Computer Creativity

Object Oriented Programming

Okanagan

Slides courtesy of Dr. Abdallah Mohamed.

Key Points

1) Introducing OOP (Object Oriented Programming) in Processing

2) Define classes, objects, methods, and attributes (instance variables).

3) Create objects from classes using `new`.

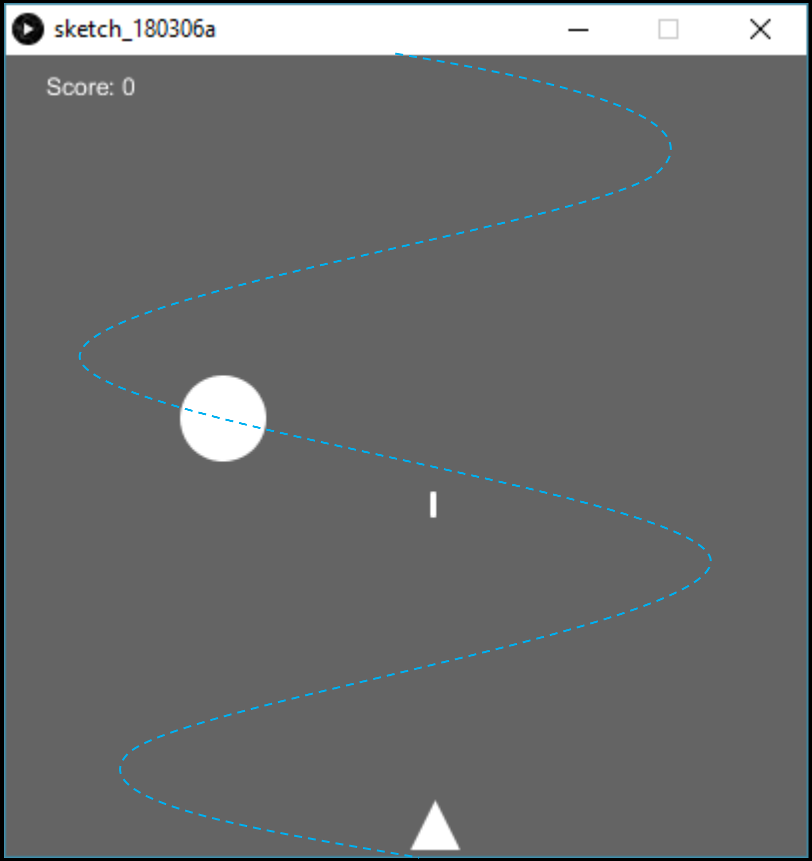
4) Using OOP in your Animations

Previously…

- Java constructs and data types
  - **Variables**: `int`, `float`, `boolean`, …
  - **Drawing:** `line`, `ellipse`, `image`, `text`, …
  - **Conditionals**: `if`, `if-else`, `switch`
  - **Loops**: `while`, `for`
  - **Functions**
- You used these concepts for simple, interesting programs
  - Bouncing ball, your custom superhero, fading images, moving shapes, …
- **There are more interesting ways of building programs…**

Introductory Problem: The Space Shooter Game Revisited

- You have exactly
  - 1 spaceship
  - 1 enemy
  - 1 bullet at any time
- Spaceship moves horizontally with the mouse, but it doesn't move vertically at all.
- Enemy moves in a sin wave
  - Two full cycles
- You can shoot one bullet by mouse click – you can't shoot another one until bullet goes out of screen (top)
- If bullet hits enemy, score++



```
float ship_x = 0, ship_y = 375;
float bullet_x = 0, bullet_y = 375, bullet_len = 10;
boolean bullet_active = false;
float enemy_x = 200, enemy_y = 0, enemy_size = 40;
int score = 0;

void setup(){
  size(400,400);
  stroke(255);
  strokeWeight(3);}

void draw(){
  background(100);
  text("Score: " + score, 20,20);
  //game loop
  moveSpaceship();
  moveBullet();
  moveEnemy();
  detectCollisions();
  displaySpaceship();
  displayBullet();
  displayEnemy();
}
```

