$$\cos^2 x + \sin^2 x = 1$$

Compound angles

$$\sin(A + B) = \sin A\cos B + \cos A\sin B$$

$$\cos(A + B) = \cos A\cos B - \sin A\sin B$$

$$\tan(A + B) = \frac{\tan A + \tan B}{1 - \tan A\tan B}$$

If $t = \tan\frac{A}{2}$ then $\sin A = \frac{2t}{1 + t^2}$

$$\cos A = \frac{1 - t^2}{1 + t^2}$$

$$\tan A = \frac{2t}{1 - t^2}$$

$$\cos A\cos B = \frac{1}{2}\left[\cos(A - B) + \cos(A + B)\right]$$

$$\sin A\sin B = \frac{1}{2}\left[\cos(A - B) - \cos(A + B)\right]$$

$$\sin A\cos B = \frac{1}{2}\left[\sin(A + B) + \sin(A - B)\right]$$

$$\cos A\sin B = \frac{1}{2}\left[\sin(A + B) - \sin(A - B)\right]$$

$$\sin^2 nx = \frac{1}{2}(1 - \cos 2nx)$$

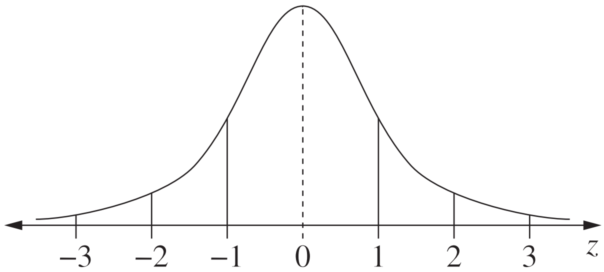
$$\cos^2 nx = \frac{1}{2}(1 + \cos 2nx)$$

Statistical Analysis

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

An outlier is a score
less than $Q_1 - 1.5 \times IQR$
or
more than $Q_3 + 1.5 \times IQR$

Normal distribution



- approximately 68% of scores have z-scores between –1 and 1
- approximately 95% of scores have z-scores between –2 and 2
- approximately 99.7% of scores have z-scores between –3 and 3

$$E(X) = \mu$$

$$\operatorname{Var}(X) = E\left[(X - \mu)^2\right] = E\left(X^2\right) - \mu^2$$

Probability

$$P(A \cap B) = P(A)P(B)$$

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

$$P(A|B) = \frac{P(A \cap B)}{P(B)}, \ P(B) \neq 0$$

Continuous random variables

$$P(X \le r) = \int_a^r f(x)\,dx$$

$$P(a < X < b) = \int_a^b f(x)\,dx$$

Binomial distribution

$$P(X = r) = {}^nC_r p^r(1 - p)^{n - r}$$

$$X \sim \operatorname{Bin}(n, p)$$

$$\Rightarrow \quad P(X = x)$$

$$= \binom{n}{x}p^x(1 - p)^{n - x}, \ x = 0, 1, \ldots, n$$

$$E(X) = np$$

$$\operatorname{Var}(X) = np(1 - p)$$

Differential Calculus

Function	Derivative
$y = f(x)^n$	$\dfrac{dy}{dx} = nf'(x)\left[f(x)\right]^{n-1}$
$y = uv$	$\dfrac{dy}{dx} = u\dfrac{dv}{dx} + v\dfrac{du}{dx}$
$y = g(u)$ where $u = f(x)$	$\dfrac{dy}{dx} = \dfrac{dy}{du} \times \dfrac{du}{dx}$
$y = \dfrac{u}{v}$	$\dfrac{dy}{dx} = \dfrac{v\dfrac{du}{dx} - u\dfrac{dv}{dx}}{v^2}$
$y = \sin f(x)$	$\dfrac{dy}{dx} = f'(x)\cos f(x)$
$y = \cos f(x)$	$\dfrac{dy}{dx} = -f'(x)\sin f(x)$
$y = \tan f(x)$	$\dfrac{dy}{dx} = f'(x)\sec^2 f(x)$
$y = e^{f(x)}$	$\dfrac{dy}{dx} = f'(x)e^{f(x)}$
$y = \ln f(x)$	$\dfrac{dy}{dx} = \dfrac{f'(x)}{f(x)}$
$y = a^{f(x)}$	$\dfrac{dy}{dx} = (\ln a)f'(x)a^{f(x)}$
$y = \log_a f(x)$	$\dfrac{dy}{dx} = \dfrac{f'(x)}{(\ln a)f(x)}$
$y = \sin^{-1} f(x)$	$\dfrac{dy}{dx} = \dfrac{f'(x)}{\sqrt{1-\left[f(x)\right]^2}}$
$y = \cos^{-1} f(x)$	$\dfrac{dy}{dx} = -\dfrac{f'(x)}{\sqrt{1-\left[f(x)\right]^2}}$
$y = \tan^{-1} f(x)$	$\dfrac{dy}{dx} = \dfrac{f'(x)}{1+\left[f(x)\right]^2}$

