2 JUN 1994 I

香港考試局
HONG KONG EXAMINATIONS AUTHORITY

一九九四年香港中學會考
HONG KONG CERTIFICATE OF EDUCATION EXAMINATION, 1994

附加數學卷一
ADDITIONAL MATHEMATICS PAPER I

評卷參考
MARKING SCHEME

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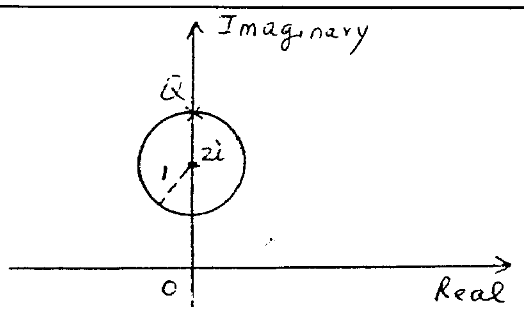
本評卷參考並非標準答案，故極不宜落於學生手中，以免引起誤會。

遇有學生求取此文件時，閱卷員應嚴予拒絕。閱卷員如向學生披露本評卷參考內容，即違背閱卷員守則。

Solution	Marks	Remarks
1. $\frac{2(x+1)}{x-2} \geq 1$		
$\frac{2(x+1)}{x-2} - 1 \geq 0$	1M	
$\frac{x+4}{x-2} \geq 0$	1A	
$x > 2$ or $x \leq -4$	2A	1A for $x \geq 2$ or $x \leq -4$
	4	
Alternative solution (1)		
$\frac{2(x+1)}{x-2} \geq 1$		
Consider the following 2 cases (i) $x > 2$, (ii) $x < 2$:	1M	Awarded even if equality sign is included.
Case 1 : $x > 2$		
$2(x+1) \geq x-2$		
$x \geq -4$		
Since $x > 2$, $\therefore x > 2$	1A	
Case 2 : $x < 2$		
$2(x+1) \leq x-2$		
$x \leq -4$		
Since $x < 2$, $\therefore x \leq -4$		
Combining the 2 cases, $x > 2$ or $x \leq -4$	2A	1A for $x \geq 2$ or $x \leq -4$
Alternative solution (2)		
$\frac{2(x+1)}{(x-2)} \geq 1$		
$2(x+1)(x-2) \geq (x-2)^2$ (and $x \neq 2$)	1M	
$x^2 + 2x - 8 \geq 0$ (and $x \neq 2$)		
$(x-2)(x+4) \geq 0$ (and $x \neq 2$)	1A	
$x > 2$ or $x \leq -4$	2A	1A for $x \geq 2$ or $x \leq -4$
2. 	1A	For circle
	1A	For centred at $z = 2i$
	1A	For radius = 1
Position of Q	1M+1A	1M for being farthest away from O
		Axes not labelled - (pp-1)
	5	

