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HONG KONG CERTIFICATE OF EDUCATION EXAMINATION, 1984

ADD. MATHEMATICS PAPER I

MARKING SCHEME

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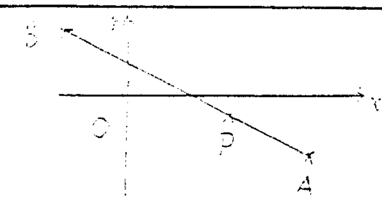
SOLUTIONS	MARKS	REMARKS
1. (a) $\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA}$	1	
$= (-\vec{i} - \vec{j}) - (3\vec{i} - 2\vec{j})$		
$= -4\vec{i} + 3\vec{j}$	1A	
The unit vector $= \dfrac{-4\vec{i} + 3\vec{j}}{\sqrt{(-4)^2+3^2}}$	1M	Method to find unit vector
$= -\dfrac{4}{5}\vec{i} + \dfrac{3}{5}\vec{j}$	1A	
(b) $\overrightarrow{OP} = \overrightarrow{OA} + \overrightarrow{AP}$	1	Alternatively: $\overrightarrow{OP} = m\vec{b} + (1-m)\vec{a}$ 2A
$= \overrightarrow{OA} + m\,\overrightarrow{AB}$	1M	$= m(-\vec{i}+\vec{j}) + (1-m)(3\vec{i}-2\vec{j})$
$= (3\vec{i} - 2\vec{j}) + (-4m\vec{i} + 3m\vec{j})$		$= (3-4m)\vec{i} + (3m-2)\vec{j}$ 1A
$= (3 - 4m)\vec{i} + (3m - 2)\vec{j}$	1A	
	7	
2. $S = 4\pi r^2$, $V = \dfrac{4}{3}\pi r^3$		
$\dfrac{dS}{dt} = \dfrac{dS}{dr} \cdot \dfrac{dr}{dt} = 8\pi r \cdot \dfrac{dr}{dt}$	1A+1A	
$\therefore 8\pi r \dfrac{dr}{dt} = 8$	1M	Equate $\dfrac{dS}{dt} = 8$
At $S = 36\pi$, $r = 3$	1A	
$\dfrac{dr}{dt} = \dfrac{8}{8\pi r} = \dfrac{1}{3\pi}$	1A	
$\dfrac{dV}{dt} = \dfrac{dV}{dr} \cdot \dfrac{dr}{dt}$		
$= 4\pi r^2 \cdot \dfrac{dr}{dt}$	1A	
At $S = 36\pi$, $\dfrac{dV}{dt} = 36\pi \cdot \dfrac{1}{3\pi}$	1M	Sub for r
$= 12$		
The volume is increasing at a rate of 12 cm^3/s	1A	
	8	
Alternatively		
$S = 4\pi r^2$		
$V = \dfrac{4}{3}\pi r^3 = \dfrac{4}{3}\pi \cdot \left(\dfrac{S}{4\pi}\right)^{\frac{3}{2}}$	1M+2A	1M for attempt to eliminate r
$\dfrac{dV}{dt} = \dfrac{dV}{dS} \cdot \dfrac{dS}{dt}$	1	
$= \dfrac{4}{3}\pi \cdot \left(\dfrac{1}{4\pi}\right)^{\frac{3}{2}} \cdot \dfrac{3}{2} S^{\frac{1}{2}} \cdot \dfrac{dS}{dt}$	1A	
$= \dfrac{4}{3}\pi\left(\dfrac{1}{4\pi}\right)^{\frac{3}{2}} \cdot \dfrac{3}{2}(36\pi)^{\frac{1}{2}} \cdot 8$	1M+1A	1M for sub $S = 36\pi$, $\dfrac{dS}{dt} = 8$
$= 12$	1A	
The volume is increasing at a rate of 12 cm^3/s	1A	

