Core 4 - June 2013

(1) a) $\dfrac{5-8x}{(2+x)(1-3x)} = \dfrac{A}{2+x} + \dfrac{B}{1-3x}$

$\rightarrow \quad 5 - 8x = A(1-3x) + B(2+x)$

Let $x = 1/3$: $\quad 5 - 8/3 = B(2 + 1/3)$

$\rightarrow \quad 7/3 = B(7/3) \rightarrow B = 1$

Let $x = -2$: $\quad 5 - 8(-2) = A(1 - 3(-2))$

$\rightarrow \quad 21 = A(7) \rightarrow A = 3$

$\rightarrow \quad \dfrac{3}{2+x} + \dfrac{1}{1-3x}$

ii) $\displaystyle\int_{-1}^{0} \frac{3}{2+x} + \frac{1}{1-3x} = \left[3\ln(2+x) - \tfrac{1}{3}\ln(1-3x)\right]_{-1}^{0}$

$= \left[3\ln(2) - \tfrac{1}{3}\ln(1)\right] - \left[3\ln(1) - \tfrac{1}{3}\ln(4)\right]$

$= 3\ln(2) + \tfrac{1}{3}\ln(4)$

$= 3\ln(2) + \tfrac{1}{3}\ln(2^2)$

$= 3\ln(2) + \tfrac{2}{3}\ln(2)$

$= 11/3 \ln(2)$

b) i) $6x^2 \div 3x^2 = 2 \rightarrow c = 2$

ii) Area $= \displaystyle\int_{-1}^{0} 2 + \frac{5-8x}{2-5x-3x^2}$

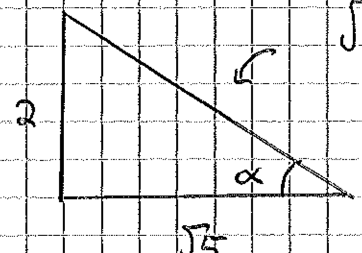
$= \displaystyle\int_{-1}^{0} 2 + \int_{-1}^{0} \frac{5-8x}{(2+x)(1-3x)}$

$= \left[2x\right]_{-1}^{0} + 11/3 \ln(2)$

$= -(-2) + 11/3\ln(2)$

$= 2 + 11/3 \ln(2)$

(2) a) i)



$\sqrt{2^2 + (\sqrt{5})^2} = \sqrt{9} = 3$

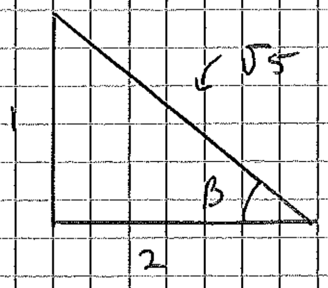
$\rightarrow \sin\alpha = 2/3$

$\rightarrow \cos\alpha = \sqrt{5}/3$

ii) $\sin 2\alpha = 2\sin\alpha\cos\alpha$

$= 2\left(\frac{2}{3}\right)\left(\frac{\sqrt{5}}{3}\right) = \frac{4}{9}\sqrt{5}$

b)



$\sin\beta = \frac{1}{\sqrt{5}}$

$\cos\beta = \frac{2}{\sqrt{5}}$

$\cos(\alpha - \beta) = \cos\alpha\cos\beta + \sin\alpha\sin\beta$

$= \left(\frac{\sqrt{5}}{3}\right)\left(\frac{2}{\sqrt{5}}\right) + \left(\frac{2}{3}\right)\left(\frac{1}{\sqrt{5}}\right)$

$= \frac{2\sqrt{5}}{3\sqrt{5}} + \frac{2}{3\sqrt{5}}$ ↙ rationalise denominator

$= \frac{2}{3} + \frac{2\sqrt{5}}{15}$

$= \frac{2}{15}\left(5 + \sqrt{5}\right)$

(3) a) $(1+6x)^{-1/3} = 1 + \left(-\frac{1}{3}\right)(6x) + \frac{\left(-\frac{1}{3}\right)\left(-\frac{4}{3}\right)}{2!}(6x)^2$

