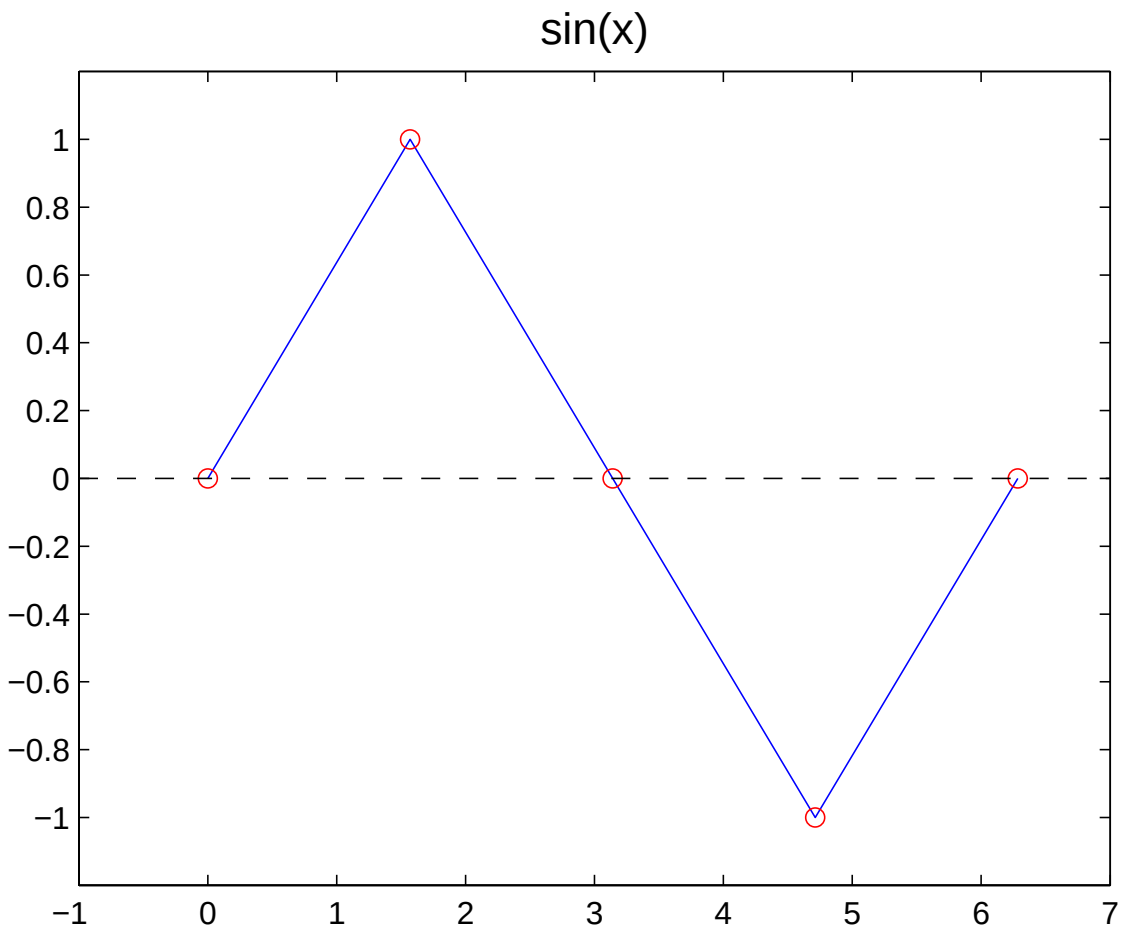
L10. Using Arrays to Plot Continuous Functions

Linspace

Array Operations

Table → Plot

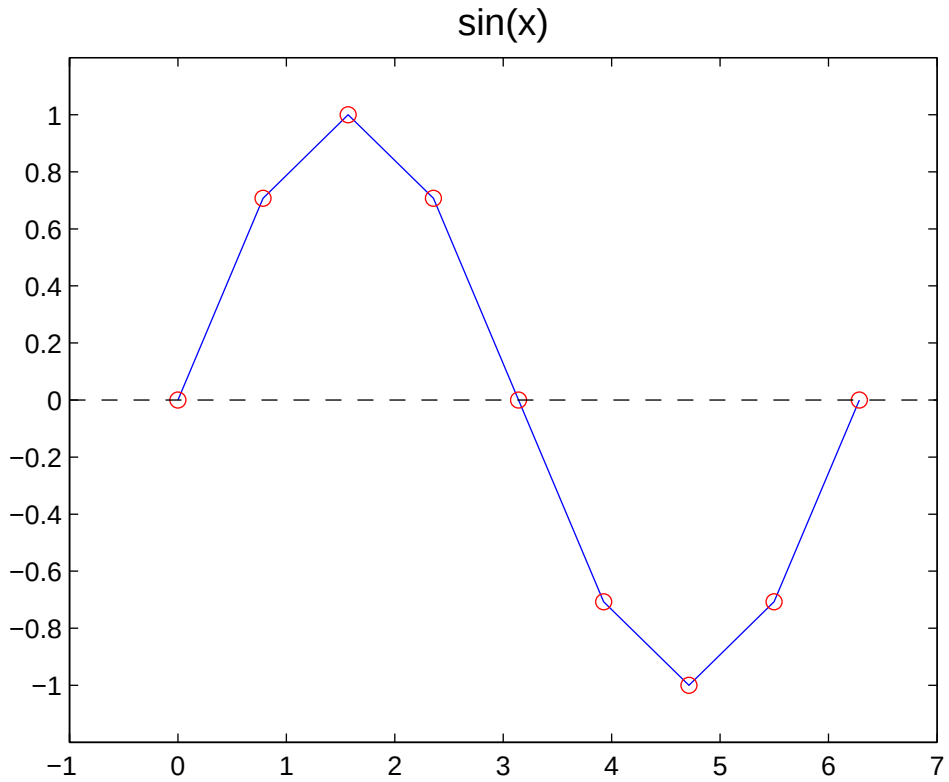
x	sin(x)
0.00	0.0
1.57	1.0
3.14	0.0
4.71	-1.0
6.28	0.0