Solution	Marks	Remarks
3. (a) $\overrightarrow{PQ} = \overrightarrow{OQ} - \overrightarrow{OP}$	1M	Omit vector sign (pp-1)
$= 2\vec{i} - \vec{j}$	1A	
$\lvert\overrightarrow{PQ}\rvert = \sqrt{2^2 + (-1)^2} = \sqrt{5}$	1A	
(b) Let $\angle QPR = \theta$		
$\overrightarrow{PQ} \cdot \overrightarrow{PR} = (2\vec{i} - \vec{j}) \cdot (-3\vec{i} - 2\vec{j}) = -4$	1A	Omit dot sign (pp-1)
$\cos\theta = \dfrac{\overrightarrow{PQ} \cdot \overrightarrow{PR}}{\lvert\overrightarrow{PQ}\rvert\lvert\overrightarrow{PR}\rvert}$	1M	
$= \dfrac{-4}{\sqrt{65}}$	1A / 6	
Alternative solution		
(b) $\lvert\overrightarrow{PR}\rvert = \sqrt{13}$		
$\overrightarrow{RQ} = 5\vec{i} + \vec{j}$		
$\lvert\overrightarrow{RQ}\rvert = \sqrt{26}$	1A	
$\cos\angle QPR = \dfrac{\lvert\overrightarrow{PQ}\rvert^2 + \lvert\overrightarrow{PR}\rvert^2 - \lvert\overrightarrow{QR}\rvert^2}{2\lvert\overrightarrow{PQ}\rvert\lvert\overrightarrow{PR}\rvert}$	1M	
$= \dfrac{5 + 13 - 26}{2\sqrt{5}\sqrt{13}}$		
$= \dfrac{-4}{\sqrt{65}}$	1A	
4. $y = \tan(\frac{1}{x})$		
$\dfrac{dy}{dx} = -\dfrac{1}{x^2}\sec^2(\frac{1}{x})$	1M+1A	1M for $\frac{d}{dx}(\tan x) = \sec^2 x$
$x^2\dfrac{dy}{dx} + (y^2 + 1) = -\sec^2(\frac{1}{x}) + \tan^2(\frac{1}{x}) + 1$	1M	or $= -(1 + y^2) + y^2 + 1$
$= 0$	1	
Differentiating $x^2\dfrac{dy}{dx} + (y^2 + 1) = 0$ with respect to x		
$2x\dfrac{dy}{dx} + x^2\dfrac{d^2y}{dx^2} + 2y\dfrac{dy}{dx} = 0$	1A	
$x^2\dfrac{d^2y}{dx^2} + 2(x + y)\dfrac{dy}{dx} = 0$		
$\dfrac{d^2y}{dx^2} + \dfrac{2(x + y)}{x^2}\dfrac{dy}{dx} = 0$	1 / 6	

Solution	Marks	Remarks
5. $z^2 - \sqrt{2}z + 1 = 0$		
$z = \frac{\sqrt{2}}{2} \pm \frac{\sqrt{2}}{2}i$	1A	Accept $\frac{\sqrt{2}}{2} \pm \frac{\sqrt{-2}}{2}$
$= \cos\frac{\pi}{4} + i\sin\frac{\pi}{4}$ or $\cos(-\frac{\pi}{4}) + i\sin(-\frac{\pi}{4})$	1A+1A	Do not accept degrees Do not accept $\cos\frac{\pi}{4} - i\sin\frac{\pi}{4}$ (Note : Mark the rest of the Q if z is correct but not in the specified format.)
$w^4 - \sqrt{2}w^2 + 1 = 0$		
$w^2 = \cos\frac{\pi}{4} + i\sin\frac{\pi}{4}$ or $w^2 = \cos(-\frac{\pi}{4}) + i\sin(-\frac{\pi}{4})$	1M	
$w = \cos(\frac{2k\pi + \frac{\pi}{4}}{2}) + i\sin(\frac{2k\pi + \frac{\pi}{4}}{2})$ $= \cos(k\pi + \frac{\pi}{8}) + i\sin(k\pi + \frac{\pi}{8})$ or $w = \cos(\frac{2k\pi - \frac{\pi}{4}}{2}) + i\sin(\frac{2k\pi - \frac{\pi}{4}}{2})$, $= \cos(k\pi - \frac{\pi}{8}) + i\sin(k\pi - \frac{\pi}{8})$	1M+1A +1A	1M for De Moivre's Theorem
where k = 0, 1 (or any 2 consecutive integers)	7	
or $w = \cos\theta + i\sin\theta$, where $\theta = \frac{\pi}{8}$(or $-15\frac{\pi}{8}$ etc.), $-\frac{\pi}{8}$(or $\frac{15\pi}{8}$), $\frac{7\pi}{8}$(or $-\frac{9\pi}{8}$), $-\frac{7\pi}{8}$(or $\frac{9\pi}{8}$)	1A	Accept other equivalent values. Accept degrees