Integral Calculus

$$\int f'(x)\left[f(x)\right]^n dx = \frac{1}{n+1}\left[f(x)\right]^{n+1} + c$$

where $n \neq -1$

$$\int f'(x)\sin f(x)\,dx = -\cos f(x) + c$$

$$\int f'(x)\cos f(x)\,dx = \sin f(x) + c$$

$$\int f'(x)\sec^2 f(x)\,dx = \tan f(x) + c$$

$$\int f'(x)e^{f(x)}\,dx = e^{f(x)} + c$$

$$\int \frac{f'(x)}{f(x)}\,dx = \ln\left|f(x)\right| + c$$

$$\int f'(x)a^{f(x)}\,dx = \frac{a^{f(x)}}{\ln a} + c$$

$$\int \frac{f'(x)}{\sqrt{a^2-\left[f(x)\right]^2}}\,dx = \sin^{-1}\frac{f(x)}{a} + c$$

$$\int \frac{f'(x)}{a^2+\left[f(x)\right]^2}\,dx = \frac{1}{a}\tan^{-1}\frac{f(x)}{a} + c$$

$$\int u\frac{dv}{dx}\,dx = uv - \int v\frac{du}{dx}\,dx$$

$$\int_a^b f(x)\,dx$$

$$\approx \frac{b-a}{2n}\left\{f(a) + f(b) + 2\left[f(x_1) + \cdots + f(x_{n-1})\right]\right\}$$

where $a = x_0$ and $b = x_n$

Combinatorics

$$^nP_r = \frac{n!}{(n-r)!}$$

$$\binom{n}{r} = {}^nC_r = \frac{n!}{r!\,(n-r)!}$$

$$(x+a)^n = x^n + \binom{n}{1}x^{n-1}a + \cdots + \binom{n}{r}x^{n-r}a^r + \cdots + a^n$$

Vectors

$$\left|\underset{\sim}{u}\right| = \left|x\underset{\sim}{i} + y\underset{\sim}{j}\right| = \sqrt{x^2 + y^2}$$

$$\underset{\sim}{u} \cdot \underset{\sim}{v} = \left|\underset{\sim}{u}\right|\left|\underset{\sim}{v}\right|\cos\theta = x_1x_2 + y_1y_2,$$

where $\underset{\sim}{u} = x_1\underset{\sim}{i} + y_1\underset{\sim}{j}$

and $\underset{\sim}{v} = x_2\underset{\sim}{i} + y_2\underset{\sim}{j}$

$$\underset{\sim}{r} = \underset{\sim}{a} + \lambda\underset{\sim}{b}$$

Complex Numbers

$$\begin{aligned} z = a + ib &= r(\cos\theta + i\sin\theta) \\ &= re^{i\theta} \end{aligned}$$

$$\begin{aligned} \left[r(\cos\theta + i\sin\theta)\right]^n &= r^n(\cos n\theta + i\sin n\theta) \\ &= r^n e^{in\theta} \end{aligned}$$

Mechanics

$$\frac{d^2x}{dt^2} = \frac{dv}{dt} = v\frac{dv}{dx} = \frac{d}{dx}\left(\frac{1}{2}v^2\right)$$

$$x = a\cos(nt + \alpha) + c$$

$$x = a\sin(nt + \alpha) + c$$

$$\ddot{x} = -n^2(x - c)$$

Mathematics Extension 1
Sample HSC Marking Guidelines

Section I

Multiple-choice Answer Key

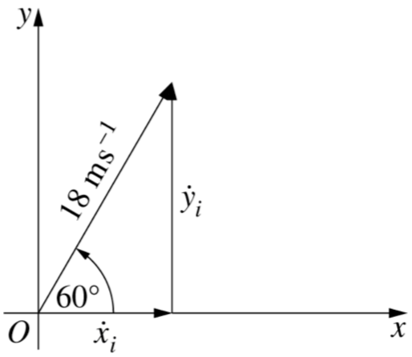
Question	Answer
1	D
2	D
3	D
4	C
5	D
6	C
7	D
8	B
9	C
10	A

Section II

Question 11 (a) (i)

Criteria	Marks
• Provides correct solution	1

Sample answer:



$$\dot{x}_i = 18\cos\frac{\pi}{3} \qquad \dot{y}_i = 18\sin\frac{\pi}{3}$$
$$= 9\text{ m s}^{-1} \qquad = 9\sqrt{3}\text{ m s}^{-1}$$

$$\dot{x} = \int \frac{d^2x}{dt^2}.dt$$
$$= \int 0.dt$$
$$\therefore \dot{x} = C \qquad \dot{x}_i = 9\text{ m s}^{-1}$$
$$\therefore \dot{x} = 9\text{ m s}^{-1}$$
$$x = \int \dot{x}\,dt$$
$$= \int 9.dt$$
$$x = 9t + C' \qquad \text{when } t = 0,\ x = 0\ \therefore C' = 0$$
$$\therefore x = 9t$$

Question 11 (a) (ii)

Criteria	Marks
• Provides correct solution	2
• Determines $\dot{y}$ or equivalent merit	1

Sample answer:

$$\dot{y} = \int \frac{d^2y}{dt^2}.dt$$

$$\dot{y} = \int -10.dt$$

$$\dot{y} = -10t + C \qquad \text{when} \quad t = 0, \ \dot{y} = 9\sqrt{3}\,\text{m s}^{-1}$$

$$\therefore \dot{y} = 9\sqrt{3} - 10t$$

$$y = \int \dot{y}\,dt$$

$$y = \int \left(9\sqrt{3} - 10t\right)dt$$

$$y = 9\sqrt{3}\,t - 5t^2 + C' \qquad \text{when} \quad t = 0, \ y = 0 \ \therefore C' = 0$$

$$\therefore y = 9\sqrt{3}\,t - 5t^2$$

Question 11 (a) (iii)

