SAINT IGNATIUS' COLLEGE

Trial Higher School Certificate

2004

MATHEMATICS EXTENSION 1

1:25pm – 3:30 pm
Thursday 19th August 2004

Directions to Students

- Reading Time : 5 minutes
- Working Time : 2 hours
- Write using blue or black pen. (sketches in pencil).
- Board approved calculators may be used.
- A table of standard integrals is provided at the back of this paper.
- All necessary working should be shown in every question.
- **Answer each question in the booklets provided and clearly label your name and teacher's name.**

- Total Marks 84
- Attempt Question 1 – 7
- All questions are of equal value

Total marks (84)
Attempt Questions 1 – 7
All questions are of equal value

Answer each question in a SEPARATE writing booklet.

QUESTION 1 (12 Marks) Use a SEPARATE writing booklet. **Marks**

(a) Solve $\frac{5}{2x-1} < 3$. **3**

(b) Find the acute angle between the lines $2x - y + 1 = 0$ and $x + 3y - 4 = 0$. **3**
Give answer to the nearest degree.

(c) Find the coordinates of the point that divides the interval joining **2**
(-2, 5) and (8, -9) internally in the ratio 2 : 3.

(d) If α, β, γ are the roots of the equation $x^3 - 5x^2 - 3x + 2 = 0$, **2**
find the value of $\frac{1}{\alpha\beta} + \frac{1}{\beta\gamma} + \frac{1}{\gamma\alpha}$.

(e) Write down the general solution, in terms of π, of the equation **2**

$$\cos\theta = -\frac{1}{2}.$$

QUESTION 2 (12 Marks) Use a SEPARATE writing booklet. **Marks**

(a) Use the substitution $x = u^2 + 1$, for u > 0, to evaluate **4**

$$\int_1^5 (x+1)\sqrt{x-1}\,dx.$$

(b) Evaluate $\int_0^{\frac{\pi}{4}} \sin^2(\tfrac{1}{2}x)\,dx$. **3**

(c) Prove, using the principle of mathematical induction, that $9^{n+2} - 4^n$ is divisible by 5, for n a positive integer. **5**

QUESTION 3 (12 Marks) Use a SEPARATE writing booklet. **Marks**

(a) Find the exact value of $\tan\left(2\sin^{-1}\frac{3}{4}\right)$. **3**

(b) Consider the function $f(x)=\sin^{-1}(x+1)+\frac{\pi}{2}$.

(i) What is the domain of $f(x)$? **1**

(ii) Sketch the graph of $y=f(x)$. **2**

(c) Consider the function $f(x)=\log_e(2x+1)$.

(i) Write down the domain of $f(x)$. **1**

(ii) Find the inverse function of $f(x)$, and write it in the form $f^{-1}(x)=\ldots\ldots$ **2**

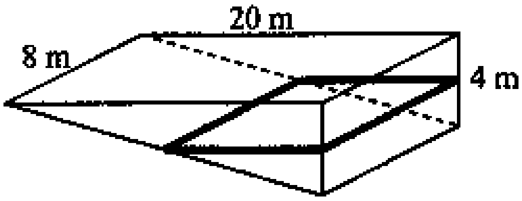
(iii) Find the gradients of the graphs of $y=f(x)$ and $y=f^{-1}(x)$ at the origin. **1**

(iv) On the same diagrams, draw the graphs of $y=f(x)$ and $y=f^{-1}(x)$. **2**

QUESTION 4 (12 Marks) Use a SEPARATE writing booklet. **Marks**

(a) Find the coefficient of x^3 in the expansion of $(2-x)(1+x)^5$. **3**

(b)



A swimming pool is 20 metres long, 8 metres wide, 4 metres deep at one end, and zero depth at the other end. The floor of the pool is a plane rectangular surface.

(i) When the depth of water at the deeper end is h metres, show that the volume (V m³) of water in the pool is given by $V = 20h^2$. **2**

(ii) If water is being poured into the pool at the rate of 2 m³/minute, find the rate at which the depth of the water is increasing at the deepest end, when the depth is 1 metre. **2**

(c) The value of a home business, $\$V$, is increasing at a rate proportional to the amount by which the value is less that \$4000.

$$\text{i.e. } \frac{dV}{dt} = k(4000 - V)$$

Initially, the value of the business was \$2000 and after 5 years it was \$3000.

