

INTRODUCTION TO PROCESSING

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What is Processing?

- Processing is a programming language designed to make programming easier
- Developers were frustrated with how difficult it was to write small programs for new programmers
 - ▣ Need for compilers
 - ▣ Software that wasn't always free
 - ▣ Didn't always work together
 - ▣ Took the joy out of process of learning programming

Goal

- Goal was to make a programming language that would allow fast prototyping of ideas
- Easy to use and teach at a middle-school and high-school level
 - With minimal setup
 - Immediate visual feedback
 - Potential to undertake big projects using the language

Processing

- ❑ Prototyping is done in the form of a *sketch*
- ❑ Programmers keep adding a few lines and adding to the sketch
- ❑ Visual feedback feeds the curiosity that is inherent in new programmers
- ❑ The vision behind processing is to enable the process of learning programming through creating interactive graphics

Let us begin!



- Easy to download and install processing from <http://processing.org>

Let us write our First Program

- Think about graph paper
- How would you draw a line between $(0, 0)$ and $(5, 5)$?
- Pick the x, y location of the starting point and the x, y location of the destination point and connect the dots in between
- Please work with another student and draw a line on the graph between
 1. $(2, 0)$ and $(2, 6)$
 2. $(2, 4)$ and $(6, 4)$



First Program

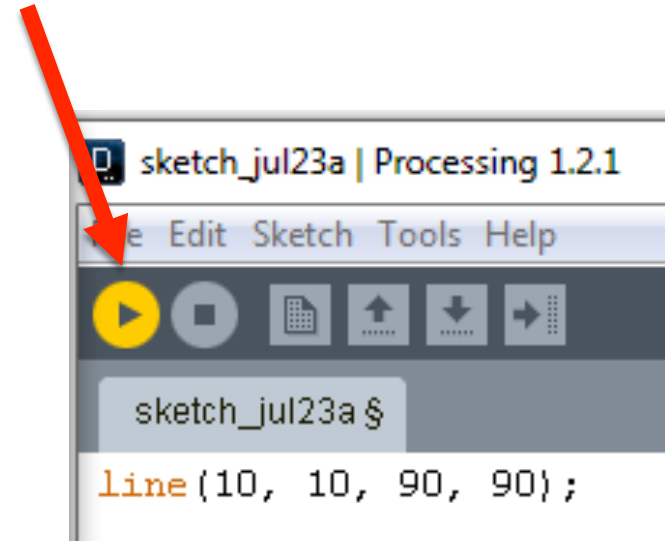
X, Y-coords
of 1st point

X, Y-coords
of 2nd point

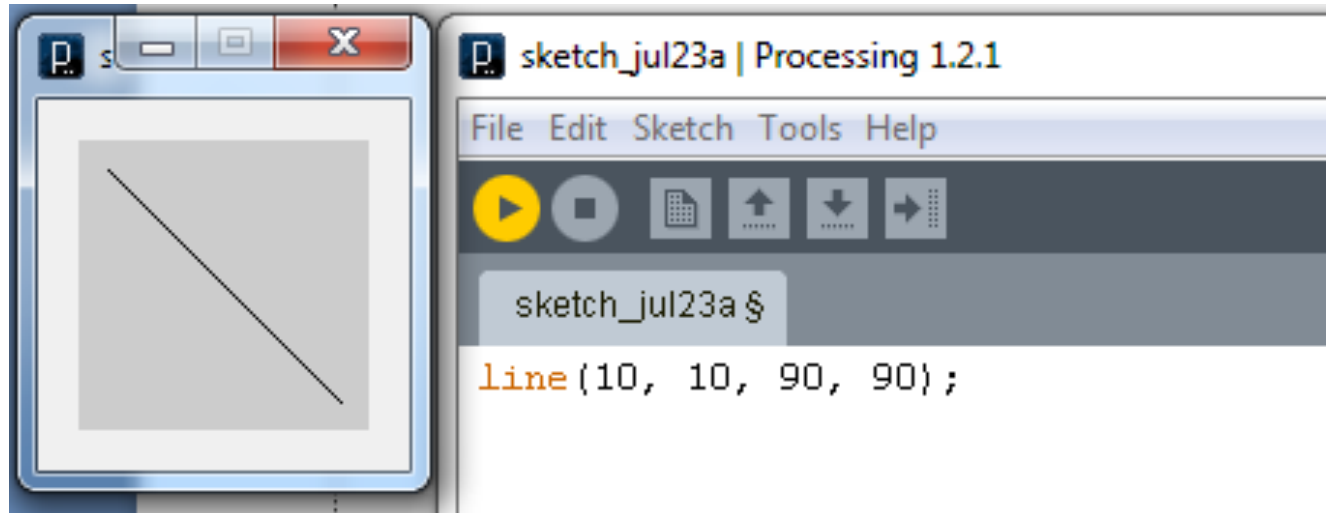
□ `line(10, 10, 90, 90);`

□ This is your first program

□ Type it in and click on the **Triangle (Play button)** in the top menu or select **Sketch→Run**



