## L8. Iteration and Graphics

Introduce Matlab Graphics

More practice with iteration and boolean-type thinking

Warm-up for functions and arrays.

---

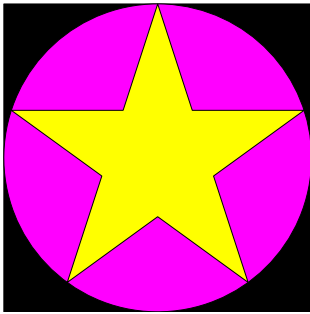## We will Draw Pictures Using Three User-Defined* Graphics Functions
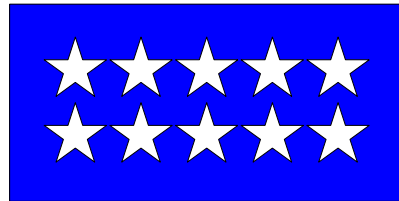
DrawRect      Rectangles
DrawDisk      Circles
DrawStar      5-pointed Stars
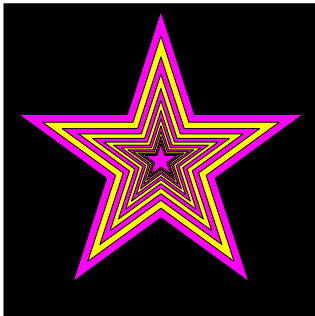
*As opposed to built-in functions like sqrt and rem.

---

## Example



---

## Example



---

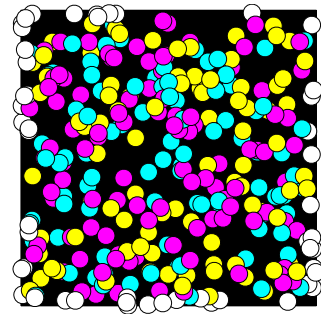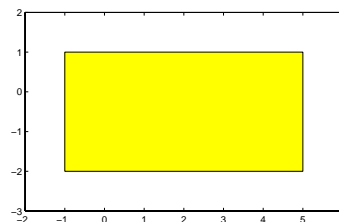## Example



---

## Example

# Why?

- Get more practice with loops and if.

- Warm-up to using Matlab's graphics functions which use arrays
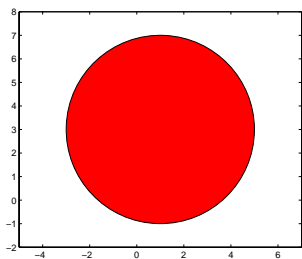
- Warm-up to writing your own user-defined functions

# DrawRect

`DrawRect(-1,-2,6,3,'y')`



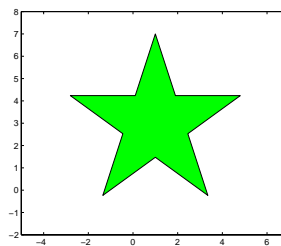# DrawDisk

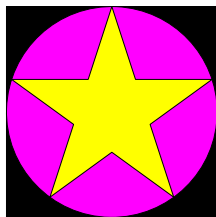`DrawDisk(1,3,4,'r')`



# DrawStar

`DrawStar(1,3,4,'g')`



# A Simple 3-line Script

Draw a black square.

Then a magenta disk.

Then a yellow star.



# Solution

```
close all
figure
axis equal off
hold on

DrawRect(-1,-1,2,2,'k')
DrawDisk(0,0,1,'m')
DrawStar(0,0,1,'y')

hold off
```

## A General Framework

```
close all
figure
axis equal off
hold on
```

Fragment involving DrawRect's, DrawDisk's and/or DrawStar's

```
hold off
shg
```

## Some Matlab Graphics Commands

```
% Close all figure windows…
close all
% Open a new figure window
figure
% Set x and y scaling to be the
% same and do not display axes
axis equal off
%  "Add-in mode" is on…
hold on
```

**IGNORE FOR NOW**

## Some Matlab Graphics Commands

```
% Exit the add-in mode…
hold off

% Bring the figure window to the
% front…
shg
```
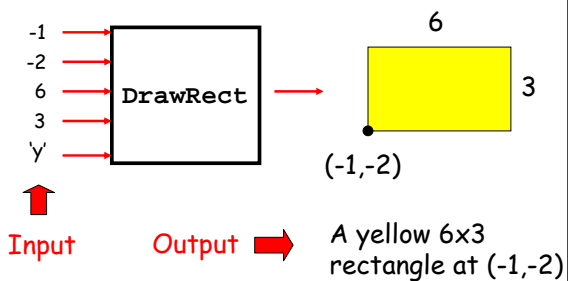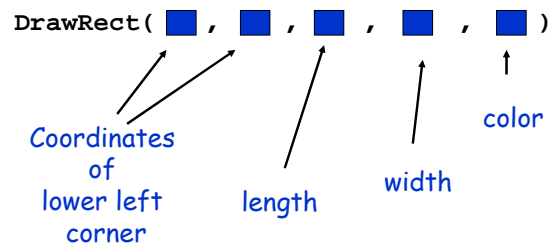
**IGNORE FOR NOW**