(i) Show that $V = 4000 - Ae^{-kt}$ satisfies this equation. **1**

(ii) Find the value of A and the value of k to 4 decimal places. **2**

(iii) Find the number of years for the value of the business to grow to \$3800. **2**

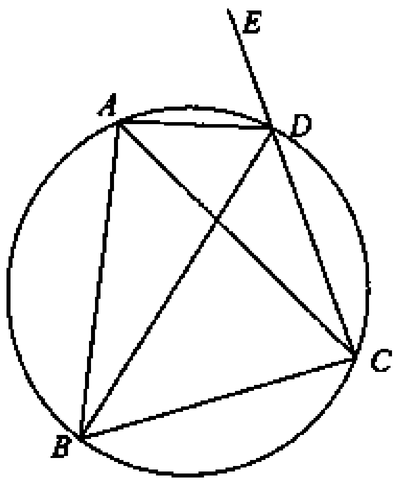
QUESTION 5 (12 Marks) Use a SEPARATE writing booklet. **Marks**

(a) (i) Show that the derivative of x^2e^{-x} is $xe^{-x}(2-x)$. **1**

(ii) Show that $x^2e^{-x} = 0.4$ has a root between $x = 1$ and $x = 2$. **1**

(iii) Use Newton's approximation to find an approximation to the root of $x^2e^{-x} = 0.4$, taking $x = 1$ as a first approximation. **3**

(b)



$ABCD$ is a cyclic quadrilateral in which $AB = AC$, and CD is produced to E. **3**
Prove that AD bisects the angle BDE.

(c) In the expansion of $(3+2x)^8$, c_r is the coefficient of x^r.

(i) Show that $\dfrac{c_r}{c_{r-1}} = \dfrac{18-2r}{3r}$. **2**

(ii) Hence or otherwise find the largest coefficient in the expansion of $(3+2x)^8$. **2**

QUESTION 6 (12 Marks) Use a SEPARATE writing booklet. **Marks**

(a) The position of a particle at time t is given by:

$$x = 3\sin 2t - 4\cos 2t.$$

(i) Show that this equation satisfies $\ddot{x} = -n^2 x$. **2**

(ii) What is the initial velocity of the particle? **1**

(iii) At what time does the particle first come to rest? **3**

(b) The acceleration of a particle at position x is given by:

$$\ddot{x} = -\frac{1}{4x^3}.$$

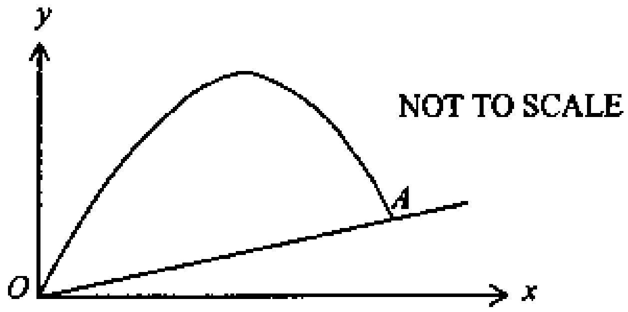
Initially the particle is at $x = 1$ moving with a velocity of ½ unit in the positive direction.

(i) Prove that the velocity of the particle at position x is given by: **3**

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

(ii) Hence find the position of the particle at time t. **3**

QUESTION 7 (12 Marks) Use a SEPARATE writing booklet. **Marks**



An object is thrown from ground level with a speed of 40 m/s at an angle of 60° to the horizontal.
Assume acceleration due to gravity is 10 m/s² and neglect air resistance.

(a) Find equations for x and y in terms of time t seconds, starting from the acceleration equations $\ddot{x} = 0$ and $\ddot{y} = -10$, and hence show that: **4**

$$y = \sqrt{3}\,x - \frac{x^2}{80}.$$

(b) The object is thrown up a slope with a gradient of ¼. **2**
Show that the horizontal distance travelled by the object when it lands on the slope is given by:

$$x = 80\sqrt{3} - 20.$$

(c) Hence find the distance OA (to the nearest metre) up the slope from the point of projection to the point of landing. **2**

(d) Show that the maximum height reached by the object above the slope is **4**

$$(61.25 - 10\sqrt{3}) \text{ metres.}$$

End of paper

(2004 Trials)

