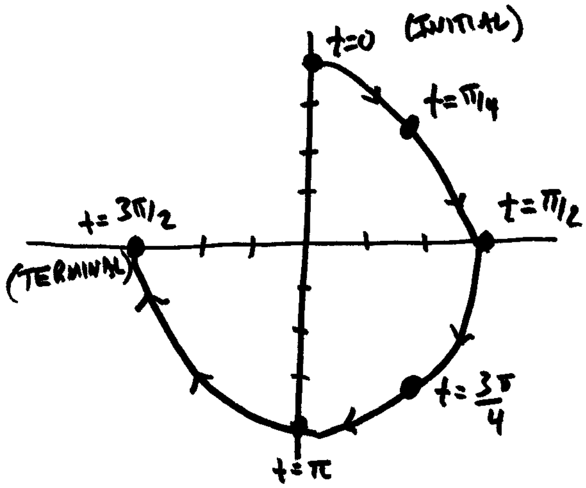
(1) CONSIDER $x = 3\sin t$, $y = 4\cos t$ FOR $0 \le t \le 3\pi/2$

(a) SKETCH



t	x	y
0	0	4
$\frac{\pi}{4}$	$\frac{3\sqrt{2}}{2}$	$\frac{4\sqrt{2}}{2}$
$\frac{\pi}{2}$	3	0
$\frac{3\pi}{4}$	$\frac{3\sqrt{2}}{2}$	$\frac{-4\sqrt{2}}{2}$
π	0	-4
$\frac{3\pi}{2}$	-3	0

(b) FIND EQUATION OF TANGENT LINE AT $t = \pi$

$$\frac{dy}{dx} = \frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{-4\sin t}{3\cos t} \quad ; \quad m = \left.\frac{dy}{dx}\right|_{t=\pi} = \frac{-4\sin\pi}{3\cos\pi} = \frac{-4(0)}{3(-1)} = 0$$

TANGENT AT $t = \pi$ (OR $x = 3\sin\pi = 0$, $y = 4\cos\pi = -4$) IS

$$y + 4 = 0(x - 0)$$

$$\boxed{y = -4}$$

(c) FIND LENGTH OF CURVE: $L = \int_a^b \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}\, dt$

$$\Rightarrow \int_0^{3\pi/2} \sqrt{(3\cos t)^2 + (-4\sin t)^2}\, dt$$

(2) LET $x=\sin(\pi t)$, $y=t^2+t$. FIND THE EQUATION OF THE TANGENT LINE(S) AT $(0,2)$

(i) POINT $(0,2)$ OCCURS WHEN $x=0, y=2$

$$x=0=\sin(\pi t), \quad t=0,1,2,3,4,\ldots, -1,-2,-3,\ldots$$

$$y=2=t^2+t \rightarrow 0=t^2+t-2$$

$$0=(t+2)(t-1), \quad t=-2,1$$

POINT $(0,2)$ OCCURS WHEN $t=-2,1$

(ii) FIND $\frac{dy}{dx}$:

$$\left.\frac{dy}{dx}\right| = \frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{2t+1}{\pi\cos(\pi t)}$$

(iii) FIND $\left.\frac{dy}{dx}\right|_{t=-2,1}$

$$\left.\frac{dy}{dx}\right|_{t=-2} = \frac{2(-2)+1}{\pi\cos(-2\pi)} = \frac{-3}{\pi} = -\frac{3}{\pi}$$

$$\left.\frac{dy}{dx}\right|_{t=1} = \frac{2(1)+1}{\pi\cos(\pi)} = \frac{3}{-\pi} = \frac{-3}{\pi}$$

(iii) TANGENT LINE(S)

$t=-2$: $\quad y-2=\frac{-3}{\pi}(x-0) \longrightarrow y=\frac{-3}{\pi}x+2$

$t=1$: $\quad y-2=-\frac{3}{\pi}(x-0) \longrightarrow y=\frac{-3}{\pi}x+2$

(3) FIND THE LENGTH OF THE PARAMETRIC CURVE

$$x = t\sin(t)$$
$$y = t\cos(t)$$
$$0 \le t \le 1$$

$$L = \int_a^b \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}\, dt$$

(i) $\frac{dx}{dt} = t\cos t + \sin t$ (ii) $\frac{dy}{dt} = -t\sin t + \cos t$

$$L = \int_0^1 \sqrt{(t\cos t + \sin t)^2 + (-t\sin t + \cos t)^2}\, dt$$

$$= \int_0^1 \sqrt{t^2\cos^2 t + 2t\cos t\sin t + \sin^2 t + t^2\sin^2 t - 2t\sin t\cos t + \cos^2 t}\, dt$$