Plot based on 5 points

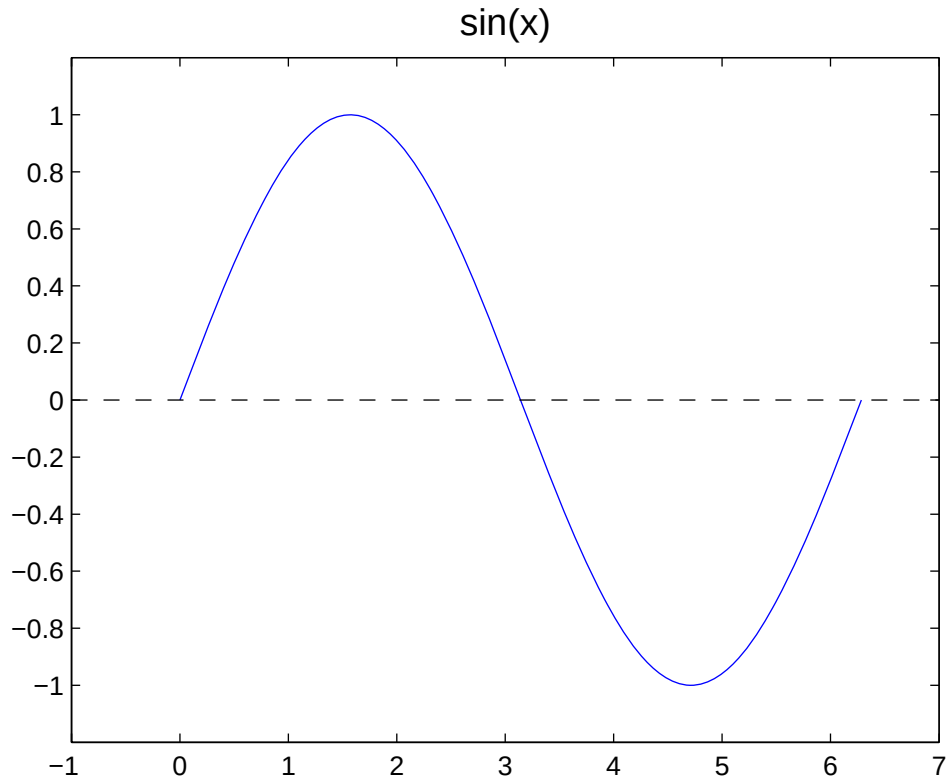
Table → Plot

x	sin(x)
0.000	0.000
0.784	0.707
1.571	1.000
2.357	0.707
3.142	0.000
3.927	-0.707
4.712	-1.000
5.498	-0.707
6.283	0.000



Plot based on 9 points

Table → Plot

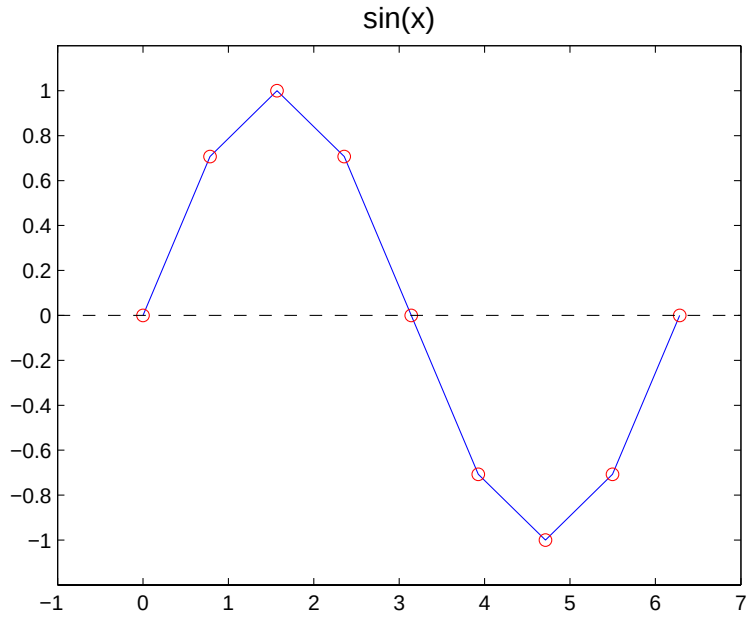


Plot based on 200 points—looks smooth

Generating Tables and Plots

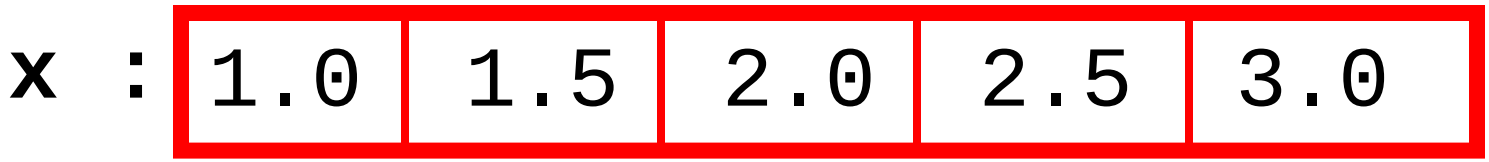
x	sin(x)
0.000	0.000
0.784	0.707
1.571	1.000
2.357	0.707
3.142	0.000
3.927	-0.707
4.712	-1.000
5.498	-0.707
6.283	0.000

```
x = linspace(0,2*pi,9);
y = sin(x);
plot(x,y)
```



linspace

```
x = linspace(1,3,5)
```



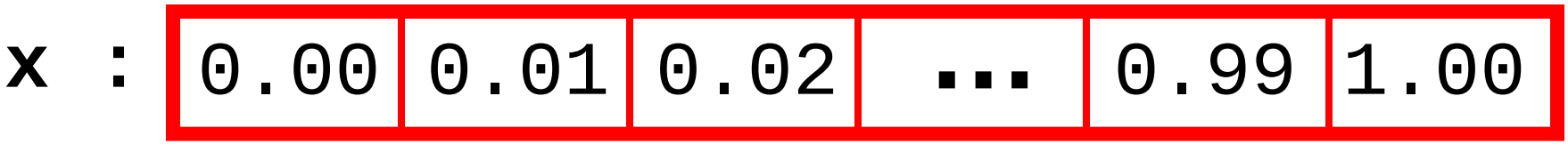
"x is a table of values"

"x is an array"

"x is a vector"