MATHEMATICS EXTENSION 1 – QUESTION 1

(a)
$$\frac{5}{2x-1} < 3$$
$$5(2x-1) < 3(2x-1)^2$$
$$3(2x-1)^2 - 5(2x-1) > 0$$
$$(2x-1)[3(2x-1)-5] > 0$$
$$(2x-1)(6x-8) > 0$$
$$x < \tfrac{1}{2},\ x > 1\tfrac{1}{3}$$

③

(b)
$$2x - y + 1 = 0 \qquad m_1 = 2$$
$$x + 3y - 4 = 0 \qquad m_2 = -\tfrac{1}{3}$$
$$\tan\theta = \left|\frac{m_1 - m_2}{1 + m_1 m_2}\right|$$
$$= \left|\frac{2 - (-\frac{1}{3})}{1 + 2(-\frac{1}{3})}\right|$$
$$= \frac{2\frac{1}{3}}{\frac{1}{3}}$$
$$= 7$$
$$\theta = 82^\circ$$

③

(c) $(-2, 5)$, $(8, -9)$ $2:3$
$$\left(\frac{m_1x_2 + m_2x_1}{m_1+m_2}, \frac{m_1y_2 + m_2y_1}{m_1+m_2}\right) = \left(\frac{2\times 8 + 3\times(-2)}{2+3}, \frac{2\times(-9)+3\times 5}{2+3}\right)$$
$$= \left(2, -\tfrac{3}{5}\right)$$

②

(d)
$$x^3 - 5x^2 - 3x + 2 = 0$$
$$\frac{1}{\alpha\beta} + \frac{1}{\beta\gamma} + \frac{1}{\gamma\alpha} = \frac{\gamma + \alpha + \beta}{\alpha\beta\gamma} = \frac{5}{-2} = -2.5$$

②

(e)
$$\cos\theta = -\tfrac{1}{2}$$
$$\theta = 2n\pi \pm \tfrac{2\pi}{3}$$
OR $\theta = (2n+1)\pi \pm \frac{\pi}{3}$

or equivalent.

②

Mathematics Extension One: Question Number 1   Marker: CJF

Marks Awarded	Marker's Comments
(a). 1 mark 1 mark 1 mark	$5(2x-1) < 3(2x-1)^2$ ... or critical points. $2(2x-1)(3x-4) > 0$ $x < \frac{1}{2}$, $x > 4/3$. or correctly solving the inequality obtained. (unless trivial).
(b). 1 mark 1 mark 1 mark.	$m_1 = 2$ / $m_2 = -\frac{1}{3}$. $\tan\theta = \left\lvert\frac{m_1 - m_2}{1 + m_1m_2}\right\rvert$ ... understanding this is formula to use even if not stated in this form. number crunching → 82°.
(c). 1 mark. 1 mark	$\frac{(2\times 8) + 3(-2)}{2+3}$ $\frac{2\times(-9) + (3\times 5)}{2+3}$. $(2, -3/5)$
(d) 1 mark 1 mark	$\frac{\gamma + \beta + \alpha}{\alpha\beta\gamma}$ $\alpha + \beta + \gamma = 5$ and $\alpha\beta\gamma = -2$.
(e) 1 mark. 1 mark	$2n\pi$ or equivalent $\pm\frac{2\pi}{3}$ or equivalent (must be ±)

Question 2

a) $\int_1^5 (x+1)\sqrt{x-1}\,dx$

$x = u^2+1$

$\frac{dx}{du} = 2u$

$dx = 2u\,du$ [1]

$x=1 \quad u=0$

$x=5 \quad u=2$

$= \int_0^2 (u^2+2)\sqrt{u^2}\,2u\,du$

$= \int_0^2 (2u^4+4u^2)\,du$ [2]

$= \left[\frac{2u^5}{5} + \frac{4u^3}{3}\right]_0^2$

$= \left[\left(\frac{64}{5}+\frac{32}{3}\right) - (0)\right]$

$= \frac{352}{15} = 23\frac{7}{15}$ [1]

---

b) $\int_0^{\frac{\pi}{4}} \sin^2\left(\tfrac{1}{2}x\right)dx = \int_0^{\frac{\pi}{4}} \frac{1}{2}(1-\cos x)\,dx$ [1]

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

$= \frac{1}{2}\left[\frac{\pi}{4} - \frac{1}{\sqrt{2}}\right]$ [1]

---

c) Prove $9^{n+2} - 4^n$ is divisible by 5.

i) Let $n=1$ $\quad 9^3 - 4 = 725$ $\therefore$ True for $n=1$ [1]

ii) Assume true for $n=k$ ie $9^{k+2} - 4^k = 5m$ (m is pos integer) [1]

iii) When $n=k+1$ $\quad 9^{k+3} - 4^{k+1} = 9(9^{k+2}) - 4(4^k)$

$= 9(5m+4^k) - 4(4^k)$

$= 45m + 9.4^k - 4.4^k$

$= 45m + 5.4^k$ [2]

$= 5[9m + 4^k]$

This is divisible by 5.