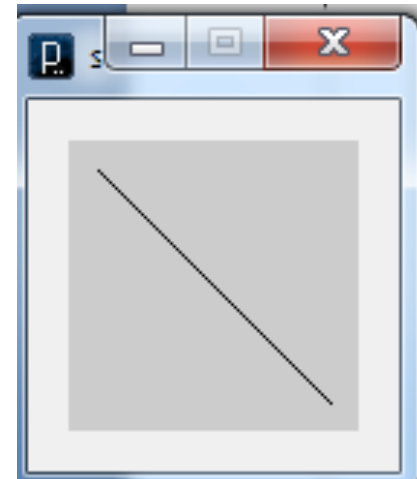
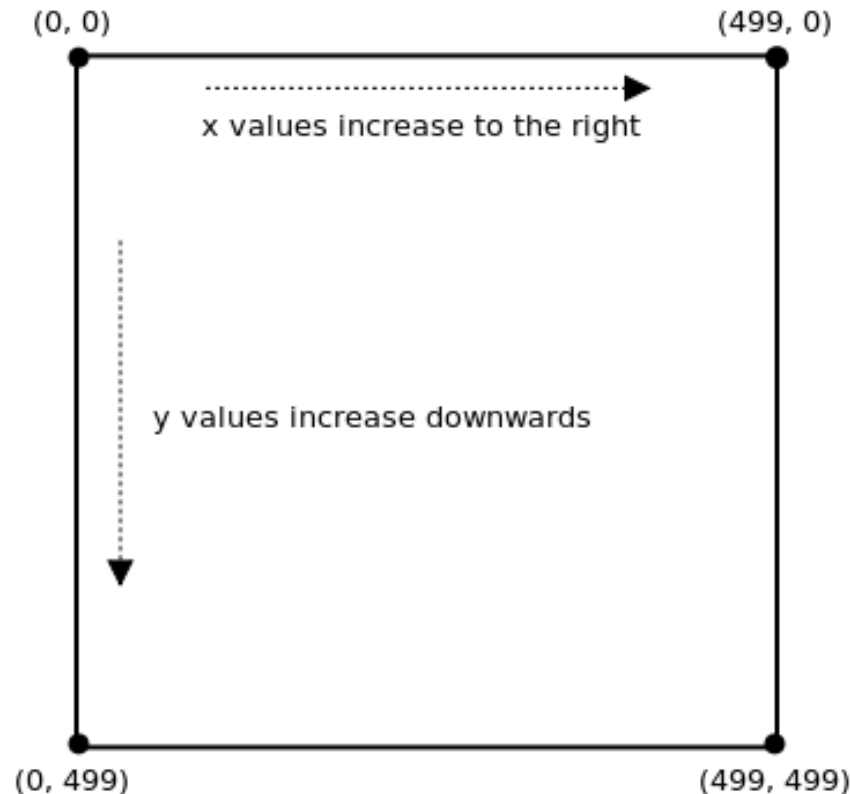
First Program



What is *different* about the direction of the line?

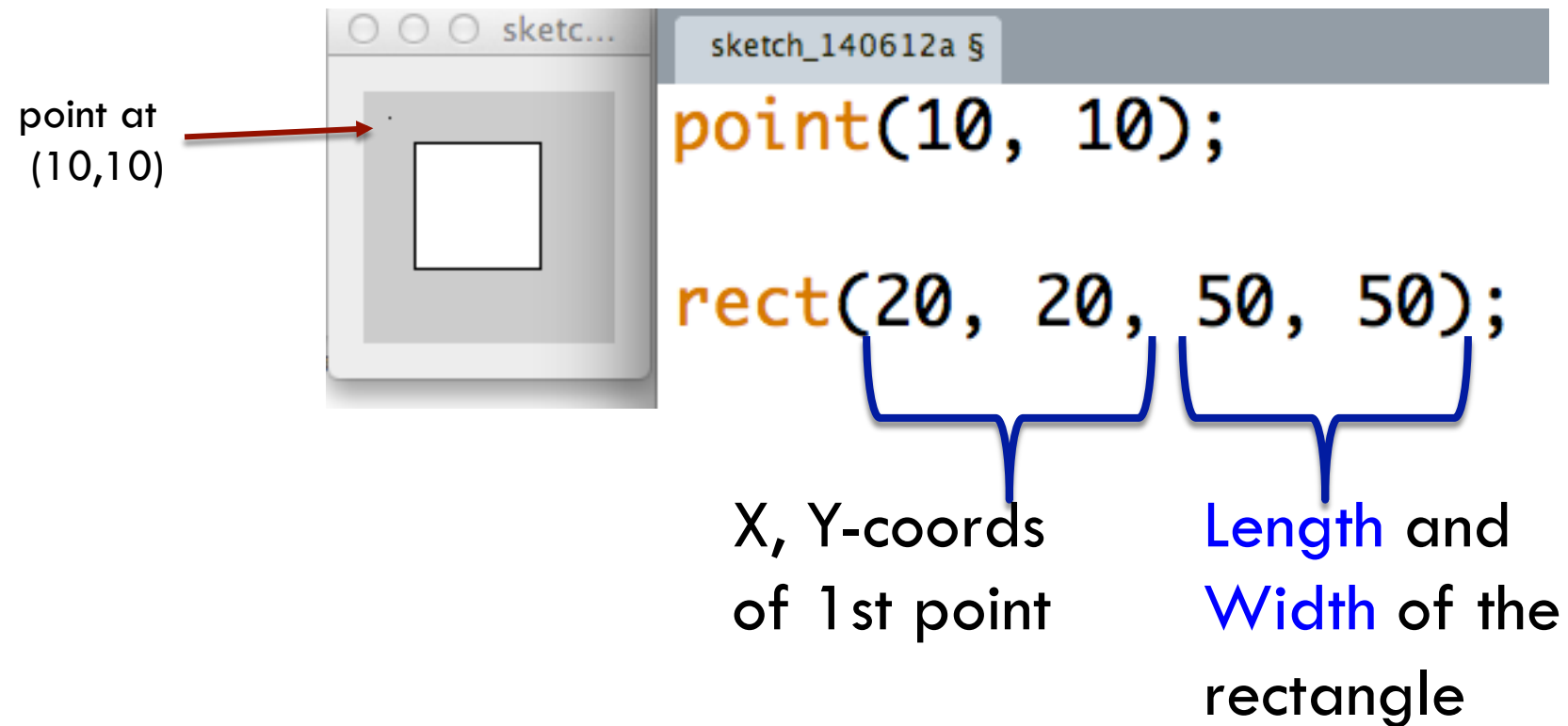
Coordinates on the Screen

- On a computer screen, the origin $(0, 0)$ is **always** at the top left location of the screen