## Syntax

Let's look at the rules associated with using DrawRect, DrawDisk, and DrawStar.
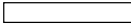
---

```
DrawRect(-1,-2,6,3,'y')
```

-1
-2
6
3
'y'

DrawRect

6

3

(-1,-2)

Input     Output     A yellow 6x3 rectangle at (-1,-2)

---

## DrawRect

```
DrawRect( ■ , ■ , ■ , ■ , ■ )
```

Coordinates of lower left corner

length

width

color

## Color Options

| | | |
|---|---|---|
| White | 'w' | |
| Black | 'k' | |
| Red | 'r' | |
| Blue | 'b' | |
| Green | 'g' | |
| Yellow | 'y' | |
| Magenta | 'm' | |
| Cyan | 'c' | |

## Question Time

What is the area of the red region?

```
for k=1:3
   if rem(k,2)==1
      DrawRect(0,0,k,k,'r')  % red
   else
      DrawRect(0,0,k,k,'w')  % white
   end
end
```

A. 1    B. 3    C. 6    D. 9

---

**DrawDisk(-1,-2,6,'m')**

-1 →
-2 →
6 → | DrawDisk | →
'm' →

6
(-1,-2)

**Input**    **Output** →

A magenta disk with radius 6 & center at (-1,-2)

---

## DrawDisk

DrawDisk( ▪ , ▪ , ▪ , ▪ )

Coordinates of center      radius      color

---

**DrawStar(-1,-2,6,'g')**

-1 →
-2 →
6 → | DrawStar | →
'g' →

6
(-1,-2)

**Input**    **Output** →

A green star with radius 6 and center at (-1,-2)

---

## DrawStar
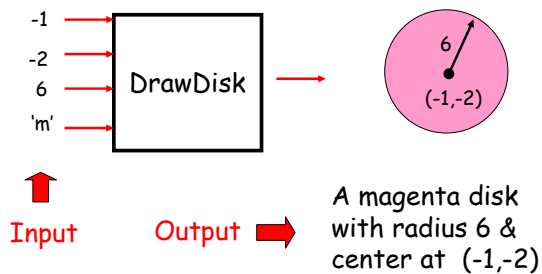
DrawDisk( ▪ , ▪ , ▪ , ▪ )
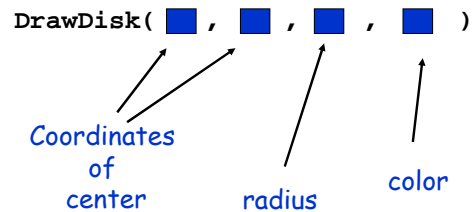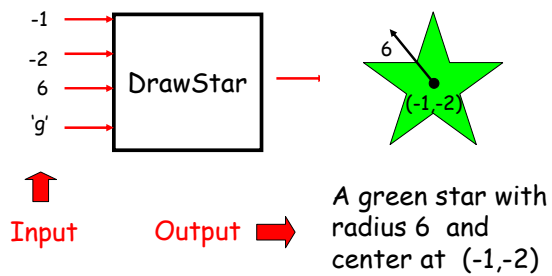
Coordinates of center      radius      color
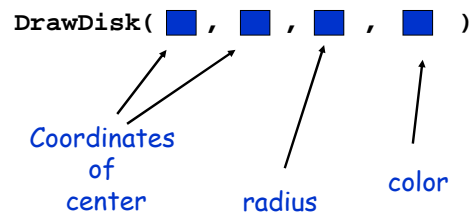
## Now Let's Solve 3 Problems



Star Array      Nested Stars      PaintBall
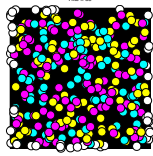
---

## The Framework (Again)

```
close all
figure
axis equal off
hold on
```

Fragment involving `DrawRect`'s, `DrawDisk`'s and/or `DrawStar`'s

We Focus On this part

```
hold off
shg
```

---

## Problem 1: Star Array



Blue 12-by-6 rectangle with lower left corner at (0,0).

White radius-1 stars with centers at
(2,4), (4,4), (6,4), (8,4) (10,4)
(2,2), (4,2), (6,2), (8,2) (10,2)

---

## Preliminary Notes



← Top Row: y = 4
← Bot Row: y = 2

1   2   3   4   5    ← column
2   4   6   8   10   ← x-value

The x-value in the k-th column is 2k

---

## Pseudocode

Draw the blue rectangle

```
for k = 1:5
    Draw the kth star in the top row
end

for k = 1:5
    Draw the kth star in the bottom row
end
```

---

## Pseudocode

Draw the blue rectangle

```
for k = 1:5
    Draw the kth star in the top row
    Draw the kth star in the bottom row
end
```

## Refinement

Draw the blue rectangle

⬇

Draw the blue 12-by-6 rectangle with lower left corner at (0,0).