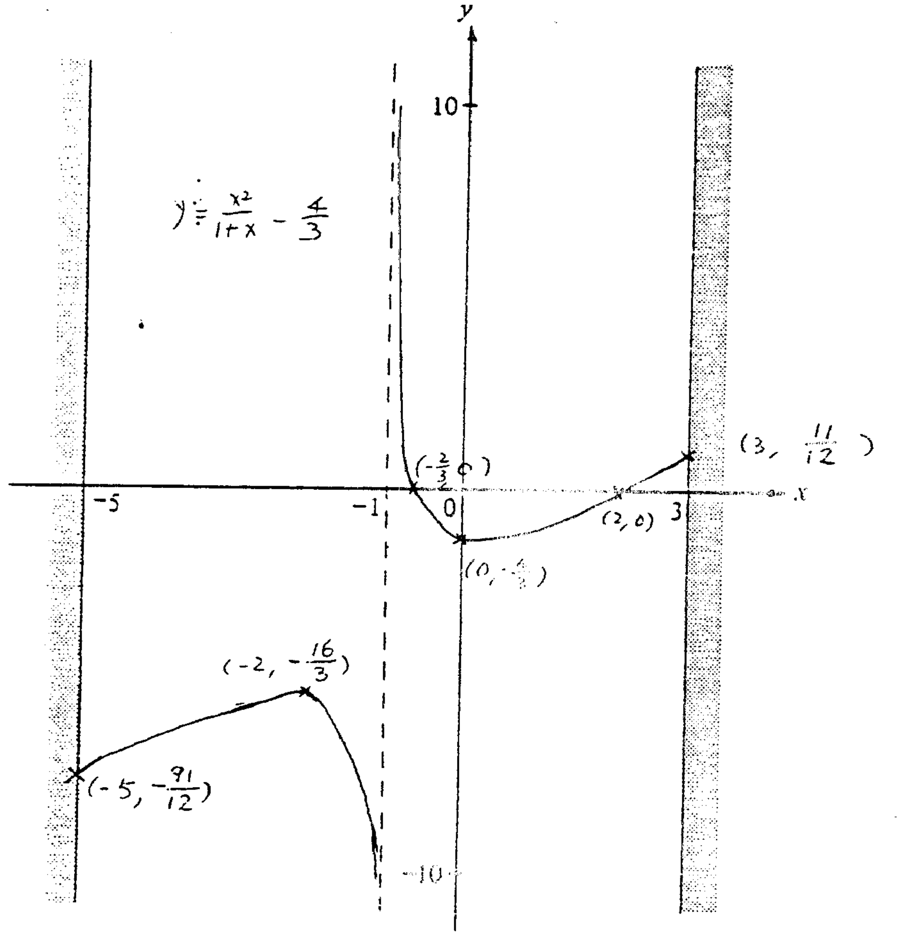
Solution	Marks	Remarks
6. (a) $x^2 + y\cos x - y^2 = 0$		
$2x + \cos x\frac{dy}{dx} - y\sin x - 2y\frac{dy}{dx} = 0$	1A+1A	1A for $\frac{d}{dx}(y\cos x)$ 1A for other terms
$\frac{dy}{dx} = \frac{y\sin x - 2x}{\cos x - 2y}$	1A	
(b) At P, $\frac{dy}{dx} = \frac{-\frac{\pi}{2}\sin\frac{\pi}{2} - \pi}{\cos\frac{\pi}{2} - (-\pi)}$	1M	
$= -\frac{3}{2}$	1A	
Equation of tangent is		
$\frac{y + \frac{\pi}{2}}{x - \frac{\pi}{2}} = -\frac{3}{2}$	1M	
$6x + 4y - \pi = 0$	1A 7	or $y = -\frac{3}{2}x + \frac{\pi}{4}$