Criteria	Marks
• Provides correct solution	1

Sample answer:

$$x = 9t \quad \rightarrow \quad t = \frac{x}{9}$$

$$y = 9\sqrt{3}\,t - 5t^2 \qquad \text{substitute } t = \frac{x}{9}$$

$$= 9\sqrt{3}\left(\frac{x}{9}\right) - 5\left(\frac{x}{9}\right)^2$$

$$\therefore y = \sqrt{3}\,x - \frac{5x^2}{81}$$

Question 11 (b) (i)

Criteria	Marks
• Refers to horizontal line test, or equivalent merit	1

Sample answer:

$f(x) = x^2 + 4x + 7$ is a parabola.

Therefore, for each value of $f(x)$ in the range (except at the turning point), there are two x-values. (A horizontal line will cut the graph twice.)

$\therefore$ If x and y are swapped, each x in the domain will have two y-values, and so the inverse will not be a function.

Question 11 (b) (ii)

Criteria	Marks
• Provides correct solution	2
• Swaps x and y or equivalent merit	1

Sample answer:

$$f(x) = x^2 + 4x + 7 \qquad x \geq -2$$

$$= (x+2)^2 + 3$$

$$f^{-1}(x):\ x = (y+2)^2 + 3$$

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

$$y + 2 = \sqrt{x-3} \qquad \left(-\sqrt{x-3} \text{ is discarded as } y \text{ must be} \geq -2\right)$$

$$y = \left(\sqrt{x-3}\right) - 2$$

$$\therefore f^{-1}(x) = \left(\sqrt{x-3}\right) - 2$$

Question 11 (b) (iii)

Criteria	Marks
• States correct domain and range	2
• States correct domain or range	1

Sample answer:

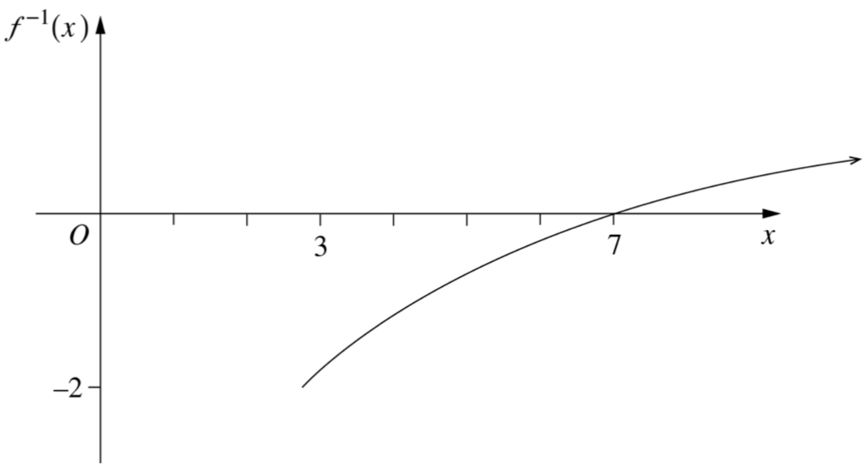
Domain: $x \geq 3$ as $x - 3 \geq 0$

Range: $y \geq -2$ as $\sqrt{x-3} \geq 0$

Question 11 (b) (iv)

Criteria	Marks
• Provides correct sketch	2
• Provides graph with correct shape, or equivalent merit	1

Sample answer:



Question 11 (c) (i)

Criteria	Marks
• Correct answer	1

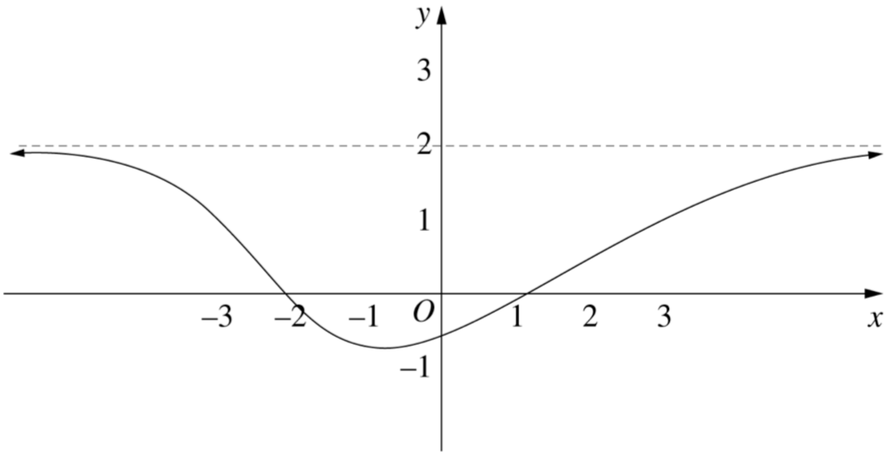
Sample answer:

$y = 2$

Question 11 (c) (ii)

Criteria	Marks
• Provides correct answer	3
• Provides correct sketch	2
• States that $y \to 2$ as $x \to \pm\infty$, or equivalent merit	1

Sample answer:



The y-coordinate of the particle approaches 2 from below as $x \to \pm\infty$.