linspace

```
x = linspace(0,1,101)
```



Linspace Syntax

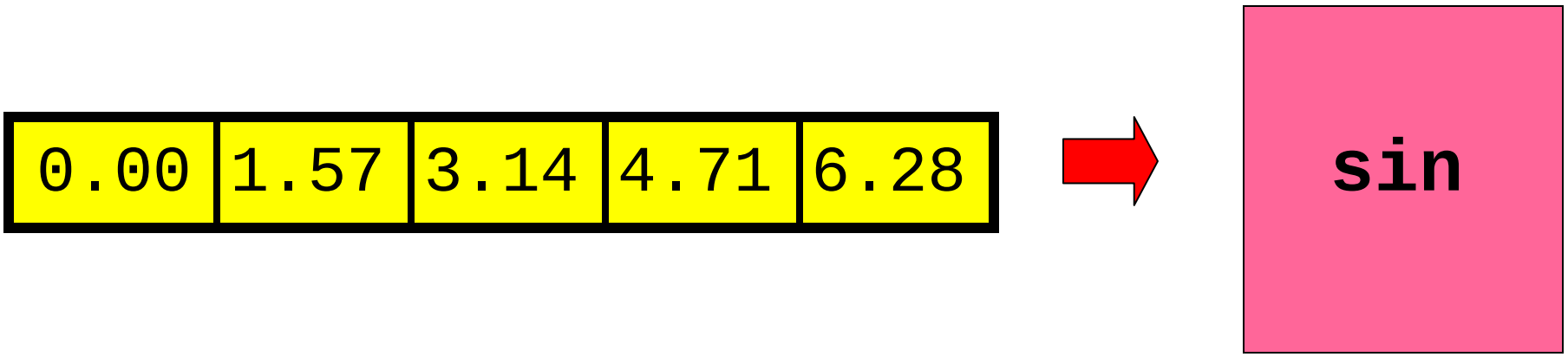
```
linspace(      ,      ,      )
```

Left Endpoint

Right Endpoint

Number of Points

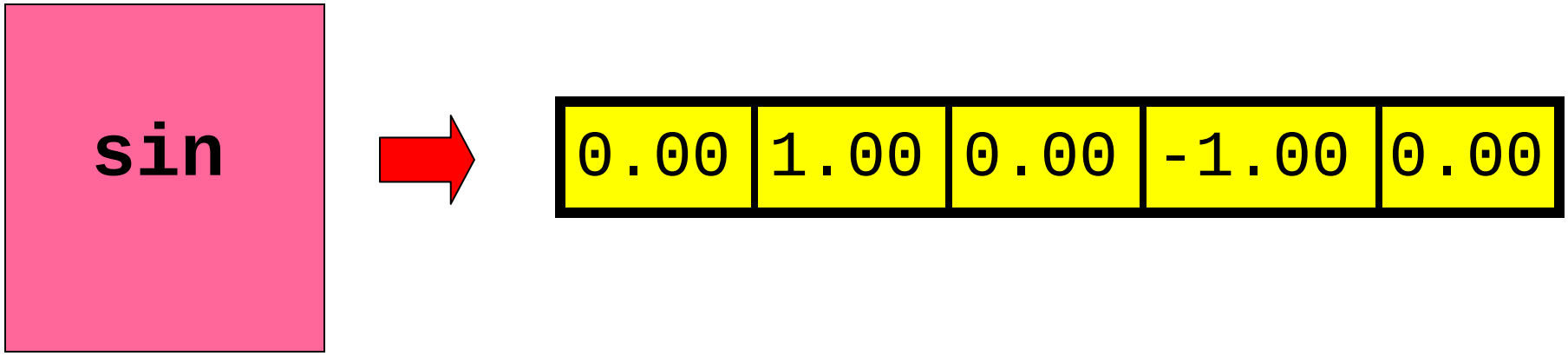
Built-In Functions Accept Arrays



x	sin(x)
0.00	0.0
1.57	1.0
3.14	0.0
4.71	-1.0
6.28	0.0

And…

Return Array of Function-evals



x	sin(x)
0.00	0.0
1.57	1.0
3.14	0.0
4.71	-1.0
6.28	0.0

Examples

```
x = linspace(0,1,200);
y = exp(x);
plot(x,y)
```

```
x = linspace(1,10,200);
y = log(x);
plot(x,y)
```

Can We Plot This?

$$f(x) = \frac{\sin(5x)\exp(-x/2)}{1+x^2}$$

-2 <= x <= 3

Can We Plot This?

$$f(x) = \frac{\sin(5x)\exp(-x/2)}{1+x^2}$$

-2 <= x <= 3

Yes!

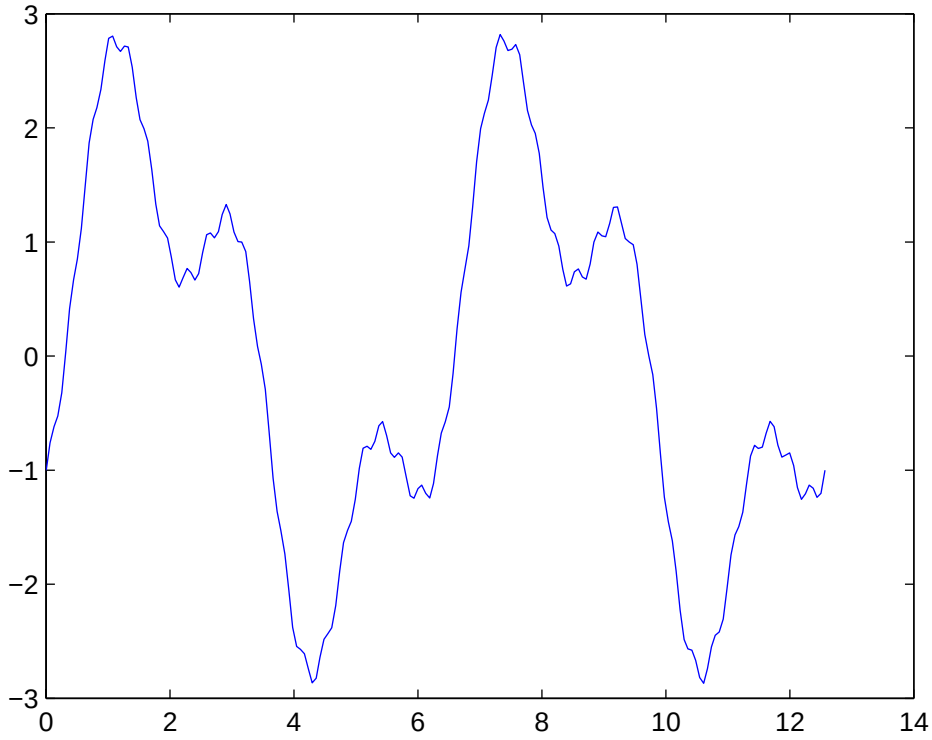
```
x = linspace(-2,3,200);
y = sin(5*x).*exp(-x/2)./(1 + x.^2)
plot(x,y)
```

Array operations

Must Learn
How to Operate on Arrays

Look at four simpler plotting challenges.

