October 9, 2012

Use limit definition of derivative to calculate the derivative of $2x^2 + 5x - 10$.

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Basic rules of differentiation

1) The Constant Rule:

The derivative of a constant function is 0. That is, if c is a real number, then

$$\frac{d}{dx}[c] = 0$$

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Use the definition to find the derivative of each: (With a partner)

a) $f(x) = x^1$

b) $f(x) = x^2$

c) $f(x) = x^3$

d) $f(x) = x^4$

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

f) $f(x) = x^{(-1)}$

g) $f(x) = x^{(-3)}$

h) $f(x) = 3x^2$

i) $f(x) = 2x^{(-3)}$

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2) The Power Rule:

If n is a rational number, then the function

$f(x) = x^n$ is differentiable and

$\frac{d}{dx}[x^n] = n\,x^{(n-1)}$

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Find the slope of the graph $y = x^4$ when

a) $x = -1$

b) $x = 0$

c) $x = 1$

d) $x = 2$

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Find an equation of a tangent line to the graph of
$f(x) = x^2$ when $x = -2$.

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3) The Constant Multiple Rule:

If f is a differentiable function and c is a real number, then cf is also differentiable and

$$\frac{d}{dx}[cf(x)] = c\,f'(x)$$

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Find the derivative of each:

a) $y = \frac{2}{x}$

b) $f(t) = \frac{4t^2}{5}$

c) $y = 2\sqrt{x}$

d) $y = \frac{3x}{2}$

e) $y = \frac{5}{(2x)^3}$

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4) The Sum and Difference Rules

The sum or difference of differentiable functions is itself differentiable.

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

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

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Find the derivative of each:

a) $f(x) = x^3 - 4x + 5$

b) $g(x) = \frac{-x^4}{2} + 3x^3 + 2x$

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Derivative of the sine and cosine functions:

(Remember the limits of the trig functions as x approaches 0?)

$\frac{d}{dx}[\sin x] = \cos x$

$\frac{d}{dx}[\cos x] = -\sin x$

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Rates of Change:

We know the derivative is used to determine slope. It can also be used to determine the rate of change of one variable with respect to another (which is exactly what slope is!)

A common use for rate of change is to describe the motion of an object moving in a straight line--in such cases, the movement to the right or upward is considered to be positive and the movement to the left or downward is considered to be negative.

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We know the formula

$D = rt$

This can be written

$r = \frac{D}{t}$

and

$$\text{Average velocity} = \frac{\text{change in distance}}{\text{change in time}}$$

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Finding the average velocity of a falling object

If a billiard ball is dropped from a height of 100 ft, its height s at time t is given by the position function

$$s = -16t^2 + 100$$

where s is measured in feet and t is measured in seconds.

Find the average velocity over each of the following time intervals:

a) [1, 2]

b) [1, 1.5]

c) [1, 1.1]

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Suppose we want to find the instantaneous velocity (or simply, the velocity) of the object when t = 1. Just as we approximated the slope of the tangent line by using a secant line, we can calculate the velocity at time t by calculating the average velocity over a very small interval [1, 1+ t].

In general, if s = s(t) is the position function for an object moving in a straight line, then the velocity at time t is

$$v(t) = \lim_{\Delta t \to 0} \frac{s(t + \Delta t) - s(t)}{\Delta t} = s'(t)$$

In other words, the velocity function is the derivative of the position function. Velocity can be positive, negative or zero.

The speed of an object is the absolute value of the velocity--speed cannot be negative.

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The position of a free-falling object (neglecting air resistance) under the influence of gravity can be represented by the equation

$s(t) = 1/2\ gt^2 + v_0t + s_0$

where s_0 is the initial height of the object,

v_0 is the initial velocity of the object and

g is the acceleration due to gravity (-32 ft/sec^2 on Earth (or -9.8 m/sec^2)

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At time t = 0, a diver jumps from a platform diving board that is 32 feet above the water. The position of the diver is given by

$s(t) = -16t^2 + 16t + 32$

where s is measured in feet and t is measured in seconds

a) When does the diver hit the water?

b) What is the diver's velocity on impact?

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