SOLUTIONS	MARKS	REMARKS
3. (a) $z = (1 - 2i)^5$		
$= 1 + 5(-2i) + 10(-2i)^2 + 10(-2i)^3 + 5(-2i)^4 + (-2i)^5$	1A	
$= (1 - 40 + 80) + (-10 + 80 - 32)i$		
$= 41 + 38i$	1A	
(b) $\frac{1}{z} = \frac{1}{41 + 38i}$		
$= \frac{1}{(41)^2 + (38)^2}(41 - 38i)$	1M	Rationalisation
$Re(\frac{1}{z}) = \frac{41}{41^2 + 38^2}$	1A	
$= \frac{41}{3125}$ (= 0.013)		
$Re(z + \frac{1}{z}) = 41 + \frac{41}{3125}$	1M	$Re(z + \frac{1}{z}) = Re(z) + Re(\frac{1}{z})$
$\doteqdot 41.013$		This step may be omitted if correct answer is directly given.
= 41 (correct to the nearest integer)	1A	
	6	

SOLUTIONS	MARKS	REMARKS
4. $\left\|2\|x\| - 1\right\| \leqslant 2$		
$-2 \leqslant 2\|x\| - 1 \leqslant 2$	1A+1A	
$-1 \leqslant 2\|x\| \leqslant 3$		
$-\frac{1}{2} \leqslant \|x\| \leqslant \frac{3}{2}$ (or $\|x\| \leqslant \frac{3}{2}$)	1A	
$\therefore -\frac{3}{2} \leqslant x \leqslant \frac{3}{2}$	1A+1A	-1 if strict inequality ' < ' given in any line
	5	
<u>Alternatively</u>		
(i) Let $2\|x\| - 1 \geqslant 0$, then $\|x\| \geqslant \frac{1}{2}$		
i.e. $x \geqslant \frac{1}{2}$ or $x \leqslant -\frac{1}{2}$		
$\left\|2\|x\| - 1\right\| \leqslant 2 \implies 2\|x\| - 1 \leqslant 2$		
$\implies \|x\| \leqslant \frac{3}{2}$		
$\implies -\frac{3}{2} \leqslant x \leqslant \frac{3}{2}$	1A	
Combining with the assumption,		
$\frac{1}{2} \leqslant x \leqslant \frac{3}{2}$ or $-\frac{3}{2} \leqslant x \leqslant -\frac{1}{2}$.	1A	
(ii) Let $2\|x\| - 1 < 0$, then $\|x\| < \frac{1}{2}$		
i.e. $-\frac{1}{2} < x < \frac{1}{2}$.		
$\left\|2\|x\| - 1\right\| \leqslant 2 \implies 1 - 2\|x\| \leqslant 2$		
$\implies -\frac{1}{2} \leqslant \|x\|$		
This is true for all x .	1A	
$\therefore -\frac{1}{2} < x < \frac{1}{2}$.	1A	
Combining (i) and (ii),		
$-\frac{3}{2} \leqslant x \leqslant \frac{3}{2}$	1A	