$= 1 - 2x + 8x^2$

b) i) $(27+6x)^{-1/3}$

$= 27^{-1/3}\left(1 + \frac{6}{27}x\right)^{-1/3}$

$= \frac{1}{3}\left[1 - \frac{2}{27}x + \frac{8}{27^2}x^2\right]$

$= \frac{1}{3}\left[1 - \frac{2}{27}x + \frac{8}{729}x^2\right]$

$= \frac{1}{3} - \frac{2}{81}x + \frac{8}{2187}x^2$

ii) $\frac{2}{\sqrt[3]{28}} = 2\,[28]^{-1/3} = 2\,[27+1]^{-1/3}$

Let $x = \frac{1}{6} \rightarrow 2\left[27 + 6\left(\frac{1}{6}\right)\right]^{-1/3}$

$= 2\left[\frac{1}{3} - \frac{2}{81}\left(\frac{1}{6}\right) + \frac{8}{2187}\left(\frac{1}{6}\right)^2\right]$

$= 0.658639\ldots$ (6dp)

(4) a) $\frac{dx}{dt} = -16e^{-2t}$ $\frac{dy}{dt} = 4e^{2t}$

$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx} =$ ~~$-16e^{-2t} \times 4e^{2t}$~~

$4e^{2t} \times \frac{1}{-16e^{-2t}}$

$= -\frac{1}{4}e^{4t}$

b) i) $t = \ln(2) \rightarrow dy/dx = -\frac{1}{4} e^{4(\ln 2)}$

$= -\frac{1}{4} e^{\ln(16)} = -\frac{1}{4} \times 16 = -4$

ii) $x = 8e^{-2(\ln 2)} - 4 = 8e^{\ln \frac{1}{4}} - 4 = 2 - 4 = -2$

$y = 2e^{2(\ln 2)} + 4 = 2e^{\ln(4)} + 4 = 8 + 4 = 12$

$\therefore$ co-ordinates are $(-2, 12)$

iii) Gradient of normal $= \frac{1}{4}$

$x_1 = -2$ Equation: $y - 12 = \frac{1}{4}(x + 2)$

$y_1 = 12$ crosses x-axis when $y = 0$

$\rightarrow -12 = \frac{1}{4}(x + 2)$

$\rightarrow -48 = x + 2$

$\rightarrow x = -50$ $(-50, 0)$

c) $xy = (8e^{-2t} - 4)(2e^{2t} + 4)$

$= 16 + 32e^{-2t} - 8e^{2t} - 16 = 32e^{-2t} - 8e^{2t}$

$4y = 4(2e^{2t} + 4) = 8e^{2t} + 16$

$-4x = -4(8e^{-2t} - 4) = -32e^{-2t} + 16$

$\therefore xy + 4y - 4x = 32$

(5) a) Need $2x + 3 = 0 \rightarrow x = -\frac{3}{2}$

$f(-3/2) = 4(-3/2)^3 - 11(-3/2) - 3$

$= 4(-27/8) + 33/2 - 3 = 0$

$\therefore (2x + 3)$ is a factor

b)

$$\begin{array}{r l} & 2x^2 - 3x + 1 \\ 2x + 3 & \overline{)\, 4x^3 + 0x^2 - 11x - 3} \\ & 4x^3 + 6x^2 \\ & \quad -6x^2 - 9x \\ & \quad\quad -2x - 3 \end{array}$$