$$= \int_0^1 \sqrt{t^2\cos^2 t + t^2\sin^2 t + \sin^2 t + \cos^2 t}\, dt$$

$$= \int_0^1 \sqrt{t^2 + 1}\, dt$$

TABLE OF INTEGRALS

$$= \frac{t}{2}\sqrt{t^2+1} + \frac{1}{2}\ln\left|t + \sqrt{t^2+1}\right| \Big|_{t=0}^{t=1}$$

$$= \left[\frac{1}{2}\sqrt{2} + \frac{1}{2}\ln\left|1+\sqrt{2}\right|\right] - \left[0\sqrt{1} + \frac{1}{2}\ln\left|0+\sqrt{1}\right|\right]$$

$$= \frac{1}{2}\sqrt{2} + \frac{1}{2}\ln\left|1+\sqrt{2}\right|$$

(4) FIND $\frac{d^2y}{dx^2}$ FOR THE PARAMETRIC CURVE

$$x = t^2 + 1$$
$$y = e^t - 1$$

(i) FIND $\frac{dy}{dx} = \frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{e^t}{2t}$

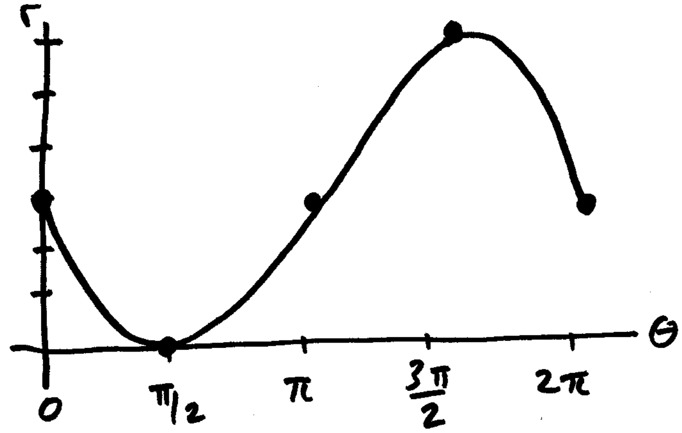
(ii) $$\frac{d^2y}{dx^2} = \frac{\frac{d}{dt}\left(\frac{dy}{dx}\right)}{\frac{dx}{dt}} = \frac{\frac{d}{dt}\left(\frac{e^t}{2t}\right)}{2t}$$