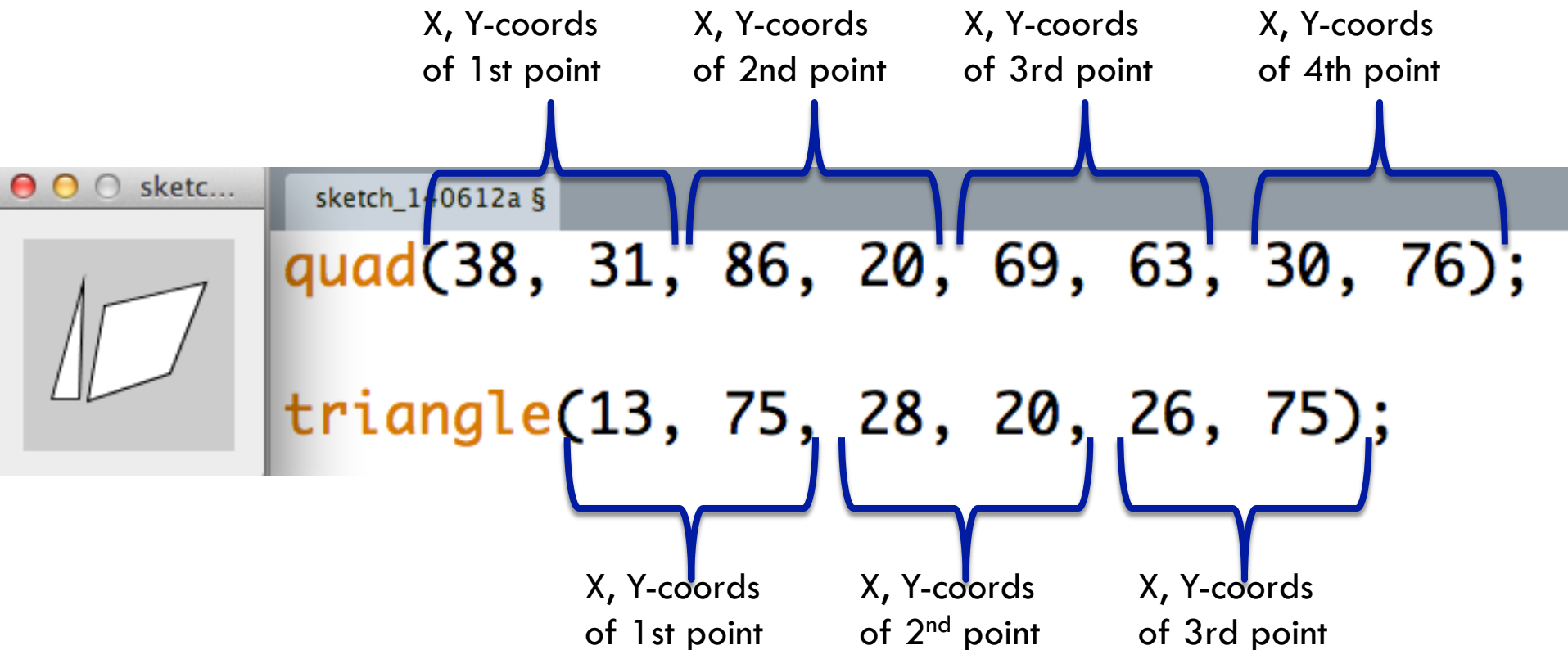
Basic Shapes

- Points, Rectangles, Triangles, Quadrilaterals etc.



Basic Shapes

- Points, Rectangles, Triangles, Quadrilaterals etc.



Draw basic shapes

- Type out the code in Processing and Click on Run to see a rectangle, a quadrilateral, and a triangle



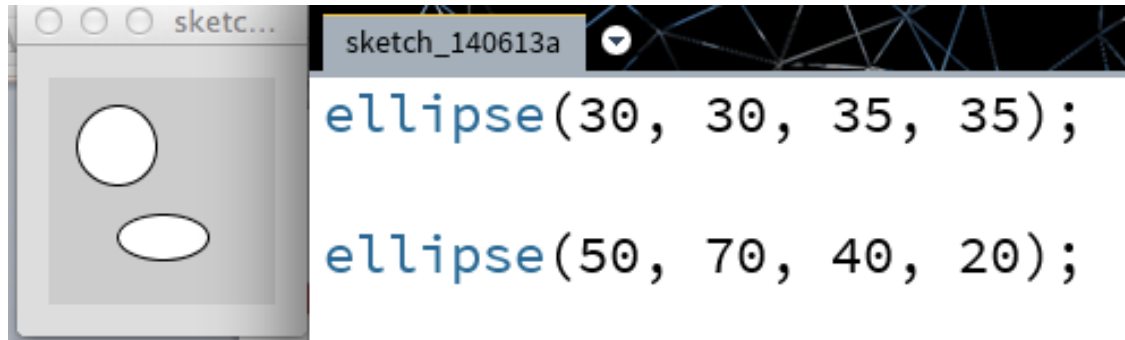
```
rect(15, 15, 20, 20);
```

```
quad(38, 31, 86, 20, 69, 63, 30, 76);
```

```
triangle(13, 75, 28, 20, 26, 75);
```