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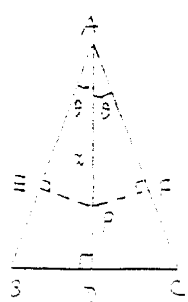
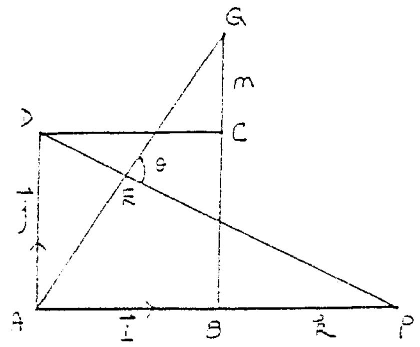
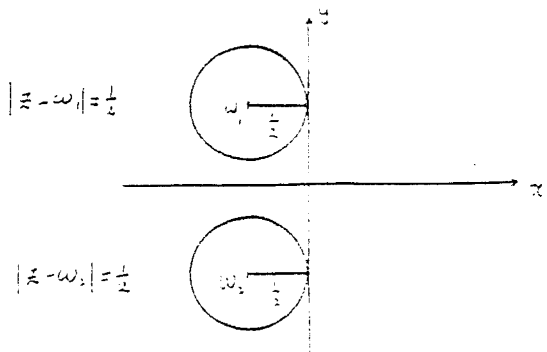
SOLUTIONS	MARKS	REMARKS
5. (a) $(\alpha-\beta)^2 = (\alpha+\beta)^2 - 4\alpha\beta$	1A	**Alternatively:**
$= 2^2 + 4(m^2 - m + 1)$ (sub $\alpha+\beta$, $\alpha\beta$) $\longrightarrow$	1M+1M	$D = 4 + 4(m^2 - m + 1)$
$= 4(m^2 - m + 2)$		$= 4(m^2 - m + 2)$.........1A
$= 4[(m - \frac{1}{2})^2 + \frac{7}{4}]$ completing square $\rightarrow$	1M+1A	> 0 because the
> 0 $(\forall m \in \mathbb{R})$		discriminant of $4(m^2-m+2) = 0$
		is negative and 1M
		coeff. of m^2 is positive..1M
		$\therefore \alpha, \beta$ are real & distinct...1M
		Hence $(\alpha-\beta)^2 > 0$.....1A
(b) Since $(\alpha-\beta)^2$ is real, $\lvert\alpha-\beta\rvert = \sqrt{(\alpha-\beta)^2}$		
Minimum value of $\lvert\alpha-\beta\rvert$		
is $\sqrt{7}$.	1M+1A	1M for $(m - \frac{1}{2})^2 = 0$
	7	
		Alternatively:
6. Let $AP = x$. Since $AB = AC$,		Let $PD = x$.
$AD \perp BC$ and $\angle BAD = \angle CAD = \theta$	1	$AD \perp BC$, $\angle BAD = \angle CAD = \theta$
$PE = PF = x\sin\theta$.	1A	$PE = PF = (h - x)\sin\theta$
Product of distances $p = x^2\sin^2\theta\,(h - x)$	1M	$p = x(h - x)^2\sin^2\theta$
$\frac{dp}{dx} = \sin^2\theta\,(2xh - 3x^2)$		$\frac{dp}{dx} = (h^2-4hx+3x^2)\sin^2\theta$
$= x\sin^2\theta\,(2h - 3x)$		$= (h-3x)(h-x)\sin^2\theta = 0$
$\frac{dp}{dx} = 0 \iff x = 0$ or $\frac{2}{3}h$	1M+1A	$\frac{dp}{dx} = 0 \Rightarrow x = h$ or $\frac{1}{3}h$
At $x = \frac{2}{3}h$, $\frac{dp}{dx}$ changes sign from +ve to -ve.	1A	Max. at $x = \frac{1}{3}h$
$\therefore p$ is a maximum at $x = \frac{2}{3}h$.		(working necessary)
	6	



SOLUTIONS	MARKS	REMARKS
7. (a) $\overrightarrow{BQ} = (1+m)\vec{j}$		
$\overrightarrow{AQ} = \overrightarrow{AB} + \overrightarrow{BQ} = \vec{i} + (1+m)\vec{j}$		
$\overrightarrow{AP} = (1+k)\vec{i}$		
$\overrightarrow{DP} = \overrightarrow{DA} + \overrightarrow{AP} = (1+k)\vec{i} - \vec{j}$	2A+1A	
$\overrightarrow{AQ} \cdot \overrightarrow{DP} = (1+k) - (1+m)$	1M	
$= k - m$	1A	
But $\overrightarrow{AQ} \cdot \overrightarrow{DP} = \lvert\overrightarrow{AQ}\rvert\lvert\overrightarrow{DP}\rvert \cos\theta$	1	
$= \sqrt{m^2+2m+2}\sqrt{k^2+2k+2}\cos\theta$	1M	
$k - m = \sqrt{(m^2+2m+2)(k^2+2k+2)}\cos\theta$		
$\Rightarrow \cos\theta = \dfrac{k-m}{\sqrt{(m^2+2m+2)(k^2+2k+2)}}$	1A	
	8	
(b) (i) $\overrightarrow{AE} = \frac{1}{5}(\overrightarrow{AP} + 4\overrightarrow{AD})$	1	
$= \frac{1+k}{5}\vec{i} + \frac{4}{5}\vec{j}$	1A	
(ii) $\overrightarrow{AE} = r\overrightarrow{AQ}$	1	
$= r(\vec{i} + (1+m)\vec{j})$		
$= r\vec{i} + r(1+m)\vec{j}$	1A	
(iii) If $\theta = 90°$, $\cos\theta = 0$	1A	
$\therefore k = m$	1A	
Equating $\overrightarrow{AE}$ in (b)(i) and (ii),	1M	
$\frac{1+k}{5} = r$, $\frac{4}{5} = r(1+m)$.	1A	
From 1st equation $1+k = 5r$		Attempt to solve............1M
From 2nd equation $\frac{4}{5r} = 1+m = 1+k$		$r = \frac{2}{5}$ 1A
$5r = \frac{4}{5r}$	1M+1A + 1A+1A	$k = 1$ 1A
$r^2 = \frac{4}{25}$		$m = 1$ 1A
$r = \frac{2}{5}$ (−ve root rejected)		−1 for not rejecting negative roots
$m = k = 1$		
	12	



