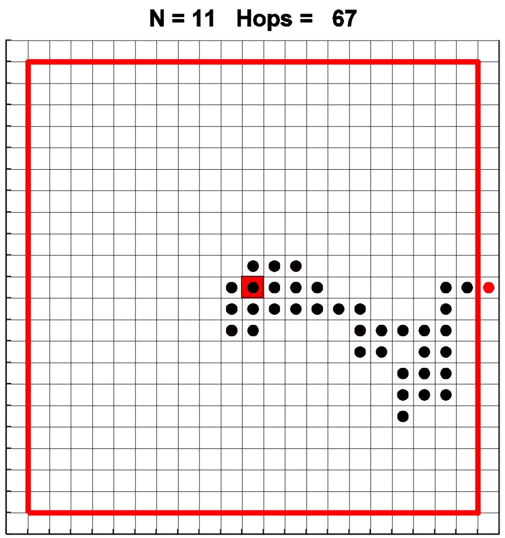
- Previous Lecture:
  - Executing a user-defined function
  - Function scope
  - Subfunction



- Today's Lecture:
  - 1-d array—vector
  - Simulation using random numbers, vectors

- Announcements:
  - No lec/dis Tues due to Feb Break. See course website for reduced office hours. See CMS for tutoring slots.
  - Next week's Ex6 to be done online. Wed dis sections (10:10am–3:20pm) are converted to office hrs (focus on Ex6). All students are welcome at these office hrs.
  - Project 3 due Wednesday 3/4 at 11pm
  - Prelim 1 Tues 3/10 at 7:30pm. Tell us <u>now</u> if you have an exam conflict—see Exams page of course website. Email Amy Elser <ahf42@cornell.edu> with your conflict info (course no., instructor email, conflict time, etc.)

Execute the statement

```
y= foo(x)
```

```
function w = foo(v)
w= v + rand();
```

File `foo.m`

- Matlab looks for function foo (m-file called foo.m)
- Argument (value of x) is copied into function foo's local parameter
  - Local parameter (`v`) lives in function's own workspace
  - called "pass-by-value," one of several argument passing schemes used by programming languages
- Function code executes within its own workspace
- At the end, the function's output argument (value of `w`) is sent from the function to the place that calls the function. E.g., the value is assigned to y.
- Function's workspace is deleted
  - If foo is called again, it starts with a new, empty workspace

Analogy: stack of scratch paper

- All of *your* work is done on one sheet of scratch paper
- To call a function, first evaluate the arguments you will pass to it, based on the contents of your paper
- Copy those argument *values* to the next sheet of paper in the stack, labeled with parameter names
- Pass the stack to a friend (keeping your original sheet)
- Friend evaluates function, circles final answer, crosses out everything else
- You copy final answer to your sheet, then continue working

Trace 2: What is the output?


```
y= 3;
x= 1;
x= f(y,x);
y= x;
disp(y)
```

```
function y = f(x,y)
x= y + 1;
y= x + 1;
```

A: 3 | B: 4 | C: 5 | D: 6 | E: 7

Script's memory space

Function f memory space

Functions and expressions

- Expressions may be passed as function arguments

```
y= max(2*x – 1, 0);
```

- Returned values may be used in expressions

```
fprintf('%f\n', ...
        100*abs(d)/y)
```

- Combine for effect

```
c= max(min(x^2.4, 255), 0);
```

User-defined functions work just like built-in functions

Do these do the same thing?

```
meas= randDouble(6, 6+3) + …
      randDouble(1-2, 1);
```

```
sLo= 6; sHi= sLo + 3;
samp= randDouble(sLo, sHi);
nHi= 1; nLo= nHi - 2;
noise= randDouble(nLo, nHi);
meas= samp + noise;
```

