# 3.6 The Chain Rule

Objectives:

- I can use the chain rule to take the derivative of composed functions

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## RS #~~60~~ 7 The Chain Rule

$$\frac{d}{dx}\left(f(u)\right)=f'\left(u\right)\bullet u'$$

u= the inside function

If $y=f(u)$ where us is the inside function, then

$$\frac{dy}{dx}=\frac{dy}{du}\bullet\frac{du}{dx} \qquad \frac{dy}{dx}=\frac{dy}{du}\bullet\frac{du}{dv}\bullet\frac{dv}{dx}$$

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## Take the derivative of the following

1. $y = (x-3)^2$

$u = x-3$ $\quad y = u^2$

$du = 1$ $\quad y' = 2u \cdot du$

$y' = 2(x-3)(1)$

$= 2(x-3)$ or $2x-6$

2. $y = \sin(x^2+3)$

$y' = \cos(x^2+3) \cdot 2x$

$= 2x\cos(x^2+3)$

3. $y = \cos(\tan x)$

$y' = -\sin(\tan x) \sec^2 x$

$= -\sec^2 x \sin(\tan x)$

4. $y = \dfrac{1}{x^2-5}$

$u = x^2-5$ $\quad y = \frac{1}{u}$

$du = 2x$ $\quad y = u^{-1}$

$y' = -u^{-2}\, du$

$y' = \frac{-1}{u^2}\, du$

$y' = -\frac{1}{(x^2-5)^2} \cdot 2x$

$y' = \dfrac{-2x}{(x^2-5)^2}$

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## Take the derivative of the following

5. $y = \tan^2 x$

$y = (\tan x)^2$

$y' = 2\tan x \sec^2 x$

6. $y = \dfrac{1}{(2x^2+1)^2}$

$u = 2x^2+1$ $\quad y = \frac{1}{u^2}$

$du = 4x$ $\quad = u^{-2}$

$y' = -2u^{-3}\, du$

$y' = \frac{-2}{u^3}\, du$

$y' = \frac{-2}{u^3} \cdot 4x$

$y' = \dfrac{-8x}{(2x^2+1)^3}$

8. $y = 3\sin\left(\dfrac{2}{x}\right)$

$u = \frac{2}{x}$

$du = 2x^{-1}$

$= -2x^{-2}$

$= \frac{-2}{x^2}$

$y' = 3\cos\left(\frac{2}{x}\right) \cdot -\frac{2}{x^2}$

$y' = \dfrac{-6\cos\left(\frac{2}{x}\right)}{x^2}$

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7. $y=\left(\dfrac{\cos x}{\sin x+1}\right)^2$

$u=\dfrac{\cos x}{\sin x+1}$

$du=\dfrac{(\sin x+1)(-\sin x)-\cos x(\cos x)}{(\sin x+1)^2}$

$y=u^2$

$y'=2u\,du$

$du=\dfrac{-\sin^2 x-\sin x-\cos^2 x}{(\sin x+1)^2}$

$=1$

$du=\dfrac{-(\sin^2 x+\cos^2 x+\sin x)}{(\sin x+1)^2}$

$du=\dfrac{-(+\sin x+1)}{(\sin x+1)^2}=\dfrac{-1}{\sin x+1}$

$y'=2\left(\dfrac{\cos x}{\sin x+1}\right)\left(\dfrac{-1}{\sin x+1}\right)$

$y'=\dfrac{-2\cos x}{(\sin x+1)^2}$

## Take the derivative of the following

9. $y=(1+\sin 2x)^2$

$y=u^2$

$v=2x$

$dv=2$

$u=1+\sin 2x$

$y'=2u\,du$

$du=1+\sin v$

$du=\cos v\cdot dv$

$du=\cos(2x)\cdot 2$

$du=2\cos(2x)$

$y'=2(1+\sin 2x)\cdot 2\cos(2x)$

$y'=4\cos(2x)(1+\sin 2x)$

11. $y=\sin\left(\dfrac{3}{x}\right)$

12. $y=\dfrac{1}{\sin x}$

10. $y=\sqrt{\sin 3x}$

$y=(\sin 3x)^{\frac{1}{2}}$

$y'=\frac{1}{2}(\sin 3x)^{-\frac{1}{2}}\cdot \cos 3x \cdot 3$

$y'=\frac{1}{2(\sin 3x)^{\frac{1}{2}}}\cdot 3\cos 3x$

$=\frac{1}{2\sqrt{\sin 3x}}\cdot 3\cos 3x$

$y'=\frac{3\cos 3x}{2\sqrt{\sin 3x}}$

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Find the derivative of each function

13. $y=\sqrt{x+\cos x}$

$f(x)=\sin^2 x$

$g(x)=\frac{3}{(x^2+1)^2}$

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Find the derivative

1. $y = (\csc x + \cot x)^{-1}$

2. $f(x) = x^3(2x-5)^4$

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Find the derivative

3. $y = 4\sqrt{\sec x + \tan x}$

4. $g(x) = \dfrac{x}{\sqrt{1+x^2}}$

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Find the derivative:

5. $y=(1+\cos 2x)^2$

6. $y=\sqrt{\tan 5x}$

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Find the derivative:

7. $r=\sec(2\theta)\tan(2\theta)$

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Find the second derivative

8. $f(x)=\cot x$

9. $f(x)=9\tan\left(\dfrac{x}{3}\right)$

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Working with Numerical Values

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