Question 12 (a) (i)

Criteria	Marks
• Provides correct mean and standard deviation	2
• Provides correct mean or standard deviation	1

Sample answer:

$\tilde{x} = np = 20,\ \sigma^2 = np(1-p) = 16$ so $\sigma = 4$

$$\therefore \tilde{x}_{\text{proportion}} = \frac{20}{100} = .2 \quad \sigma_{\text{proportion}} = \frac{4}{100} = 0.04$$

Question 12 (a) (ii)

Criteria	Marks
• Provides correct answer	2
• Calculates $z = (0.15 - 0.20)/0.04$ OR uses the table appropriately with an incorrect value for z	1

Sample answer:

$P(Z < (0.15-0.20)/0.04) = P(Z < -1.25) = 1 - P(z < 1.25)$ so estimate is $1 - 0.8944 = 0.1056$.

Question 12 (b) (i)

Criteria	Marks
• Provides correct answer	2
• Attempts to find the projection of $\underset{\sim}{F}$ in the direction of ℓ	1

Sample answer:

A unit vector in the direction of ℓ is $\hat{\underset{\sim}{v}} = \frac{1}{5}\begin{pmatrix} 3 \\ 4 \end{pmatrix}$, so the component of $\underset{\sim}{F}$ in the direction of ℓ is

$\left(\underset{\sim}{F} \cdot \hat{\underset{\sim}{v}}\right)\hat{\underset{\sim}{v}} = 2\hat{\underset{\sim}{v}} = \begin{pmatrix} 1.2 \\ 1.6 \end{pmatrix}$.

Question 12 (b) (ii)

Criteria	Marks
• Provides correct answer	1

Sample answer:

The component of $\underset{\sim}{F}$ perpendicular to ℓ is $\underset{\sim}{F} - \begin{pmatrix} 1.2 \\ 1.6 \end{pmatrix} = \begin{pmatrix} 0.8 \\ -0.6 \end{pmatrix}$.

Question 12 (c) (i)

Criteria	Marks
• Provides correct explanation	1

Sample answer:

$\overrightarrow{PA} = \left(\underset{\sim}{a} - \underset{\sim}{p}\right)$, while $\overrightarrow{PB} = \left(\underset{\sim}{b} - \underset{\sim}{p}\right)$. Since we are given that they are perpendicular, the dot product of these two vectors is zero.

Question 12 (c) (ii)

Criteria	Marks
• Obtains a correct expression for $\lvert \underset{\sim}{p} - \underset{\sim}{m} \rvert^2$ involving only $\underset{\sim}{a}, \underset{\sim}{b}$ or $\underset{\sim}{m}$	3
• Replaces $\underset{\sim}{m}$ by $\frac{1}{2}(\underset{\sim}{a} + \underset{\sim}{b})$ and uses the result of part (i) appropriately	2
• Replaces $\underset{\sim}{m}$ by $\frac{1}{2}(\underset{\sim}{a} + \underset{\sim}{b})$ and attempts to simplify	1

Sample answer:

From part (i) $\underset{\sim}{a} \cdot \underset{\sim}{b} - \underset{\sim}{p} \cdot (\underset{\sim}{a} + \underset{\sim}{b}) + \underset{\sim}{p} \cdot \underset{\sim}{p} = 0,$ so

$$\begin{aligned}
\lvert \underset{\sim}{p} - \underset{\sim}{m} \rvert^2 &= \frac{1}{4}\left(2\underset{\sim}{p} - (\underset{\sim}{a} + \underset{\sim}{b})\right) \cdot \left(2\underset{\sim}{p} - (\underset{\sim}{a} + \underset{\sim}{b})\right) \\
&= \underset{\sim}{p} \cdot \underset{\sim}{p} - \underset{\sim}{p} \cdot (\underset{\sim}{a} + \underset{\sim}{b}) \cdot \frac{1}{4}(\underset{\sim}{a} + \underset{\sim}{b}) \cdot (\underset{\sim}{a} + \underset{\sim}{b}) \\
&= \frac{1}{4}(\underset{\sim}{a} + \underset{\sim}{b}) \cdot (\underset{\sim}{a} + \underset{\sim}{b}) - \underset{\sim}{a} \cdot \underset{\sim}{b} && \text{independent of } \underset{\sim}{p}
\end{aligned}$$