A: No – one has an error

B: No – they compute meas differently

C: Yes, but one pattern is better in every way

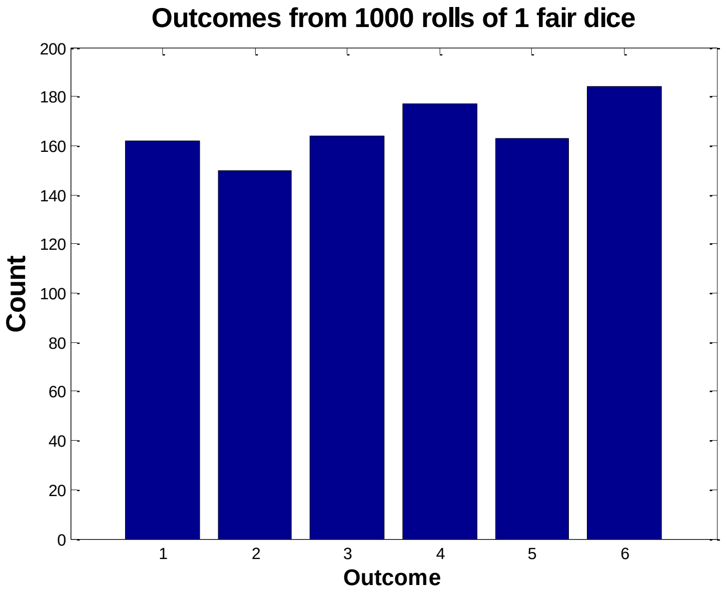
D: Yes, and neither is superior in all cases

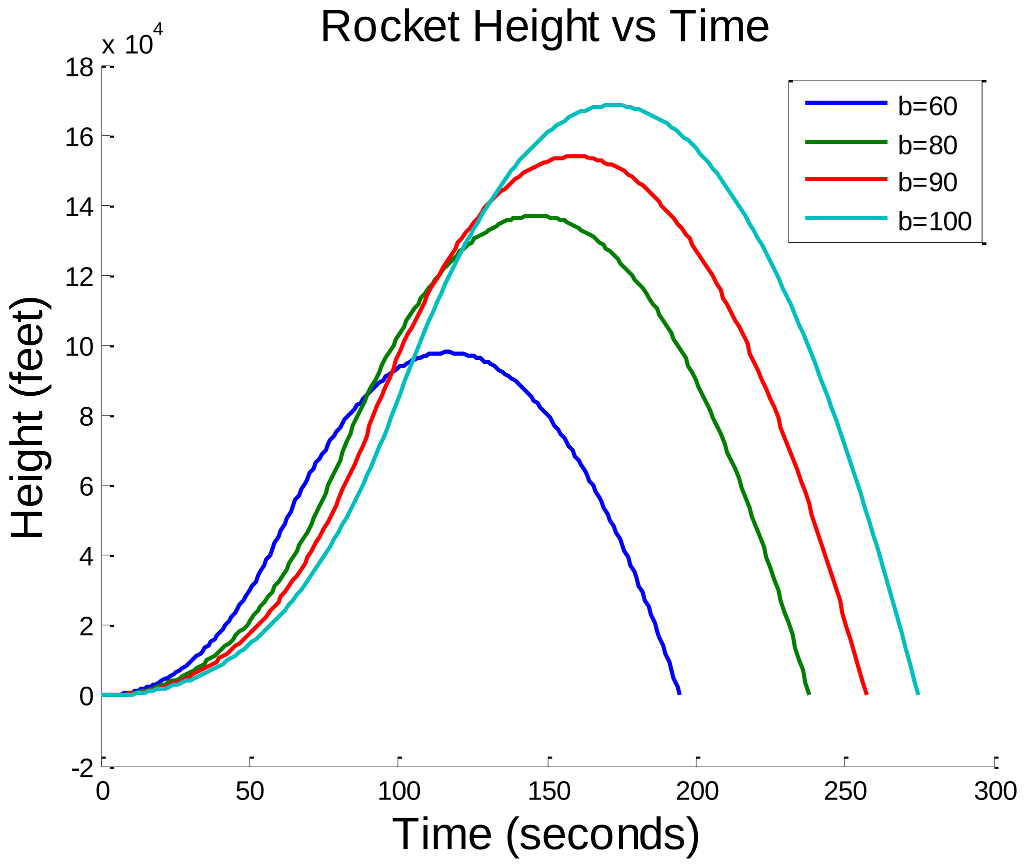
New topic:

Vectors

Simple data: 1-dimensional arrays

[162 150 164 177 163 184]





Drawing a single line segment

```
x1= 0;   % x-coord of pt 1
y1= 1;   % y-coord of pt 1
x2= 5;   % x-coord of pt 2
y2= 3;   % y-coord of pt 2
plot([x1 x2], [y1 y2], '-*')
```

x-values
(a vector)

y-values
(a vector)

Line/marker
format

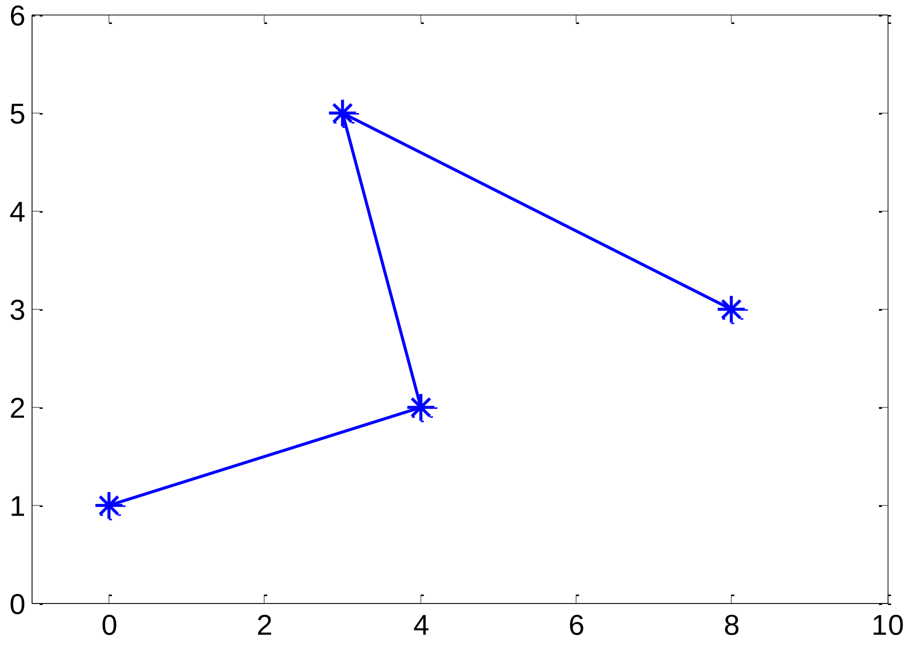
Making an x-y plot

```
xs= [0 4 3 8];   % x-coords
ys= [1 2 5 3];   % y-coords
plot(xs, ys, '-*')
```

x-values
(a vector)

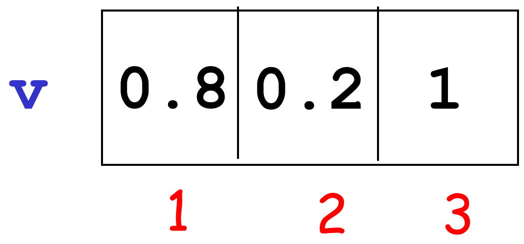
y-values
(a vector)

Line/marker
format



1-d array: **vector**

- An *array* is a collection of like data organized into rows and columns
- A 1-d array is a row or a column, called a *vector*
- An *index* identifies the position of a value in a vector