Algebraic Long Division

$\rightarrow (2x + 3)(2x^2 - 3x + 1)$

c) i) $2\cos(2\theta)\sin\theta + 9\sin\theta + 3 = 0$

$= 2(1-2\sin^2\theta)\sin\theta + 9\sin\theta + 3 = 0$

$= 2\sin\theta - 4\sin^3\theta + 9\sin\theta + 3 = 0$

$\rightarrow 4\sin^3\theta - 11\sin\theta - 3 = 0$

$\rightarrow 4x^3 - 11x - 3 = 0$ $[x = \sin\theta]$

ii) $(2x+3)(2x^2-3x-1) = 0$

$x = -3/2$

$\sin\theta = -3/2$

NO SOLUTIONS

$2x^2 - 3x - 1 = 0$

Formula: $x = \frac{3 \pm \sqrt{9 - 4 \times 2 \times -1}}{4}$

$\rightarrow x = \frac{3 \pm \sqrt{17}}{4}$

$x = 1.780...$ or $x = -0.2807...$

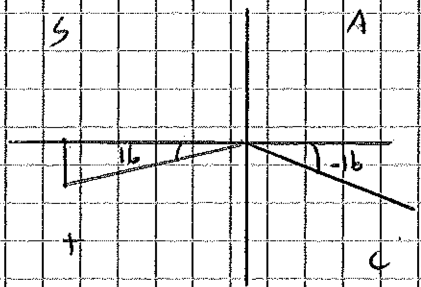
$\sin\theta = 1.780$

$\rightarrow$ NO SOLUTIONS

$\sin\theta = -0.2807...$

$\theta = \sin^{-1}(-0.2807)$

$= -16.3^{\circ}$



$\theta = 344^{\circ}$

and

196°

(6) a) $\begin{bmatrix} 3 \\ -2 \\ 4 \end{bmatrix} + \lambda \begin{bmatrix} 7 \\ -7 \\ 5 \end{bmatrix} = \begin{bmatrix} -4 \\ 5 \\ -1 \end{bmatrix} \rightarrow$ $3 + 7\lambda = -4$, $-2 - 7\lambda = 5$, $4 + 5\lambda = -1$

All satisfied by $\lambda = -1$

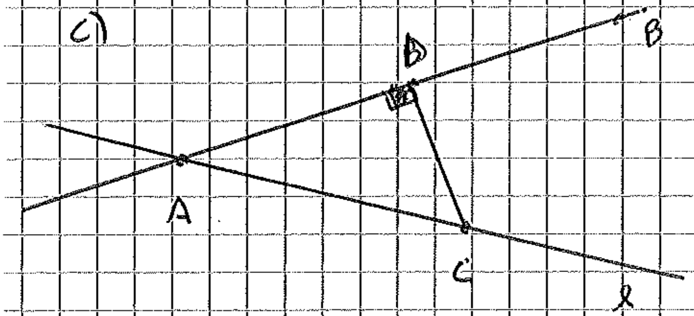
$\therefore$ C lies on line

b) $\vec{AB} = \vec{AO} + \vec{OB}$

$= \begin{bmatrix} -3 \\ 2 \\ -4 \end{bmatrix} + \begin{bmatrix} 1 \\ -5 \\ 6 \end{bmatrix} = \begin{bmatrix} -2 \\ -3 \\ 2 \end{bmatrix}$

$\therefore$ Equation $= \begin{bmatrix} 3 \\ -2 \\ 4 \end{bmatrix} + \mu \begin{bmatrix} -2 \\ -3 \\ 2 \end{bmatrix}$

c)



As D lies on AB, its co-ordinates must be:

$$\begin{pmatrix} 3 - 2\mu \\ -2 - 3\mu \\ 4 + 2\mu \end{pmatrix}$$

$$\vec{CD} = \vec{CO} + \vec{OD}$$

$$= \begin{bmatrix} 4 \\ -5 \\ 1 \end{bmatrix} + \begin{pmatrix} 3 - 2\mu \\ -2 - 3\mu \\ 4 + 2\mu \end{pmatrix} = \begin{bmatrix} 7 - 2\mu \\ -7 - 3\mu \\ 5 + 2\mu \end{bmatrix}$$

As $90°$, $\vec{CD} \cdot \vec{AB} = 0$

$$\rightarrow \begin{pmatrix} 7 - 2\mu \\ -7 - 3\mu \\ 5 + 2\mu \end{pmatrix} \cdot \begin{pmatrix} -2 \\ -3 \\ 2 \end{pmatrix} = 0$$

$$\rightarrow -14 + 4\mu + 21 + 9\mu + 10 + 4\mu = 0$$

$$\rightarrow 17\mu + 17 = 0 \rightarrow \mu = -1$$

∴ co-ordinates of D are:

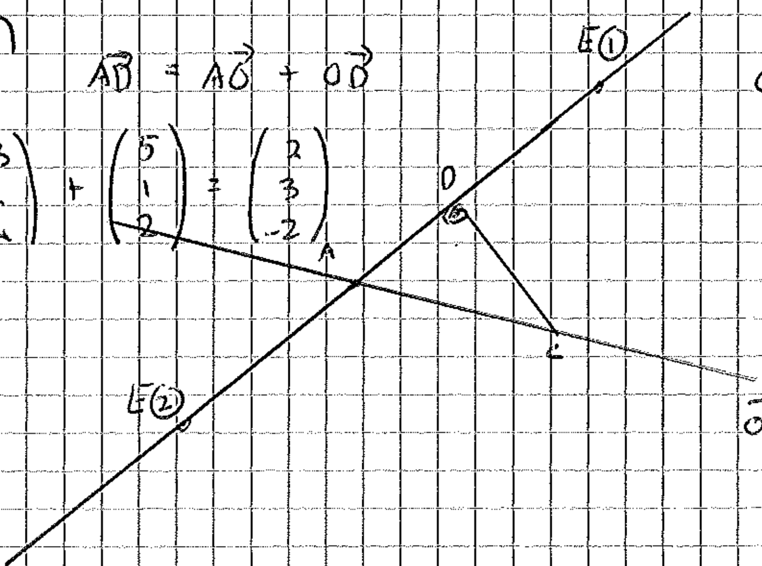
$$3 - 2(-1) = 5$$
$$-2 - 3(-1) = 1$$
$$4 + 2(-1) = 2$$

$\rightarrow (5, 1, 2)$

d)

$$\vec{AD} = \vec{AO} + \vec{OD}$$

$$= \begin{pmatrix} -3 \\ 2 \\ -4 \end{pmatrix} + \begin{pmatrix} 5 \\ 1 \\ 2 \end{pmatrix} = \begin{pmatrix} 2 \\ 3 \\ -2 \end{pmatrix}$$



$$\vec{OE_1} = \vec{OA} + 3\vec{AD}$$

$$= \begin{pmatrix} 3 \\ -2 \\ 4 \end{pmatrix} + 3\begin{pmatrix} 2 \\ 3 \\ -2 \end{pmatrix} = \begin{pmatrix} 9 \\ 7 \\ -2 \end{pmatrix}$$

$$\vec{OE_2} = \vec{OA} - 3\vec{AD}$$

$$\begin{pmatrix} 3 \\ -2 \\ 4 \end{pmatrix} - 3\begin{pmatrix} 2 \\ 3 \\ -2 \end{pmatrix} = \begin{pmatrix} -3 \\ -11 \\ 10 \end{pmatrix}$$

∴ Possible co-ordinates of E

$= (9, -7, -2)$ or $(-3, -11, 10)$

(7) Max value = 1.3 $\rightarrow$ $a = 1.3$

cos repeats every 2π, $\therefore$ k must be $2\pi/12$

$\rightarrow$ $dh/dt = 1.3 \cos(2\pi/12 \; t)$

(8) a) $\int t \cos(\pi/4 \; t) \, dt$

Integration by parts $u = t$ $dv/dt = \cos(\pi/4 \; t)$

$du/dt = 1$ $v = 4/\pi \sin(\pi/4 \; t)$

$\rightarrow uv - \int v \, du/dt$

$\rightarrow t \; 4/\pi \sin(\pi/4 \; t) - \int 4/\pi \sin(\pi/4 \; t)$

$\rightarrow t \; 4/\pi \sin(\pi/4 \; t) + 4/\pi \times 4/\pi \cos(\pi/4 \; t)$

$\rightarrow t \; 4/\pi \sin(\pi/4 \; t) + 16/\pi^2 \cos(\pi/4 \; t)$

b) $\frac{dx}{dt} = \frac{t \cos(\pi/4 \; t)}{32x}$

$\int 32x \, dx = \int t \cos(\pi/4 \; t) \, dt$

$16x^2 = t \; 4/\pi \sin(\pi/4 \; t) + 16/\pi^2 \cos(\pi/4 \; t) + c$

when $t = 0$, $x = 4$

$\rightarrow 16(4^2) = 16/\pi^2 \cos(0) + c$

$\rightarrow 256 = 16/\pi^2 + c$

$\rightarrow c = 256 - 16/\pi^2$

when $t = 45$

$\rightarrow 16x^2 = 45 \times 4/\pi \sin(\pi/4 \times 45) + 16/\pi^2 \cos(\pi/4 \times 45)$
$+ 256 - 16/\pi^2$

$\rightarrow 16x^2 = 212.718...$

$\rightarrow x^2 = 13.294...$

$\rightarrow x = 3.646... \text{ m}$

$= 3.65 \text{ m}$ (nearest cm)