SOLUTIONS	MARKS	REMARKS
8. (a) $f(\frac{1}{2}) = 5(\frac{1}{2})^2 + b(\frac{1}{2}) + c$		
$\therefore \frac{5}{4} + \frac{b}{2} + c < 0$	1A	
Consider $5x^2 + bx + c = 0$		
Discriminant $= b^2 - 20c$	1A	
$> b^2 + 20(\frac{5}{4} + \frac{b}{2})$	1M	(sub. c)
$= b^2 + 10b + 25$		
$= (b+5)^2$	1M	
Thus the discriminant is always positive		
$\therefore f(x) = 0$ has two distinct real roots.	1A	
	6	
(b) (i) $f(x) = 5x^2 + bx + c$		The omission of the factor 5 will not be penalised again.
$= 5(x-\alpha)(x-\beta)$	2A	
Since $f(\frac{1}{2}) < 0$		
$(\frac{1}{2}-\alpha)(\frac{1}{2}-\beta) < 0$	1M	
$\therefore$ either $\beta < \frac{1}{2} < \alpha$ or $\alpha < \frac{1}{2} < \beta$	1A	Accept "≤"
Since $\alpha < \beta$,		
$\alpha < \frac{1}{2} < \beta$	1A	Explanation necessary
Further $\alpha\beta = \frac{c}{5}$	1	
$\therefore \alpha\beta > 0$ ~~(c > 0)~~	1A	
and $\alpha > 0$ as $\beta > 0$	1A	
$\therefore 0 < \alpha < \frac{1}{2} < \beta$		
	8	
(b) (ii) $\lvert\alpha - \frac{1}{2}\rvert = \lvert\beta - \frac{1}{2}\rvert$		
$\Rightarrow \frac{1}{2} - \alpha = \beta - \frac{1}{2}$	1A	
$\Rightarrow \alpha + \beta = 1$	1A	
$\therefore b = -5(\alpha+\beta)$	1M	
$= -5$	1A	
$\frac{5}{4} + \frac{b}{2} + c < 0 \Rightarrow c < \frac{5}{4}$	1M	
$\therefore 0 < c < \frac{5}{4}$	1A	
	6	