$$= \frac{\frac{(2t)(e^t) - e^t(2)}{(2t)^2}}{(2t)}$$

$$= \frac{2te^t - 2e^t}{(2t)^3}$$

(5) SKETCH $r = 3 - 3\sin\theta$

(i) $r = 3 - 3\sin\theta$ on $r\theta$ PLANE

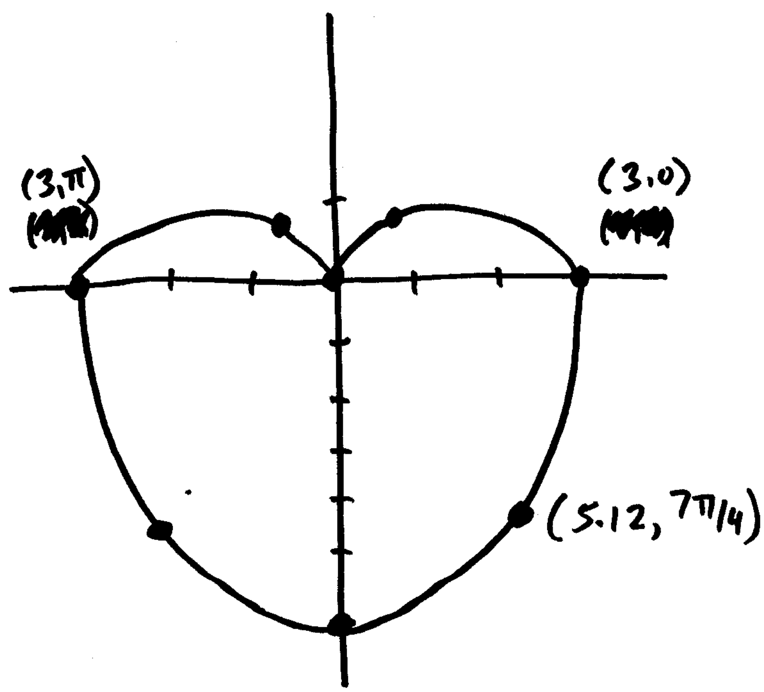


(ii) TABLE

θ	r
0	3
$\frac{\pi}{2}$	0
π	3
$\frac{3\pi}{2}$	6
2π	3

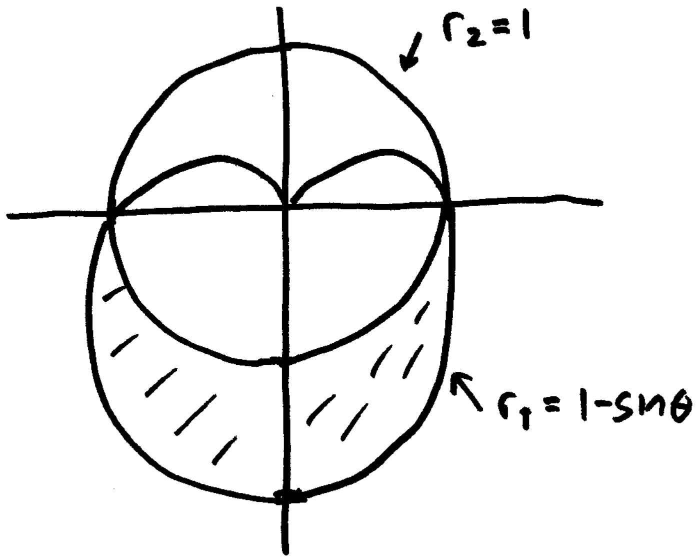
θ	r
$\frac{\pi}{4}$	$3-3\sin(\pi/4) \approx .88$
$\frac{3\pi}{4}$	$3-3\sin(3\pi/4) \approx .88$
$\frac{5\pi}{4}$	$3-3\sin(5\pi/4) \approx 5.12$
$\frac{7\pi}{4}$	$3-3\sin(\frac{7\pi}{4}) \approx 5.12$

(iii) SKETCH



(6) LET $r_1 = 1 - \sin\theta$, $r_2 = 1$

(a) SKETCH



(b) SET UP INTEGRAL TO FIND THE ARC LENGTH OF r_1 ON $0 \le \theta \le \pi/2$

$$L = \int_a^b \sqrt{r^2 + \left(\frac{dr}{d\theta}\right)^2}\, d\theta = \int_0^{\pi/2} \sqrt{(1-\sin\theta)^2 + (-\cos\theta)^2}\, d\theta$$

(c) SET UP INTEGRAL TO FIND AREA INSIDE r_1, OUTSIDE r_2.

$$\int_\pi^{2\pi} \frac{1}{2}(1-\sin\theta)^2 - \frac{1}{2}(1)^2\, d\theta = \frac{1}{2}\int_\pi^{2\pi} (1-\sin\theta)^2 - 1\, d\theta$$

$$= \frac{1}{2}\int_\pi^{2\pi} 1 - 2\sin\theta + \sin^2\theta - 1\, d\theta = \frac{1}{2}\int_\pi^{2\pi} \sin^2\theta - 2\sin\theta\, d\theta$$

$$= \frac{1}{2}\int_\pi^{2\pi} \frac{1}{2} - \frac{1}{2}\cos 2\theta - 2\sin\theta\, d\theta = \int_\pi^{2\pi} \frac{1}{4} - \frac{1}{4}\cos 2\theta - 1\sin\theta\, d\theta$$

