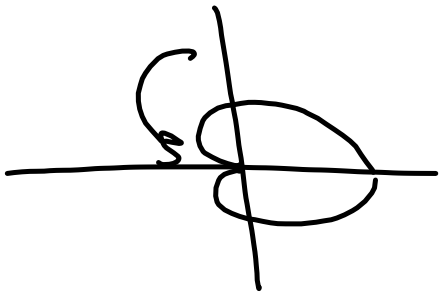
$r = 1 + \cos\theta$



$x = r\cos\theta$

$= (1+\cos\theta)\cos\theta = \cos\theta + \cos^2\theta$

$\frac{dx}{d\theta} = -\sin\theta + (2\cos\theta)(-\sin\theta)$ $\qquad (fg)' = f'g + fg'$

$= -\sin\theta - 2\sin\theta\cos\theta$

$y = r\sin\theta = (1+\cos\theta)\sin\theta = \sin\theta + \sin\theta\cos\theta$

$\frac{dy}{d\theta} = \cos\theta + \cos^2\theta - \sin^2\theta$

$\frac{dy}{dx} = \frac{\cos\theta + \cos^2\theta - \sin^2\theta}{-\sin\theta - 2\sin\theta\cos\theta}$

SET $0 \Rightarrow \cos\theta + \cos^2\theta - (1 - \cos^2\theta)$

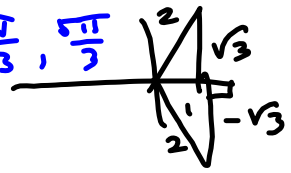
$2u^2 + u - 1 = \cos\theta + 2\cos^2\theta - 1$

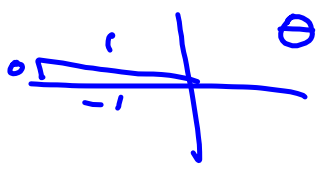
$= 2\cos^2\theta + \cos\theta - 1 = 0$

$(2\cos\theta - 1)(\cos\theta + 1) = 0$

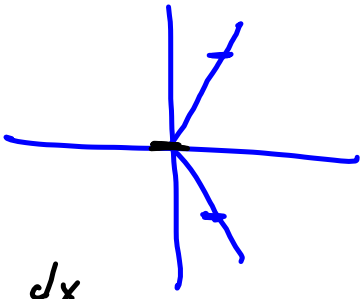
$\cos\theta = \frac{1}{2}$ OR $\cos\theta = -1$

$\theta = \frac{\pi}{3}, \frac{5\pi}{3}$





$\theta = \pi$



so fun

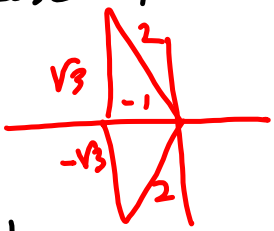
Vertical $\frac{dx}{d\theta} = -\sin\theta - 2\sin\theta\cos\theta$

$= -2\sin\theta\cos\theta - \sin\theta$

$= -\sin\theta(2\cos\theta + 1)$

$\sin\theta = 0$ $2\cos\theta = -1$ $\cos\theta = -\frac{1}{2}$

$\theta = 0, \pi$

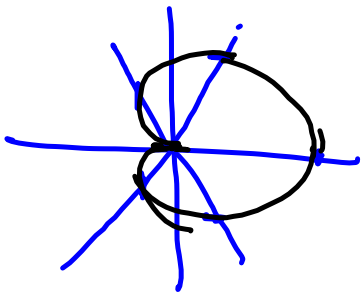


$\frac{2\pi}{3}, \frac{4\pi}{3}$

So $\frac{dx}{d\theta}$ & $\frac{dy}{d\theta}$ BOTH $= 0$ @ $x = \frac{\pi}{3}, \frac{5\pi}{3}$