Solution	Marks	Remarks
7. $(x-3)^2 - \lvert x-3\rvert - 12 = 0$		
<u>Solution (1)</u> :		
$(x-3)^2 = \lvert x-3\rvert^2$	2M	
$\lvert x-3\rvert^2 - \lvert x-3\rvert - 12 = 0$		
$(\lvert x-3\rvert + 3)(\lvert x-3\rvert - 4) = 0$	1A	
$\lvert x-3\rvert = 4$ or $\lvert x-3\rvert = -3$		
$\therefore \lvert x-3\rvert = 4$		
$\therefore x = 7$ or -1	1A+1A+2A 7	2A for rejecting $\lvert x-3\rvert = -3$
<u>Solution (2)</u> :		
Consider 2 cases : (1) $x \geq 3$ (2) $x < 3$	1M	Accept omitting equality sign
Case (1) : $x \geq 3$		
$(x-3)^2 - (x-3) - 12 = 0$	1A	
$[(x-3)+3][(x-3)-4] = 0$		
$x^2 - 7x = 0$		
$x = 0$ or 7	1A	
Rejecting $x = 0$, $\therefore x = 7$	1A	
Case (2) : $x < 3$		
$(x-3)^2 + (x-3) - 12 = 0$	1A	
$[(x-3)-3][(x-3)+4]$		
$x^2 - 5x - 6 = 0$		
$x = 6$ or -1	1A	
Rejecting $x = 6$, $\therefore x = -1$	1A	
Combining the 2 cases, $x = -1$ or 7		
<u>Solution (3)</u> :		
$(x-3)^2 - \lvert x-3\rvert - 12 = 0$		
Let $x - 3 = u$		
$u^2 - 12 = \lvert u\rvert$		
$u^4 - 24u^2 + 144 = u^2$	2M	
$u^4 - 25u^2 + 144 = 0$		
$(u^2-9)(u^2-16) = 0$	1A	
$u = \pm 3$ or $u = \pm 4$		
$x = 0$ or 6 or $x = -1$ or 7	1A+1A	
Rejecting $x = 0$ and 6, $\therefore x = -1$ or 7	1A+1A	

Solution	Marks	Remarks
8. (a) $x = 0$	1A	
	1	
(b) $x^2 + kx + (2k - 3) = 0$ has no real root.	1M	Can be omitted
$\Delta = k^2 - 4(2k - 3) < 0$	1M	
$k^2 - 8k + 12 < 0$		
$(k - 2)(k - 6) < 0$	1A	
$2 < k < 6$	1	
	4	
(c) (i) $f'(x) = 3x^2 + 2kx + (2k - 3)$	1A	
$\begin{cases} \alpha + \beta = \dfrac{-2k}{3} \\ \alpha\beta = \dfrac{2k - 3}{3} \end{cases}$	1M	
$(\alpha - \beta)^2 = (\alpha + \beta)^2 - 4\alpha\beta$	1A	Can be omitted
$= (\frac{-2k}{3})^2 - 4(\frac{2k - 3}{3})$		
$= \frac{4}{9}(k^2 - 6k + 9)$	1A	
$= \frac{4}{9}(k - 3)^2$	1A	$\Delta = 4k^2 - 12(2k - 3)$
Since $\alpha \neq \beta$, $\therefore k \neq 3$	1	$= 4(k - 3)^2$ .... 1A Since $\Delta > 0$, $\therefore k \neq 3$ .. 1
1		
(ii) $\left\lvert \frac{2}{3}(k - 3) \right\rvert \leq \frac{2}{3}$	1M	
$\lvert k - 3 \rvert \leq 1$	1A	or $-1 \leq k - 3 \leq 1$
$2 \leq k \leq 4$	1A	
Combining with $2 < k < 6$, $k \neq 3$ and k is an integer,		
$k = 4$	2A	
	11	
Alternative solution		
(c) (ii) $\frac{4}{9}(k^2 - 6k + 9) \leq \frac{4}{9}$	1M	
$k^2 - 6k + 8 \leq 0$	1A	
$(k - 2)(k - 4) \leq 0$		
$2 \leq k \leq 4$	1A	
$\therefore k = 4$	2A	