⬇

```
DrawRect(0,0,12,6,'b')
```

## Refinement

Draw the k-th star in the top row

⬇

Draw a white star with radius 1 and center (2k,4)

⬇

```
DrawStar(2*k,4,1,'w')
```

## Refinement

Draw the k-th star in the bottom row

⬇

Draw a white star with radius 1 and center (2k,2)

⬇

```
DrawStar(2*k,2,1,'w')
```

## Solution

```
DrawRect(0,0,12,6,'b')

for k = 1:5
    DrawStar(2*k,4,1,'w')
    DrawStar(2*k,2,1,'w')
end
```

## Problem 2: Nested Stars
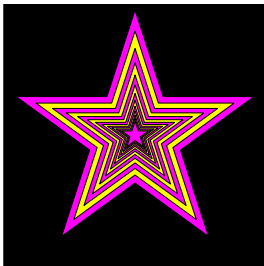


Draw black square with center (0,0) & side 2.1

Draw radius 1 magenta star with center (0,0)

Draw nested sequence of yellow and magenta stars, each with center (0,0) and radius reduced by a factor of 1.2.

Stop when radius <= .1

## Preliminary Notes

Star #1 : `DrawStar(0,0,1,'m')`

Star #2 : `DrawStar(0,0,1/1.2,'y')`

Star #3 : `DrawStar(0,0,1/(1.2)^2,'m')`

Star #4 : `DrawStar(0,0,1/(1.2)^3,'y')`

## Preliminary Notes

```
R = 1
Star #1 :  DrawStar(0,0,R,'m')
R = R/1.2
Star #2 :  DrawStar(0,0,R,'y')
R = R/1.2
Star #3 : DrawStar(0,0,R,'m')
R = R/1.2
Star #4 : DrawStar(0,0,R,'y')
```

## Pseudocode

Draw the Black Square

R = 1; k = 1;
Repeat while R > 0.1
   Draw the k-th star
   Update R and k

## Refinement

Draw the black square

⬇

Draw a black square with side 2.1
And center (0,0)

⬇

```
s = 2.1;
DrawRect(-s/2,-s/2,s,s,'k')
```

## Refinement

R = 1; k = 1;
Repeat while R >.1
   Draw the k-th star
   Update R and k

⬇

```
R = 1; k = 1;
while R >.1
    Draw the k-th star
    R = R/1.2; k= k+1;
end
```

## Refinement

Draw the kth star

⬇

if k is odd
      Magenta , radius R. center (0,0)
otherwise
      Yellow, radius R, center (0,0)

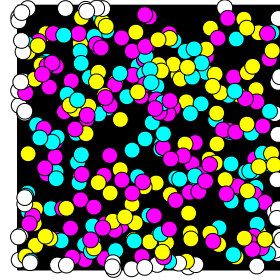## Refinement

⬇

```
if rem(k,2)==1
    DrawStar(0,0,R,'m')
else
    DrawStar(0,0,R,'y')
end
```

## Solution

```
R = 1; k = 1;
while R >.1
    if rem(k,2)==1
        DrawStar(0,0,R,'m')
    else
        DrawStar(0,0,R,'y')
    end
    R = R/1.2; k= k+1;
end
```
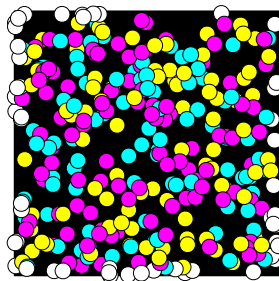
## Problem 3: Paintball

Draw a black unit square with lower left corner at (0,0).

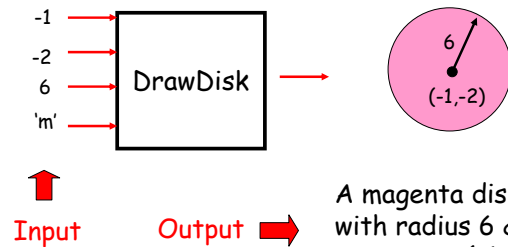Draw a radius .03 disk with center randomly located in square.

## Problem 3: Paintball

If the disk is entirely in square, randomly color it 'c', 'y', or 'm' with equal probability. Otherwise, color it White.
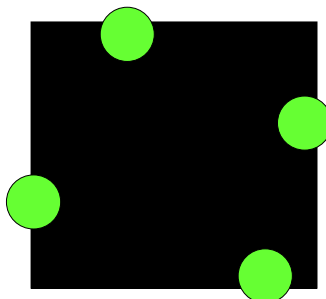
Repeat this process until 50 white disks drawn.