Ellipses and Circles

- Ellipse can be represented by specifying the
 1. The coordinates of the center of the ellipse
 2. The radius of the ellipse in the **X-direction**
 3. The radius of the ellipse in the **Y-direction**
- `ellipse(xc, yc, xrad, yrad);`



- A circle is an ellipse with the **same** value for the x-radius and y-radius

Arcs

- ❑ Partial ellipses/circles can be drawn by the arc function.
`arc (x, y, width, height, startAngle, stopAngle);`
- ❑ The outer edge of the ellipse defined by x, y, width and height (where x, y is the center if `ellipseMode()` is defined to be **CENTER**)
- ❑ The angle is in radians or use `radians(degrees)` to convert degrees to radians
- ❑ Try the following:
 - ❑ `arc (50, 50, 100, 100, 0, radians(180));`
 - ❑ `arc (50, 50, 100, 100, radians(270), radians(360));`
 - ❑ `arc (50, 50, 100, 100, radians(270), radians(90));`
 - ❑ `arc (50, 50, 100, 100, radians(270), radians(450));`



Representing Colors

- Colors in Processing are represented as a combination of Red, Green and Blue values
- 0 = no contribution of a particular color
- 255 = maximum contribution of a particular color
- Pure Red = 255, 0, 0
- Pure Green = 0, 255, 0

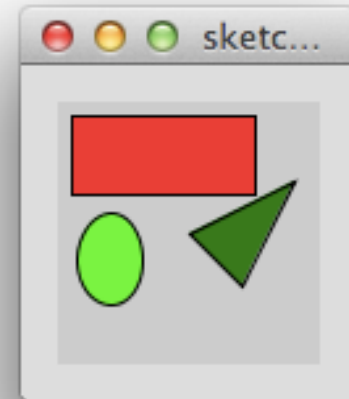
Filling in shapes

- Shapes can be filled in with different colors

```
// Set fill color to Red  
fill(255, 0, 0);  
rect(5, 5, 70, 30);
```

```
// Set fill color to Green  
fill(0, 255, 0);  
ellipse(20, 60, 25, 35);
```

```
// Set fill color to a shade of Green  
fill(0, 127, 0);  
triangle(50, 50, 70, 70, 90, 30);
```



Experiment with Color

- Type out the following lines and see if you can change the shapes and their fill colors

```
// Set fill color to Red
```

```
fill(255, 0, 0);  
rect(5, 5, 70, 30);
```

```
// Set fill color to Green
```

```
fill(0, 255, 0);  
ellipse(20, 60, 25, 35);
```

```
// Set fill color to a shade of Green
```

```
fill(0, 127, 0);  
triangle(50, 50, 70, 70, 90, 30);
```

Red, Green, Blue combinations

Black = 0, 0, 0

Yellow = 255, 255, 0

Orange = 255, 102, 0

Brown = 165, 42, 42

Fuchsia = 255, 0, 255

Olive = 128, 128, 0

White = 255, 255, 255

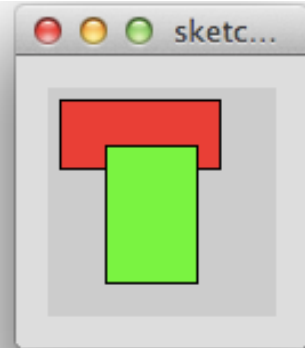
More combinations can be found using the Color Selector tool under the Tools menu

Opacity/Transparency

- Opacity/Transparency also defined separately
- 0 = completely transparent
- 255 = completely opaque

```
fill(255, 0, 0);  
rect(5, 5, 70, 30);
```

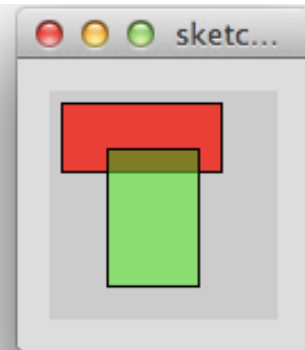
```
fill(0, 255, 0);  
rect(25, 25, 40, 60);
```



Overlapping rectangles without transparency

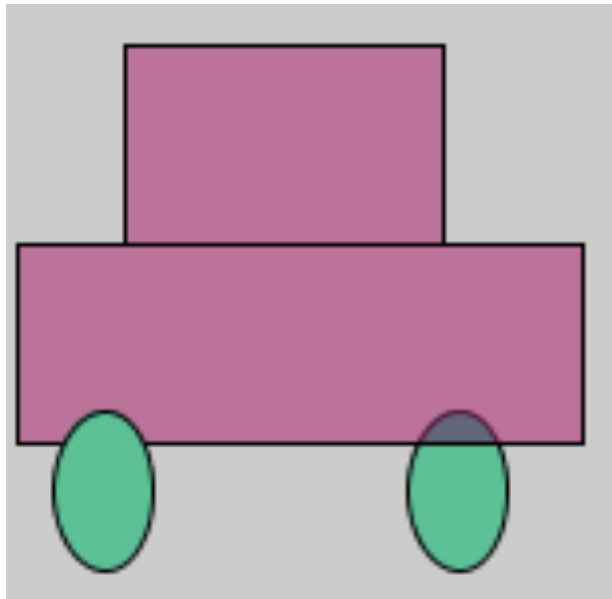
```
fill(255, 0, 0);  
rect(5, 5, 70, 30);
```

```
fill(0, 255, 0, 127);  
rect(25, 25, 40, 60);
```



