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More With Functions

Now that you know two of the three ways to define functions (symbolically and with handles) let's briefly look at what each is really good for.

Differentiation of Functions

As differentation is a symbolic operation we must do it on the symblic definition of a function like this:

```
syms x;
f = 'x^3+2*x';
diff(f)
```

```
ans =

   -26   -43    -8     7    -8    78
```

If you have a function handle this might leave you wondering how to do the job. But Matlab is more flexible than you might think! Even though function handles are symbolic, their output is. In other words if `f` is a function handle and `x` is symbolic then `f(x)` is symbolic. This means that the following will work just fine:

```
g = @(x) x^2+x;
syms x;
diff(g(x))
```

```
ans =

2*x + 1
```

Of course since the result of diff is a symblic expression if we wish to plug something in we'll have to go back to the subs command. The following declares a function handle, differentiates the function and then plugs in a number:

```
g = @(x) x^2+x;
```

```
syms x;
subs(diff(g(x)),3)
```

```
ans =

     7
```

Integration of Functions

As was true for differentiation is true for integration. Consider the following which creates a file handle, converts it to a string and performs a definite integral:

```
g = @(x) sin(5*x)+tan(x)+x;
syms x;
int(g(x),0,pi/4)
```

```
ans =

log(2)/2 + 2^(1/2)/10 + pi^2/32 + 1/5
```

Or some other examples:

```
g = @(x) sin(5*x)+tan(x)+x;
syms x;
int(g(x))
int(g,x)
int(g,x,0,pi/4)
```

```
ans =

log(tan(x)^2 + 1)/2 - cos(5*x)/5 + x^2/2
```

```
ans =

log(tan(x)^2 + 1)/2 - cos(5*x)/5 + x^2/2
```

```
ans =

log(2)/2 + 2^(1/2)/10 + pi^2/32 + 1/5
```

Numerical Integration

The commands `quad` and `quadl` will numerically integrate but only function handles, not symbolic expressions. However we must recall that back when we learned the `quad` command we had to use our special operations `.*`, `./` and `.^`. So for example the following will work:

```
g = @(x) x.^2+sin(x);
quad(g,0,2)
```

```
ans =

    4.0828
```

The `matlabFunction` command

It often occurs that we have a symbolic expression and we wish to use `quad` on it. To do this we need to convert it to a function handle. Luckly the Matlab command `matlabFunction` does this. For example:

```
syms x
f=x^2+sin(x)
fh=matlabFunction(f)
quad(fh,0,pi)
```

```
f =

sin(x) + x^2


fh =

    @(x)sin(x)+x.^2


ans =

   12.3354
```

Think about what this does. First `x` is defined symbolically, then `f` is defined symbolically in terms of `x`. Then the function handle `fh` is created. Lastly we apply `quad`. I've purposefully left of the semicolons so you can see the output of each step.

Now you might wonder why we didn't just define the function as a function handle to begin with and in this example you'd be right, it would be easier that way. But suppose you want to do the following: Suppose you want to define a function, take the derivative, square it and multiply it by `x` and then apply `quad`. As you know the output from the derivative is symbolic so we have to somehow turn it back into a function handle before applying `quad`. Well, here we go, and in only one `quad` line too:

```
f = @(x) x.^3+x;
syms x;
quad(matlabFunction(x.*diff(f(x)).^2),-1,2)
```

