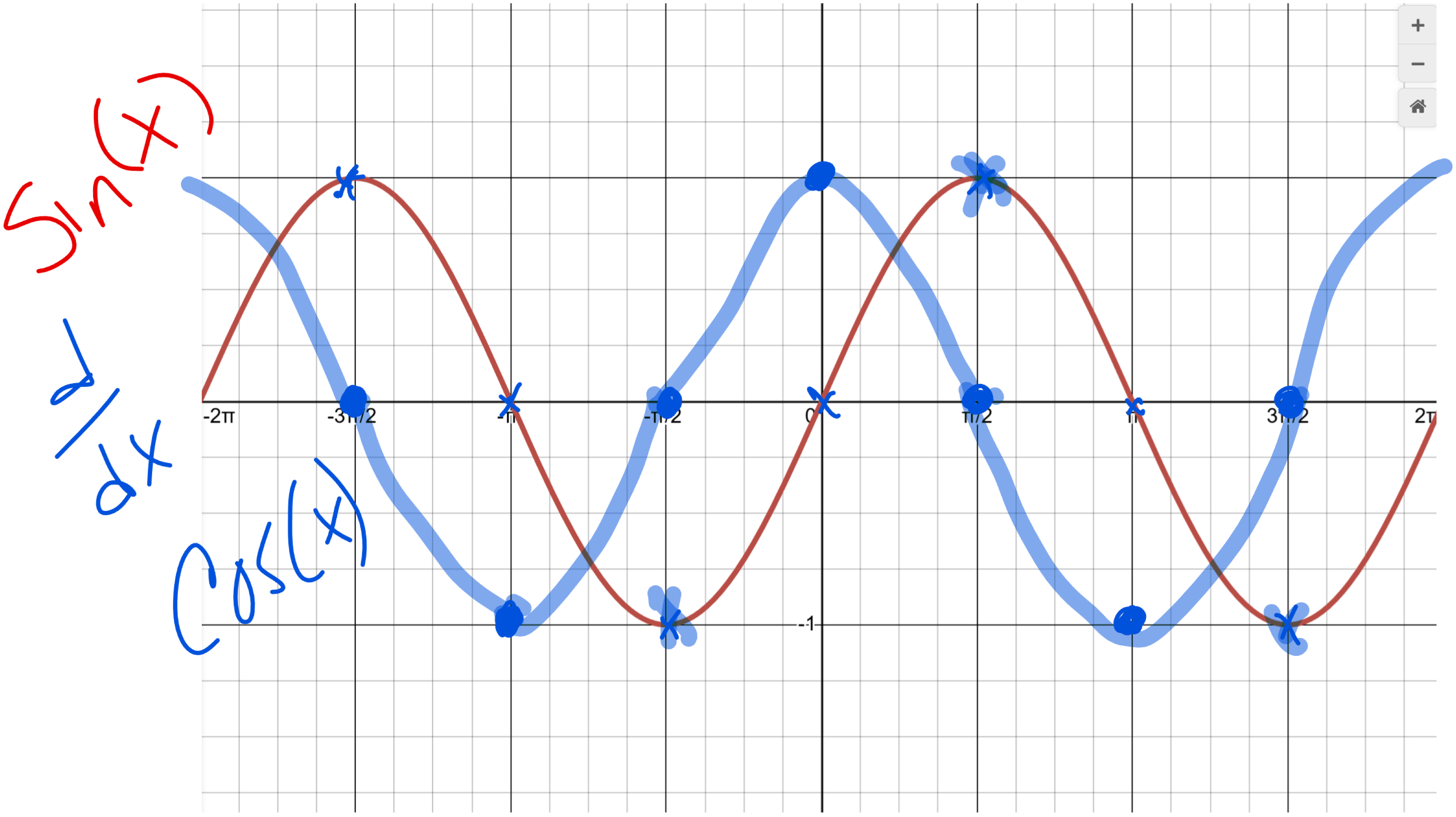
Sin(x)
d/dx
Cos(x)
-2π
-3π/2
-π
-π/2
0
π/2
π
3π/2
2π
-1

$$\sin(x)$$
$$\downarrow$$
$$\cos(x)$$
$$\downarrow$$
$$-\sin(x)$$
$$\downarrow$$
$$-\cos(x)$$
$$\downarrow$$
$$-(-\sin(x)) \rightarrow \sin(x)$$

$$\sin(x) \xrightarrow{d/dx} \cos(x)$$

$$\cos(x) \xrightarrow{d/dx} -\sin(x)$$

$$\tan(x) \rightarrow \sec^2(x)$$

$$\frac{d}{dx}(\tan(x)) = \frac{d}{dx}\left(\frac{\sin x}{\cos x}\right)$$

$$\frac{f'(x)\,g(x) - f(x)\,g'(x)}{g(x)^2}$$

$f \quad \sin x \to \cos x$

$g \quad \cos x \to -\sin x$

$$\frac{(\cos x)(\cos x) - (\sin x)(-\sin x)}{\cos^4(x)} = \frac{\cos^2 x + \sin^2 x}{\cos^2 x}$$