Without Objects…

Green is ***Spaceship's*** attributes & actions

Blue is ***Bullet's*** attributes & actions

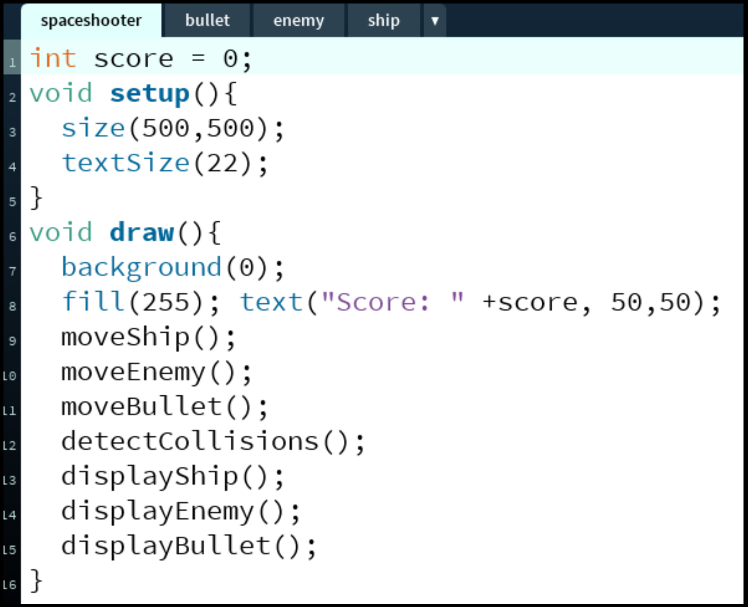
Red is ***Enemy's*** attributes & actions

```
void moveSpaceship(){ ship_x = mouseX; }
void moveEnemy(){
  enemy_y += 0.3;
  enemy_x = 200+100*sin(map(enemy_y, 0, height, 0, 8*PI));
}
void moveBullet(){
  if(bullet_active){
    bullet_y-=6;
    if(bullet_y<0) bullet_active = false;
  }else{
    bullet_x = ship_x;
    bullet_y = ship_y;
  }
}

void displaySpaceship(){
  triangle(ship_x,ship_y,ship_x+10,ship_y+20,ship_x-10,ship_y+20);
}

void
displayBullet(){line(bullet_x,bullet_y,bullet_x,bullet_y+bullent_len);}

void displayEnemy(){  ellipse(enemy_x,enemy_y,enemy_size,enemy_size); }
void detectCollisions(){
  if(dist(bullet_x,bullet_y,enemy_x,enemy_y)<enemy_size/2)
        score++; //not accurate
}

void mouseReleased(){
  bullet_active = true;
```

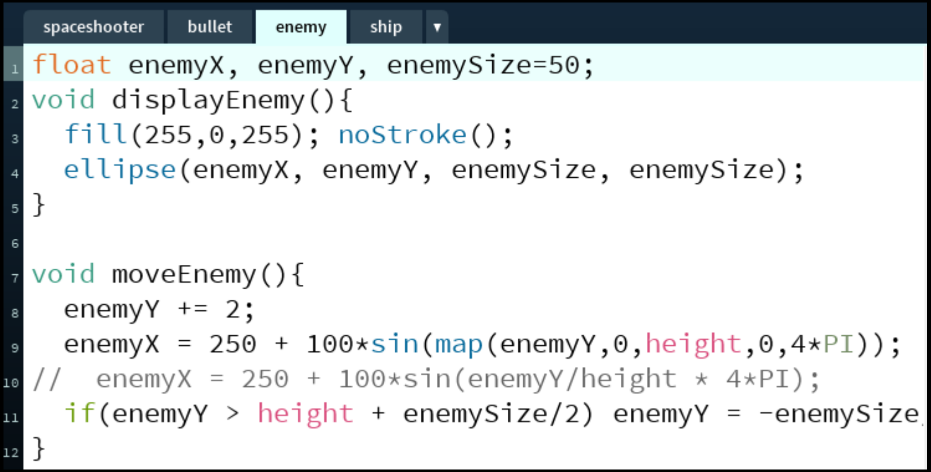
It is very tedious to name the variables and functions for each item in the game. This can get worse when we have a real game with many many items.

