

## §2.4a The Chain Rule

The Chain Rule

The General Power Rule

Transcendental Functions and the Chain Rule

Notes based on: *Calculus for AP* by Larson & Battaglia. © 2017 Cengage Learning.  
*Calculus, AP Edition, 9th ed.* by Larson & Edwards. © 2010 Brooks/Cole, Cengage Learning.

Learning Goals: Students will be able to...

- Find the derivative of a composite function using the Chain Rule.
- Find the derivative of a function using the General Power Rule.
- Simplify the derivative of a function using algebra.
- Find the derivative of a trigonometric function using the Chain Rule.

Learning Objectives: Students will be able to...

- 2.1C Calculate derivatives.  
 2.1D Determine higher order derivatives.

## The Chain Rule

**THEOREM THE CHAIN RULE**

If  $y = f(u)$  is a differentiable function of  $u$  and  $u = g(x)$  is a differentiable function of  $x$ , then  $y = f(g(x))$  is a differentiable function of  $x$  and

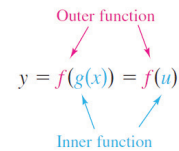
$$\frac{dy}{dx} = \frac{dy}{du} \cdot \frac{du}{dx}$$

or, equivalently,

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

## The Chain Rule

When applying the Chain Rule, it is helpful to think of the composite function  $f \circ g$  as having two parts—an inner part and an outer part.



The derivative of  $y = f(u)$  is the derivative of the outer function (at the inner function  $u$ ) times the derivative of the inner function:  $y' = f'(u) \cdot u'$

## The General Power Rule

**THEOREM THE GENERAL POWER RULE**

If  $y = [u(x)]^n$ , where  $u$  is a differentiable function of  $x$  and  $n$  is a rational number, then

$$\frac{dy}{dx} = n[u(x)]^{n-1} \frac{du}{dx}$$

or, equivalently,

$$\frac{d}{dx}[u^n] = nu^{n-1} u'.$$

## Example: The General Power Rule

Find the derivative of  $y = \frac{2}{(5-x^2)^3}$ .

Example: The General Power Rule

Find the derivative of  $f(x) = x\sqrt{x^4 + 1}$ .

Transcendental Functions and the Chain Rule

$$\frac{d}{dx}[\sin u] = (\cos u) u' \qquad \frac{d}{dx}[\cos u] = -(\sin u) u'$$

$$\frac{d}{dx}[\tan u] = (\sec^2 u) u' \qquad \frac{d}{dx}[\cot u] = -(\csc^2 u) u'$$

$$\frac{d}{dx}[\sec u] = (\sec u \tan u) u' \qquad \frac{d}{dx}[\csc u] = -(\csc u \cot u) u'$$

Example: Transcendental Functions and the Chain Rule

Find the second derivative of  $f(\theta) = \sin(4\theta^2)$ .

Example: Transcendental Functions and the Chain Rule

Find the derivative of  $y = \frac{\tan(4x)}{x^3}$ .

Example: Transcendental Functions and the Chain Rule

Find the derivative of  $g(t) = \sec^3(5t)$ .