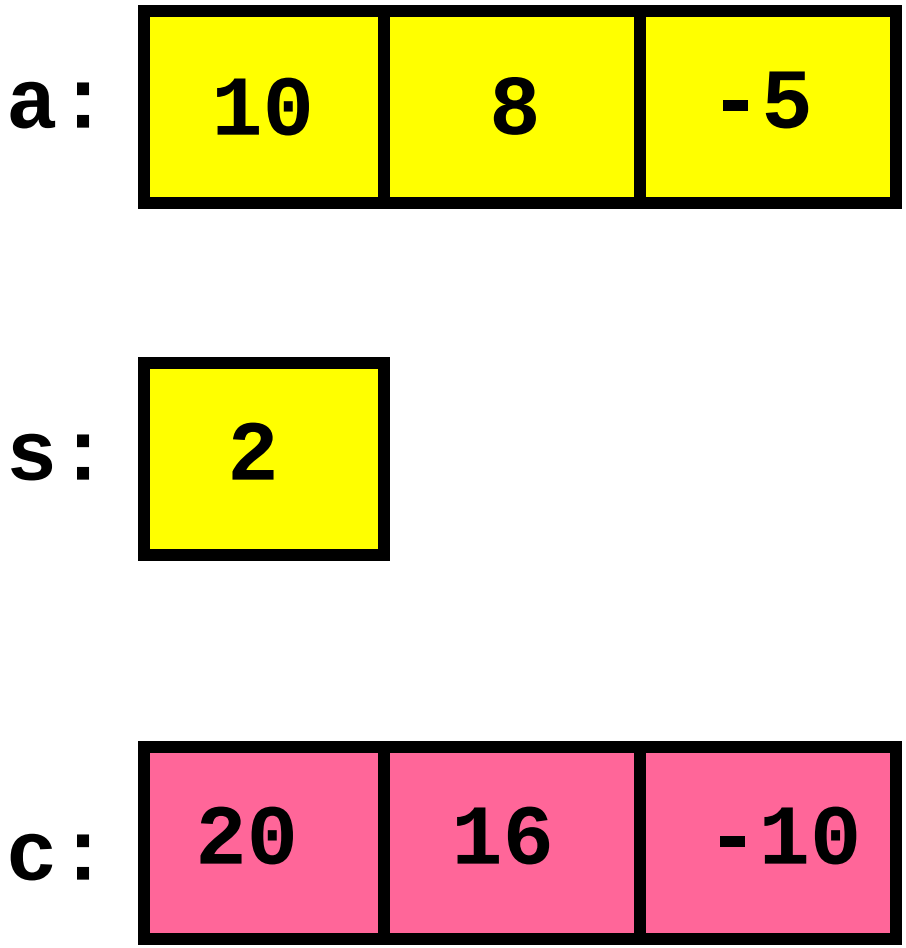
Example 1



$$f(x) = 2\sin(x) - \cos(3x) + .1*\sin(20x)$$

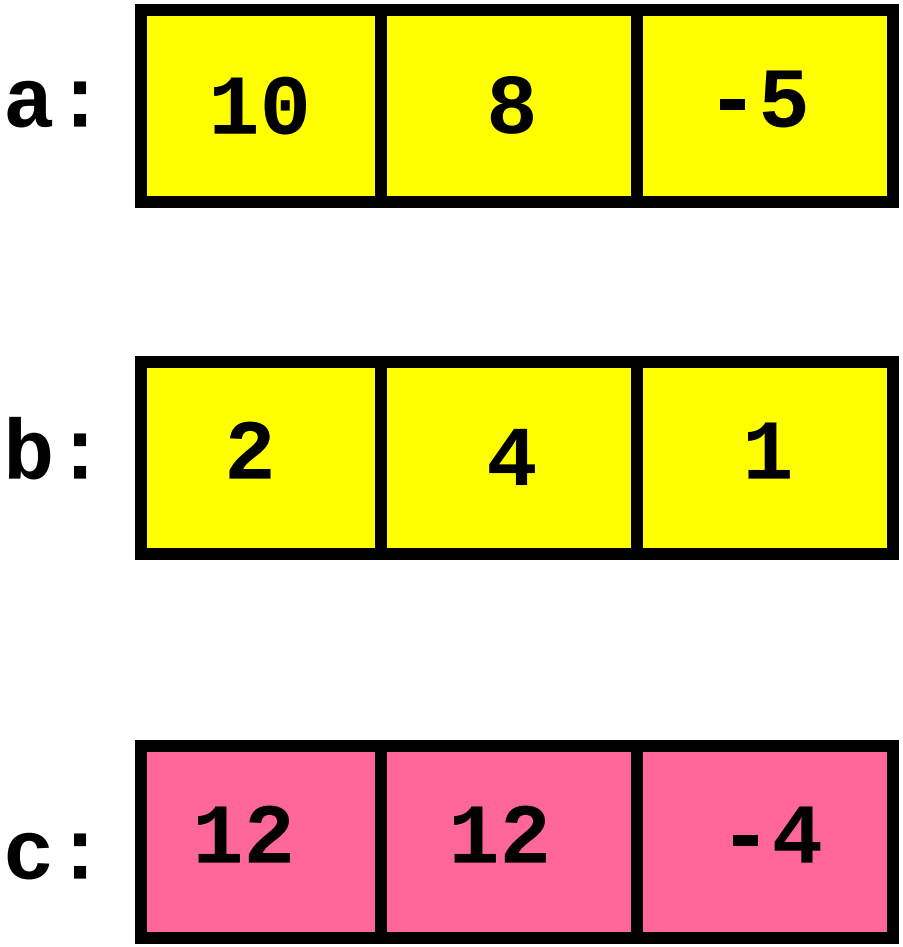
Scale (*)

```
c = s*a
```



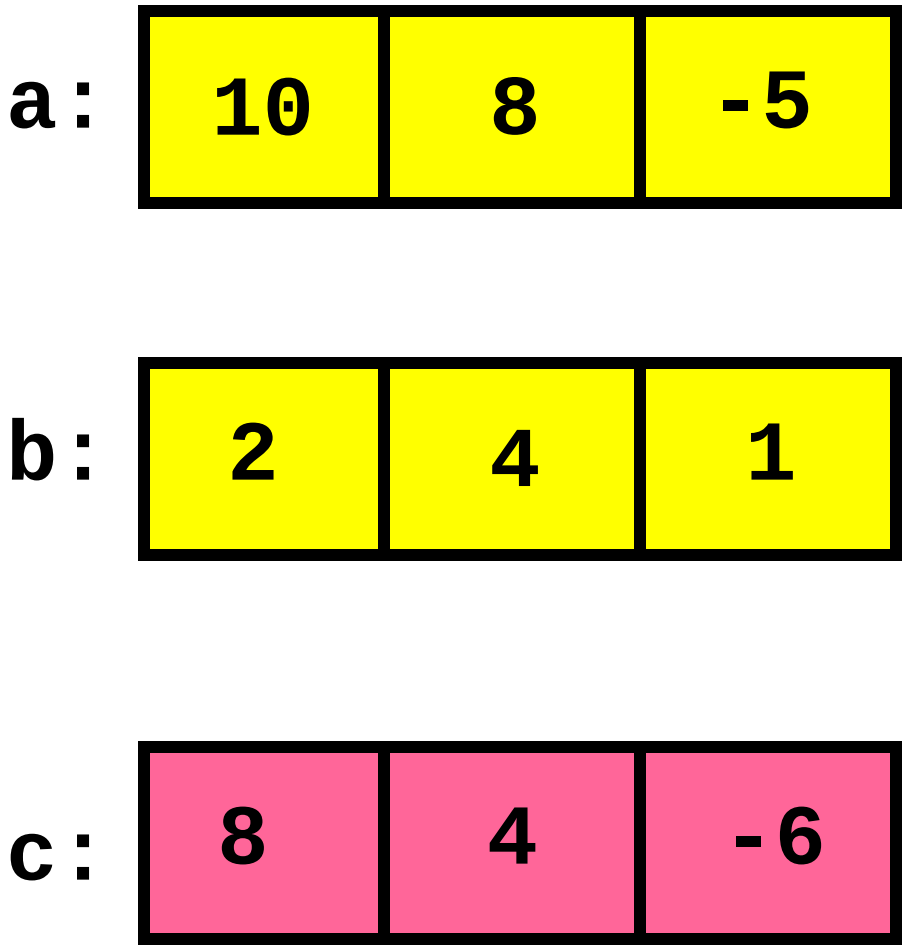
Addition

```
c = a + b
```



Subtraction

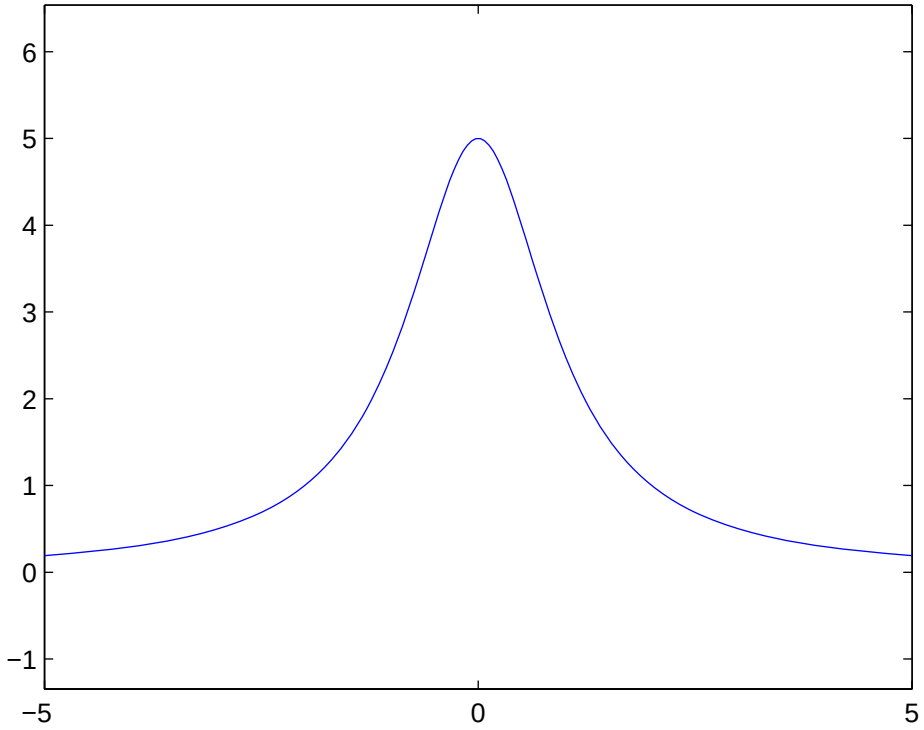
```
c = a - b
```



E.g.1 Sol'n

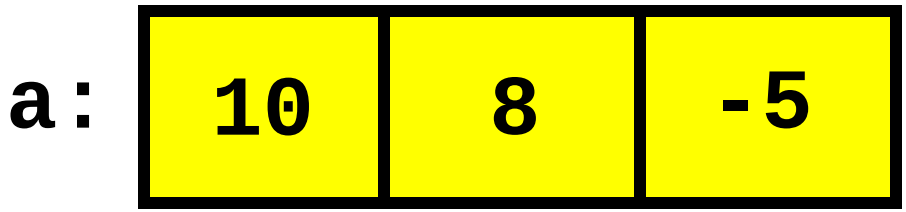
```
x = linspace(0,4*pi,200);
y1 = sin(x);
y2 = cos(3*x);
y3 = sin(20*x);
y = 2*y1 - y2 + .1*y3;
plot(x,y)
```

Example 2.