One way to organize code – Use Tabs

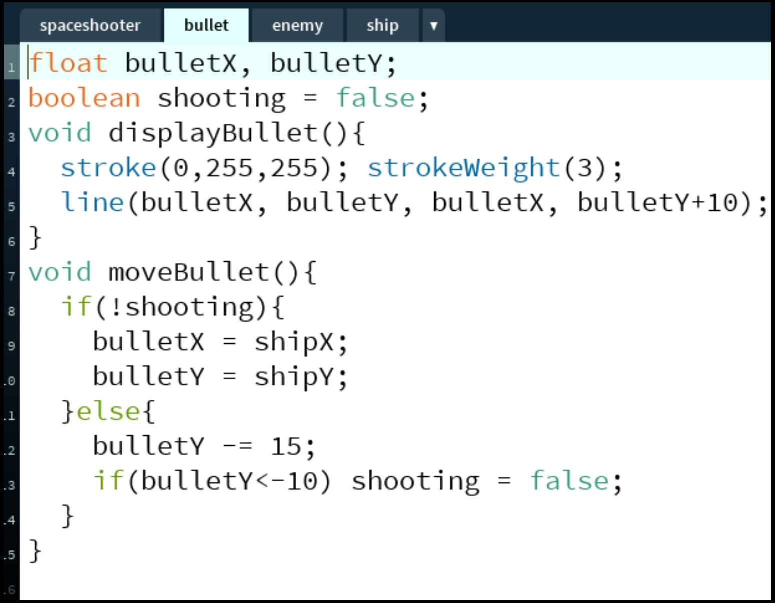
- Put all the attributes and methods for each game item in one tab



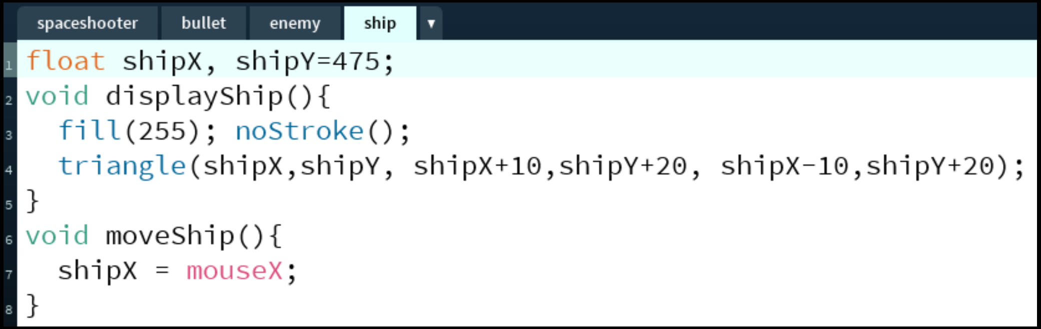
```
int score = 0;
void setup(){
  size(500,500);
  textSize(22);
}
void draw(){
  background(0);
  fill(255); text("Score: " +score, 50,50);
  moveShip();
  moveEnemy();
  moveBullet();
  detectCollisions();
  displayShip();
  displayEnemy();
  displayBullet();
}
```



```
float enemyX, enemyY, enemySize=50;
void displayEnemy(){
  fill(255,0,255); noStroke();
  ellipse(enemyX, enemyY, enemySize, enemySize);
}

void moveEnemy(){
  enemyY += 2;
  enemyX = 250 + 100*sin(map(enemyY,0,height,0,4*PI));
//  enemyX = 250 + 100*sin(enemyY/height * 4*PI);
  if(enemyY > height + enemySize/2) enemyY = -enemySize
}
```



```
float bulletX, bulletY;
boolean shooting = false;
void displayBullet(){
  stroke(0,255,255); strokeWeight(3);
  line(bulletX, bulletY, bulletX, bulletY+10);
}
void moveBullet(){
  if(!shooting){
    bulletX = shipX;
    bulletY = shipY;
  }else{
    bulletY -= 15;
    if(bulletY<-10) shooting = false;
  }
}
```



```
float shipX, shipY=475;
void displayShip(){
  fill(255); noStroke();
  triangle(shipX,shipY, shipX+10,shipY+20, shipX-10,shipY+20);
}
void moveShip(){
  shipX = mouseX;
}
```

