Office Hours!

Instructor:
Peter M. Garfield, `garfield@math.ucsb.edu`

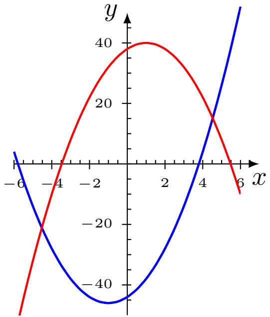
Office Hours:
Mondays 2–3PM
Tuesdays 10:30–11:30AM
Thursdays 1–2PM
or by appointment

Office:
South Hall 6510

Sketching some simple graphs

It's useful to be able to sketch...

(1) Quadratics



$y = 2x^2 + 4x - 44$

$y = -2x^2 + 4x + 38$

- $y = ax^2 + bx + c$
- Bowl-shaped:
  - ⋆ Opens up if $a > 0$
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- Model curve: $y = x^2$

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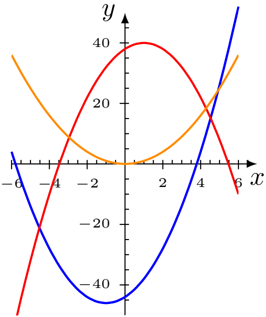

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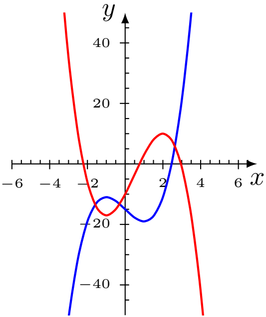
(2) Cubics



$y = 2x^3 - 6x - 15$

$y = -2x^3 + 3x^2 + 12x - 10$

- $y = ax^3 + bx^2 + cx + d$
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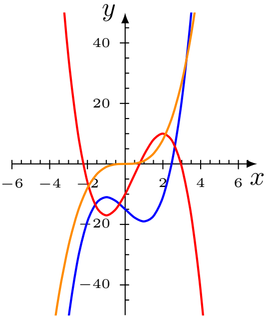

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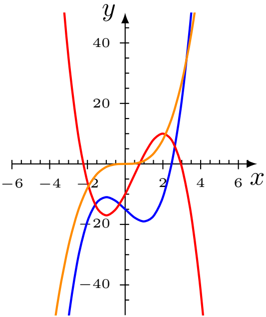

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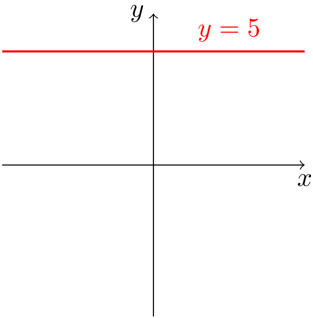
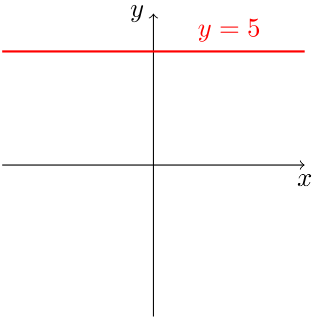
For a polynomial, the highest power of x dominates when x is big

The Derivatives of Simple Functions



The derivative of a constant is…?

The Derivatives of Simple Functions



The derivative of a constant is zero because:

- derivative = rate of change
- constants don't change

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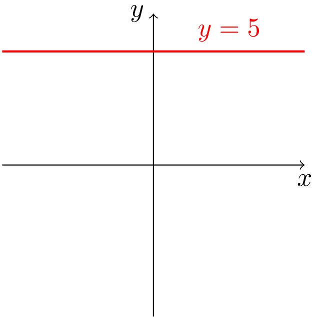

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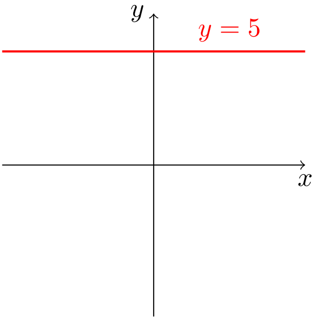

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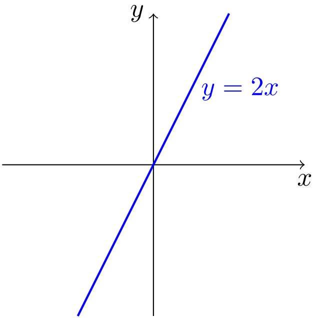

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The derivative of a straight line is...?