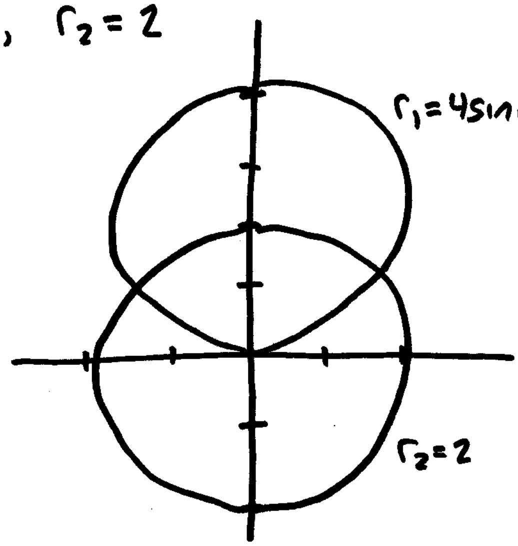
$$= \frac{1}{4}\theta - \frac{1}{8}\sin 2\theta + \cos\theta \Big|_{\theta=\pi}^{\theta=2\pi}$$

$$= \left[\frac{1}{4}(2\pi) - \frac{1}{8}\sin 4\pi + \cos 2\pi\right] - \left[\frac{1}{4}\pi - \frac{1}{8}\sin 2\pi + \cos\pi\right]$$

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

(7) LET $r_1 = 4\sin\theta$, $r_2 = 2$

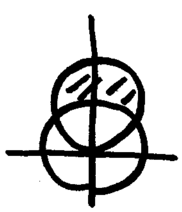
(a) SKETCH



(b) SET UP INTEGRAL TO FIND ARC LENGTH OF r_1, $0 \le \theta \le \pi/2$

$$L = \int_a^b \sqrt{r^2 + \left(\frac{dr}{d\theta}\right)^2}\, d\theta = \int_0^{\pi/2} \sqrt{(4\sin\theta)^2 + (4\cos\theta)^2}\, d\theta$$

(c) FIND THE AREA INSIDE r_1 AND OUTSIDE r_2



(i) FIND INTERSECTION BETWEEN r_1 AND r_2

$$4\sin\theta = 2$$

$$\Rightarrow \sin\theta = \tfrac{1}{2}$$

$$\Rightarrow \theta = \pi/6,\ 5\pi/6$$

(ii) SETUP

$$\int_{\pi/6}^{5\pi/6} \tfrac{1}{2}(4\sin\theta)^2 - \tfrac{1}{2}(2)^2 = \int_{\pi/6}^{5\pi/6} 8\sin^2\theta - 2\, d\theta = \int_{\pi/6}^{5\pi/6} 8\left(\tfrac{1}{2} - \tfrac{1}{2}\cos 2\theta\right) - 2\, d\theta$$

$$= \int_{\pi/6}^{5\pi/6} 4 - 4\cos 2\theta - 2\, d\theta = \int_{\pi/6}^{5\pi/6} 2 - 4\cos 2\theta\, d\theta$$

$$= 2\theta - 2\sin 2\theta \Big|_{\theta=\pi/6}^{\theta=5\pi/6} = \left[2(5\pi/6) - 2\sin\left(2\cdot 5\pi/6\right)\right] - \left[2(\pi/6) - 2\sin(2\cdot\pi/6)\right]$$

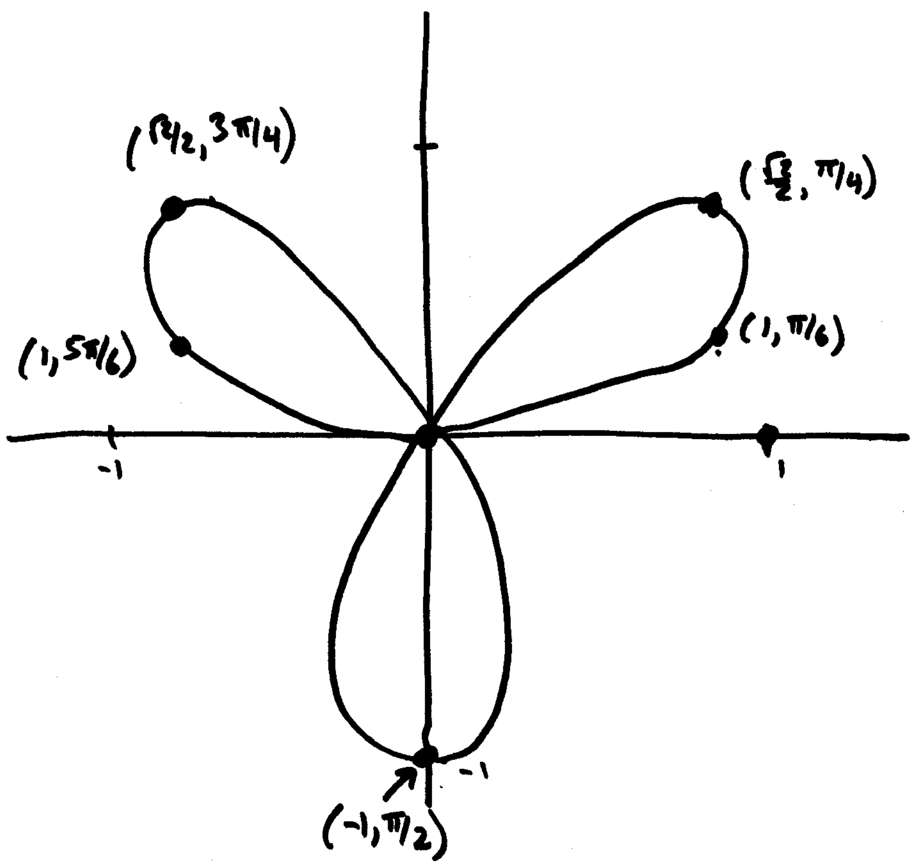
$$= \frac{10\pi}{6} - 2\cdot\left(-\sqrt{3}/2\right) - \frac{2\pi}{6} + 2\cdot\sqrt{3}/2 = \underline{\underline{\frac{4\pi}{3} + 2\sqrt{3}}}$$