$\therefore$ if true for $n=k$, then true for $n=k+1$

[illegible] [1]

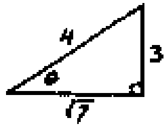
Mathematics Extension One: Question Number 2 Marker: NM.

Marks Awarded	Marker's Comments
1	Many mucked up the conversion.
2	Those with correct step one went on to get the correct integral
1	and find the correct numeric value.
1	Many did not know $\sin^2 x = \frac{1}{2}(1-\cos 2x)$
1	most integrated correctly.
1	most had correct evaluation.
1	Almost all proved true for $n=1$.
1	$9^{k+2} - 4^k = 5m$ well stated. most DID NOT state that m was a positive integer.
2	Many could not set out the correct steps for this section. Many used "m" again. Is it the same "m" used earlier?
1	Many were lazy in their final statement. $\therefore$ most did not get the mark.

MATHEMATICS EXTENSION I - QUESTION 3

(a) $\tan\left(2\sin^{-1}\frac{3}{4}\right)$

Let $\theta = \sin^{-1}\frac{3}{4}$ $\therefore \sin\theta = \frac{3}{4}$



$\tan\left(2\sin^{-1}\frac{3}{4}\right) = \tan 2\theta$

$= \dfrac{2\tan\theta}{1-\tan^2\theta}$

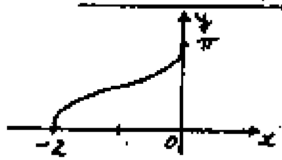
$= \dfrac{2\times\frac{3}{\sqrt7}}{1-\frac{9}{7}}$

$= -3\sqrt7$ ③

(b) $f(x) = \sin^{-1}(x+1) + \frac{\pi}{2}$

(i) Domain: $-1 \le x+1 \le 1$ $\therefore -2 \le x \le 0$ ①

(ii)



②

(c) $f(x) = \log_e(2x+1)$.

(i) Domain: $2x+1>0$ $\therefore x > -\frac{1}{2}$ ①

(ii) $y = \log_e(2x+1)$

$2x+1 = e^y$

Inverse is: $2y+1 = e^x$

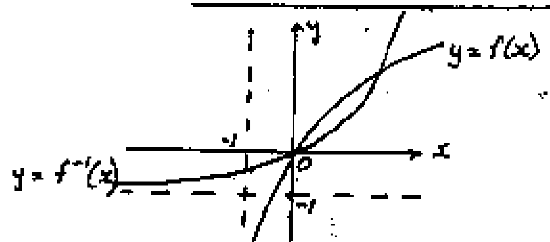
$y = \frac{1}{2}(e^x - 1)$

$f^{-1}(x) = \frac{1}{2}(e^x-1)$ ②

(iii) $f'(x) = \frac{2}{2x+1}$; $f'(0) = 2$

$\frac{d}{dx}f^{-1}(x) = \frac{1}{2}e^x$; At $x=0$, $\frac{d}{dx}f^{-1}(x) = \frac{1}{2}$. ①

(v)



②

Mathematics Extension One: Question Number 3 Marker: Mr M'Car

	Marks Awarded	Marker's Comments
(a)	1	$\tan\theta = \frac{3}{\sqrt7}$
	1	double angle formula substit^{n}
	1	correct final answer.
		Note - 1 mark awarded for calculator answer ~ 7.94
(b) (i)	1	Correct domain $-2 \le x \le 0$
(ii)	1	Correct shape
	1	Correct position
		Note - Use a stencil !!
(c) (i)	1	Correct domain $x > -\frac{1}{2}$
(ii)	1	Interchange $x \Leftrightarrow y$
	1	Make y the subject (Generally well done)
(iii)	1	Either answer $f'(0) = 2$ or $\frac{d}{dx}f^{-1}(0) = \frac{1}{2}$
(iv)	1	One correct function
	or	or
	2	- Must pass thru' origin - Show both asymptotes - intersect twice } required for FULL marks