SOLUTION	MARKS	REMARKS
9. (a) (i) $w^3 = 1$	1	
$\Rightarrow w^3 - 1 = 0$		
$\Rightarrow (w-1)(w^2+w+1) = 0$	1A	
$\Rightarrow w^2 + w + 1 = 0$ since $w \neq 1$	1A	must mention $w \neq 1$
(ii) $(w^2)^{3k+1} + w^{3k+1} + 1$		
$= (w^3)^{2k} \cdot w^2 + (w^3)^k w + 1$	1M	Factorise powers of w^3
$= w^2 + w + 1 = 0$	1A	
$(w^2)^{3k+2} + w^{3k+2} + 1$		
$= (w^3)^{2k} \cdot w^4 + w^{3k} w^2 + 1$		
$= w^4 + w^2 + 1$		
$= w^2 + w + 1 = 0$	1A	
	6	
(b) $\lvert 1 - w\bar{z} \rvert^2 = (1 - w\bar{z})\overline{(1 - w\bar{z})}$	1	
$= (1 - w\bar{z})(1 - \bar{w}z)$		
$= 1 - w\bar{z} - \bar{w}z + w\bar{w}z\bar{z}$		
$= 1 - w\bar{z} - \bar{w}z + z\bar{z}$	1A	
$\lvert z - w \rvert^2 = (z - w)\overline{(z - w)}$	1	
$= (z - w)(\bar{z} - \bar{w})$		
$= z\bar{z} - z\bar{w} - \bar{z}w + w\bar{w}$		
$= z\bar{z} - z\bar{w} - \bar{z}w + 1$	1A	
$\therefore \lvert 1 - w\bar{z} \rvert = \lvert z - w \rvert$	1A	
	5	
(c) $\lvert 1 - w\bar{z} \rvert = c$		
$\Leftrightarrow \lvert z - w \rvert = c$	2	
which is a circle with	1A	
centre w and radius c	1A	
Let $w_1 = -\frac{1}{2} + \frac{\sqrt{3}}{2}i$ $(= \text{cis}\ \frac{2}{3}\pi)$	1A	
$w_2 = -\frac{1}{2} - \frac{\sqrt{3}}{2}i$ $(= \text{cis}\ -\frac{3}{2}\pi)$	1A	
	3	Deduct 1 mark for ommision of each of the following features: (i) 2 circles in appropriate quadrants (ii) radius = $\frac{1}{2}$ (iii) touching y-axis (iv) not cutting x-axis note (iii) $\Rightarrow$ (ii)
	9	

(b) **Alternative 1:**

Let $z = x + iy$, $\quad w = -\frac{1}{2} + \frac{\sqrt{3}}{2} i$

$$w\bar{z} = \left(-\frac{1}{2} + \frac{\sqrt{3}}{2} i\right)(x - iy)$$

$$= \left(-\frac{x}{2} + \frac{\sqrt{3}y}{2}\right) + \left(\frac{y}{2} + \frac{\sqrt{3}x}{2}\right)i \quad \ldots\ldots\ldots\ldots 1A$$

$$|1 - w\bar{z}|^2 = \left(1 + \frac{x}{2} - \frac{\sqrt{3}y}{2}\right)^2 + \left(\frac{y}{2} + \frac{\sqrt{3}x}{2}\right)^2$$

$$= 1 + \frac{x^2}{4} + \frac{3y^2}{4} + x - \sqrt{3}y - \frac{\sqrt{3}xy}{2} + \frac{y^2}{4} + \frac{3x^2}{4} + \frac{\sqrt{3}xy}{2}$$

$$= x^2 + y^2 + x - \sqrt{3}y + 1 \quad \ldots\ldots\ldots\ldots 1A$$

$$|z - w|^2 = \left(x^2 + x + \frac{1}{4}\right) + \left(y^2 - \sqrt{3}y + \frac{3}{4}\right)$$

$$= x^2 + y^2 + x - \sqrt{3}y + 1 \quad \ldots\ldots\ldots\ldots 1A$$

$$\therefore \; |1 - w\bar{z}| = |z - w| \quad \ldots\ldots\ldots\ldots 1A$$

Let $w = -\frac{1}{2} - \frac{\sqrt{3}}{2} i$,

$|1 - w\bar{z}|^2 =$ etc.

Answer 1A

Alternative 2:

Let $z = r\,\text{cis}\,\theta$

$w = \text{cis}\,\phi$

$$|1 - w\bar{z}|^2 = 1 + |w\bar{z}|^2 - 2|w\bar{z}|\cos(\phi - \theta) \quad \ldots\ldots\ldots\ldots 1A$$

$$= 1 + |z|^2 - 2|z|\cos(\phi - \theta) \quad \ldots\ldots\ldots\ldots 1A$$

$$|w - z|^2 = |w|^2 + |z|^2 - 2|w||\bar{z}|\cos(\phi - \theta) \quad \ldots\ldots\ldots\ldots 1A$$