(8) CONSIDER $r = \sin 3\theta$

(a) SKETCH

θ	r
0	0
$\pi/6$	1
$\pi/4$	$\sqrt{2}/2$
$\pi/3$	0
$\pi/2$	-1

θ	r
$2\pi/3$	0
$3\pi/4$	$\sqrt{2}/2$
$5\pi/6$	1
π	0
	POINTS REPEAT



(8b) EVALUATE SLOPE OF THE TANGENT LINE AT $\theta = \pi/6$

$$\frac{dy}{dx} = \frac{\frac{dr}{d\theta}\sin\theta + r\cos\theta}{\frac{dr}{d\theta}\cos\theta - r\sin\theta}$$

$$= \frac{(3\cos 3\theta)\sin\theta + \sin 3\theta \cos\theta}{(3\cos 3\theta)\cos\theta - \sin 3\theta \sin\theta}$$

$$\left.\frac{dy}{dx}\right|_{\theta=\pi/6} = \frac{3\cos(\pi/2)\sin(\pi/6) + \sin(\pi/2)\cos(\pi/6)}{3\cos(\pi/2)\cos(\pi/6) - \sin(\pi/2)\sin(\pi/6)}$$

$$= \frac{\sqrt{3}/2}{-1/2} = -\sqrt{3}$$

(8c) TANGENT LINE?

(i) SLOPE: $m = -\sqrt{3}$

(ii) POINT: $x = r\cos\theta = \sin 3\theta \cos\theta$, $x = \sin\pi/2 \cos\pi/6 = \sqrt{3}/2$

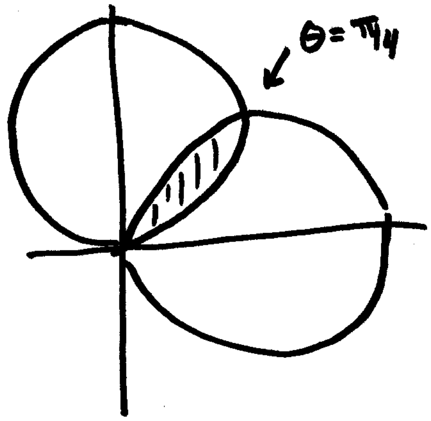
$y = r\sin\theta = \sin 3\theta \sin\theta$, $y = \sin\pi/2 \sin\pi/6 = 1/2$

$$y - \frac{1}{2} = -\sqrt{3}\,(x - \sqrt{3}/2)$$

$$y - \frac{1}{2} = -\sqrt{3}x + 3/2$$

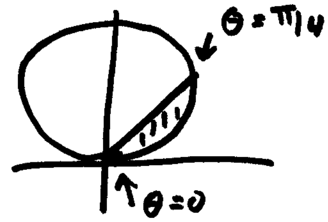
$$y = -\sqrt{3}x + 2$$

(9) FIND AREA OF THE REGION INSIDE $r = \cos\theta$, $r = \sin\theta$



(i) $\cos\theta = \sin\theta \rightarrow \theta = \pi/4$

(ii) $A = 2 \cdot \int_0^{\pi/4} \frac{1}{2}(\sin\theta)^2 \, d\theta$



THIS IS HALF THE AREA

$$A = 2 \cdot \int_0^{\pi/4} \frac{1}{2}(\sin\theta)^2 \, d\theta = \int_0^{\pi/4} \sin^2\theta \, d\theta$$