Solution	Marks	Remarks
9. (a) Put $x = 0$, $y = -\frac{4}{3}$ $\therefore$ y-intercept is $-\frac{4}{3}$	1A	
Put $y = 0$, $\frac{x^2}{1+x} - \frac{4}{3} = 0$		
$3x^2 - 4x - 4 = 0$		
$x = 2, -\frac{2}{3}$		
$\therefore$ x-intercepts are 2 and $-\frac{2}{3}$.	1A	
	2	
(b) $\frac{dy}{dx} = \frac{2x(1+x) - x^2}{(1+x)^2}$	1M	For quotient rule
$= \frac{2x + x^2}{(1+x)^2}$	1A	
$\frac{d^2y}{dx^2} = \frac{(2+2x)(1+x)^2 - 2(1+x)(2x+x^2)}{(1+x)^4}$		
$= \frac{2}{(1+x)^3}$	1	
	3	
(c) $\frac{2x + x^2}{(1+x)^2} = 0$	1M	
$x = 0$ or -2	1A+1A	
When $x = 0$, $y = -\frac{4}{3}$		
$\frac{d^2y}{dx^2} = 2$ (or > 0)	1M	
$\therefore (0, -\frac{4}{3})$ is a minimum point	1A	No mark if checking is omitted
When $x = -2$, $y = -\frac{16}{3}$		
$\frac{d^2y}{dx^2} = -2$ (or < 0)		
$\therefore (-2, -\frac{16}{3})$ is a maximum point	1A	No mark if checking is omitted
	6	

Solution	Marks	Remarks
(d)		



Solution	Marks	Remarks
(i) For $-5 \le x < -1$	1A	Shape
	$\frac{1}{2}$A	For $(-5, -\frac{91}{12})$. Accept $-\frac{91}{12} \approx -7.6$
	$\frac{1}{2}$A	For $(-2, -\frac{16}{3})$ as a maximum point
(ii) For $-1 < x \le 3$	1A	Shape
	$\frac{1}{2}$A	For $(-\frac{2}{3}, 0)$
	$\frac{1}{2}$A	For $(2, 0)$
	$\frac{1}{2}$A	For $(3, \frac{11}{12})$. Accept $\frac{11}{12} \approx 0.92$
	$\frac{1}{2}$A	For $(0, -\frac{4}{3})$ as a minimum point
		Note : Round up to the nearest mark
	5	

Solution	Marks	Remarks
10. (a) $\overrightarrow{OC} = \frac{1}{3}\vec{a} + \frac{2}{3}\vec{b}$	1A	Omit vector sign (pp-1)
$\overrightarrow{DA} = \overrightarrow{OA} - \overrightarrow{OD}$	1M	Can be omitted
$= \vec{a} - \frac{1}{2}\vec{b}$	1A	
	3	
(b) $\overrightarrow{BE} = \overrightarrow{OE} - \overrightarrow{OB}$		
$= (k+1)\overrightarrow{OC} - \overrightarrow{OB}$	1A	For $\overrightarrow{OE} = (k+1)\overrightarrow{OC}$
$= \frac{k+1}{3}\vec{a} + \frac{2k-1}{3}\vec{b}$	1	$\frac{\overrightarrow{OC}}{\overrightarrow{CE}} = \frac{1}{k}$ (pp-1)
	2	
<u>Alternative solution</u>		
$\overrightarrow{BE} = \overrightarrow{BC} + \overrightarrow{CE}$		
$= \frac{1}{3}\overrightarrow{BA} + k\overrightarrow{OC}$	1A	
$= \frac{1}{3}(\vec{a} - \vec{b}) + k(\frac{\vec{a} + 2\vec{b}}{3})$		
$= \frac{k+1}{3}\vec{a} + \frac{2k-1}{3}\vec{b}$	1	
(c) $\vec{a} - \frac{1}{2}\vec{b} = \lambda(\frac{k+1}{3}\vec{a} + \frac{2k-1}{3}\vec{b})$	1M	No mark if λ is omitted
$\begin{cases} 1 = \lambda(\frac{k+1}{3}) \\ -\frac{1}{2} = \lambda(\frac{2k-1}{3}) \end{cases}$	1M	No mark if λ is omitted
$k = \frac{1}{5}$	1A	
<u>Alternative solution</u>		
$\frac{\frac{k+1}{3}}{1} = \frac{\frac{2k-1}{3}}{-\frac{1}{2}}$	2M	(pp−1) for considering the slope of the vectors
$k = \frac{1}{5}$	1A	
	3	
(d) (i) $\vec{a} \cdot \vec{b} = \lvert\vec{a}\rvert\,\lvert\vec{b}\rvert \cos\frac{\pi}{3}$	1M	Omit dot sign (pp-1)
$= (1)(2)\cos\frac{\pi}{3} = 1$	1A	