Here are a few different ways to create a vector

```
count= zeros(1,6)
```

Similar functions: `ones()`, `rand()`

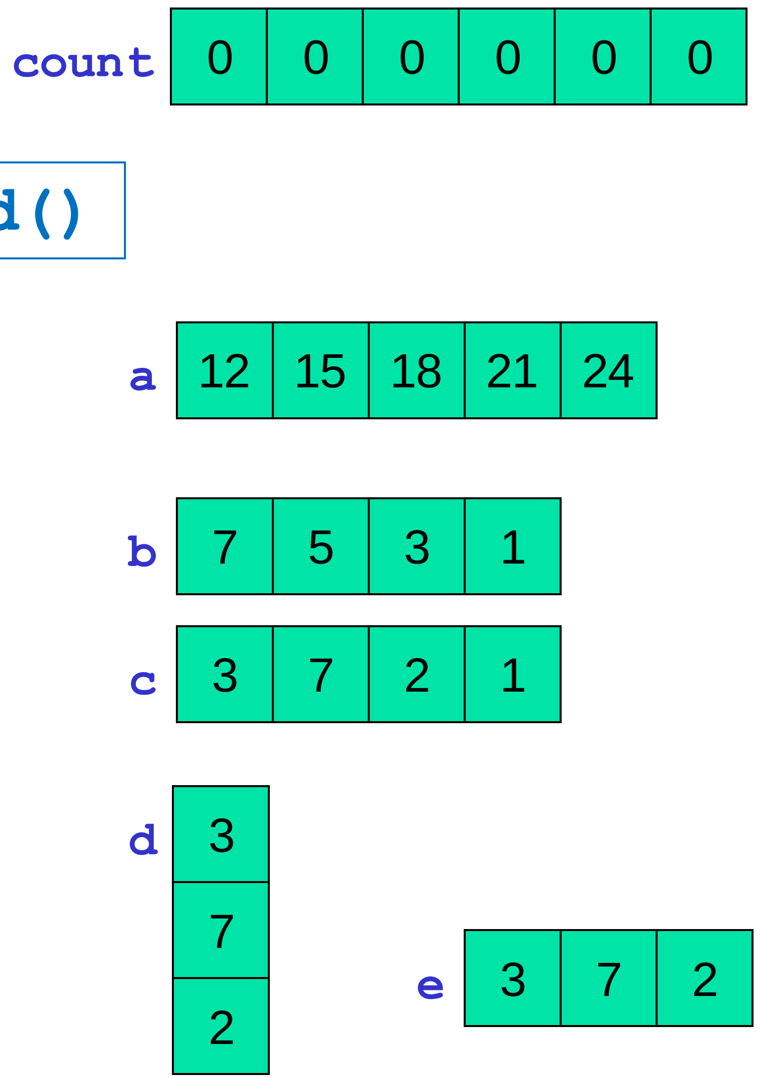
```
a= linspace(12,24,5)

b= 7:-2:0

c= [3 7 2 1]

d= [3; 7; 2]

e= d'
```



Array index starts at 1

x	5	.4	.91	-4	-1	7
	1	2	3	4	5	6

Let k be the index of vector x, then

- k must be a positive integer
- `1 <= k && k <= length(x)`
- To access the kth element: `x(k)`

