

## Section 3.4: Derivatives of Trigonometric Functions

It is important to remember that everything for six trigonometric functions ( $\sin x$ ,  $\cos x$ ,  $\tan x$ ,  $\cot x$ ,  $\csc x$ ,  $\sec x$ ) will be done in radians.

EXAMPLE 1. *Compute:*

$$(a) \lim_{x \rightarrow 0} \sin x =$$

$$(b) \lim_{x \rightarrow 0} \cos x =$$

THEOREM 2.

$$\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1,$$

$$\lim_{x \rightarrow 0} \frac{\cos x - 1}{x} = 0.$$

*Proof*

EXAMPLE 3. *Find these limits:*

$$(a) \lim_{x \rightarrow 0} \frac{\sin(5x)}{x}$$

$$(b) \lim_{x \rightarrow 0} \frac{\sin(9x)}{\sin(7x)}$$

$$(c) \lim_{x \rightarrow 0} \frac{x}{\sin(4x)}$$

**Conclusion:** If  $a, b \neq 0$  then

$$\lim_{x \rightarrow 0} \frac{\sin(ax)}{x} = \quad ,$$

$$\lim_{x \rightarrow 0} \frac{x}{\sin(ax)} = \quad ,$$

$$\lim_{x \rightarrow 0} \frac{\sin(ax)}{\sin(bx)} =$$

$$(d) \lim_{x \rightarrow 0} \frac{1}{x^2 \cot^2(3x)}$$

$$(e) \lim_{x \rightarrow 0} \frac{\cos x - 1}{\sin x}$$

EXAMPLE 4. Find the following derivatives:

$$(a) \frac{d}{dx} \sin x =$$

Remark Similarly one can get  $(\cos x)' = -\sin x$ .

$$(b) \frac{d}{dx} \tan x =$$

Derivatives of Trig Functions (memorize these!)

$\frac{d}{dx} \sin x =$	$\frac{d}{dx} \cos x = -\sin x$	$\frac{d}{dx} \tan x =$
$\frac{d}{dx} \csc x = -\csc x \cot x$	$\frac{d}{dx} \sec x = \sec x \tan x$	$\frac{d}{dx} \cot x = -\csc^2 x$

EXAMPLE 5. *Find the derivative of these functions.*

(a)  $y = \cot x + 5 \sec x + x\sqrt{x}$

(b)  $f(x) = \frac{\cos x}{1 + \sin x}$

EXAMPLE 6. *Find the equation of the tangent line to the graph of function  $y = x^2 \sin x$  at  $x = \frac{\pi}{4}$ .*