

Higher Order Derivatives 2

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2020

## Higher Order Derivatives

So far we have considered taking a derivative of a function, implicitly or explicitly, once only. This is the first derivative we have been considering. When we take the derivative of the first derivative, we have a second derivative; the derivative of the second derivative is the third derivative; and so on. Notation-wise we have the following:

Function	$f(x) = y$
1st derivative	$f'(x) = \frac{dy}{dx}$
2nd derivative	$f''(x) = \frac{d^2y}{dx^2}$
3rd derivative	$f'''(x) = \frac{d^3y}{dx^3}$

Let's consider an example.

### Example

Find the second derivative of  $f(x) = \frac{x}{1+x}$ .

**Solution:** We need to use the *quotient rule*.

$$f'(x) = \frac{1+x-x}{(1+x)^2} = \frac{1}{(1+x)^2}$$

$$f''(x) = (1+x)^{-2}$$

Now we can use the power rule.

$$f''(x) = -2(1+x)^{-3}$$

Let's find the third derivative of the function above.

$$f'''(x) = (-2)(-3)(1+x)^{-4} = 6(1+x)^{-4}$$

## Exercises

Find the second derivative of the following functions,

a)  $f(x) = 8x^4 + \frac{1}{3}x^2 + 9x - 5$

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

b)  $f(x) = 2x^5 - 7x^3 + 9x^2$

h)  $Q(v) = \frac{2}{(6+2v+v^2)^4}$

c)  $f(x) = \sin 5x$

i)  $y = e^{-5x} + 8 \ln(2x^4)$

d)  $f(x) = \tan 3x$

j)  $y = 4\sqrt[5]{x^3}$

e)  $f(x) = \ln(9x + 2)$

k)  $y = \frac{1}{8x^2} - \sqrt{x}$

f)  $f(x) = e^{x^2+1}$