OR

$$\begin{aligned}
4\lvert \underset{\sim}{p} - \underset{\sim}{m} \rvert^2 &= \left(2\underset{\sim}{p} - 2\underset{\sim}{m}\right) \cdot \left(2\underset{\sim}{p} - 2\underset{\sim}{m}\right) \\
&= \left((\underset{\sim}{p} - \underset{\sim}{a}) + (\underset{\sim}{p} - \underset{\sim}{b})\right) \cdot (\underset{\sim}{p} - \underset{\sim}{a}) + (\underset{\sim}{p} - \underset{\sim}{b}) && \text{since } 2\underset{\sim}{m} = \underset{\sim}{a} + \underset{\sim}{b} \\
&= (\underset{\sim}{p} - \underset{\sim}{a}) \cdot (\underset{\sim}{p} - \underset{\sim}{a}) + 2(\underset{\sim}{p} - \underset{\sim}{a}) \cdot (\underset{\sim}{p} - \underset{\sim}{b}) + (\underset{\sim}{p} - \underset{\sim}{b}) \cdot (\underset{\sim}{p} - \underset{\sim}{b}) && \text{expanding} \\
&= (\underset{\sim}{p} - \underset{\sim}{a}) \cdot (\underset{\sim}{p} - \underset{\sim}{a}) - 2(\underset{\sim}{p} - \underset{\sim}{a}) \cdot (\underset{\sim}{p} - \underset{\sim}{b}) + (\underset{\sim}{p} - \underset{\sim}{b}) \cdot (\underset{\sim}{p} - \underset{\sim}{b}) && \text{by part (i)} \\
&= \left((\underset{\sim}{p} - \underset{\sim}{a}) - (\underset{\sim}{p} - \underset{\sim}{b})\right) \cdot \left((\underset{\sim}{p} - \underset{\sim}{a}) - (\underset{\sim}{p} - \underset{\sim}{b})\right) && \text{factoring} \\
&= (\underset{\sim}{b} - \underset{\sim}{a}) \cdot (\underset{\sim}{b} - \underset{\sim}{a}) && \text{simplifying} \\
&= \lvert (\underset{\sim}{b} - \underset{\sim}{a}) \rvert^2 && \text{independent of } \underset{\sim}{p}
\end{aligned}$$

so $\lvert \underset{\sim}{p} - \underset{\sim}{m} \rvert^2 = \frac{1}{4}\lvert (\underset{\sim}{b} - \underset{\sim}{a}) \rvert^2$

OR

Let $\underset{\sim}{u} = \frac{1}{2}(\underset{\sim}{b} - \underset{\sim}{a})$ so $\underset{\sim}{m} = \underset{\sim}{a} + \underset{\sim}{u} = \underset{\sim}{b} - \underset{\sim}{u}$

Then

$$|\underset{\sim}{p} - \underset{\sim}{m}|^2 = \left((\underset{\sim}{p} - \underset{\sim}{a}) - \underset{\sim}{u}\right) \cdot \left((\underset{\sim}{p} - \underset{\sim}{b}) + \underset{\sim}{u}\right)$$

$$= (\underset{\sim}{p} - \underset{\sim}{a}) \cdot (\underset{\sim}{p} - \underset{\sim}{b}) + \underset{\sim}{u} \cdot \left((\underset{\sim}{p} - \underset{\sim}{a}) - (\underset{\sim}{p} - \underset{\sim}{b}) - \underset{\sim}{u}\right) \quad \text{expanding}$$

$$= 0 + \underset{\sim}{u} \cdot (\underset{\sim}{b} - \underset{\sim}{a} - \underset{\sim}{u}) \quad \text{by part (i)}$$

$$= |\underset{\sim}{u}|^2 \quad \text{independent of } \underset{\sim}{p}$$

OR

$$|\underset{\sim}{p} - \underset{\sim}{m}|^2 - |\underset{\sim}{m} - \underset{\sim}{a}|^2 = (\underset{\sim}{p} - \underset{\sim}{m}) \cdot (\underset{\sim}{p} - \underset{\sim}{m}) - (\underset{\sim}{m} - \underset{\sim}{a}) \cdot (\underset{\sim}{m} - \underset{\sim}{a})$$

$$= \left((\underset{\sim}{p} - \underset{\sim}{m}) - (\underset{\sim}{m} - \underset{\sim}{a})\right) \cdot \left((\underset{\sim}{p} - \underset{\sim}{m}) + (\underset{\sim}{m} - \underset{\sim}{a})\right)$$

$$= \left(\underset{\sim}{p} - (2\underset{\sim}{m} - \underset{\sim}{a})\right) \cdot (\underset{\sim}{p} - \underset{\sim}{a})$$

$$= (\underset{\sim}{p} - \underset{\sim}{b}) \cdot (\underset{\sim}{p} - \underset{\sim}{a})$$

$$= 0$$

Therefore $|\underset{\sim}{p} - \underset{\sim}{m}|^2 = |\underset{\sim}{m} - \underset{\sim}{a}|^2$ which is independent of $\underset{\sim}{p}$.

Question 12 (c) (iii)

Criteria	Marks
• Provides correct statement	1

Sample answer:

P lies on the circle whose diameter is AB.

OR

P lies on a circle centre M and radius $\sqrt{\frac{1}{4}(\underset{\sim}{a} + \underset{\sim}{b}) \cdot (\underset{\sim}{a} + \underset{\sim}{b}) - \underset{\sim}{a} \cdot \underset{\sim}{b}}$.

Question 12 (d)

Criteria	Marks
• Provides correct proof	3
• Attempts to do the induction step	2
• Proves cases for $n = 1$, or equivalent merit	1

Sample answer:

If $n = 1$, then $2^3 - 3 = 8 - 3$

$= 5$ which is divisible by 5.

Assume true for $n = k$

ie $2^{3k} - 3^k = 5j$ for some integer j.

Then if $n = k + 1$

$$2^{3(k+1)} - 3^{k+1} = 2^{3k+3} - 3^k \times 3$$
$$= 8\left(5j + 3^k\right) - 3 \times 3^k \quad \text{(using the assumption)}$$
$$= 8 \times 5j + 5 \times 3^k$$
$$= 5\left(8j + 3^k\right) \quad \text{which is divisible by 5.}$$

Hence the claim is true for $n = k + 1$. Since shown true for $n = 1$, so is true for $n = 2, 3, \ldots$ and so true for all integers $n \geq 1$.