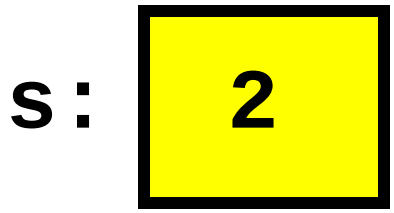


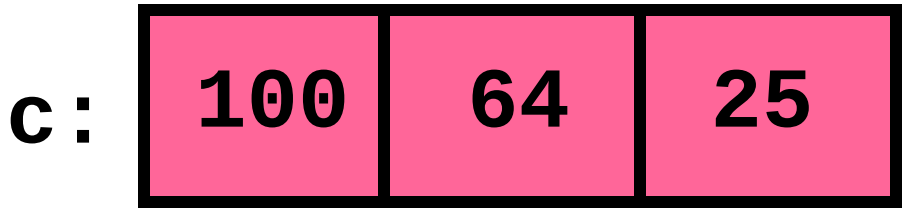
$$f(x) = \frac{5}{1+x^2}$$

Exponentiation

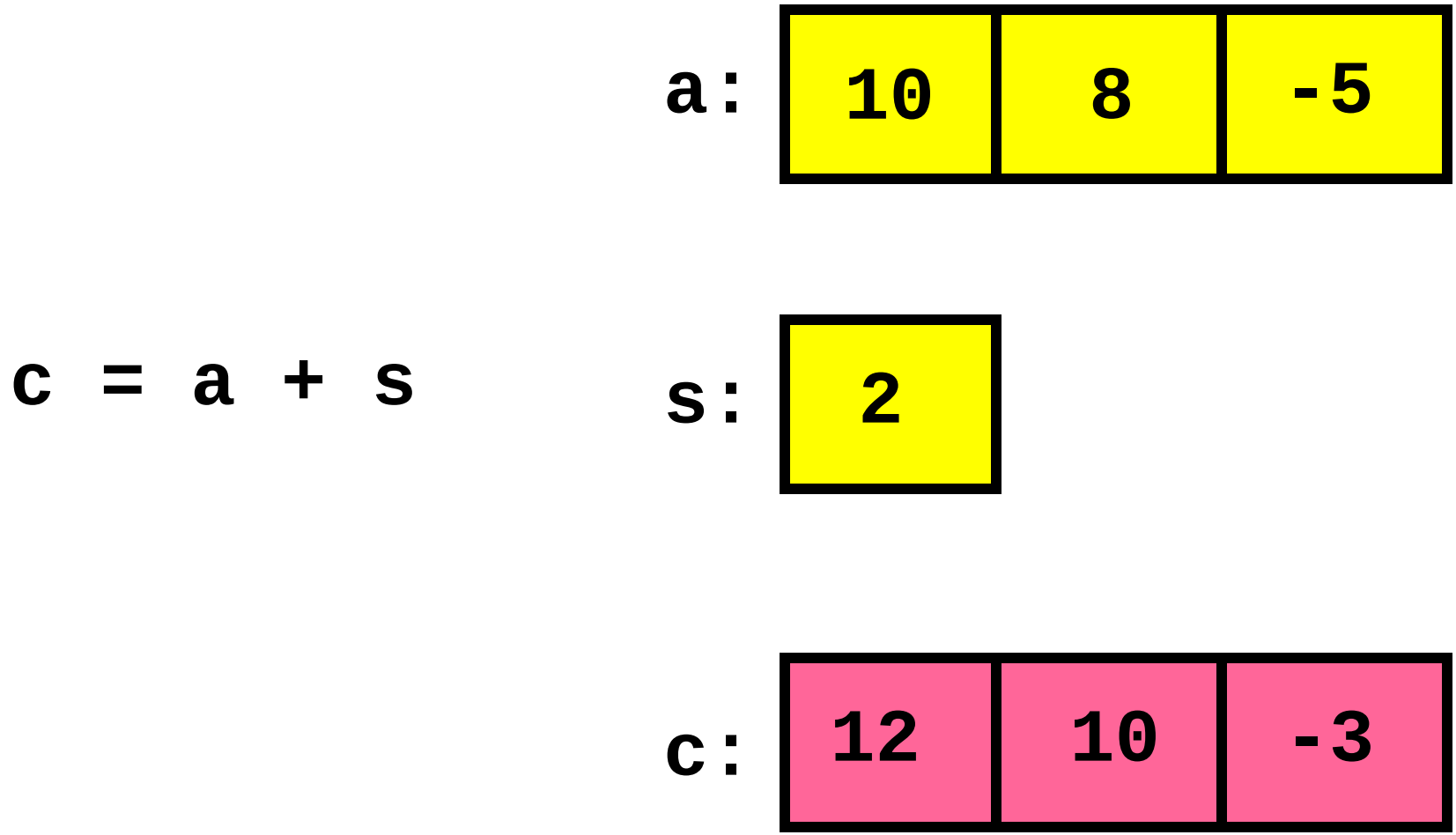



```
c = a.^s
```

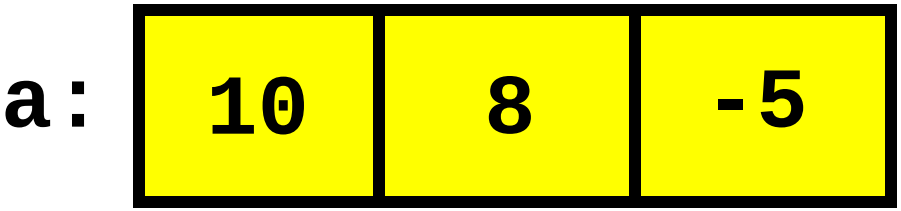




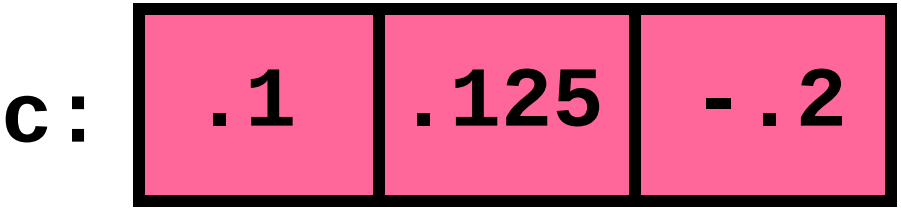
Shift



Reciprocation



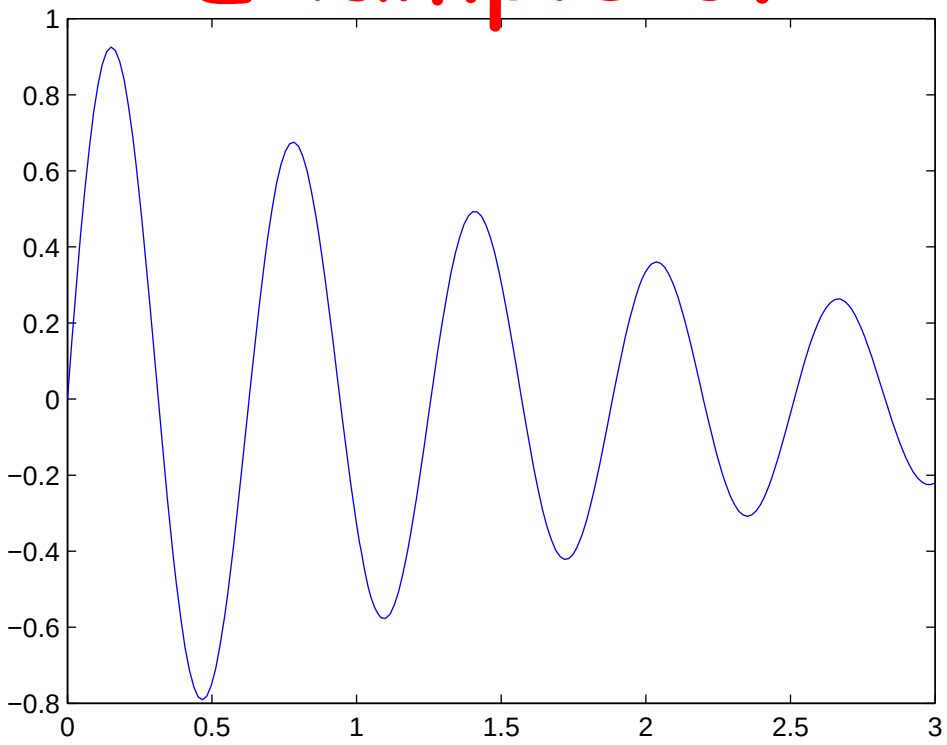