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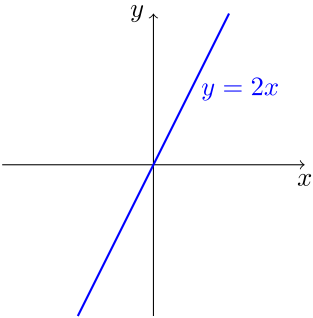

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The derivative of a straight line is its slope because

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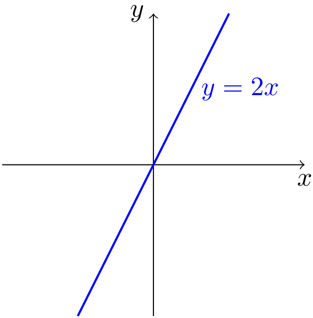

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The derivative of a straight line is its slope because

- derivative = slope

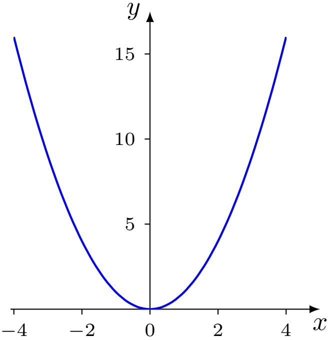
So $\dfrac{d}{dx}(2x) = 2$

Meaning of Derivatives

$$\frac{d}{dx}\left(x^2\right) = 2x$$

What this means

The slope of the graph of $y = x^2$ at $x = a$ is $2a$



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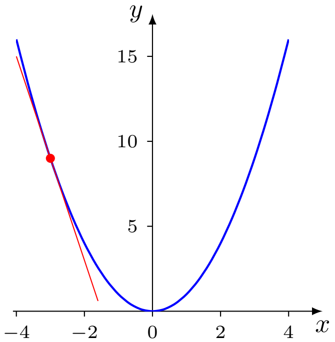

at $x = -3$, slope is $2(-3) = -6$

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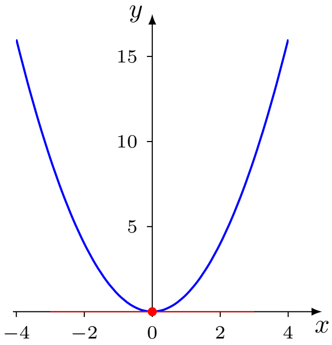

at $x = 0$, slope is $2(0) = 0$

Meaning of Derivatives

$$\boxed{\frac{d}{dx}\left(x^2\right) = 2x}$$

What this means

The slope of the graph
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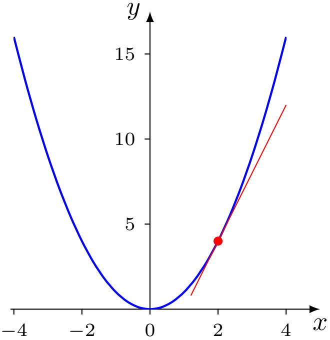

at $x = 2$, slope is $2(2) = 4$

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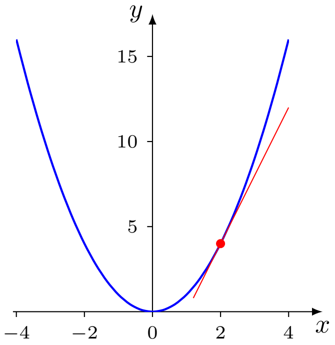

at $x = 2$, slope is $2(2) = 4$

derivative = rate of change = slope of graph = slope of tangent line

General Rule:

$$\frac{d}{dx}\left(x^{2}\right) = 2x$$

$$\frac{d}{dx}\left(x^{3}\right) = 3x^{2}$$

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The exponent comes out front. Then subtract one from exponent.