Question 13 (a)

Criteria	Marks
• Provides correct solution	3
• Attempts to use a double angle result, or equivalent merit	2
• Obtains correct integrand in terms of θ, or equivalent merit	1

Sample answer:

$$x = \sin^2\theta$$

$$dx = 2\sin\theta\cos\theta\, d\theta$$

$$\int_0^{\frac{1}{2}} \sqrt{\frac{x}{1-x}} \times dx = \int_0^{\frac{\pi}{4}} \sqrt{\frac{\sin^2\theta}{1-\sin^2\theta}} \times 2\sin\theta\cos\theta\, d\theta$$

$$= \int_0^{\frac{\pi}{4}} \frac{\sin\theta}{\cos\theta} \times 2\sin\theta\cos\theta\, d\theta$$

$$= 2\int_0^{\frac{\pi}{4}} \sin^2\theta\, d\theta$$

$$= \int_0^{\frac{\pi}{4}} (1-\cos 2\theta)\, d\theta$$

$$= \left. \theta - \frac{1}{2}\sin 2\theta \right]_0^{\frac{\pi}{4}}$$

$$= \left(\frac{\pi}{4} - \frac{1}{2}\sin\frac{\pi}{2}\right) - (0)$$

$$= \frac{\pi}{4} - \frac{1}{2}$$

Question 13 (b)

Criteria	Marks
• Provides correct answer	4
• Considers when $\lvert\cos\theta\rvert \geq \frac{\sqrt{3}}{2}$ but obtains incorrect proportion, or equivalent merit	3
• Correctly deduces that $\sqrt{2}\sin t + \cos t = \sqrt{3}\cos(t-\alpha)$ for some α, or equivalent merit	2
• Attempts to write $\sqrt{2}\sin t + \cos t$ in the form $A\cos(t-\alpha)$ or equivalent merit	1

Sample answer:

$$x = \sqrt{2}\sin t + \cos t = \sqrt{3}\left(\sqrt{\frac{1}{3}}\cos t + \sqrt{\frac{2}{3}}\sin t\right) = \sqrt{3}\cos(t-\alpha), \text{ where } \tan\alpha = \sqrt{2}.$$

Thus $\lvert x\rvert \geq 1.5$ whenever $\lvert\cos(t-\alpha)\rvert \geq \frac{\sqrt{3}}{2}$.

Now the region in the interval $\left[0, \frac{\pi}{2}\right]$ where $\cos\theta \geq \frac{\sqrt{3}}{2}$ is $\left[0, \frac{\pi}{6}\right]$, and other intervals between multiples of $\frac{\pi}{2}$ are similar.

So distortion occurs $\frac{1}{3}$ of the time.

Question 13 (c) (i)

Criteria	Marks
• Provides correct proof	3
• Obtains a correct expression for $\cos 3\theta$ involving only $\cos\theta$ and $\sin\theta$	2
• Obtains a correct expression for $\cos 3\theta$ involving only $\cos\theta$, $\sin\theta$, $\cos 2\theta$ and $\sin 2\theta$	1

Sample answer:

$$\begin{aligned}
\cos 3\theta &= \cos\theta\cos 2\theta - \sin\theta\sin 2\theta && \text{angle sum formula} \\
&= \cos\theta\left(\cos^2\theta - \sin^2\theta\right) - \sin\theta(2\sin\theta\cos\theta) && \text{angle sum formula} \\
&= \cos^3\theta - 3\cos\theta\sin^2\theta && \\
&= \cos^3\theta - 3\cos\theta\left(1-\cos^2\theta\right) && \cos^2\theta + \sin^2\theta = 1 \\
&= 4\cos^3\theta - 3\cos\theta &&
\end{aligned}$$

Question 13 (c) (ii)

Criteria	Marks
• Finds correct expressions for the three solutions	4
• Deduces that $3\theta = \pm\frac{\pi}{3} \pm 2n\pi$, where n is an integer	3
• Deduces that $\cos 3\theta = \frac{1}{2}$	2
• Makes the substitution $x = \cos\theta$	1

Sample answer:

Writing $x = \cos\theta$ we get $8\cos^3\theta - 6\cos\theta = 2\cos 3\theta = 1$.

Consequently $\cos 3\theta = \frac{1}{2}$, and so $3\theta = \pm\frac{\pi}{3} \pm 2n\pi$, where n is an integer.

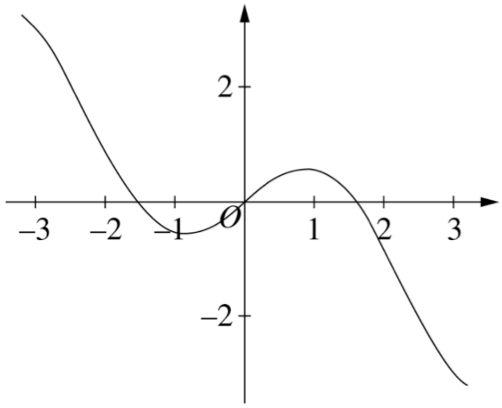
Thus $\theta = \pm\frac{\pi}{9} \pm n\frac{2\pi}{3}$, and so $x = \cos\left(\frac{\pi}{9}\right)$ or $\cos\left(\frac{7\pi}{9}\right)$ or $\cos\left(\frac{13\pi}{9}\right)$.