Accessing values in a vector

score	93	99	87	80	85	82
	1	*2*	*3*	*4*	*5*	*6*

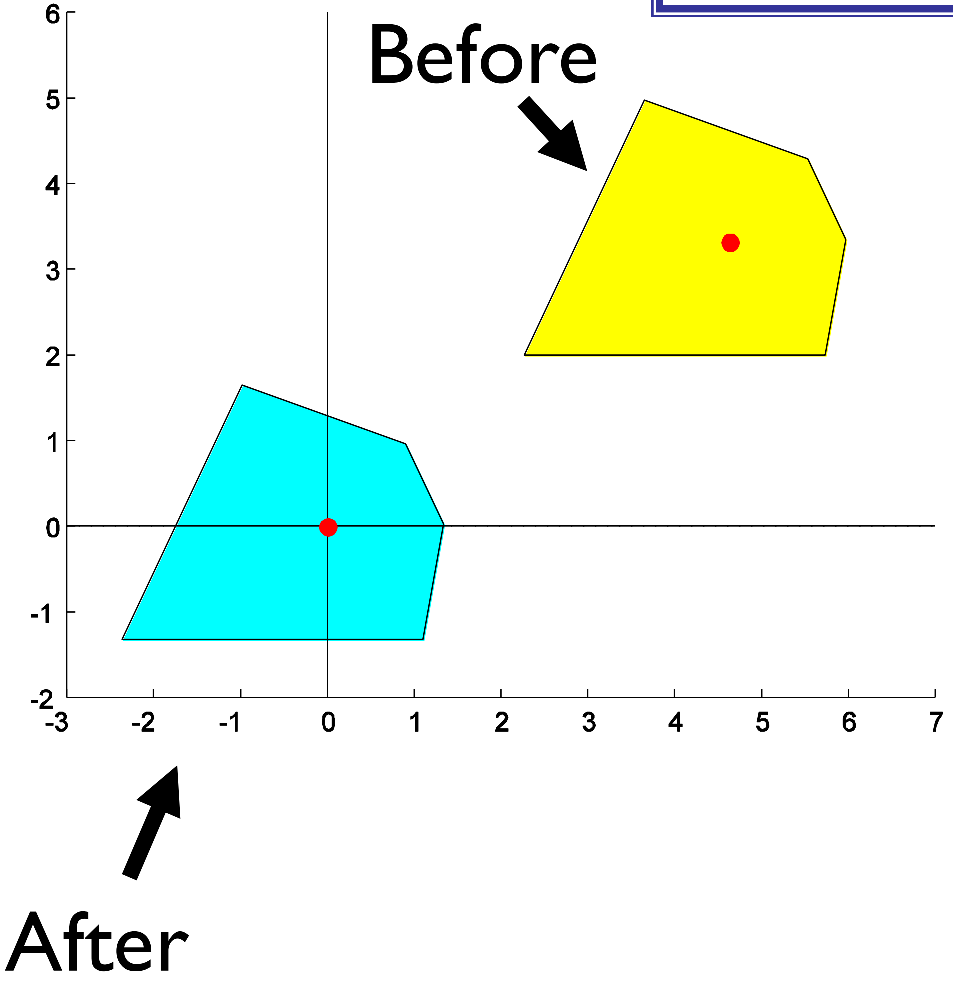
Given the vector **score** …

```
score(4)= 80;
score(5)= (score(4)+score(5))/2;
k= 1;
score(k+1)= 99;
```