```
c = 1./a
```



E.g.2 Sol'n

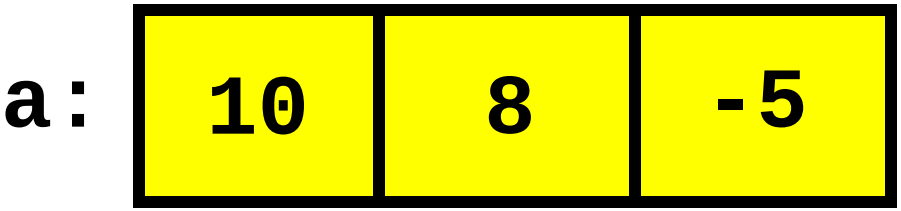
```
x = linspace(-5,5,200);
y = 5./(1+ x.^2);
plot(x,y)
```

Example 3.

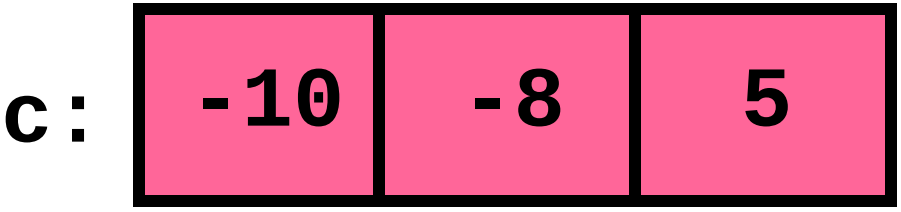


$$f(x) = \exp(-x/2)\sin(10x)$$

Negation

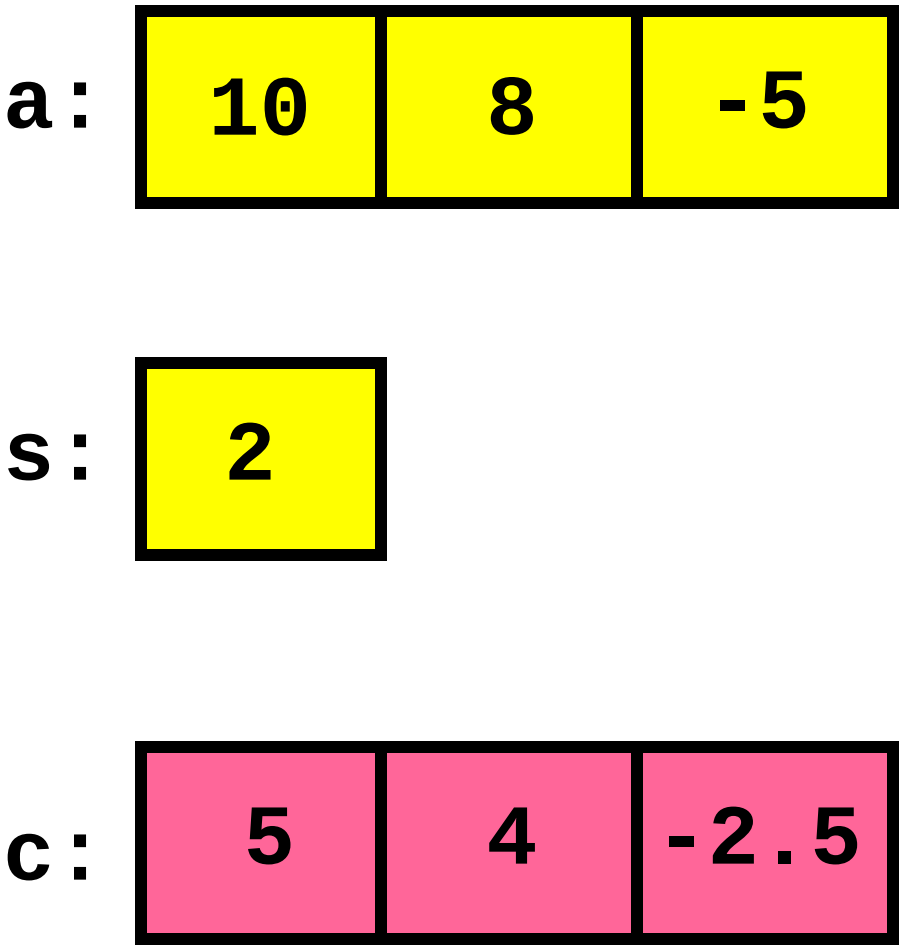



```
c = -a
```



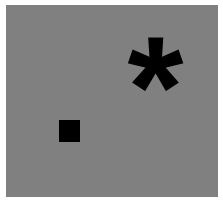
Scale (/)