NB $\cos\left(\frac{7\pi}{9}\right) = -\cos\left(\frac{2\pi}{9}\right)$ and $\cos\left(\frac{13\pi}{9}\right) = \cos\left(\frac{5\pi}{9}\right) = -\cos\left(\frac{4\pi}{9}\right)$.

Question 14 (a) (i)

Criteria	Marks
• Provides correct sketch and explanation	3
• Provides correct sketch, or equivalent merit	2
• Provides a sketch that is an odd function or has three zeros, or equivalent merit	1

Sample answer:



$$\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} x \cos x \, dx = 0 \qquad \text{because the function is odd}$$

$$\text{ie } \int_{-\frac{\pi}{2}}^{0} x \cos x \, dx = -\int_{0}^{\frac{\pi}{2}} x \cos x \, dx$$

Question 14 (a) (ii)

Criteria	Marks
• Provides correct answer	3
• Expands integrand and evaluates at least one of the resulting integrals between $-\frac{\pi}{2}$ and $\frac{\pi}{2}$	2
• Provides correct integrand for volume of revolution	1

Sample answer:

$$V = \pi \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} (x - \cos x)^2 \, dx$$

$$= \pi \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left(x^2 - 2x\cos x + \cos^2 x\right) dx$$

$$= \pi \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left(x^2 - 2x\cos x + \frac{1}{2}(1 + \cos 2x)\right) dx$$

$$= \pi \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \left(x^2 + \frac{1}{2}\right) dx \qquad \text{by part (i)}$$

$$= \pi \left[\frac{x^3}{3} + \frac{x}{2}\right]_{-\frac{\pi}{2}}^{\frac{\pi}{2}}$$

$$= \frac{\pi^4 + 6\pi^2}{12}$$

Question 14 (b) (i)

Criteria	Marks
• Provides correct answer	2
• Provides correct expression for $\dfrac{dy}{dt}$ in terms of w and $\dfrac{dw}{dt}$ or deduces that $y(1-y)=\dfrac{-w}{(1-w)^2}$	1

Sample answer:

$$\frac{dy}{dt}=\frac{w'}{(1-w)^2} \text{ and } y(1-y)=\frac{-w}{(1-w)^2}, \text{ so } \frac{dw}{dt}=-w.$$

Question 14 (b) (ii)

Criteria	Marks
• Provides correct answer	2
• Deduces that $w=-3e^{t}$ or deduces that $y=11-ke^{-t}$ for some k	1

Sample answer:

$$w=-3 \text{ when } t=0 \text{ so } w=-3e^{-t}. \text{ Thus } y=\frac{1}{1+3e^{-t}}.$$

Question 14 (b) (iii)

Criteria	Marks
• Provides correct answer	2
• Makes some progress towards finding the value of t for which $y=\dfrac{3}{4}$	1

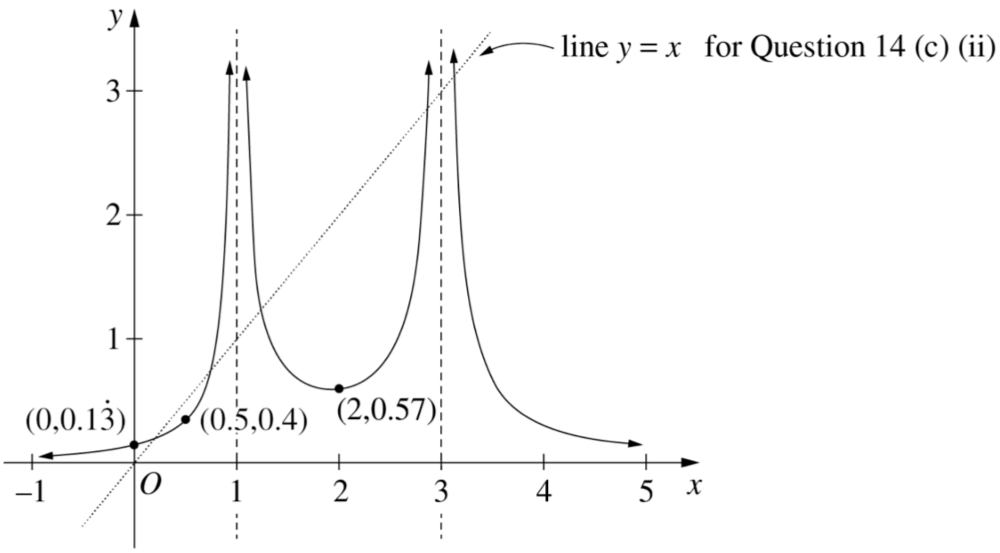
Sample answer:

$$1+3e^{-t}=\frac{4}{3} \text{ so } e^{-t}=\frac{1}{9} \text{ so } t=\ln 9 \text{ years.}$$

Question 14 (c) (i)

Criteria	Marks
• Provides correct sketch including location information	3
• Provides correct shape and asymptotes	2
• Provides a sketch with asymptotes at $x = 1,\ x = 3$ and $y = 0$	1

Sample answer:



Question 14 (c) (ii)

Criteria	Marks
• Identifies that the equation has (at least) five solutions	1

Sample answer:

The equation has at least five solutions. (It might have more depending on the behaviour outside the region shown in the sketch in the question.)

