
Differentiation

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Differentiation is the most important thing in calculus so let's get to it!

Using `diff`

What about calculus? Don't worry -- Matlab will not let you down! Suppose you'd like to differentiate the function $\log(6*x+2)$. You could either do it yourself or... just ask Matlab to do it with the `diff` command:

```
syms x
diff(log(6 * x + 2))
```

```
ans =
6/(6*x + 2)
```

Or with a symbolic function:

```
syms f(x);
f(x) = cos(x^2+2*tan(x));
diff(f(x))
```

```
ans =
-sin(2*tan(x) + x^2)*(2*x + 2*tan(x)^2 + 2)
```

Higher Derivatives

What could be easier?

Would you like to find the *third* derivative of the function $\log(6*x+2)$? That's easy too -- just pass 3 as a second parameter to the `diff` command:

```
diff(log(6 * x + 2), 3)
```

```
ans =  
432/(6*x + 2)^3
```

IMPORTANT

It is a common mistake to believe that the 3 in the above calculation will take the first derivative and plug in $x=3$. **It does not do this!** If you want to differentiate and then plug in just wait a bit and we'll cover that.

Higher Derivatives - An Alternate Way

It's worth noting that we could have taken the third derivative this way, though we probably wouldn't:

```
diff(diff(diff(log(6*x+2))))
```

```
ans =  
432/(6*x + 2)^3
```

A Different Variable

Suppose our expression has two variables and we want the derivative with respect to one of them. As usual x is the default

```
syms a x  
diff(a^3*x^4)
```

```
ans =  
4*a^3*x^3
```

but we can tell Matlab differently.

```
diff(a^3*x^4,a)
```

```
ans =  
3*a^2*x^4
```

We can even do the second derivative with respect to a .

```
diff(a^3*x^4,a,2)
```

```
ans =
```

$$6*a*x^4$$

Wait, that Second Parameter?

Matlab is smart. If the second parameter is a variable it will take the derivative with respect to that variable. If it's a number it will take that numbered derivative. If it sees a variable and *then* a number it will take that numbered derivative with respect to that variable.

Again with Symbolic Functions

If we have a symbolic function of multiple variables we can differentiate too:

```
syms f(x,y);  
f(x,y) = 2*x^2*y^3+x*sin(x*y);  
diff(f(x,y),x)
```

$$\text{ans} =$$
$$\sin(x*y) + 4*x*y^3 + x*y*\cos(x*y)$$

We could even take the derivative with respect to x and then with respect to y . This might only make sense to those with multidimensional calculus:

```
diff(diff(f(x,y),x),y)
```

$$\text{ans} =$$
$$2*x*\cos(x*y) + 12*x*y^2 - x^2*y*\sin(x*y)$$

Differentiating and then Plugging In - Using subs.

It may seem a bit late but this is the perfect time to talk about plugging things into symbolic expressions. Here's how. Suppose we simply want to plug $x=3$ into x^2-x+2 . We do:

```
subs(x^2-x+2,x,3)
```

$$\text{ans} =$$
$$8$$

So now to take the derivative and then plug in, we simply nest the commands. Here's the second derivative of $x^3+\exp(x^2)$ with $x=1$ plugged in:

```
subs(diff(x^3+exp(x^2),2),x,1)
```

```
ans =  
22.3097
```

Or with a function:

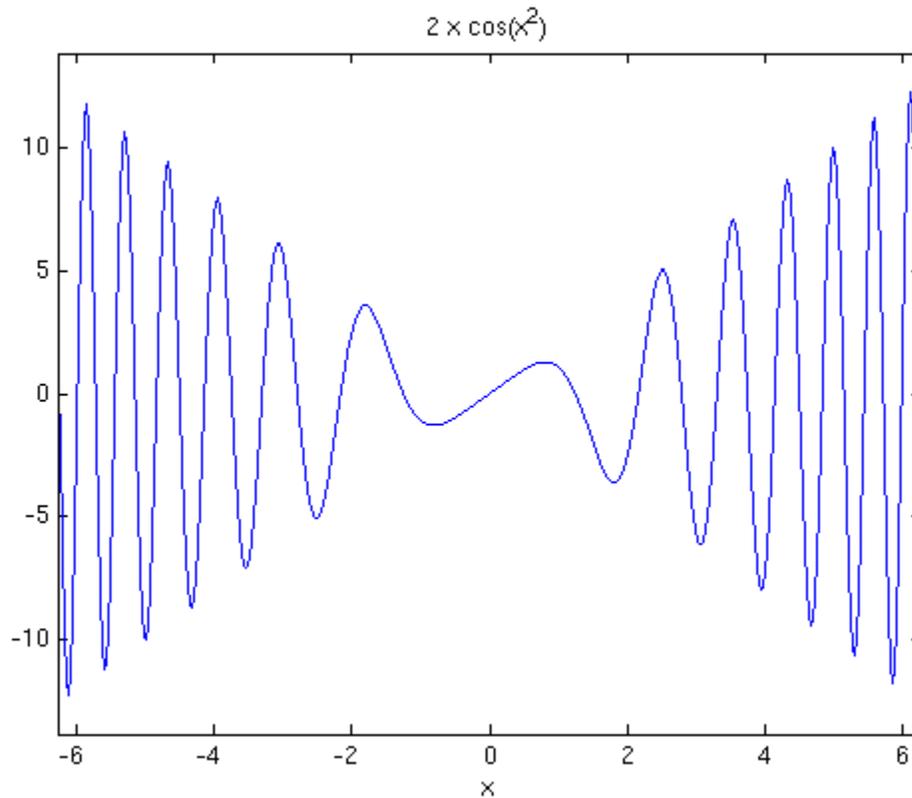
```
syms f(x);  
f(x) = 1/(x^2+3);  
subs(diff(f(x)),x,-3)
```

```
ans =  
0.0417
```

Plotting Derivatives

Likewise we can nest `diff` inside `ezplot`. Here's an example, a plot of the derivative of $\sin(x^2)$:

```
ezplot(diff(sin(x^2)))
```



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