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

$$= \frac{1}{2}\theta - \frac{1}{4}\sin 2\theta \Big|_{\theta=0}^{\theta=\pi/4}$$

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

$$= \frac{\pi}{8} - \frac{1}{4}$$

(10) DETERMINE WHETHER VECTORS ARE PARALLEL, ORTHOGONAL, OR NEITHER.

(a) $\vec{a} = \langle -3, 5, 11 \rangle$, $\vec{b} = \langle 10, -5, 5 \rangle$

ORTHOGONAL? CHECK IF $\vec{a} \cdot \vec{b} = 0$

$$\langle -3, 5, 11 \rangle \cdot \langle 10, -5, 5 \rangle = -30 - 25 + 55 = 0 \checkmark$$

VECTORS ARE ORTHOGONAL

EVEN THOUGH PROBLEM IS COMPLETE, LET'S CHECK FOR PARALLEL

(i) FIRST (AND EASIER) WAY. DOES $\vec{a} = \lambda \vec{b}$, WHERE λ IS CONSTANT?

$$-3 = \lambda(10) \longrightarrow \lambda = -3/10$$
$$5 = \lambda(-5) \rightarrow \lambda = -1$$
$$11 = \lambda(5) \rightarrow \lambda = \frac{11}{5}$$

THEY NEED TO MATCH. TO BE PARALLEL.

(ii) SECOND (AND HARDER) WAY. DOES $\vec{a} \times \vec{b} = 0$

$$\vec{a} \times \vec{b} = \begin{vmatrix} i & j & k \\ -3 & 5 & 11 \\ 10 & -5 & 5 \end{vmatrix} = i \begin{vmatrix} 5 & 11 \\ -5 & 5 \end{vmatrix} - j \begin{vmatrix} -3 & 11 \\ 10 & 5 \end{vmatrix} + k \begin{vmatrix} -3 & 5 \\ 10 & -5 \end{vmatrix}$$

$$= i(25+55) - j(-15-110) + k(15-50)$$

$$= 80i + 125j - 35k$$

$$\neq 0$$

(10b) $\vec{a} = \langle 1, 2, -1 \rangle$, $\vec{b} = \langle 3, 6, 3 \rangle$

(i) ORTHOGONAL? $\vec{a} \cdot \vec{b} = 0?$

$$\langle 1, 2, -1 \rangle \cdot \langle 3, 6, 3 \rangle = 3 + 12 + -3 = 12 \neq 0$$

SO NOT ORTHOGONAL.

(ii) PARALLEL?

• EASY WAY. DOES $\vec{a} = \lambda \vec{b}$?

$$\begin{aligned} 1 &= \lambda(3) \rightarrow \lambda = 1/3 \\ 2 &= \lambda(6) \rightarrow \lambda = 1/3 \\ -1 &= \lambda(3) \rightarrow \lambda = -1/3 \end{aligned}$$

λ NOT THE SAME. NOT PARALLEL

• HARD WAY.

$$\vec{a} \times \vec{b} = \begin{vmatrix} i & j & k \\ 1 & 2 & -1 \\ 3 & 6 & 3 \end{vmatrix} = i \begin{vmatrix} 2 & -1 \\ 6 & 3 \end{vmatrix} - j \begin{vmatrix} 1 & -1 \\ 3 & 3 \end{vmatrix} + k \begin{vmatrix} 1 & 2 \\ 3 & 6 \end{vmatrix}$$

$$= i(6+6) - j(3+3) + k(6-6)$$

$$= 12i - 6j + 0k$$

(iii) ANSWER IS NEITHER. ALSO CALLED SKEWED

(10c) $\vec{a} = \langle 2, -3, 8 \rangle$, $\vec{b} = \langle -6, 9, -24 \rangle$

(i) ORTHOGONAL?

$$\vec{a} \cdot \vec{b} = \langle 2, -3, 8 \rangle \cdot \langle -6, 9, -24 \rangle = -12 - 27 - 192 = -231 \neq 0$$

NOT ORTHOGONAL

(iii) PARALLEL?