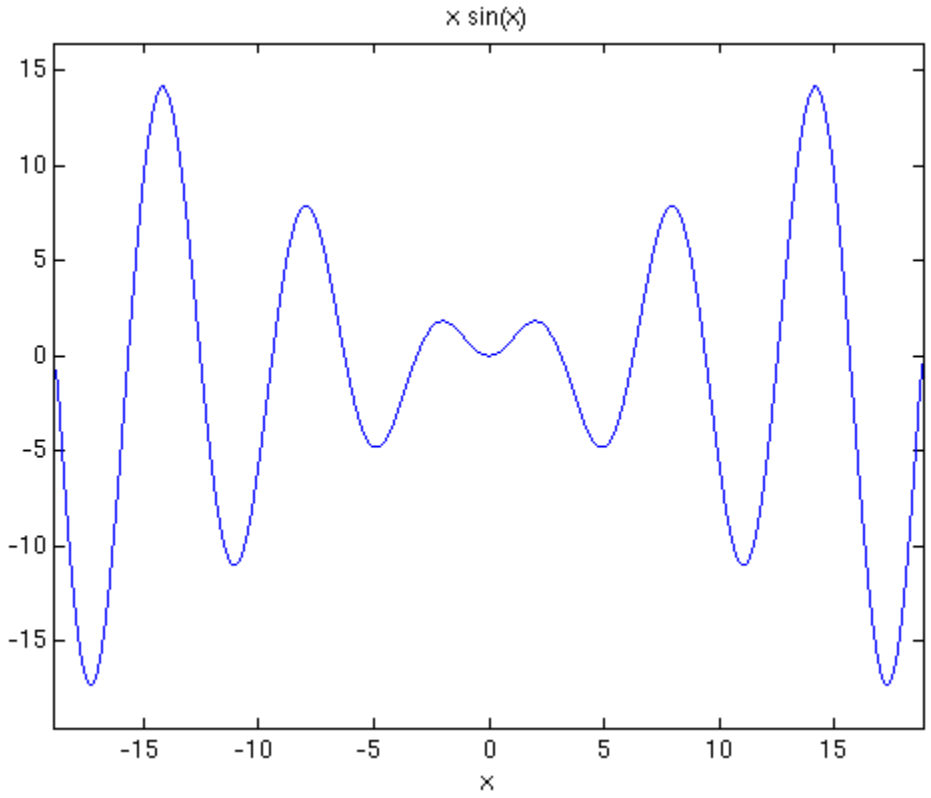
```
ans =

  118.5000
```

I've put the semicolons back in to keep it quiet but read through and think about what each step does. First define a function handle `f`. Define `x` symbolically so that `f(x)` is also symbolic. In the third line we apply `diff(f(x))` which gives a symbolic answer which is then fed into `matlabFunction` to give a function handle result. This means that `fh` is a function handle and we can do `quad` in the final line.

Graphing

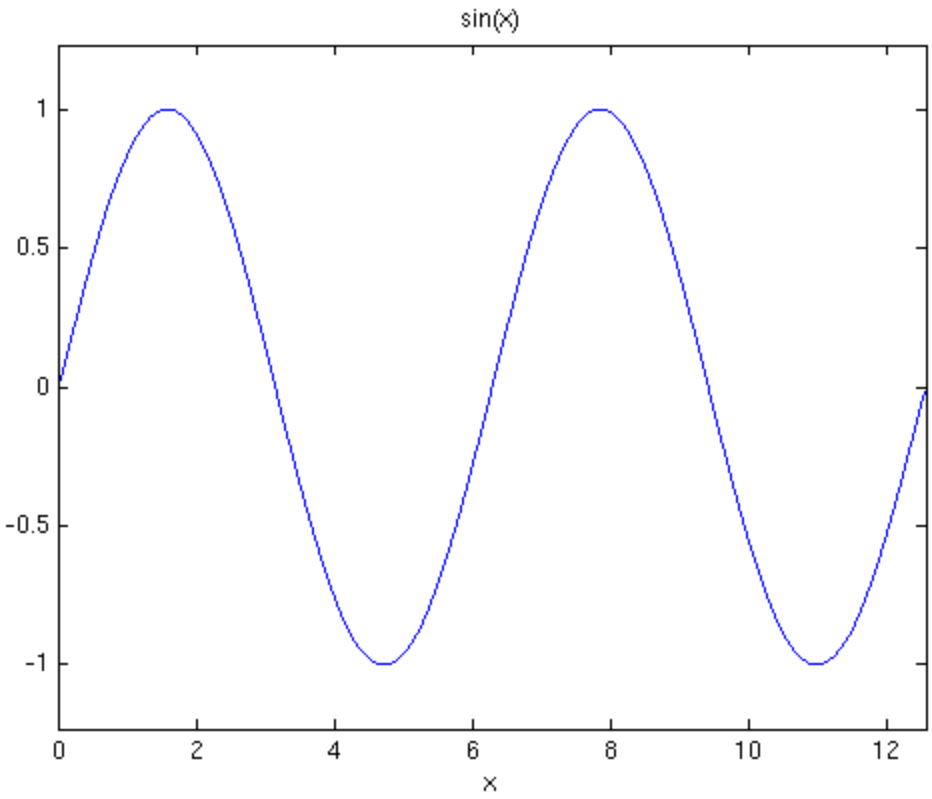
We saw earlier how ezplot can be used to graph functions as follows:

```
syms x;
ezplot(x*sin(x),[-6*pi,6*pi]);
```