(poorly answered)

Question 4

a) $(2-x)(1+x)^5 = (2-x)(1+5x+10x^2+10x^3 \dots)$ [1]

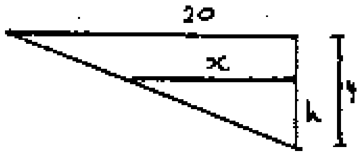
$= 2(10x^3) + (-x \times 10x^2)$

$= 20x^3 - 10x^3$ [1]

$= 10x^3$ $\quad \therefore$ Coefficient $= 10$ [1]

---

b) i)



$\frac{h}{x} = \frac{4}{20}$

$20h = 4x$

$x = 5h$ [1]

$V = \frac{1}{2}hx \times 8$

$= \frac{1}{2}h.5h.8$

$= 20h^2$. [1]

ii) $\frac{dV}{dt} = 2$ $\quad h = 1$

$\frac{dh}{dt} = ?$

$\frac{dV}{dt} = \frac{dV}{dh} \times \frac{dh}{dt}$ [1]

$2 = 40h \times \frac{dh}{dt}$

$\frac{dh}{dt} = 0.05$ [1]

---

c) $\frac{dV}{dt} = k(4000 - v)$

i) $V = 4000 - Ae^{-kt}$

$\frac{dV}{dt} = -k(-Ae^{-kt})$ [1]

$= +k(4000 - V)$.

ii) $t = 0$ $V = 2000$ $\quad 2000 = 4000 - Ae^0$ [1]

$A = 2000$

$t = 5$ $V = 3000$ $\quad 3000 = 4000 - 2000e^{-k5}$.

$e^{-5k} = \frac{1}{2}$ [1]

$k = -\frac{1}{5}\ln 0.5 = 0.1386$

iii) $3800 = 4000 - 2000e^{-kt}$ [1]

$e^{-k.t} = 0.1$ [1]

Mathematics Extension One: Question Number 4 $\quad$ Marker: NM

Marks Awarded	Marker's Comments
1	Correct expansion
1	Correct collection of coefficients
1	10. (Well done)
1	Correct explanation of why ratio was 5 : 1.
1	Correct explanation of why $V = 20h^2$. (Poorly done)
1	$\frac{dV}{dt} = \frac{dV}{dh} \times \frac{dh}{dt}$ or equivalent.
1	0.05 or $\frac{1}{20}$ or equivalent (Well done)
1	Use of $Ae^{-kt} = 4000 - V$.
1	Evaluate A
1	Evaluate k (correct dp's).
1	Correct equation.
1	Correct value of t.

MATHEMATICS EXTENSION I - QUESTION 5.

(a) $y = x^2 e^{-x}$

(i) $\frac{dy}{dx} = e^{-x}(2x) + x^2 \cdot (-e^{-x})$

$= 2x e^{-x} - x^2 . e^{-x}$

$= x e^{-x}(2 - x)$ ①

(ii) Let $f(x) = x^2 e^{-x} - 0.4$: $f(1) = e^{-1} - 0.4 = -0.03 < 0$

$f(2) = 4e^{-2} - 0.4 = 0.14 > 0$

Since $f(x)$ is continuous and $f(1), f(2)$ have opposite signs, a root lies between 1 and 2. ①

(iii) $x_2 = x_1 - \frac{f(x_1)}{f'(x_1)}$ $f'(1) = e^{-1} \times 1 = 0.3679$

$= 1 - \frac{-0.03}{0.3679}$

$= 1.08$ ③

b) Let $\angle ADF = \theta$

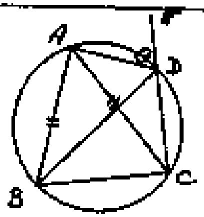
$\therefore \angle ABC = \theta$ (exterior angle cyclic quad)

$\therefore \angle ACB = \theta$ (base angles isosceles triangle)

$\therefore \angle ADB = \theta$ (angles in same segment)

$\therefore \angle ADF = \angle ADB$

$\therefore$ AD bisects $\angle BDF$. ③



c) $(3 + 2x)^8$

(i) $\frac{c_r}{c_{r-1}} = \frac{\binom{8}{r} 3^{8-r} 2^r}{\binom{8}{r-1} 3^{9-r} 2^{r-1}}$