• EASY WAY. DOES $\vec{a} = \lambda \vec{b}$?

$2 = \lambda(-6) \rightarrow \lambda = -1/3$

$-3 = \lambda(9) \rightarrow \lambda = -1/3$

$8 = \lambda(-24) \rightarrow \lambda = -1/3$

ALL MATCH. $\vec{a}$ AND $\vec{b}$ ARE PARALLEL.

. HARD WAY DOES $\vec{a} \times \vec{b} = 0$

$$\vec{a} \times \vec{b} = \begin{vmatrix} i & j & k \\ 2 & -3 & 8 \\ -6 & 9 & -24 \end{vmatrix} = i \begin{vmatrix} -3 & 8 \\ 9 & -24 \end{vmatrix} - j \begin{vmatrix} 2 & 8 \\ -6 & -24 \end{vmatrix} + k \begin{vmatrix} 2 & -3 \\ -6 & 9 \end{vmatrix}$$

$$= i(72 - 72) - j(-48 + 48) + k(18 - 18)$$

$$= 0i + 0j + 0k$$

$$= 0$$

SINCE $\vec{a} \times \vec{b} = 0$, $\vec{a}$ AND $\vec{b}$ ARE PARALLEL.

(11) GIVEN THAT $\vec{a} = \langle 3,-4,-5 \rangle$ AND $\vec{b} = \langle -2,1,2 \rangle$ AND $\vec{c} = \langle -6,-3,2 \rangle$

(a) EVALUATE $2\vec{a} - 3\vec{b} + 2\vec{c}$

$$= 2\langle 3,-4,-5 \rangle - 3\langle -2,1,2 \rangle + 2\langle -6,-3,2 \rangle$$

$$= \langle 6,-8,-10 \rangle + \langle 6,-3,-6 \rangle + \langle -12,-6,4 \rangle$$

$$= \langle 0,-17,-12 \rangle$$

(b) EVAVATE $\dfrac{|\vec{a}|\vec{b}}{|\vec{c}|}$

(i) $|\vec{a}| = \sqrt{(3)^2 + (-4)^2 + (-5)^2} = \sqrt{50}$

(ii) $|\vec{c}| = \sqrt{(-6)^2 + (-3)^2 + (2)^2} = \sqrt{49} = 7$

(iii) $\dfrac{|\vec{a}|\vec{b}}{|\vec{c}|} = \dfrac{\sqrt{50}\langle -2,1,2 \rangle}{\sqrt{49}} = \dfrac{5}{7}\sqrt{2}\langle -2,1,2 \rangle$

$$= \left\langle \frac{-10\sqrt{2}}{7}, \frac{5\sqrt{2}}{7}, \frac{10\sqrt{2}}{7} \right\rangle$$

(c) FIND ANGLES BETWEEN $\vec{b}$ AND $\vec{c}$

VSE $\vec{b} \cdot \vec{c} = |\vec{b}||\vec{c}|\cos\theta \rightarrow \cos\theta = \dfrac{\vec{b} \cdot \vec{c}}{|\vec{b}||\vec{c}|}$

- $\vec{b} \cdot \vec{c} = \langle -2,1,2 \rangle \cdot \langle -6,-3,2 \rangle = 12 - 3 + 4 = 13$
- $|\vec{b}| = \sqrt{(-2)^2 + (1)^2 + (2)^2} = \sqrt{9} = 3$, $|\vec{c}| = 7$
- $\cos\theta = \dfrac{13}{3 \cdot 7} = \dfrac{13}{21} \rightarrow \theta = \cos^{-1}\left(\dfrac{13}{21}\right) \approx 52^\circ$

(11d) ARE $\vec{b}$ AND $\vec{a}$ ORTHOGONAL?

$$\vec{a}\cdot\vec{b} = \langle 3,-4,-5\rangle\cdot\langle -2,1,2\rangle = -6-4-10 = -20$$