Overlapping rectangles with transparency

Using color & opacity



Resize the drawing canvas

```
size(200, 200);  
fill(0, 200, 150);  
ellipse(117, 130, 25, 40);  
  
fill(200, 0, 100, 125);  
rect(6, 68, 142, 50);  
rect(33, 18, 80, 50);  
  
fill(0, 200, 150);  
ellipse(28, 130, 25, 40);
```

Stroke Weight

□ `strokeWeight(value);`

```
size(480, 120);
```

```
smooth();
```

```
ellipse(75, 60, 90, 90);
```

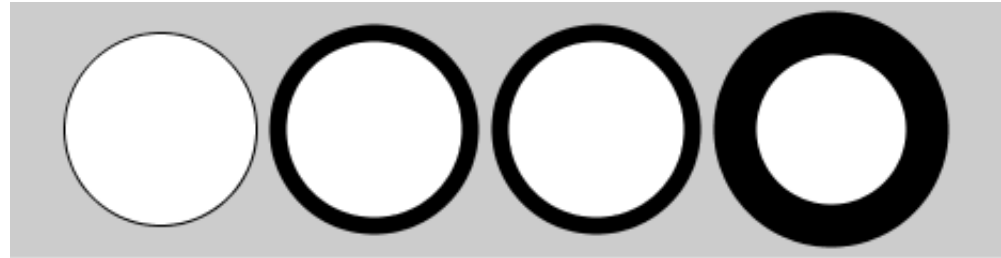
```
strokeWeight(8); // weight = 8 pix
```

```
ellipse(175, 60, 90, 90);
```

```
ellipse(279, 60, 90, 90);
```

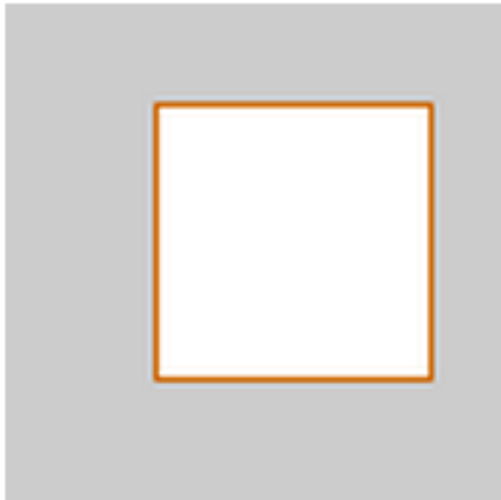
```
strokeWeight(20); // weight = 20 pix
```

```
ellipse(389, 60, 90, 90);
```



Stroke Color

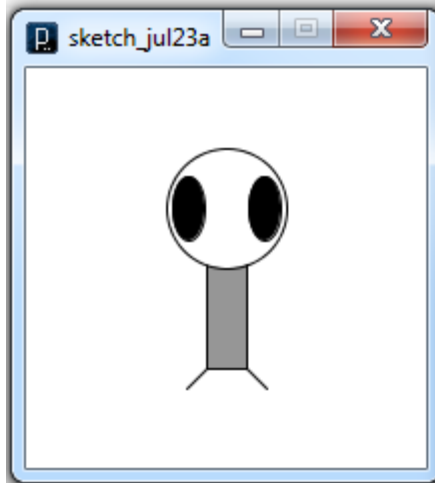
- `stroke(color);`
 - ▣ Could be a single value (to specify gray scale)
 - ▣ Could be 3 values for RGB



```
stroke(204, 102, 0);  
rect(30, 20, 55, 55);
```

Composition of Shapes

□ Drawing an alien – Lets call him Rooba



```
size(200,200);  
background(255); // Specifies the background color  
smooth();       // Specifies extra smoothing of drawn primitives  
  
ellipseMode(CENTER);  
rectMode(CENTER);  
  
// Body  
stroke(0);  
fill(150);  
rect(100,100,20,100);  
  
// Head  
fill(255);  
ellipse(100,70,60,60);  
  
// Eyes  
fill(0);  
ellipse(81,70,16,32);  
ellipse(119,70,16,32);  
  
// Legs  
stroke(0);  
line(90,150,80,160);  
line(110,150,120,160);
```

Activity – Modify Rooba

Modify the Rooba program to give the Alien a Square head.
Change its eyes and body to red. Then make it have three legs!

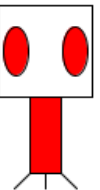
```
size(200,200); // Set the size of the window
background(255); // White background
smooth();
// Set ellipses and rects to CENTER mode
ellipseMode(CENTER);
rectMode(CENTER);

// Draw Rooba's body
stroke(0);
fill(150);
rect(100,100,20,100);
```

```
// Draw Rooba's head
fill(255);
ellipse(100,70,60,60);

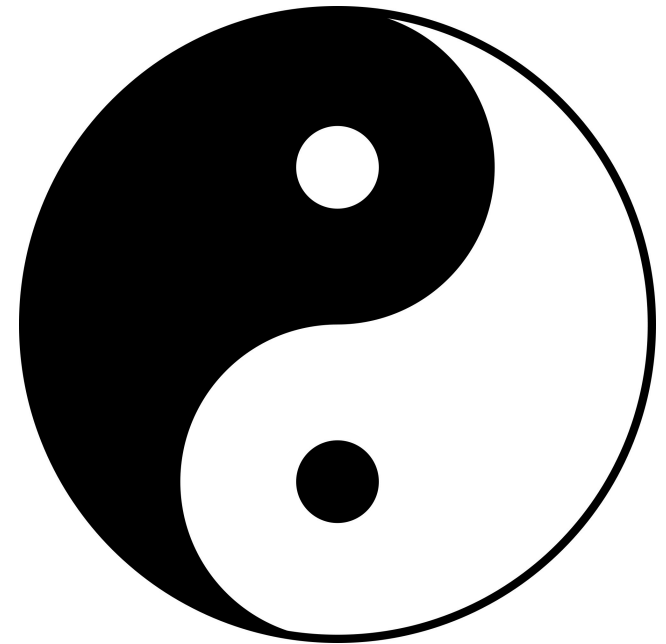
// Draw Rooba's eyes
fill(0);
ellipse(81,70,16,32);
ellipse(119,70,16,32);

// Draw Rooba's legs
stroke(0);
line(90,150,80,160);
line(110,150,120,160);
```