Solution	Marks	Remarks
(ii) $\overrightarrow{BE} \cdot \overrightarrow{OE} = 0$	1M	
$\left(\frac{k+1}{3}\vec{a} + \frac{2k-1}{3}\vec{b}\right) \cdot \frac{k+1}{3}(\vec{a} + 2\vec{b}) = 0$		
$\frac{k+1}{9}[(k+1)\vec{a}\cdot\vec{a} + (2k+2+2k-1)$		
$\vec{a}\cdot\vec{b} + 2(2k-1)\vec{b}\cdot\vec{b}] = 0$	1M	For distribution
$k + 1 + 4k + 1 + 8(2k-1) = 0 \quad (k \neq -1)$		
$k = \frac{2}{7}$	1A	
For $k = \frac{2}{7}$, $\overrightarrow{BE} = \frac{3}{7}\vec{a} - \frac{1}{7}\vec{b}$	1M	Trying to find $\overrightarrow{BE}$
$\lvert\overrightarrow{BE}\rvert^2 = \overrightarrow{BE} \cdot \overrightarrow{BE}$	1M	Trying to find $\lvert\overrightarrow{BE}\rvert$
$= \left(\frac{3}{7}\vec{a} - \frac{1}{7}\vec{b}\right) \cdot \left(\frac{3}{7}\vec{a} - \frac{1}{7}\vec{b}\right)$		
$= \frac{9}{49}\vec{a}\cdot\vec{a} - \frac{6}{49}\vec{a}\cdot\vec{b} + \frac{1}{49}\vec{b}\cdot\vec{b}$		
$= \frac{9}{49} - \frac{6}{49} + \frac{4}{49} = \frac{1}{7}$		
$\therefore$ Distance of B from $OC = \frac{\sqrt{7}}{7}$.	1A	
	8	

Solution	Marks	Remarks
11. (a) (i) $\frac{z^2}{\bar{z}} = \frac{r^2(\cos 2\theta + i\sin 2\theta)}{r(\cos\theta - i\sin\theta)}$	1A+1A	1A for denominator 1A for numerator
$= \frac{r^2(\cos 2\theta + i\sin 2\theta)}{r(\cos(-\theta) + i\sin(-\theta))}$	1A	For denominator
$= r(\cos 3\theta + i\sin 3\theta)$	1	
(ii) $z^2 = i\bar{z}$		
$r(\cos 3\theta + i\sin 3\theta) = i$	1A	
$= \cos\frac{\pi}{2} + i\sin\frac{\pi}{2}$	1A	Or other equivalent polar form (can be omitted)
$r = 1$	1A	
$3\theta = 2n\pi + \frac{\pi}{2}$		
$\theta = -\frac{\pi}{2}, \frac{\pi}{6}, \frac{5\pi}{6}$	1A+1A	Any one correct – 1A
(or $\theta = \frac{2n\pi}{3} + \frac{\pi}{6}$, where $k = -1, 0, 1$)		All correct – 2A
Alternative solution		
(ii) $r(\cos 3\theta + i\sin 3\theta) = i$	1A	
$\begin{cases} r\cos 3\theta = 0 \\ r\sin 3\theta = 1 \end{cases}$	1A	or $\begin{cases} \cos 3\theta = 0 \\ \sin 3\theta = 1 \end{cases}$ (can be omitted)
$r^2(\sin^2 3\theta + \cos^2 3\theta) = 1$		
$r = 1$	1A	
$3\theta = 2n\pi + \frac{\pi}{2}$		
$\theta = -\frac{\pi}{2}, \frac{\pi}{6}, \frac{5\pi}{6}$	1A+1A	Any one correct – 1A All correct – 2A
	9	