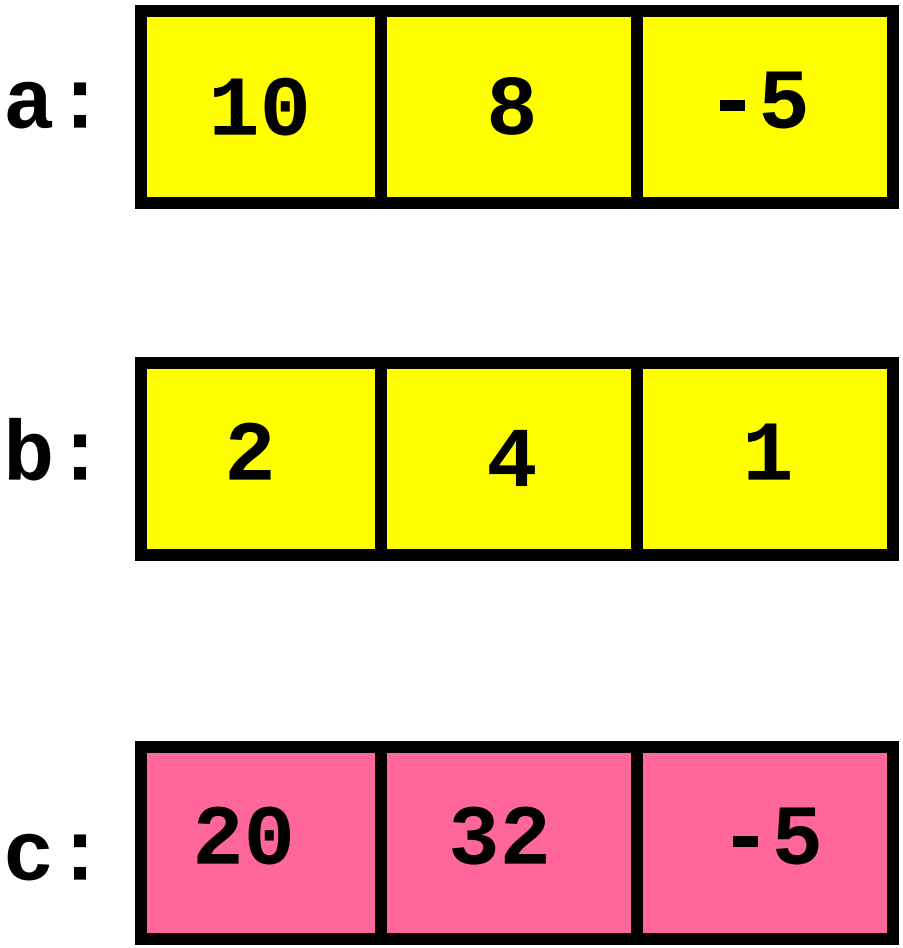
```
c = a/s
```



Multiplication

```
c = a .* b
```

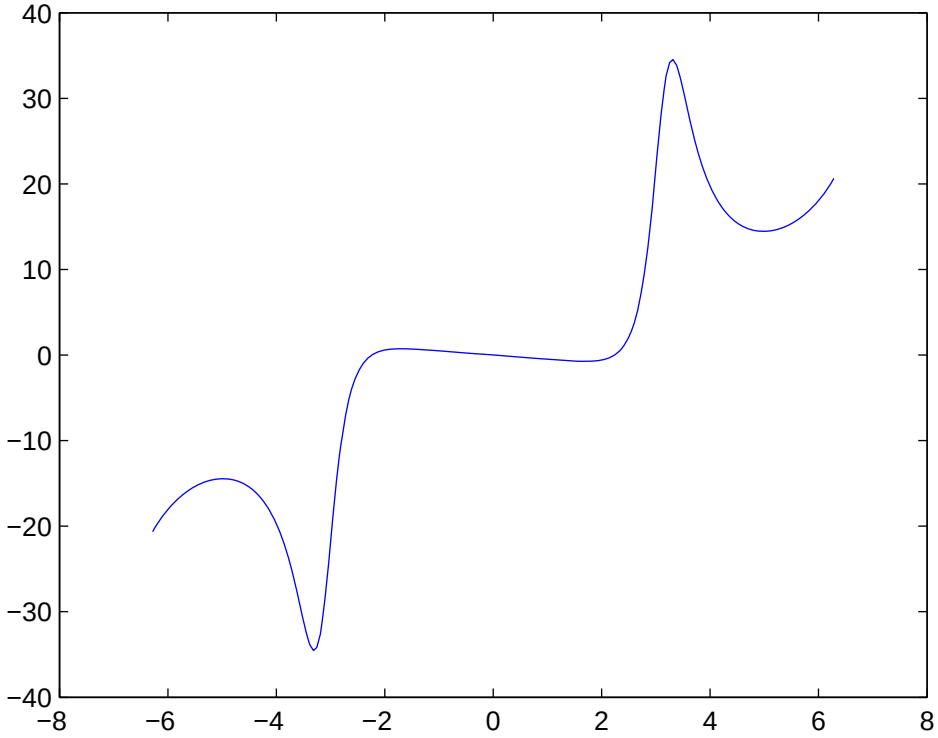




E.g.3 Sol'n

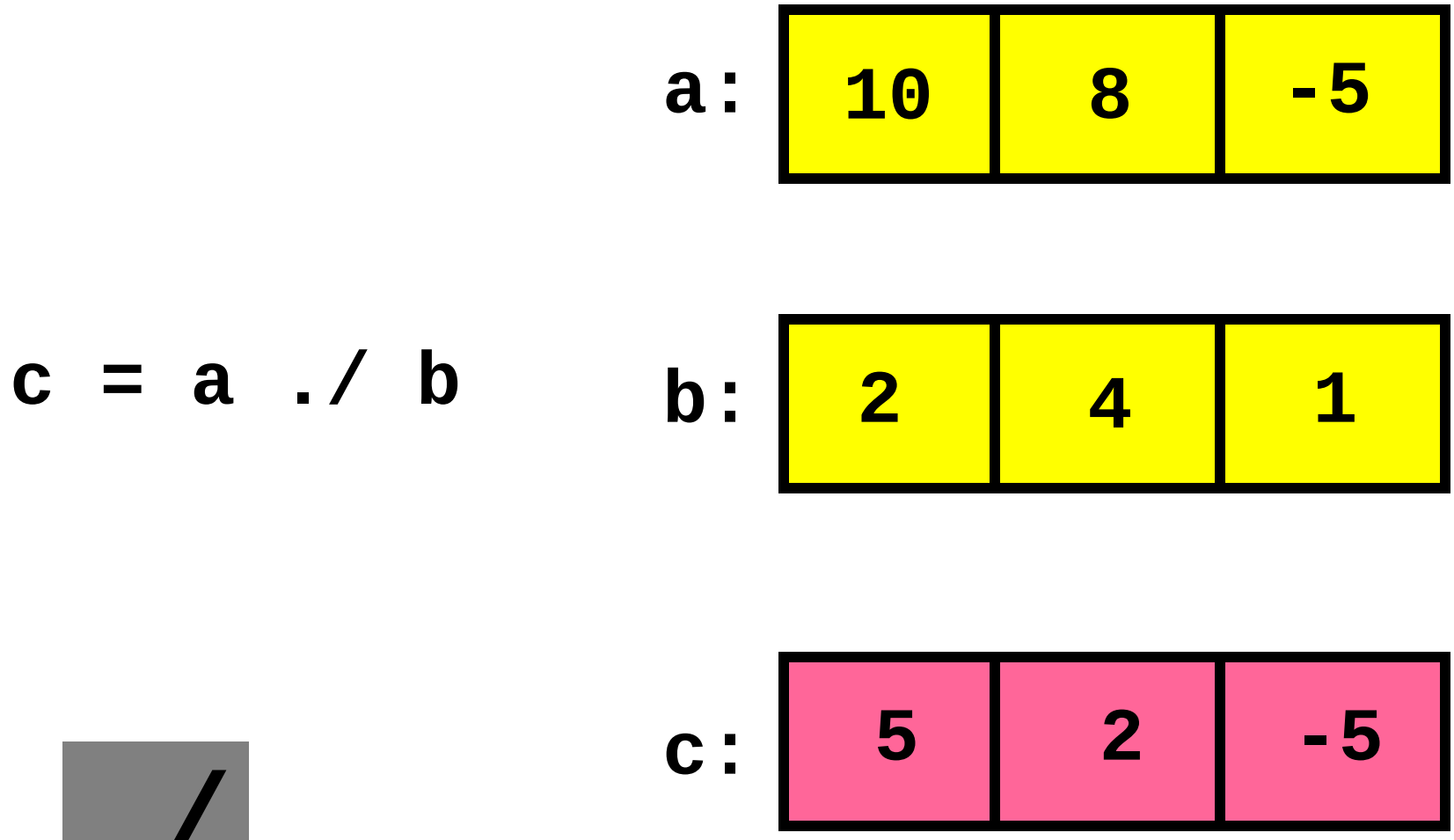
```
x = linspace(0,3,200);
y = exp(-x/2).*sin(10*x);
plot(x,y)
```