An Even Better way?

- A better way is ***group*** (or *encapsulate*) all ***functions and attributes*** of ***each item*** under a ***code block***, and then giving them ***simpler*** names.

- This can be done using **OOP**

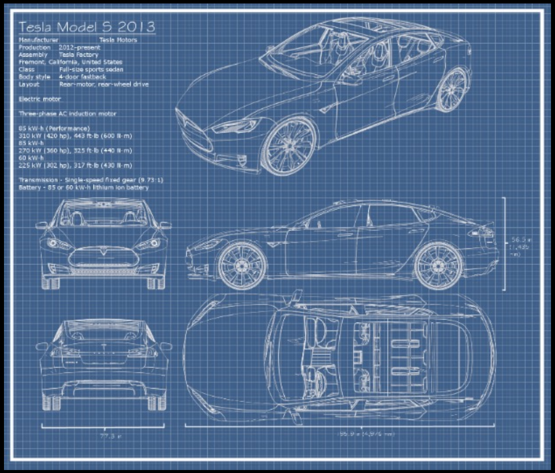
OOP Basics

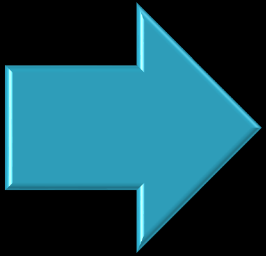
Two Phases to Code With Objects

- The Object Oriented Programming allow you to ***encapsulate*** the attributes and actions (functions) into objects, and then ask these objects to ***act!***
- In order to use objects, we must go through two phases,
  - Phase (1) create the ***design*** of the object
    - The design is represented using a ***class*** which has
      - The ***attributes*** as ***variables***
      - The ***actions*** as ***functions***
  - Phase (2) ***build*** objects based on the design and use them.

Two Phases to Code With Objects, cont'd

- **How are objects created in the real-world?**
  - **TWO PHASES**. Example: Cars.





Phase 1: Blueprint

- **Attributes**
- **Behaviour (Actions)**

Phase 2: Construction

In Processing, all objects of a design have the same actions and attributes (although the attribute values can be different).