---

`DrawDisk(-1,-2,6,'m')`

-1 →
-2 →
6 → DrawDisk →
'm' →

6

(-1,-2)

**Input**       **Output** ➡

A magenta disk with radius 6 & center at (-1,-2)

## Preliminary Notes

y+r > 1

x+r > 1

x-r < 0

y-r < 0

Dot: radius r, center (x,y)      "Edge Hits"

## Preliminary Notes

How we simulate a 3-way random event?

If `ink = rand(1)`, then

1/3 the time we have:    0 < `ink` < 1/3
1/3 the time we have:    1/3 <= `ink` < 2/3
1/3 the time we have:    2/3 <= `ink` < 1

Check the inequalities and do the right thing.

## Pseudocode

Draw black square.
Repeat until 50 white disks:
    Locate a random disk.
    If the disk is in the square then
        randomly color it'c', 'y', or 'm'.
    Otherwise,
        color it 'w'
    end

## Refinement

"Draw the black square"

⬇

Draw a unit black square
With lower left corner at (0,0)

⬇

```
DrawRect(0,0,1,1,'k')
```

## Pseudocode

```
DrawRect(0,0,1,1,'k')
EdgeHits = 0;
while EdgeHits < 50
```
    Locate a random disk.
    If the disk is in the square then
        randomly color it'c', 'y', or 'm'.
    Otherwise,
        color it 'w'
```
        EdgeHits = EdgeHits + 1;
```
    end
```
end
```

## Variable Definition

We use a variable

```
EdgeHits
```

to keep track of the number of disks
that intersect the square's boundary.

## Refinement

"Locate a random disk"

⬇

The center (x,y)
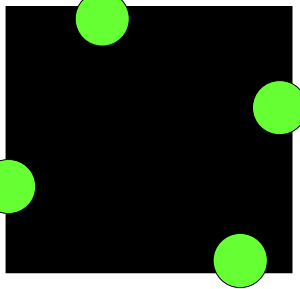satisfies 0<x<1 and 0<y<1.

⬇

```
x = rand; y = rand;
```

## Refinement

If the disk is in the square then
    randomly color it'c', 'y', or 'm'.
Otherwise,
    color it 'w'
```
    EdgeHits = EdgeHits + 1;
```
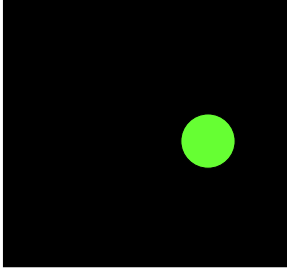end

How do we check that?
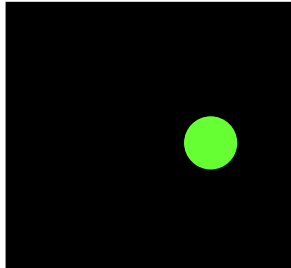
## Slide 1

y+r > 1

x+r > 1

x-r < 0

y-r < 0

Dot: radius r, center (x,y)

## Slide 2

y+r <= 1

x+r <= 1

x-r >= 0

y-r >= 0

Dot: radius r, center (x,y)

## Slide 3

y+r <= 1

x+r <= 1

x-r >= 0

y-r >= 0

`y+r<=1 && x+r<=1 && x-r>=0 && y-r>=0`

## Slide 4

# Question Time

Want to count upper right corner hits. Which of these boolean conditions guarantees that (1,1) is covered?

```
(i)    x + r >= 1  && y + r >= 1
(ii)   x + y >=  2 - 2*r
```

A. Neither        C. Both
B. (i) only       D. (ii) only

## Slide 5

# Answer Time

```
(i) x + r >= 1  && y + r >= 1
(ii) x + y >=  2 - 2*r
```

A.  Neither        C. Both
B.  (i) only       D. (ii) only

The case x = 1, y = 1 – r - .000001, fools Condition (ii).

## Slide 6

# Refinement

If the disk is in the square then
   randomly color it 'c', 'y', or 'm'.
Otherwise,
      color it 'w'
      `EdgeHits = EdgeHits + 1;`
end

   How do we do that?

# Refinement

randomly color it 'c', 'y', or 'm'

⬇

1/3 of the time the disk should be 'm'
1/3 of the time the disk should be 'y'
1/3 of the time the disk should be 'c'

# Refinement

⬇

```
ink = rand(1);
if ink < 1/3;
    DrawDisk(x,y,r,'m')
elseif 1/3 <= ink && ink < 2/3
    DrawDisk(x,y,r,'y')
else
    DrawDisk(x,y,r,'c')
end
```