$f(cx)$

$cf(x)$

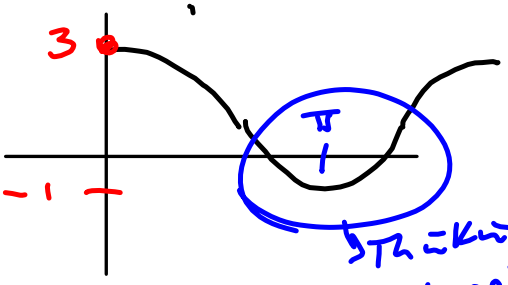


$f(x+c)$ Left c

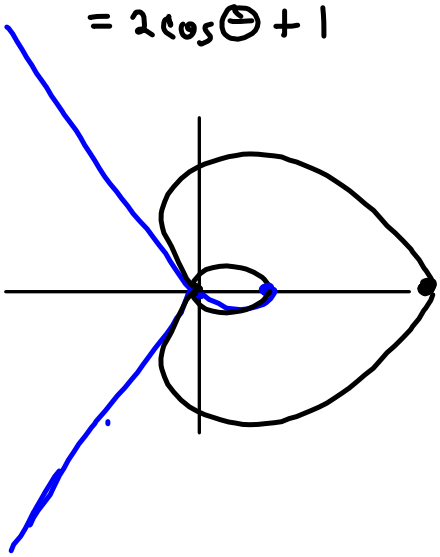
$f(cx)$ Divide by c

$1 + 2\cos\theta$

$= 2\cos\theta + 1$



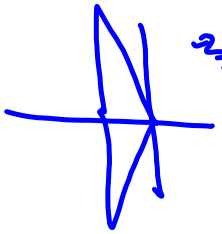
Thinking Loop.



Analysis:

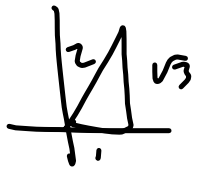
$2\cos\theta + 1 = 0$

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



$\frac{2\pi}{3}, \frac{4\pi}{3}$

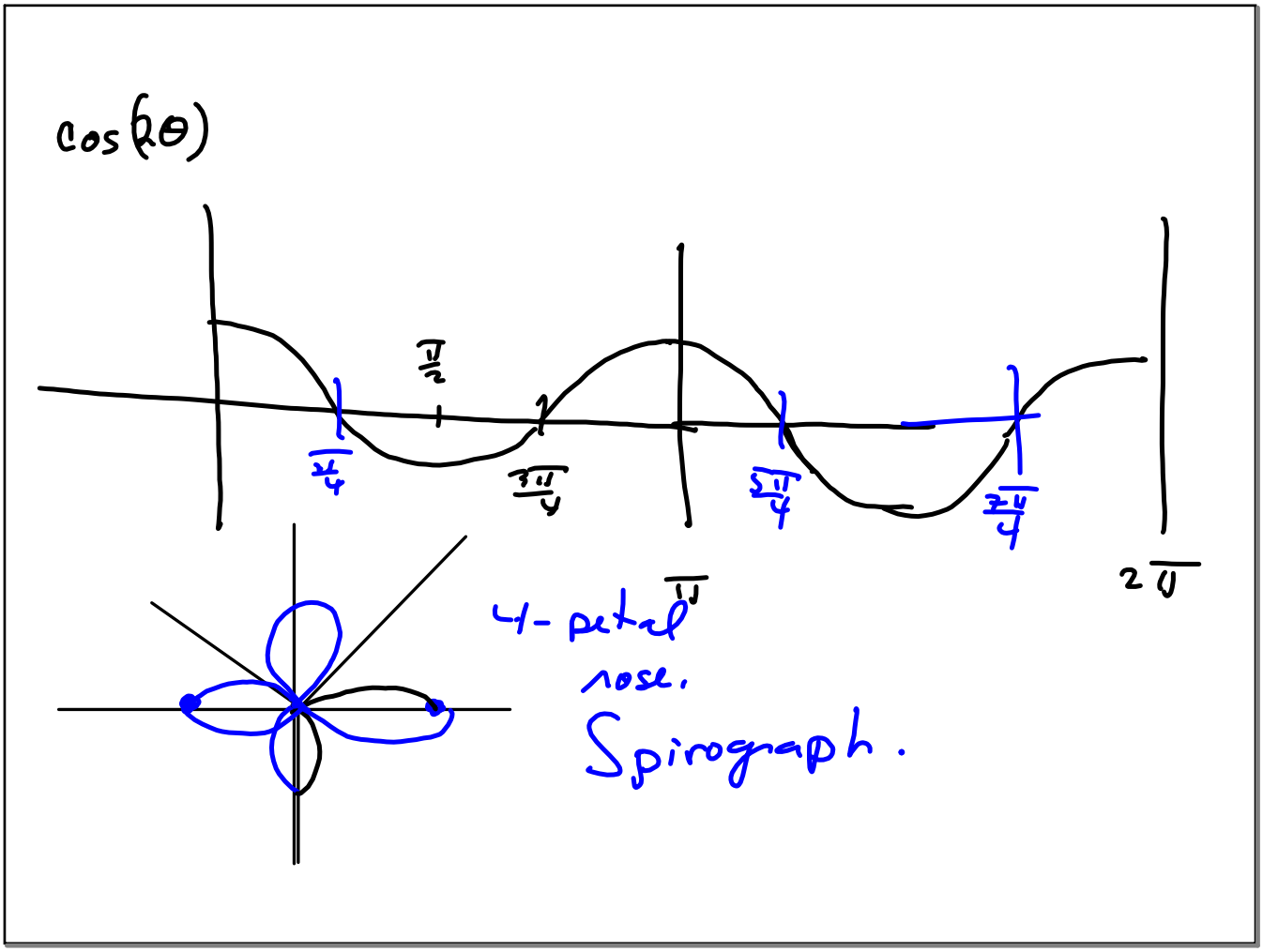
$$\frac{dy}{dx} = \frac{\cos\theta + \cos^2\theta - \sin^2\theta}{-\sin\theta - 2\sin\theta\cos\theta} = \frac{f}{g}$$



$$\frac{f'}{g'} = \frac{-\sin\theta + 2\cos\theta(-\sin\theta) - 2\sin\theta\cos\theta}{-\cos\theta - 2\cos^2\theta + 2\sin^2\theta}$$

$$\theta \to \frac{\pi}{3} \longrightarrow \frac{-\frac{\sqrt{3}}{2} + 2\left(\frac{1}{2}\right)\left(-\frac{\sqrt{3}}{2}\right) - 2\left(\frac{\sqrt{3}}{2}\right)\left(\frac{1}{2}\right)}{-\frac{1}{2} - 2\left(\frac{1}{2}\right)^2 + 2\left(\frac{\sqrt{3}}{2}\right)^2}$$

$$= \frac{-\frac{\sqrt{3}}{2} - \frac{\sqrt{3}}{2} - \frac{\sqrt{3}}{2}}{-\frac{1}{2} - \frac{1}{2} + \frac{3}{2}} = \frac{-\frac{3\sqrt{3}}{2}}{\frac{1}{2}} = -3\sqrt{3}$$ so what?


cos(2θ)
π/2
π/4
3π/4
5π/4
7π/4
2π
4-petal rose.
Spirograph.

$e^t \sin(\pi t)$ $\quad t=0$

$y = e^{2t}$ $\quad (x(0), y(0)) = (0, 1)$

$$\frac{dx}{dt} = e^t \sin t + \pi e^t \cos(\pi t)$$

$$\frac{dy}{dt} = 2e^{2t}$$

$$\left.\frac{dy}{dx}\right|_{t=0} = \left.\frac{2e^{2t}}{e^t \sin t + \pi e^t \cos(\pi t)}\right|_{t=0} = \frac{2}{\pi}$$

$$y = \frac{2}{\pi}(x-0)+1 = \frac{2}{\pi}x + 1$$