Solution	Marks	Remarks
(b) (i) $w - i = \cos\alpha + i\sin\alpha$	1A	
$\|w - i\| = (\sqrt{\cos^2\alpha + \sin^2\alpha}) = 1$	1A	
(ii) Since $(w - i)^2 = = i\overline{w} - 1$		
$= i(\overline{w - i})$,	1A	
$\therefore w - i$ satisfies the equation $z^2 = i\overline{z}$		
Using the result of (a),		
$w - i = \cos\theta + i\sin\theta$, where $\theta = -\frac{\pi}{2}, \frac{\pi}{6}, \frac{5\pi}{6}$	1M	
$w - i = -i, \frac{\sqrt{3}}{2} + \frac{1}{2}i, \frac{-\sqrt{3}}{2} + \frac{1}{2}i$		
$w = 0, \frac{\sqrt{3}}{2} + \frac{3}{2}i, \frac{-\sqrt{3}}{2} + \frac{3}{2}i$	1A+1A+1A	(pp-1) for $w = \cos\alpha + i(1 + \sin\alpha)$
	7	where $\alpha = -\frac{\pi}{2}, \frac{\pi}{6}, \frac{5\pi}{6}$

Solution	Marks	Remarks
12. (a) $x = 4\sin\theta$	1A	
$\frac{dx}{dt} = 4\cos\theta\frac{d\theta}{dt}$	1M	For differentiating wrt t
Put $\frac{dx}{dt} = \frac{1}{2}$		
$\frac{d\theta}{dt} = \frac{1}{8\cos\theta}$	1A	
	3	
(b) $y = 4\cos\theta$	1A	
$\frac{dy}{dt} = -4\sin\theta\frac{d\theta}{dt}$		
$= -\frac{\tan\theta}{2}$	1A	
$z = \sqrt{25-16\sin^2\theta}$	1M	or $\sqrt{25-x^2}$
$\frac{dz}{dt} = \frac{-32\sin\theta\cos\theta}{2\sqrt{25-16\sin^2\theta}}\frac{d\theta}{dt}$		
$= \frac{-2\sin\theta}{\sqrt{25-16\sin^2\theta}}$	1A	
Rate of change $= \frac{dy}{dt} + \frac{dz}{dt}$	1M	
At $\theta = \frac{\pi}{6}$, Rate $= -\frac{\tan\frac{\pi}{6}}{2} - \frac{2\sin\frac{\pi}{6}}{\sqrt{25-16\sin^2\frac{\pi}{6}}}$		
$= -0.507$ (m s^{-1})	1A	
	6	
(c) Let A be the area of ΔOPR		
$A = \frac{1}{2}xy$		
$= 8\sin\theta\cos\theta$	1A	
$= 4\sin 2\theta$		
A is maximum when $\sin 2\theta = 1$	2M	
$2\theta = \frac{\pi}{2}$		
$\therefore \theta = \frac{\pi}{4}$	1A	

Solution	Marks	Remarks
Alternative solution (1)		
$A = 8\sin\theta\cos\theta$	1A	
$\frac{dA}{d\theta} = 8(\cos^2\theta - \sin^2\theta)$		
$\frac{dA}{d\theta} = 0$, $\cos^2\theta - \sin^2\theta = 0$	1M	
$\tan^2\theta = 1$		
$\theta = \frac{\pi}{4}$	1A	
$\frac{d^2A}{d\theta^2} = -32\sin\theta\cos\theta$		
$\frac{d^2A}{d\theta^2} < 0$ at $\theta = \frac{\pi}{4}$		
$\therefore$ A is maximum when $\theta = \frac{\pi}{4}$	1M	For checking
Alternative solution (2)		
$A = 4\sin2\theta$	1A	
$\frac{dA}{d\theta} = 8\cos2\theta$		
$\frac{dA}{d\theta} = 0$, $\cos2\theta = 0$	1M	
$\theta = \frac{\pi}{4}$	1A	
$\frac{d^2A}{d\theta^2} = -16\sin2\theta$		
$\frac{d^2A}{d\theta^2} < 0$ at $\theta = \frac{\pi}{4}$		
$\therefore$ A is a maximum when $\theta = \frac{\pi}{4}$	1M	For checking
Similarly, area of ΔORQ is maximum when		
$\angle OQR = \frac{\pi}{4}$	1M	
By Sine Law,		
$\frac{\sin\frac{\pi}{4}}{4} = \frac{\sin\theta}{5}$	1M	
$\theta = 1.08$	1A 7	