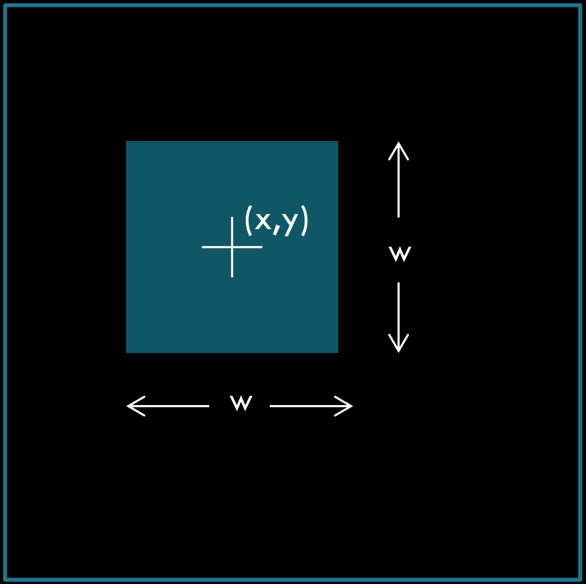
Phase 1: *Class Definition*

- To define a ***class*** that represents a ***design***:
  - use the keyword `class` and provide a name for your class
  - enclose the contents of your class in brackets "**{**", "**}**"
  - define any ***attributes*** (*instance variables*) for your class
  - define any ***actions*** (*functions*) in your class
- Syntax:

```
class classname {
     //attributes
     variableType variableName;

     //actions
     returnType functionName(par1, par2, …, parN){
          function implementation
     }
}
```

Let's Design our First Class

- Instead of using objects in the SpaceShooter game, let's start with something simple … a ***Square***!
- Assume we want to create a `Square` class as follows:
  - Attributes:
    - A square has position x,y and side length w, all of float type.
    - A square has fill color but not an outline.
  - Functions:
    - A square can move in the four directions
      - right, left, up, and down
    - A square can tell us its area using getArea() that returns the area value.
    - A square draw itself at (x,y)



Example

The Square Class

Square

x : float
y : float
w : float
c : color

moveUp(): void
moveDown(): void
moveLeft(): void
moveRight(): void
getArea(): float
display(): void

```
class Square {
 //attributes
 float x = 100, y = 100, w = 50;
 color c = color(0,0,255);
 //behavior
  void moveRight()  {x += 10;}
  void moveLeft()   {x -= 10;}
  void moveUp()     {y -= 10;}
  void moveDown()   {y += 10;}
  float getArea(){ return w*w;}
  void display() {
    rectMode(CENTER);
    fill(c);
    noStroke();
    rect(x, y, w, w);
  }
}
```

Phase 2: Creating and Using Objects

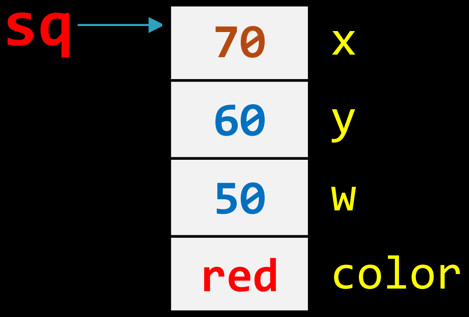
- A class is just a blue-print for creating objects.
    - By itself, a class performs no work or stores no data.
- For a class to be useful, we must create objects of the class.
    - Each object created is called an ***object instance***.
- To create an object, we use the `new` keyword.
- When an object is created using the `new` keyword:
    - Processing allocates space for the object in memory.
    - The attributes are initialized to some values.
        - If no values specified, ***default values*** are used: 0 for numeric attributes, null for string, and false for Boolean variables.
    - Processing returns a pointer to where the object is stored in memory which we will call an ***object reference***.

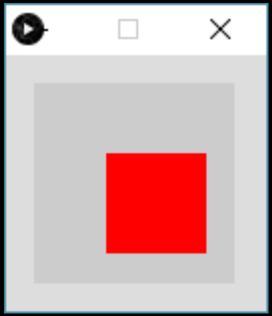
Creating and Using Objects (2)

- Objects are created using the `new` keyword.
- To access any of the object's attributes or functions, provide the object reference, followed by a dot (.), and then the name of the variable or function.
- Example:

```
// create a square object
Square sq = new Square();
// assign values to attributes
sq.x = 60;
sq.y = 60;
sq.w = 50;
sq.c = color(255,0,0);
// call square's functions
sq.moveRight();
sq.display();
```

Each object has its own space in ***memory***





Object Oriented SpaceShooter Game

- Now, let's go back to our space-ship game and try to use objects to model the game.
- As you saw, each of the Spaceship, Bullet, and Enemy has its own ***attributes*** and ***actions***.
- Let's now design our classes and use them to create the game objects.