$= \frac{2}{3} \times \frac{8!}{r!(8-r)!} \times \frac{(r-1)!(9-r)!}{8!}$

$= \frac{2}{3} \times \frac{9-r}{r}$

$= \frac{18-2r}{3r}$ ②

(ii) $\frac{18-2r}{3r} > 1$

$18 > 5r$

$r < 3\frac{3}{5}$

Greatest coefficient = coefficient of x^3

$= \binom{8}{3} 3^5 2^3$

OR 108 864 ②

Mathematics Extension One: Question Number 5 Marker: Mr M

Part	Marks Awarded	Marker's Comments
(a) (i)	1	Correct use of product rule
(ii)	1	Show a change of sign
(iii)	1	$f(1) = -0.03$
	1	$f'(1) = 0.368$
	1	Correct estimate $x_1 = 1.087$
		Note. must use $f(x) = x^2 e^{-x} - 0.4$
		Poorly answered by many students.
(b)	1	Exterior ∠ of cyclic quad.
	1	Base ∠s of isos. Δ
	1	Angles in same segment.
		Note - very poor structure - drawing a diagram helps.
(c) (i)	1	$\frac{^8C_r 3^{8-r} 2^r}{^8C_{r-1} 3^{9-r} 2^{r-1}}$ or $\frac{n-r+1}{r} \cdot \frac{b}{a}$
	1	Use of factorial definition to correctly simplify.
(ii)	1	Solving inequality $r < 3\frac{3}{5}$
	1	Finding greatest term 108 864
		Note: part (i) poorly answered.

Question 6

a) i) $x = 3\sin 2t - 4\cos 2t$

$\dot{x} = 6\cos 2t + 8\sin 2t$ [1]

$\ddot{x} = -12\sin 2t + 16\cos 2t$

$= -4[3\sin 2t - 4\cos 2t]$ [1]

$= -4x$ (ie $-n^2x$)

ii) $t = 0$ $\dot{x} = 6\cos 0 + 8\sin 0$

$= 6$ [1]

iii) $\dot{x} = 0$ $6\cos 2t + 8\sin 2t = 0$ [1]

$8\sin 2t = -6\cos 2t$

$\tan 2t = \frac{-3}{4}$ [1]

$2t = \pi - 0.6435$

$t = 1.249$ [1]

---

b) i) $\ddot{x} = -\frac{1}{4x^3}$

$\frac{d}{dx}\left(\frac{1}{2}v^2\right) = -\frac{1}{4}x^{-3}$ [1]

$\frac{1}{2}v^2 = \frac{1}{8}x^{-2} + C$

$v = \frac{1}{2}$ $x = 1$ $\frac{1}{2}\left(\frac{1}{4}\right) = \frac{1}{8} + C$

$\therefore C = 0$ [1]

$\frac{1}{2}v^2 = \frac{1}{8x^2}$ [1]

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

ii) $\frac{dx}{dt} = \frac{1}{2x}$ $\frac{dt}{dx} = 2x$ [1]

[1] $t = x^2 + C$

Mathematics Extension One: Question Number 6. Marker: NM.

Marks Awarded		Marker's Comments
a) i)	1	Correct expression for $\dot{x}$
	1	Correct manipulation to $\ddot{x} = -n^2x$ (well done)
ii)	1	$\dot{x} = 6$ (Very well done)
iii)	1	Let $\dot{x} = 0$ (Generally OK.
	1	$\tan 2t = -3/4$ Some poor solutions to
	1	$t = 1.249$ $\tan 2t = -3/4$)
b) i)	1	Correct version of $\ddot{x} = \frac{d}{dx}\left(\frac{1}{2}v^2\right)$
	1	Evaluate $C = 0$
	1	Correct "tidy up" to $v = \frac{1}{2x}$ (Many forgot c)
ii)	1	For $\frac{dt}{dx} = 2x$
	1	Evaluate C.
	1	Manipulate to $x = \sqrt{t+1}$

MATHEMATICS EXTENSION 1 - QUESTION 7

a) Initially, $\dot{x} = V\cos\theta = 40\cos 60° = 20$; $\dot{y} = V\sin\theta = 40\sin 60° = 20\sqrt{3}$.