$$= 1 + |z|^2 - 2|z|\cos(\phi - \theta) \quad \ldots\ldots\ldots\ldots 1A$$

$$\therefore \; |1 - w\bar{z}| = |w - z| \quad \ldots\ldots\ldots\ldots 1A$$

Alternative 3:

$$|1 - w\bar{z}| = \left|w\left(\frac{1}{w} - \bar{z}\right)\right| \quad \ldots\ldots\ldots\ldots 1A$$

$$= \left|\frac{1}{w} - \bar{z}\right| \quad (\because |w| = 1) \quad \ldots\ldots\ldots\ldots 1A$$

$$= |\bar{w} - \bar{z}| \quad \ldots\ldots\ldots\ldots 1A$$

$$= |w - z| \quad \ldots\ldots\ldots\ldots 1A$$

$$= |z - w| \quad \ldots\ldots\ldots\ldots 1A$$

Alternative 4:

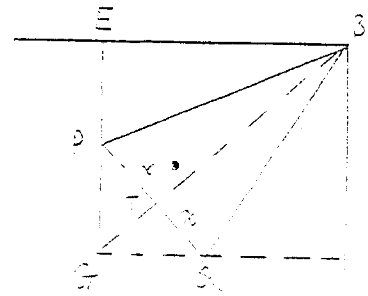
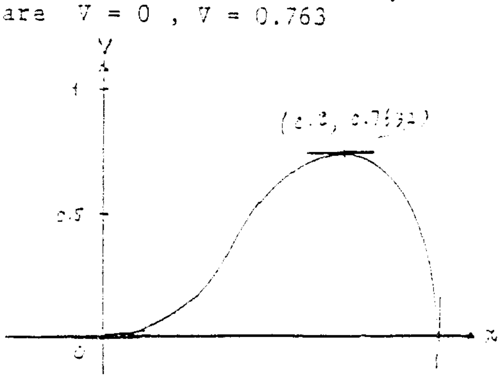
$$|1 - w\bar{z}| = |w\bar{w} - w\bar{z}| \quad \ldots\ldots\ldots\ldots 1A$$

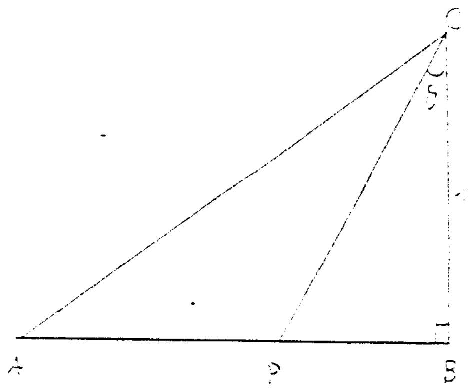
$$= |w||\bar{w} - \bar{z}| \quad \ldots\ldots\ldots\ldots 1M$$