Processing Sketch for Yin and Yang

- Write a sketch to draw Yin and Yang.
Make the sketch be 400 x 400 and the Yin and Yang be 200 x 200
- Need to use ellipses and arcs
- Write **Yin and Yang** on the screen using
 - ▣ `text("Yin Yang", 10, 30);`



Variables

- If you have a number stored on your computer and would like to add 1 to it
 - ▣ An easy way to access to that location
 - ▣ Find the value of the number stored at that location
 - ▣ Increment the value
 - ▣ Store the new updated value back to that location
- Definition: A variable is contains some known or unknown quantity or information, a value.

Variable

□ Examples:

- ▣ `char value = 'a';`
- ▣ `int i = 100;`
- ▣ `Float x = 0.33;`
- ▣ `String str1 = "USA";`

Variables Program – 3 circles

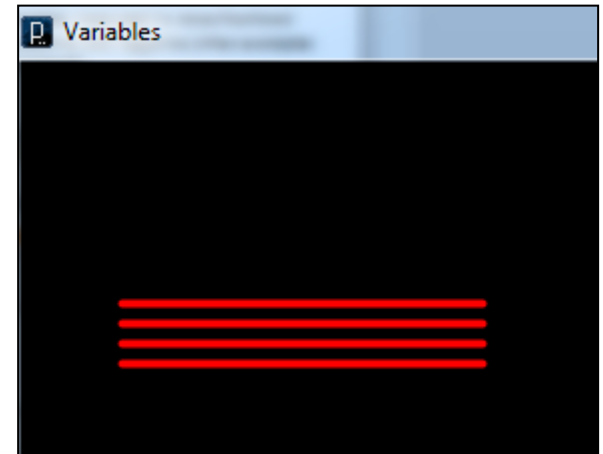
```
size(480, 120);  
smooth();  
int y = 60;  
int d = 80;  
ellipse(75, y, d, d);  
ellipse(175, y, d, d);  
ellipse(275, y, d, d);
```

Variables Program

```
stroke(255, 0, 0); // Set the Line Color to Red
strokeWeight(4);    // Set Line Thickness to 4
```

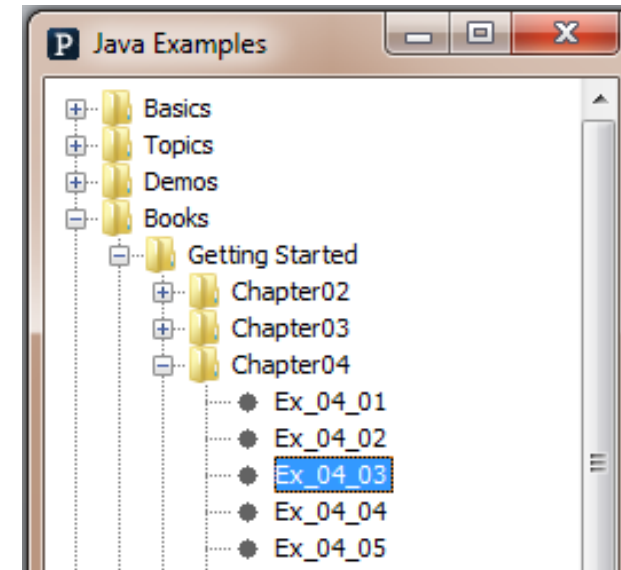
```
int a = 50;
int b = 120;
int c = 180;
int distance = 10;
```

```
line(a, b, a+c, b);
line(a, b+distance, a+c, b+distance);
line(a, b+2*distance, a+c, b+2*distance);
line(a, b+3*distance, a+c, b+3*distance);
```



Variables Program

- ❑ Running built-in examples
- ❑ File->Examples->Books->Chapter 04->
- ❑ Run Example 4-3 from the Getting started book



Variables Program

```
size(480, 120);  
// Line from (0,0) to (480, 120)  
line(0, 0, width, height);  
// Line from (480, 0) to (0, 120)  
line(width, 0, 0, height);  
ellipse(width/2, height/2, 60, 60);
```

Refactor the Yin & Yang

- Use variables to **refactor** your previous sketch such that the Yin and Yang symbol is drawn relative to one fixed point (such as the center of the Yin and Yang)
- **Refactoring** refers to restructuring a program without changing its basic behavior.