SINCE $\vec{a}\cdot\vec{b}\neq 0$, $\vec{a}$ AND $\vec{b}$ ARE NOT ORTHOGONAL

(11e) FIND $\vec{b}\times\vec{c}$

$$\vec{b}\times\vec{c} = \begin{vmatrix} i & j & k \\ -2 & 1 & 2 \\ -6 & -3 & 2 \end{vmatrix} = i\begin{vmatrix} 1 & 2 \\ -3 & 2 \end{vmatrix} - j\begin{vmatrix} -2 & 2 \\ -6 & 2 \end{vmatrix} + k\begin{vmatrix} -2 & 1 \\ -6 & -3 \end{vmatrix}$$

$$= i(2+6) - j(-4+12) + k(6+6)$$

$$= 8i - 8j + 12k$$

(11f) $|\vec{b}\times\vec{c}| = \sqrt{(8)^2+(-8)^2+12^2} = \sqrt{272}$

(11g) FIND THE VECTOR PROJECTION OF $\vec{b}$ ONTO $\vec{c}$

$$\text{proj}_{\vec{c}}\vec{b} = \left(\frac{\vec{c}\cdot\vec{b}}{|\vec{c}|^2}\right)\vec{c} = \left(\frac{13}{7^2}\right)\langle -6,-3,2\rangle = \left\langle \frac{-78}{49}, -\frac{39}{49}, \frac{26}{49}\right\rangle$$

(11h) FIND DIRECTION COSINES AND ANGLES OF $\vec{a}$

$$\cos\alpha = \frac{3}{\sqrt{50}}, \quad \cos\beta = \frac{-4}{\sqrt{50}}, \quad \cos\gamma = \frac{-5}{\sqrt{50}}$$

$$\alpha = 65^\circ, \quad \beta = 124^\circ, \quad \gamma = 135^\circ$$

(12) GIVEN THREE POINTS $P(2,1,2)$, $Q(3,8,-6)$, AND $R(-2,-3,1)$. FIND

(a) THE VECTOR EQUATION OF THE LINE PASSING THROUGH $P(2,1,2)$ AND $Q(3,8,-6)$

(i) DIRECTION VECTOR: $\vec{PQ} = \langle 3-2, 8-1, -6-2 \rangle = \langle 1, 7, -8 \rangle$

(ii) POINT/VECTOR: $\langle 2,1,2 \rangle$

$$r(t) = \langle 2,1,2 \rangle + t\langle 1,7,-8 \rangle$$

(b) THE PARAMETRIC EQUATIONS OF THE LINE PASSING THROUGH $P(2,1,2)$ AND $R(-2,-3,1)$

(i) DIRECTION VECTOR: $\vec{PR} = \langle -2-2, -3-1, 1-2 \rangle = \langle -4, -4, -1 \rangle$

(ii) POINT/VECTOR: $\langle 2,1,2 \rangle$

$$x = 2 - 4t, \quad y = 1 - 4t, \quad z = 2 - t$$

(c) ARE $\vec{PQ}$ AND $\vec{PR}$ ORTHOGONAL, PARALLEL, OR NEITHER

DOT: $\vec{PQ} \cdot \vec{PR} = \langle 1,7,-8 \rangle \cdot \langle -4,-4,-1 \rangle = -4 - 28 + 8 = -24 \neq 0$ (NOT ORTHOGONAL)

CROSS: $\vec{PQ} \times \vec{PR} = \begin{vmatrix} i & j & k \\ 1 & 7 & -8 \\ -4 & -4 & -1 \end{vmatrix} = i \begin{vmatrix} 7 & -8 \\ -4 & -1 \end{vmatrix} - j \begin{vmatrix} 1 & -8 \\ -4 & -1 \end{vmatrix} + k \begin{vmatrix} 1 & 7 \\ -4 & -4 \end{vmatrix}$

$$= i(-7-32) - j(-1-32) + k(-4+28)$$

$$= -39i + 33j + 24k \neq 0$$

NOT PARALLEL

ANSWER: NEITHER

(12 d) FIND EQUATION OF THE PLANE THAT PASSES THROUGH $P(2,1,2)$, $Q(3,8,-6)$, AND $R(-2,-3,1)$.

(i) NEED A POINT: ANY OF THE THREE WILL WORK

$$P(2,1,2)$$

(ii) NEED A NORMAL VECTOR (A VECTOR PERPENDICULAR TO THE PLANE)

- SINCE $\vec{PQ}$ AND $\vec{PR}$ LIE ON THE PLANE, THEIR CROSS PRODUCT WILL BE PERPENDICULAR TO THE PLANE.

EQUATION OF PLANE:

$$-39(x-2)+33(y-1)+24(z-2)=0$$