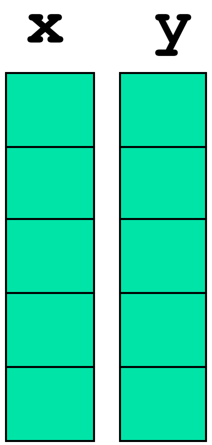
See **plotComparison2.m**

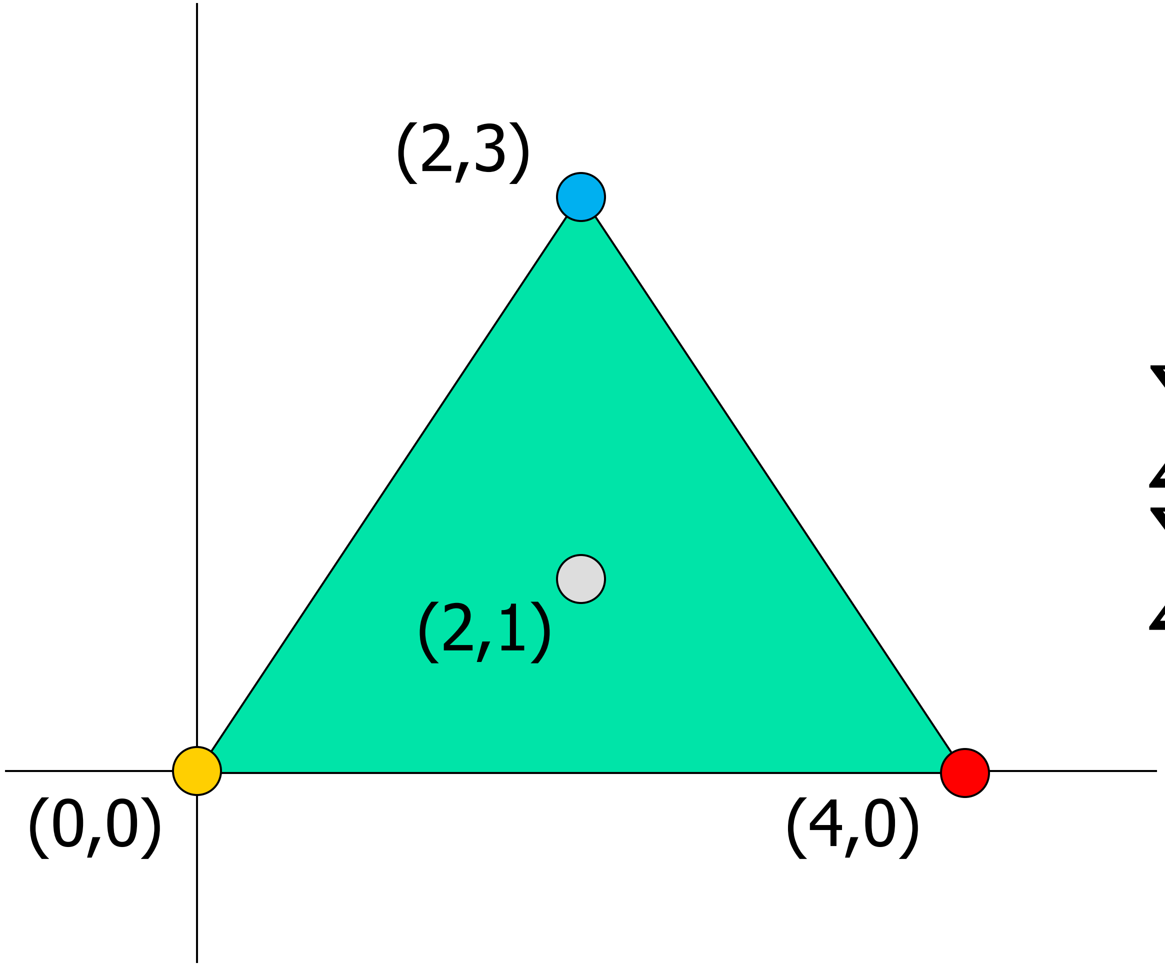
Centralize a polygon

Move a polygon so that the centroid of its vertices is at the origin



Store coordinates of the vertices in vectors x and y






```
x= [0 2 4];
y= [0 3 0];
```

$$\sum_k x_k = 0 + 2 + 4 = 6$$
$$\sum_k y_k = 0 + 3 + 0 = 3$$

$$\bar{x} = \frac{6}{N} = 2$$
$$\bar{y} = \frac{3}{N} = 1$$

```
function [xNew,yNew] = Centralize(x,y)
% Translate polygon defined by vectors
% x,y such that the centroid is on the
% origin. New polygon defined by vectors
% xNew,yNew.

n= length(x);
xNew= zeros(n,1); yNew= zeros(n,1);
xBar= sum(x)/n;   yBar= sum(y)/n;
for k = 1:n
    xNew(k)= x(k) - xBar;
    yNew(k)= y(k) - yBar;
end
```

sum returns the sum of all values in the vector