$\ddot{x} = 0$ $\ddot{y} = -10$

$\dot{x} = c$ $\dot{y} = -10t + k$

$\dot{x} = 20$ When $t=0$, $\dot{y} = 20\sqrt{3}$ ∴ $k = 20\sqrt{3}$

$x = 20t + c'$ ∴ $\dot{y} = 20\sqrt{3} - 10t$

When $t=0, x=0$ ∴ $c'=0$ $y = 20\sqrt{3}t - 5t^2 + k'$

∴ $x = 20t$ (A)   When $t=0, y=0$ ∴ $k'=0$

∴ $y = 20\sqrt{3}t - 5t^2$ (B)

From (A), $t = \frac{x}{20}$ ∴ $y = 20\sqrt{3}\left(\frac{x}{20}\right) - 5\left(\frac{x}{20}\right)^2$

$y = \sqrt{3}x - \frac{x^2}{80}$ (4)

b) Equation of slope: $y = \frac{1}{4}x$ ∴ $\sqrt{3}x - \frac{x^2}{80} = \frac{1}{4}x$

$80\sqrt{3}x - x^2 = 20x$

$(80\sqrt{3} - 20)x - x^2 = 0$

$x[80\sqrt{3} - 20 - x] = 0$

$x = 0$ or $x = 80\sqrt{3} - 20$

∴ Horizontal distance is $80\sqrt{3} - 20$ (2)

c) From $y = \frac{1}{4}x$, $y = \frac{1}{4}(80\sqrt{3} - 20) = 29.64$

$x = 80\sqrt{3} - 20 = 118.56$

Distance $OA = \sqrt{118.56^2 + 29.64^2}$

$= 122$ metres (nearest metre)   (2)

d) Height above slope: $H = \sqrt{3}x - \frac{x^2}{80} - \frac{1}{4}x$

$\frac{dH}{dx} = \sqrt{3} - \frac{1}{4} - \frac{x}{40}$

$\frac{dH}{dx} = 0$: $x = 40\left(\sqrt{3} - \frac{1}{4}\right)$

This is for maximum value of H (concave down parabola).

When $x = 40\left(\sqrt{3} - \frac{1}{4}\right)$, $H = \left(\sqrt{3} - \frac{1}{4}\right)40\left(\sqrt{3} - \frac{1}{4}\right) - \frac{1}{80}\times 40^2\left(\sqrt{3} - \frac{1}{4}\right)^2$

$= 40\left(\sqrt{3} - \frac{1}{4}\right)^2 - 20\left(\sqrt{3} - \frac{1}{4}\right)^2$

$= 20\left(\sqrt{3} - \frac{1}{4}\right)^2$

$= 20\left(3 - \frac{\sqrt{3}}{2} + \frac{1}{16}\right)$

$= 61.25 - 10\sqrt{3}$

Maximum height is $(61.25 - 10\sqrt{3})$ m.   (4)

Mathematics Extension One: Question Number 7   Marker: CJF.

Marks Awarded	Marker's Comments
(a). 1 mark.	$\dot{x} = 20$, $\dot{y} = 20\sqrt{3}$ } in whatever form and wherever stated in answer
1 mark.	$x = 20t$ ..... deriving equation / finding c'
1 mark.	$y = 20\sqrt{3}t - 5t^2$ ... deriving equation and finding k and k' (mark not awarded if k and k' ignored)
1 mark.	$t = \frac{x}{20} \rightarrow y = 20\sqrt{3}\left(\frac{x}{20}\right) - 5\left(\frac{x}{20}\right)^2$.
(b). 1 mark	$\frac{1}{4}x = \sqrt{3}.x - \frac{x^2}{80}$.
1 mark.	$x = 80\sqrt{3} - 20$ / derived from above.
(c). 1 mark	$y = \frac{1}{4}(80\sqrt{3} - 20)$ and $x = 80\sqrt{3} - 20$.
1 mark	distance $OA = 122$ m.
(d) 1 mark	$H = \sqrt{3}x - \frac{x^2}{80} - \frac{x}{4}$.
1 mark	$\frac{dH}{dt} =$
1 mark	$x = 40\left(\sqrt{3} - \frac{1}{4}\right)$
1 mark	$H = 61.25 - 10\sqrt{3}$. Note: $t = 2\sqrt{3} - \frac{1}{2}$ Not $t \neq 2\sqrt{3}$. This is because ramp is on a slope and maximum height is not in middle