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Examples:

1. $\frac{d}{dx}\left(x^{7}\right) =$

A $= 7x^7$ B $= 6x^6$ C $= 6x^7$ D $= 7x^6$ E $= 0$

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More Examples

$$\boxed{\frac{d}{dx}\left(x^{n}\right) = n x^{n-1}}$$

3. $\dfrac{d}{dx}\left(x^{1/2}\right) =$

A= $\frac{1}{2}x^{1/2}$ B= $-\frac{1}{2}x^{-1/2}$ C= $\frac{1}{2}x^{-1/2}$

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Rule: ALWAYS rewrite the thing you want derivative of as x^n

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5. $\frac{d}{dx}\left(\sqrt{x}\right) =$

A$= -\frac{1}{2}\sqrt{x}$ B$= \frac{1}{2}x^{-1/2}$ C$= -\frac{1}{2}x^{-1/2}$

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Polynomials

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A= I have an answer B= I am working on it C= Help!

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A= I have an answer B= I am working on it C= Help!

Answer: $12x^3 + 27x^2$

A= I got it B= I nearly got it C= I want my mommy!

The Meanings of Derivatives

The derivative of $f(x) = x^2 + 3x + 1$ is $f'(x) = \frac{df}{dx} = 2x + 3$. This means:

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- $\Delta f \approx 7\Delta x$ near $x = 2$.
- $f(2 + \Delta x) \approx f(2) + 7\Delta x$.

Applications

7. What is the slope of the graph $y = 3x^2 - 7x + 5$ at $x = 1$?

A$= -2$ B$= -1$ C$= 0$ D$= 1$ E$= 2$

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8. What is the instantaneous rate of change of $f(x) = x^3 - 2x + 3$ at $x = 1$?

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9. After t seconds a hamster on a skate board is $4t^2 + 2t$ cm from the origin on the x-axis. What is the exact speed of the hamster (in cm/sec) after 2 seconds?

A$= 10$ B$= 16$ C$= 18$ D$= 20$ E$= 14$

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Why This Works (§8.9)

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Example: $n = 3$: Calculate the average rate of change of x^3 between x and $x + \Delta x$ then take limit as $\Delta x \to 0$.

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Example: $n = 3$: Calculate the average rate of change of x^3 between x and $x + h$ then take limit as $h \to 0$.

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A similar calculation works for x^n for any n.

More Applications

10. What is the equation of the tangent line at $x = 1$ to the graph of $y = x^3 - x + 4$? The tangent line is $y = \ldots$?

A$= x + 3$ B$= 3x + 1$ C$= 2x - 2$ D$= 2x + 2$ E$= 6x - 2$

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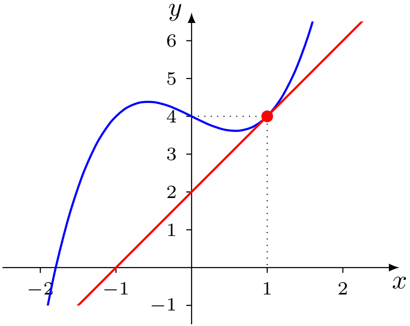
Here's a picture:



Another Example

11. The temperature in an oven after t minutes is $50 + t^3$ °F. How quickly is the temperature rising after 2 minutes?

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Example: $$5x^4 = \frac{d}{dx}\left(x^5\right) = \frac{d}{dx}\left(x^2 \cdot x^3\right) \neq (2x)(3x^2) = 6x^3$$

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12. $\frac{d}{dx}\left((x^2+1)(x^3+1)\right) = ?$

A= $6x^3$ B= $5x^4 + 3x^2 + 2x$ C= $x^5 + x^3 + x^2 + 1$ D= Other

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Answer: $\boxed{\text{B}}$

Once upon a time. . .

There was a happy math professor and he told his happy students:

Once upon a time...

There was a happy math professor and he told his happy students:

"When you work out derivatives ALWAYS write the $\frac{d}{dx}$ part so you write something like

$$\boxed{\frac{d}{dx}\left(3x^2+5x+2\right)=6x+5}$$

and you never-ever-ever write

$\boxed{3x^2+5x+2 \qquad 6x+5}$ or even worse $\boxed{3x^2+5x+2=6x+5.}$

Because if you don't do as I say I will become a sad math professor and you will repeat this class."