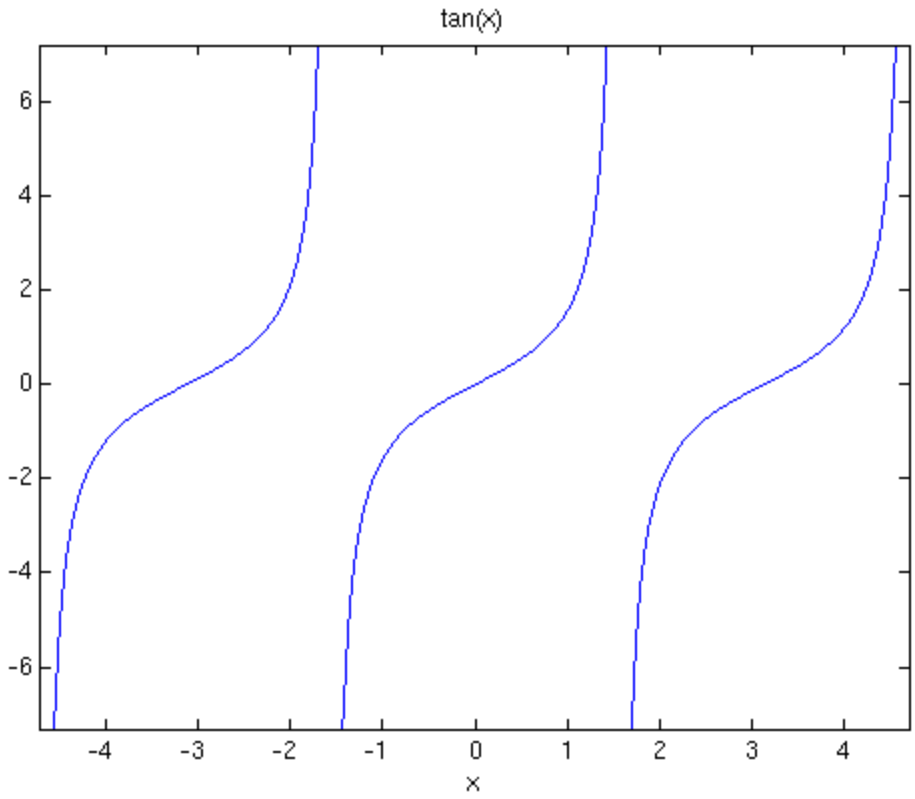
But what if you have a function defined in some manner and you wish to graph it? Can we use ezplot in these cases? Well the `ezplot` command is quite flexible and either methods can be happily fed to it. That is, any of the following will work:

```
syms x;
f=sin(x);
ezplot(f,[0,4*pi])
```



or

```
f = @(x) tan(x);
ezplot(f,[-3*pi/2,3*pi/2])
```



Finding Roots

Previously we saw the `fzero` command. This will work on either symbolic functions or function handles.

```
f = @(x) x+exp(x);
fzero(f,0)
```

```
ans =

   -0.5671
```

We can also use the `solve` command on function handles if we're careful. The trick is that `f` can be a function handle but `f(x)` (for symbolic `x`) is symbolic. Therefore for example:

```
f=@(x) x^2+2*x-6;
syms x;
solve(f(x))
```

```
ans =

   7^(1/2) - 1
 - 7^(1/2) - 1
```

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