

# AP CALC AB FORMULA STUDY GUIDE

## Properties of Limits

$$\lim_{x \rightarrow a} [f(x) + g(x)] = \lim_{x \rightarrow a} f(x) + \lim_{x \rightarrow a} g(x)$$

$$\lim_{x \rightarrow a} [f(x) - g(x)] = \lim_{x \rightarrow a} f(x) - \lim_{x \rightarrow a} g(x)$$

$$\lim_{x \rightarrow a} [c \cdot f(x)] = c \lim_{x \rightarrow a} f(x)$$

$$\lim_{x \rightarrow a} [f(x)g(x)] = \lim_{x \rightarrow a} f(x) \cdot \lim_{x \rightarrow a} g(x)$$

$$\lim_{x \rightarrow a} \frac{f(x)}{g(x)} = \frac{\lim_{x \rightarrow a} f(x)}{\lim_{x \rightarrow a} g(x)} \quad \text{if } \lim_{x \rightarrow a} g(x) \neq 0$$

$$\lim_{x \rightarrow a} [f(x)]^n = \left[ \lim_{x \rightarrow a} f(x) \right]^n$$

$$\lim_{x \rightarrow a} \sqrt[n]{f(x)} = \sqrt[n]{\lim_{x \rightarrow a} f(x)}$$

**Direct Substitution Property**  
If  $f$  is a polynomial or a rational function and  $a$  is in the domain of  $f$ , then  $\lim_{x \rightarrow a} f(x) = f(a)$ .

## Theorems

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

$$\lim_{x \rightarrow a} f(g(x)) = f(\lim_{x \rightarrow a} g(x))$$

## The Squeeze Theorem

Given  $f(x) \leq g(x) \leq h(x)$  for values of  $x$  near  $a$ , except possibly at  $a$ . If  $\lim_{x \rightarrow a} f(x) = \lim_{x \rightarrow a} h(x) = L$ ,

then  $\lim_{x \rightarrow a} g(x) = L$ .



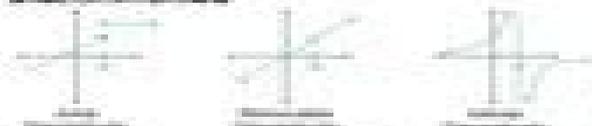
## Continuity

$f$  is continuous at a number  $a$ , if (1)  $f(a)$  is defined

(2)  $\lim_{x \rightarrow a} f(x)$  exists

(3)  $\lim_{x \rightarrow a} f(x) = f(a)$

## Discontinuities



## Vertical Asymptote(s) of $f$

The line  $x = a$  is a vertical asymptote of  $y = f(x)$  if at least one of the following statements is true:

$$\lim_{x \rightarrow a^-} f(x) = \pm\infty \quad \lim_{x \rightarrow a^+} f(x) = \pm\infty$$

$$\lim_{x \rightarrow a^-} f(x) = \pm\infty \quad \lim_{x \rightarrow a^+} f(x) = \pm\infty$$

$$\lim_{x \rightarrow a^-} f(x) = \pm\infty \quad \lim_{x \rightarrow a^+} f(x) = \pm\infty$$

## Infinite Limits

$$\lim_{x \rightarrow a} \frac{f(x)}{g(x)}$$

- if  $f(x)$  grows faster, the limit is  $\pm\infty$
- if  $g(x)$  grows faster, the limit is 0
- if  $f(x) \neq 0$  &  $g(x) \neq 0$  are polynomials with the same degree, the limit equals the ratio of their leading coefficients

## Horizontal Asymptote(s) of $f$

$$y = \lim_{x \rightarrow \pm\infty} f(x) \quad \text{or} \quad y = \lim_{x \rightarrow \pm\infty} f(x)$$

## Intermediate Value Theorem

If  $f$  is continuous on  $[a, b]$  and  $M$  is any number between  $f(a)$  and  $f(b)$ , then there is at least one number  $c$  in  $[a, b]$  such that  $f(c) = M$ .



**Average Rate of Change**  
of a function  $f(x)$  over closed

$$\text{interval } [a, b] = \frac{f(b) - f(a)}{b - a}$$

## Definition of a Derivative

$$f'(a) = \lim_{h \rightarrow 0} \frac{f(a+h) - f(a)}{h}$$

$$f'(a) = \lim_{x \rightarrow a} \frac{f(x) - f(a)}{x - a}$$

## Not Differentiable



Sharp corner      Cusp      Vertical Tangent

## Differentiation Rules

$$\frac{d}{dx}(c) = 0$$

$$\frac{d}{dx}[c \cdot f(x)] = c \frac{d}{dx}[f(x)]$$

$$\frac{d}{dx}[f(x) + g(x)] = \frac{d}{dx}f(x) + \frac{d}{dx}g(x)$$

$$\frac{d}{dx}[f(x) - g(x)] = \frac{d}{dx}f(x) - \frac{d}{dx}g(x)$$

## Derivatives

$$\frac{d}{dx}(x^n) = nx^{n-1} \quad \frac{d}{dx}(\sin x) = \cos x$$

$$\frac{d}{dx}(x^n) = x^n \quad \frac{d}{dx}(\cos x) = -\sin x$$

$$\frac{d}{dx}(x^a) = a^x \ln a \quad \frac{d}{dx}(\tan x) = \sec^2 x$$

$$\frac{d}{dx}(\ln x) = \frac{1}{x}$$

## Derivatives of Inverse

$$\frac{d}{dx}(\sin^{-1} x) = \frac{1}{\sqrt{1-x^2}}$$

$$\frac{d}{dx}(\cos^{-1} x) = \frac{-1}{\sqrt{1-x^2}}$$

$$\frac{d}{dx}(\tan^{-1} x) = \frac{1}{1+x^2}$$

$$\frac{d}{dx}(f^{-1}(x)) = \frac{1}{f'(f^{-1}(x))}$$

## Product Rule

$$\frac{d}{dx}(f(x)g(x)) = f'(x)g(x) + f(x)g'(x)$$

## Quotient Rule

$$\frac{d}{dx}\left(\frac{f(x)}{g(x)}\right) = \frac{f'(x)g(x) - f(x)g'(x)}{(g(x))^2}$$

## Chain Rule

$$\frac{d}{dx}f(g(x)) = f'(g(x))g'(x)$$

## Linear Approximation of $f$ at point

Line approximation of  $f$  at  $a$  is

$$L(x) = f(a) + f'(a)(x - a)$$

# Ap Calculus Exam Study Guide

**Dale W Johnson, Kerry J King**



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