$$= |\bar{w} - \bar{z}| \quad \ldots\ldots\ldots\ldots 1M$$

$$= |w - z| \quad \ldots\ldots\ldots\ldots 1A$$

$$= |z - w| \quad \ldots\ldots\ldots\ldots 1A$$

SOLUTIONS	MARKS	REMARKS
10. (a) Let G be the centre of the two squares and BG bisects PQ at T		Alternatively:
$BG = \frac{1}{2}\sqrt{AB^2 - BC^2}$	1	$PG = \frac{1}{2}(4x^2 + 4x^2)^{\frac{1}{2}}$
$= \frac{1}{2}\sqrt{8+8}$		$= x\sqrt{2}$ 1A
$= 2$	1A	$PE = \sqrt{2}(1-x)$.........1A
$\therefore BT = 2 - x$	1A	$BP = \sqrt{BE^2 + PE^2}$
		$= \sqrt{4 - 4x - 2x^2}$ 1A
The height of the pyramid		Height $= \sqrt{BP^2 - PG^2}$....2
$= \sqrt{BT^2 - TG^2}$	2	$= \sqrt{4 - 4x + 2x^2 - 2x^2}$..1A
$= \sqrt{(2-x)^2 - x^2}$	1A	$= 2\sqrt{1-x}$
$= 2\sqrt{1-x}$ metres		
Volume $= \frac{1}{3}$ base area X height		
$V = \frac{1}{3} \times (2x)^2 \times 2\sqrt{1-x}$	1M	
$= \frac{8}{3}x^2\sqrt{1-x}$	1A	
	8	
(b) $\frac{dV}{dx} = \frac{8}{3}\left(2x\sqrt{1-x} - \frac{x^2}{2\sqrt{1-x}}\right)$	1M	
$= \frac{4x(4-5x)}{3\sqrt{1-x}}$	1A	Follow if constant factor of V incorrect.
$\frac{dV}{dx} = 0$ iff $x = 0$ or $\frac{4}{5}$	1A	
$\therefore$ the stationary points are $(0, 0)$, $\left(\frac{4}{5}, \frac{128}{75\sqrt{5}}\right)$	1A	Accept (0.8, 0.763)
At $x = 1$, $V = 0$, and the slope is infinite	1A	
$\therefore$ Equation of tangent at $x = 1$ is $x - 1 = 0$	1A	
Equations of tangent at stationary points are $V = 0$, $V = 0.763$	1A+1A	
Graph of V(x) 	4	1 mark for slope at (0, 0), 1 mark for slope at (1, 0), 1 mark for range, 1 mark for maximum with coordinates labelled.
	12	

SOLUTIONS	MARKS	REMARKS
11. (a) $CP = h \sec\theta$ $\left(\frac{h}{\cos\theta}\right)$	1A	
$PB = h\tan\theta$		
$AP = 50 - h\tan\theta$	1A	
$N = 2h\sec\theta + (50 - h\tan\theta)$ $N = 2CP + AP$	1M+1A	
	4	
(b) If $h = 50$, $N = 100\sec\theta + 50 - 50\tan\theta$		
$\frac{dN}{d\theta} = 2h\sec\theta\tan\theta - h\sec^2\theta$	1A	
$= 100\sec\theta\tan\theta - 50\sec^2\theta$		
$\frac{dN}{d\theta} = 0 \Rightarrow 50\sec\theta(2\tan\theta - \sec\theta) = 0$	1M	
$\Rightarrow 2\tan\theta - \sec\theta = 0$		
$\Rightarrow \sin\theta = \frac{1}{2}$	1A	
$\Rightarrow \theta = \frac{\pi}{6}$ $(30°)$	1A	
$\frac{d^2N}{d\theta^2} = 100(\sec^3\theta + \sec\theta\tan^2\theta - \sec^2\theta\tan\theta)$	1M	Compulsory, however, follow if omitted or wrong
$= \frac{200}{\sqrt{3}} > 0$ at $\theta = \frac{\pi}{6}$	1A	
$\therefore N$ is least at $\theta = \frac{\pi}{6}$. The least transportation cost from C to A is		
$\$\left(100 \times \frac{2}{\sqrt{3}} + 50 - 50 \times \frac{1}{\sqrt{3}}\right)$		
$= \$\,50\left(\frac{3+\sqrt{3}}{\sqrt{3}}\right) = \$\,50(\sqrt{3}+1)$	1A	
	7	
(c) (i) As $(0 \leq)\ \theta \leq \angle ACB$	1	$AP = 50 - h\tan\theta \geq 0$ 1M
$\tan\theta \leq \tan\angle ACB$	1A	$\tan\theta \leq \frac{50}{h}$ 1A
$= \frac{50}{h}$		
For $h > 50\sqrt{3}$, $\tan\theta < \frac{1}{\sqrt{3}}$	1A	
$\therefore \theta < \frac{\pi}{6}$	1A	
Hence $\frac{dN}{d\theta} = h\sec\theta(2\tan\theta - \sec\theta)$		
$= \frac{h}{\cos^2\theta}(2\sin\theta - 1)$	1A	
< 0 as $\sin\theta < \frac{1}{2}$	1A	
(ii) If $h = 200$		
then $h > 50\sqrt{3}$	1A	
$\therefore \frac{dN}{d\theta} < 0$	1	
$\therefore N$ decreases as θ increases. Goods should be transported directly from C to A by truck for minimum cost.	1A	
	9	