Displaying text

- To display text use the print line function (`println`)
 - `println("Hello");`
 - prints a line on the screen with the words `Hello` in it
- To print the value of a variable (e.g. `celsius=32`), use
 - `println("The temperature is " + celsius);`
 - will print **The temperature is 32** on the screen

Add an Image

陰陽

- Add Chinese characters for “yin yang” (look at LoadPicture example) centered on top of yinyang.
- Add your image to your sketch
 - ▣ menu Sketch → Add File

```
Pimage img;
```

```
img = loadImage("yinyang.png");
```

```
image(img,x,y);
```



Conditional statements

- Conditional statements allow conditional execution

```
int temperature = 90;
if (temperature > 85)
{
    println("It is hot outside");
}
else
{
    println("It is pleasant outside");
}
```

Conditional statements

- What will be printed on the screen if `temperature=70`?

```
int temperature = 70;
if (temperature > 85)
{
    println("It is hot outside");
}
else
{
    println("It is pleasant outside");
}
```

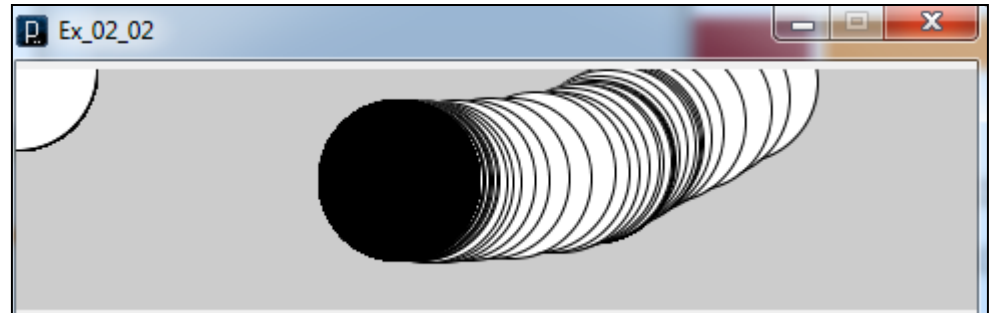
Conditional statements

□ Can we add more conditions? Sure!

```
int temperature = 70;
if (temperature > 85)
{
    println("It is hot outside");
}
else if (temperature < 50)
{
    println("It is cold outside");
}
else // Only when the variable temperature is >50 and <85
{
    println("It is pleasant outside");
}
```

Conditional Statement example

```
void setup() {  
  size(480, 120);  
  smooth();  
}  
  
void draw() {  
  if (mousePressed) {  
    fill(0, 0, 0);  
  }  
  else {  
    fill(255, 255, 255);  
  }  
  ellipse(mouseX, mouseY, 80, 80);  
}
```



Example from "Getting Started with Processing Book"

Loops

- ❑ To print all the numbers from 1-10 on the screen, you could have 10 consecutive print statements
- ❑ What would you do to print 1-1000 numbers?
- ❑ Use loops to iterate over a number and call a specific command

```
for (int i=0; i < 10; i = i + 1)
{
    println(i);
}
```

Loops

1. Initialize variable `i` to 0
2. Increment `i` by 1 until `i < 10`
3. For every distinct value of `i` execute the statements within the curly braces

```
for (int i=0;i<10;i=i+1)
{
    println("The value of i is " + i);
}
```

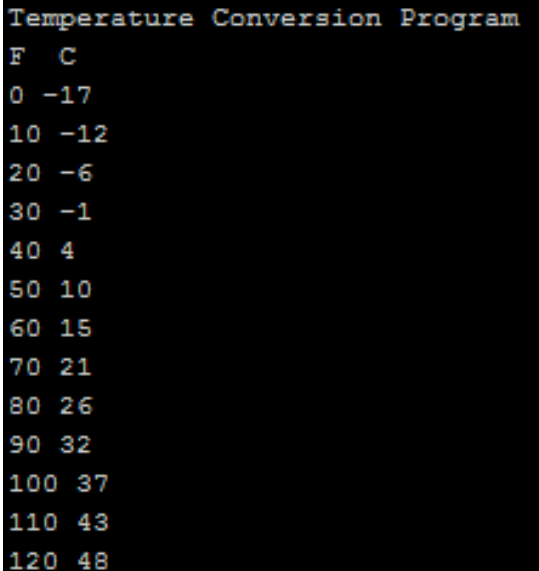
Loops



- Run Example 4-7 from the Getting started book
- Run Example 4-8 from the Getting started book

Fahrenheit to Celsius conversion

```
println("Temperature Conversion Program");
println("F " + " C");
int celsius;
for(int i=0;i<130;i=i+10)
{
    celsius = (i - 32) * 5/9;
    println(i + " " + celsius);
}
```

A screenshot of a terminal window with a black background and white text. The output of the program is displayed, showing the title 'Temperature Conversion Program', a header 'F C', and a list of Fahrenheit temperatures from 0 to 120 in increments of 10, each followed by its corresponding Celsius value.

```
Temperature Conversion Program
F C
0 -17
10 -12
20 -6
30 -1
40 4
50 10
60 15
70 21
80 26
90 32
100 37
110 43
120 48
```

Nested Loops

- Run Example 4-10 from the Getting started book
- Compare Example 4-11 with 4-10
 - ▣ What is the difference?