$$= \frac{1}{\cos^2 x} = \sec^2 x$$

Derivatives of Trigonometric Functions

$$\frac{d}{dx}(\sin x) = \cos x \qquad \frac{d}{dx}(\csc x) = -\csc x \cot x$$

$$\frac{d}{dx}(\cos x) = -\sin x \qquad \frac{d}{dx}(\sec x) = \sec x \tan x$$

$$\frac{d}{dx}(\tan x) = \sec^2 x \qquad \frac{d}{dx}(\cot x) = -\csc^2 x$$

$$\frac{(\sec x \tan x)(1+\tan x)-(\sec^2 x)(\sec^2 x)}{(1+\tan x)^2}$$

$$\sec x \tan x + \sec x \tan^2 x - \sec^3 x$$

$$\sec x\left(\tan x + \boxed{\tan^2 x - \sec^2 x}\right) \qquad \sec^2 x = \tan^2 x + 1$$

$$\sec x\left(\tan x \qquad -1\right)$$

$$= \boxed{\frac{\sec x(\tan x - 1)}{(1+\tan x)^2}}$$

Find the derivative of the function.

$$u = 2x^2 + 4\sin x$$

$$\frac{du}{dx} = \square$$

$4x + 4\cos x$

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$$g(t) = 4\cos t$$

$$g^{(33)}(t) = \square \quad -4\sin x$$

$\cos x$ 0

$-\sin x$ 1

$-\cos x$ 2

$\sin x$ 3

$$\frac{d}{dx} \sin(4x)$$

$$\frac{d}{dx}(x+3)^2 \rightarrow 2(x+3)$$

$$\downarrow \qquad\qquad\qquad =$$

$$\frac{d}{dx}(x^2+6x+9) \rightarrow 2x+6$$

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$$\frac{d}{dx}\left(3x^2+5\right)^2 = 2\left(3x^2+5\right)$$

$$\neq$$

$$\frac{d}{dx}\left(9x^4+30x^2+25\right) = 36x^3+60x$$

$$\boxed{2\left(3x^2+5\right)}\left(6x\right) \leftarrow g'(x)$$

$$12x\left(3x^2+5\right) = 36x^3+60x$$

Find the derivative of the function.

$$f(x) = (9x^2 - 2x)^{30}$$

$f(g(x))$

$g(x) = 9x^2 - 2x$

$g'(x) = 18x - 2$

$f'(x) =$

$(18x-2)(30)(9x^2-2x)^{29}$

$30(18x-2)(9x^2-2x)^{29}$

$$y = \frac{3}{(x^4 - 7x + 2)^{12}} = 3(x^4 - 7x + 2)^{-12}$$

$$3 \frac{d}{dx} (x^4 - 7x + 12)^{-12}$$

$$3\left[(4x^3 - 7)(-12)(x^4 - 7x + 12)^{-13}\right]$$

$$\boxed{\frac{-36(4x^3 - 7)}{(x^4 - 7x + 12)^{13}}}$$

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Find the derivative of the function.

$$y=\sqrt{x^5-2x^4+9}$$

$$y=(x^5-2x^4+9)^{1/2}$$

$$y'=(5x^4-8x^3)(1/2)(x^5-2x^4+9)^{-1/2}$$

$$=\boxed{\frac{5x^4-8x^3}{2\sqrt{x^5-2x^4+9}}}$$

The Chain Rule If g is differentiable at x and f is differentiable at $g(x)$, then the composite function $F = f \circ g$ defined by $F(x) = f(g(x))$ is differentiable at x and F' is given by the product

1
$$F'(x) = f'(g(x)) \cdot g'(x)$$

In Leibniz notation, if $y = f(u)$ and $u = g(x)$ are both differentiable functions, then

2
$$\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx}$$

Let $f(x)$ be defined as follows.

$$f(x) = 5x^3 \cdot \left(\frac{-3x^2+5}{3x+1} \right)^{\frac{1}{3}}$$

$f(x) = 5x^3 \to f'(x) = 15x^2$

$g(x) = \left(\frac{-3x^2+5}{3x+1} \right)^{1/3}$

$g'(x) = \frac{1}{3} \left(\boxed{\frac{-3x^2+5}{3x+1}} \right)^{-2/3} \left(\frac{-27x^2-6x-15}{(3x+1)^2} \right)$

$n = -3x^2+5 \qquad n' = -6x$

$d = 3x+1 \qquad d' = 3$

$-6x(3x+1) - (3x^2+5)(3)$

$-18x^2 - 6x - 9x^2 - 15$

$-27x^2 - 6x - 15$

$$\cdot\left(\frac{-3x^2+5}{3x+1}\right)^{\frac{1}{3}}$$

$$f(x) = 5x^3 \rightarrow f'(x) = 15x^2$$

$$g(x) = \left(\frac{-3x^2+5}{3x+1}\right)^{1/3}$$

$$g'(x) = \frac{1}{3}\left(\boxed{\frac{-3x^2+5}{3x+1}}\right)^{-2/3}\left(\frac{-27x^2-6x-15}{(3x+1)^2}\right)$$

$$x) = (15x^2)\left(\frac{-3x^2+5}{3x+1}\right)^{1/3} + \frac{1}{3}\left(\frac{-3x^2+5}{3x+1}\right)^{-2/3}\left(\frac{-27x^2-6x-15}{(3x+1)^2}\right)(5x^3)$$