Example 4.



$$f(x) = \frac{.2\ x^3 - x}{1.1 + \cos(x)}$$

Division



`c = a ./ b`

`./`

E.g.4 Sol'n

```
x = linspace(-2*pi,2*pi,200);
y = (.2*x.^3 - x)./(1.1 + cos(x));
plot(x,y)
```

Question Time

How many errors in the following statement given that

```
x = linspace(0,1,100):
```

```
Y = (3*x .+ 1)/(1 + x^2)
```

A. 0 B. 1 C. 2 D. 3 E. 4

Question Time

How many errors in the following statement given that

```
x = linspace(0,1,100):
```

```
Y = (3*x .+ 1)/(1 + x^2)

Y = (3*x + 1) ./ (1 + x.^2)
```

A. 0 B. 1 C. 2 D. 3 E. 4

Question Time

Does this assign to y the values $\sin(0^o), \sin(1^o), \ldots, \sin(90^o)$?

```
x = linspace(0,pi/2,90);
y = sin(x);
```

A. Yes **B. No**

Question Time

Does this assign to y the values $\sin(0^o), \sin(1^o), \ldots, \sin(90^o)$?

```
%x = linspace(0,pi/2,90);
 x = linspace(0,pi/2,91);
 y = sin(x);
```

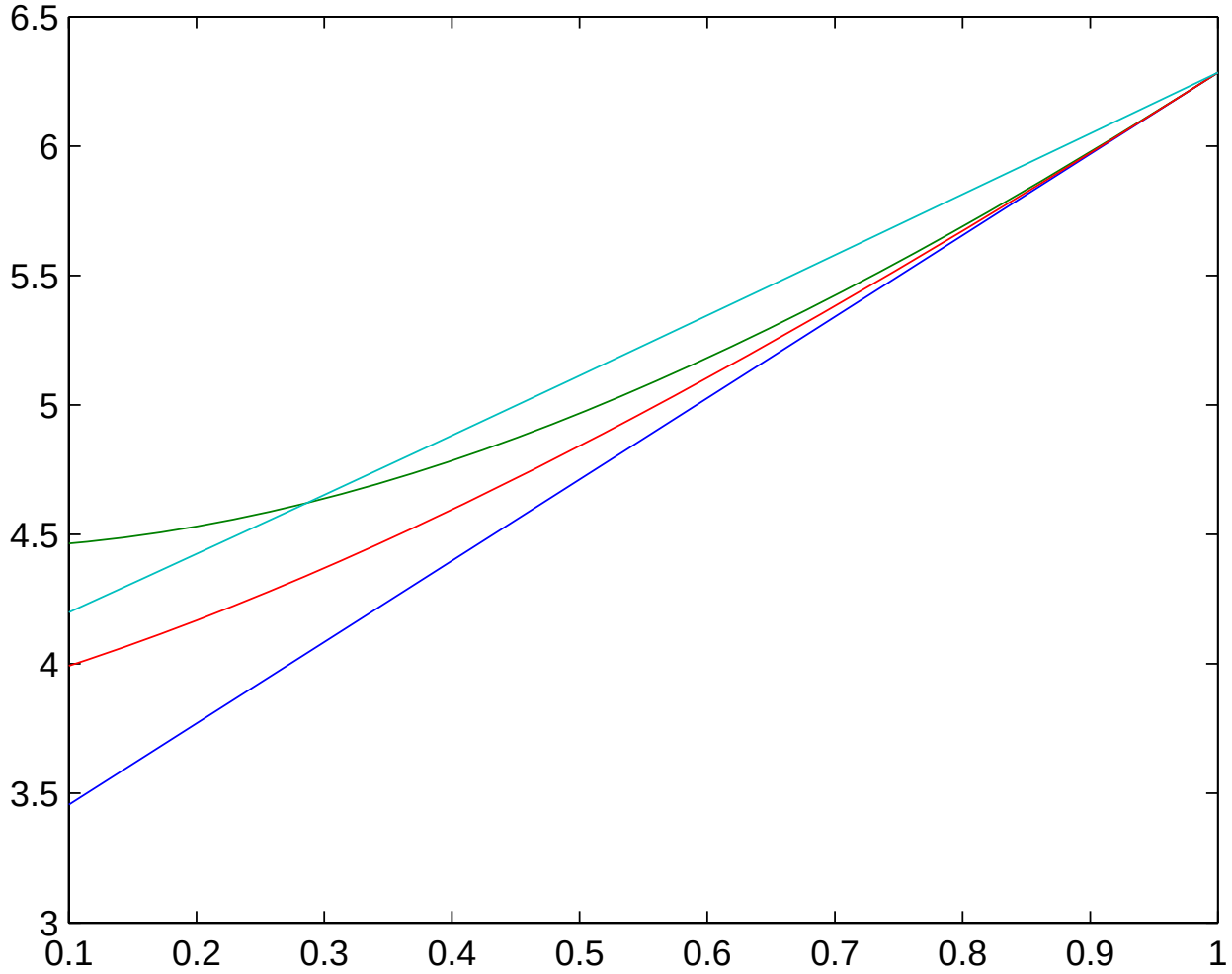
A. Yes

B. No

Ellipse Perimeter Estimates

```
b = linspace(.1,1,100);
a = 1; h = (a - b)./(a + b);
P1 = pi*(a+b);
P2 = pi*sqrt(2*(a^2+b.^2));
P3 = pi*sqrt(2*(a^2+b.^2)-…
                        ((a - b).^2)/2);
P4 = pi*(a + b).*(1 + h/8).^2;
plot(b,P1,b,P2,b,P3,b,P4)
```

Ellipse Perimeter Estimates



Plotting an Ellipse

$$\left(\frac{x}{a}\right)^2+\left(\frac{y}{b}\right)^2=1$$

Better:

$$\left(a\cos(t), b\sin(t)\right) \qquad 0 <= t <= 2\pi$$

Solution

```
a = input('Major semiaxis:');
b = input('Minor semiaxis:');

t = linspace(0,2*pi,200);
x = a*cos(t);
y = b*sin(t);
plot(x,y)
axis equal off
```

a = 5, b = 3