

**The Constant Rule**

If  $c$  is a real number, then  $\frac{d}{dx}(c) = 0$

**The Power Rule**

If  $n$  is any real number, then  $\frac{d}{dx}(cx^n) = nx^{n-1}$

**The Constant Multiple Rule**

If  $f$  is differentiable at  $x$  and  $c$  is a constant, then  $\frac{d}{dx}(cf(x)) = cf'(x)$

**The Sum and Difference Rule**

If  $f$  and  $g$  are differentiable at  $x$ , then  $\frac{d}{dx}(f(x) \pm g(x)) = f'(x) \pm g'(x)$

1. Find the derivative function  $f'(x)$  if  $f(x) = 6x^{11} - 4x^9 + 2x^4 - 8x + 23$

2. Find the derivative function  $g'(x)$  if  $g(x) = x^{12} - \frac{3}{2}x^{10} + 6x^{\frac{3}{2}} - \sqrt{7}x + e^2$

3. Find the derivative function  $h'(x)$  if  $h(x) = \sqrt[4]{x^3} + \sqrt{x}$

4. Find the derivative function  $f'(x)$  if  $f(x) = \frac{1}{x^5} + \frac{1}{\sqrt[3]{x}}$

## The number e

The number  $e = 2.718281828459 \dots$  satisfies

$$\lim_{h \rightarrow 0} \frac{e^h - 1}{h} = 1$$

It is the base of the natural exponential function  $f(x) = e^x$ .

## The Derivative of $e^x$

The function  $f(x) = e^x$  is differentiable for all real numbers  $x$ , and

$$\frac{d}{dx}(e^x) = e^x$$

5. Write an equation of the line tangent to the graph of  $f(x) = 2x - \frac{e^x}{2}$  at the point  $(0, -\frac{1}{2})$

6. Find the point(s) on the graph of  $f(x)$  (from #5) at which the tangent line is horizontal.

7. Let  $f(x) = 2x^3 - 15x^2 + 24x$ . For what values of  $x$  does the line tangent to the graph of  $f$  have a slope of 6?

## Higher – Order Derivatives

Assuming  $y = f(x)$  can be differentiated as often as necessary, the **second derivative** of  $f$  is

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

For integers  $n \geq 1$ , the **nth derivative** of  $f$  is

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

Other common notations for the second derivative of  $y = f(x)$  include  $\frac{d^2 y}{dx^2}$  and  $\frac{d^2 f}{dx^2}$ .

The notations  $\frac{d^n y}{dx^n}$ ,  $\frac{d^n f}{dx^n}$ , and  $y^{(n)}$  are used for the  $n$ th derivatives of  $f$ .

8. Find the third derivative of the following functions

a.  $f(x) = 3x^3 - 5x + 12$

b.  $y = 3t + 2e^t$