Functions

- Used to perform generalizable and repeatable tasks

```
void printTemp(int temp)
{
    println("The temperature is a balmy " + temp + " F");
}

printTemp(35);
printTemp(85);
printTemp(120);
```

Output:

```
The temperature is a balmy 35 F
The temperature is a balmy 85 F
The temperature is a balmy 120 F
```

Functions

- Invoking a function with a variable

```
int temperature = 35;  
printTemp(temperature);  
temperature = 85;  
printTemp(temperature);
```

Output:

```
The temperature is a balmy 35 F  
The temperature is a balmy 85 F
```

Functions

- ❑ Major benefit of defining functions is the flexibility
- ❑ Suppose you decide to display the temperature in Celsius instead of Fahrenheit
- ❑ Without functions, you would have to change every line that displays the temperature in Fahrenheit

```
void printTemp(int temp)
{
    int celsius = (temp - 32) * 5/9;
    println("The temperature in celsius is " + celsius);
}
```

Functions

- Now when you invoke

```
printTemp(35);  
printTemp(85);  
printTemp(120);
```

- The output is

```
The temperature in celsius is 1  
The temperature in celsius is 29  
The temperature in celsius is 48
```

Functions example - Calculator

- ❑ Writing a program for a simple calculator (+-*/)
- ❑ You need functions for addition, subtraction, division and multiplication
- ❑ You can then provide two numbers to the appropriate function and it will compute and display the result

```
add(int a, int b)
{
    int c = a + b;
    println("The result of addition is " + c);
}
```

Functions exercise - 2 minutes

- ❑ Write a function that accepts two integers and displays the value of their product
- ❑ Use the add function below for reference
- ❑ Discuss your solution with your neighbor

```
add(int a, int b)
{
    int c = a + b;
    println("The result of addition is " + c);
}
```



Built-in Functions - Processing

- ❑ `line(x1, y1, x2, y2)` – draws a line
- ❑ `println(message)` – prints a message to the screen
- ❑ `ellipse(centerX, centerY, xradius, yradius)` - draws an ellipse on the screen with specified parameters
- ❑ `stroke(255, 0, 0)` // Set the Line Color to Red
- ❑ and many more...

RESPONSE IN PROCESSING

Mouse responses

- Mouse actions:
 - `mouseX` and `mouseY` are the coordinates for where the mouse is.
 - `pmouseX`, `pmouseY` are the coordinates for where the mouse was in the previous frame
 - `mousePressed`: boolean variable that is `true` if the mouse is pressed, `false` otherwise
 - `mouseButton`: `LEFT`, `CENTER` or `RIGHT`
- Examples: 5-4, 5-5, 5-6, 5-7, 5-12
- Examples: MouseDemo

Key responses

- Key actions:

- `keyPressed`: boolean variable that is `true` if a key is pressed, `false` otherwise
- `key`: the char value of key pressed
- `keyCoded`: true if key is coded and not tied to a specific key. For example: `ALT`, `CONTROL`, `SHIFT`, `UP`, `DOWN`, `LEFT`, `RIGHT`
- `mouseButton`: `LEFT`, `CENTER` or `RIGHT`

- Examples: 5-18, 5-19, 5-21

ANIMATION

Animation

- ❑ Requires redrawing
- ❑ `setup()` function is invoked only once – at the beginning of the program
- ❑ `draw()` function is invoked repeatedly – to simulation animation

Animation

```
void setup() {  
    size(640, 480);  
    smooth();  
    noStroke();  
}
```

```
void draw() {  
    fill(mouseX, mouseY, 0);  
    ellipse(mouseX, mouseY, 30, 30);  
}
```

Animation – Speed and Direction

- Run Example 7-3 from the Getting started book
- Run Example 7-4 from the Getting started book

Please modify example 7-4 to make the pacman bouncing back and forth between left and right walls



Animation of an Orbit



□ Examples->Basics->Math->PolarToCartesian

Animated Yin Yang

- **Version 1:** Change the sketch size to be 800 x 400 and animate the Yin Yang to move left to right until it touches the right edge. Then it should reverse and move right to left until it touches the left edge. Then it continues to move back and forth.
- **Version 2:** Make the Yin Yang roll along its center! You will need to use trigonometric functions sine and cosine to calculate the coordinates of the center of the small circles. The Processing functions are named `sin()` and `cos()` and they take angles in radians. To use degrees, use the `radians()` function. For example: `sin(radians(180));`
- **Version 3:** Make it bounce! (more difficult)



A FOR ARRAYS!
A FOR AWESOME!

Store the price of an item

- ❑ To store the price of an item you would use a variable
- ❑ To store the price of two items you would use two variables
- ❑ To store the price of three items you would use three variables
- ❑ To store the price of 17 items,

15% Discount on all items

- Let us assume that you want to give a 15% discount on every item in the store
- If $A = 100$, after discount
 - $A = A - (15/100 * A) = 85$
- Find every variable (x) and perform
 - $x = x - (15/100 * x)$
 - $y = y - (15/100 * y)$
 - $z = z - (15/100 * z)$ and so on...

Find the average item price

- ❑ Find every variable
- ❑ Find their price
- ❑ Compute the sum
- ❑ Keep a track of the total number of variables/items
- ❑ Compute the average = $\text{sum} / \text{num of vars}$
- ❑ What if you forgot to include one variable??

Arrays to the rescue

- `int [] prices = {10, 20, 40, 60};`

- To sum all the prices, use a loop

```
int sum = 0;
for(int i = 0; i < prices.length; i++) {
    sum = sum + prices[i];
}
println(sum);
```

15% discount



```
for(int i = 0; i<prices.length; i++) {  
    prices[i] = prices[i] - (15/100*prices[i]);  
}
```


Average of prices

- Print the average of all the prices in the prices array

- Refer to the **sum** code snippet

```
int [] prices = {10, 20, 40, 60};
int sum = 0;
for(int i = 0; i<prices.length; i++) {
    sum = sum + prices[i];
}
avg = sum / prices.length;
// Compute the average
println("The avg is " + avg);
```

Min and Max



- ☐ Calculate the min?
- ☐ Calculate the max?
- ☐ Calculate min and max?

Arrays Make Animations Awesome

- Examples->Basics->Math->SineWave
- An army of Pacmans? Example 10-3
- A Flotilla of YingYangs?