Mathematics Extension 1
Sample HSC Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes	Targeted performance bands
1	1	ME-V1 Introduction to Vectors	ME12-2	E2-E3
2	1	ME-V1 Introduction to Vectors	ME12-2	E2-E3
3	1	ME-T3 Trigonometric Equations	ME12-3	E2-E3
4	1	ME-C2 Further Calculus Skills	ME12-1	E2-E3
5	1	ME-C3 Applications of Calculus	ME12-4	E2-E3
6	1	ME-F2 Polynomials	ME11-2	E3-E4
7	1	ME-A1 Working with Combinatorics	ME11-5	E3-E4
8	1	ME-A1 Working with Combinatorics	ME11-5	E3-E4
9	1	ME-C1 Rates of Change	ME11-4	E3-E4
10	1	ME-T1 Inverse Trigonometric Functions	ME11-3	E3-E4

Section II

Question	Marks	Content	Syllabus outcomes	Targeted performance bands
11 (a) (i)	1	ME-V1 Introduction to Vectors	ME12-2	E2-E3
11 (a) (ii)	2	ME-V1 Introduction to Vectors	ME12-2	E2-E3
11 (a) (iii)	1	ME-V1 Introduction to Vectors	ME12-2	E2-E3
11 (b) (i)	1	ME-F1 Further Work with Functions	ME11-1	E2-E3
11 (b) (ii)	2	ME-F1 Further Work with Functions	ME11-1	E2-E3
11 (b) (iii)	2	ME-F1 Further Work with Functions	ME11-1	E2-E3
11 (b) (iv)	2	ME-F1 Further Work with Functions	ME11-1	E2-E3
11 (c) (i)	1	ME-C3 Applications of Calculus	ME12-4	E2-E3
11 (c) (ii)	3	ME-C3 Applications of Calculus	ME12-4; ME12-7	E2-E4
12 (a) (i)	2	ME-S1 The Binomial Distribution	ME12-5	E2-E3
12 (a) (ii)	2	ME-S1 The Binomial Distribution	ME12-5	E2-E3
12 (b) (i)	2	ME-V1 Introduction to Vectors	ME12-2	E3-E4
12 (b) (ii)	1	ME-V1 Introduction to Vectors	ME12-2	E3-E4
12 (c) (i)	1	ME-V1 Introduction to Vectors	ME12-2	E2-E3
12 (c) (ii)	3	ME-V1 Introduction to Vectors	ME12-2	E2-E4
12 (c) (iii)	1	ME-V1 Introduction to Vectors	ME12-2; ME12-7	E2-E3
12 (d)	3	ME-P1 Proof by Mathematical Induction	ME12-1	E2-E4
13 (a)	3	ME-C2 Further Calculus Skills	ME12-1; ME12-4	E2-E4
13 (b)	4	ME-T3 Trigonometric Equations	ME12-3	E2-E4
13 (c) (i)	3	ME-T3 Trigonometric Equations	ME12-3	E2-E4
13 (c) (ii)	4	ME-T3 Trigonometric Equations	ME12-3	E2-E4
14 (a) (i)	3	ME-F1 Further Work with Functions	ME11-1	E2-E3
14 (a) (ii)	3	ME-C3 Applications of Calculus	ME12-4	E2-E4
14 (b) (i)	2	ME-C3 Applications of Calculus	ME12-4	E2-E4
14 (b) (ii)	2	ME-C3 Applications of Calculus	ME12-4	E2-E4
14 (b) (iii)	2	ME-C3 Applications of Calculus	ME12-4	E2-E4
14 (c) (i)	3	ME-F1 Further Work with Functions	ME11-2; ME11-7	E2-E4
14 (c) (ii)	1	ME-F1 Further Work with Functions	ME11-2; ME11-7	E2-E4

12345678

Student Number

NSW GOVERNMENT

123

Centre Number

NSW Education Standards Authority

2020

HIGHER SCHOOL CERTIFICATE EXAMINATION

Mathematics Extension 1

Writing Booklet

Question XX

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Instructions

- Use this booklet for Question XX. → XX
- Write the number of this booklet and the total number of booklets that you have used for this question (eg: $\boxed{1}$ of $\boxed{3}$). → ☐ of ☐ (this booklet / number of booklets for this question)
- Write in black or blue pen (black is recommended).
- 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.

Start here for
Question Number: XX

Additional writing space on back page.

☐ ⇦ Tick this box if you have continued this answer in another writing booklet.

12345678

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Centre Number

NSW Education Standards Authority

2020

HIGHER SCHOOL CERTIFICATE EXAMINATION

Mathematics Extension 1

Writing Booklet

Question XX

00000010405

00 0001 04 05

Instructions

- Use this booklet for Question XX. ⇒ XX
- Write the number of this booklet and the total number of booklets that you have used for this question (eg: $\boxed{1}$ of $\boxed{3}$). ⇒ $\boxed{}$ (this booklet) of $\boxed{}$ (number of booklets for this question)
- Write in black or blue pen (black is recommended).
- 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.

Start here for
Question Number: XX

Additional writing space on back page.

Tick this box if you have continued this answer in another writing booklet.

Office Use Only - Do NOT write anything, or make any marks below this line.