L15. Arrays and Functions (More)

Vectors of Counters
Subfunctions
Bar Plots

Rolling a Pair of Dice

Illustrate the notion of a vector of counters

Idea of a Single Counter

```
n = 1000000;
Sevens = 0;
Dice1 = ceil(6*rand(n,1))
Dice2 = ceil(6*rand(n,1))
Pair = Dice1+Dice2;
for k=1:n
    if Pair(k)==7
       Sevens = Sevens +1;
    end
end
```

A Vector of Counters

```
n = 1000000;
count = zeros(12,1)
Dice1 = ceil(6*rand(n,1))
Dice2 = ceil(6*rand(n,1))
Pair = Dice1 + Dice2;
for k=1:n
    i = Pair(k);
    count(i) = count(i)+1;
end
```

Plotting a Tilted Ellipse

Illustrate the Notion of a Subfunction

Two Facts

1. The Ellipse:

   $(x/a)^2 + (y/2)^2 = 1$

2. Rotate counter-clockwise by phi radians the point (x,y) about (0,0):

   (xNew,yNew) = (c*x –s*y, s*x + c*y)

   c = cos(phi), s = sin(phi)

Goal

```
  function DrawEllipse(a,b,phi)
% Plots the ellipse
%
%            (x/a)^2 + (y/b)^2 +1
%
% and what it looks like after it is
% rotated phi radians counterclockwise.
```

Package the Rotation

```
  function [xnew,ynew] = Rotate(x,y,phi)
% Rotates the point (x,y) about the
% origin phi radians

  c = cos(phi);
  s = sin(phi);
  xnew = c*x - s*y;
  ynew = s*x + c*y;
```

The Untilted Plot

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

Followed by the Tilted Plot

```
hold on

% Generate points on the tilted ellipse..
for k=1:n
    [x(k),y(k)] = Rotate(x(k),y(k),phi);
end

plot(x,y,'r')

hold off
```

Making **Rotate** a Subfunction

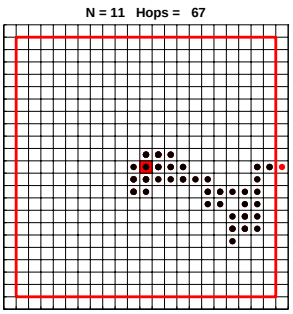
DrawEllipse.m

```
function DrawEllipse(a,b,phi)
   etc
   etc

function [xNew,yNew] = Rotate(x,y,phi)
   etc
   etc
```

Rotate is a subfunction of **DrawEllipse**

2D Random Walk



1-by-1 tiles

Start in middle tile.

Repeat until boundary reached:

- **Pick a compass heading* at random.**
- **Move one tile in that direction.**

* North, East, South, West

Function that Returns the Path

```
function [x y] = RandWalk(N)

k = 0; xc = 0; yc = 0;

while abs(xc)<N && abs(yc)< N

   Take another hop.
   Update location (xc,yc).

   k = k + 1; x(k) = xc; y(k) = yc;

end
```

k	x(k)	y(k)
1	0	-1
2	0	0
3	-1	0
4	0	0
5	0	1
6	1	1
7	1	0
8	1	1
9	0	1
:	:	:

How Many Returns to (0,0)?

```
[x,y] = RandWalk(40);
m = 0;
for k=1:length(x)
   if x(k)==0 && y(k)==0
      m = m + 1;
   end
end
Num_Returns_To_Origin = m
```

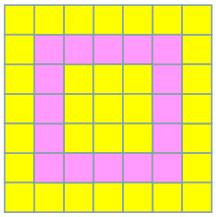
Simulating a Hop

```
r = rand(1);
if  0<= r && r < .25
   yc = yc + 1;          % north
elseif .25<=r && r < .5
   xc = xc + 1;          % east
elseif .50<=r && r < .75
   yc = yc - 1;          % south
else
   xc = xc - 1;          % west
end
```

Simulating a Hop (Better)

```
r = rand(1);
if  r < .25
   yc = yc + 1;          % north
elseif  r < .5
   xc = xc + 1;          % east
elseif .r < .75
   yc = yc - 1;          % south
else
   xc = xc - 1;          % west
end
```

Problem: Plot Average Distance Distribution



N = 3

Ring 2 Highlighted

For a given N, how many times on average does the token visit each ring?