Object Oriented SpaceShooter Game

- Let's map the attributes and actions (functions) from the previous code to these three objects

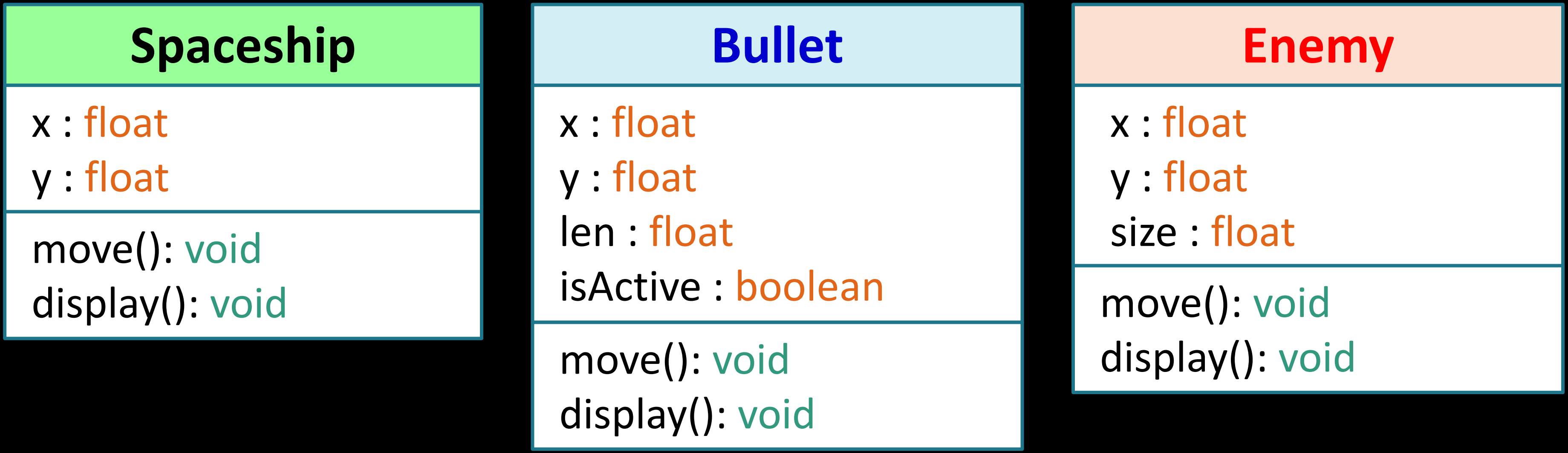
Spaceship
ship_x : float ship_y : float
moveSpaceship(): void displaySpaceship(): void

Bullet
bullet_x : float bullet_y : float bullet_len : float bullet_active : boolean
moveBullet(): void displayBullet(): void

Enemy
enemy_x : float enemy_y : float enemy_size : float
moveEnemy(): void displayEnemy(): void

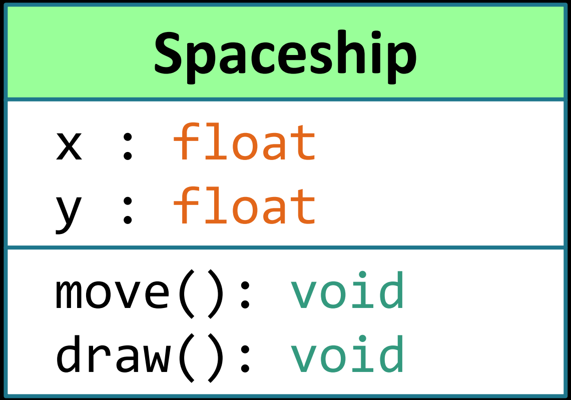
Object Oriented SpaceShooter Game

- Now, let's simplify the function and attribute names



Spaceship Class

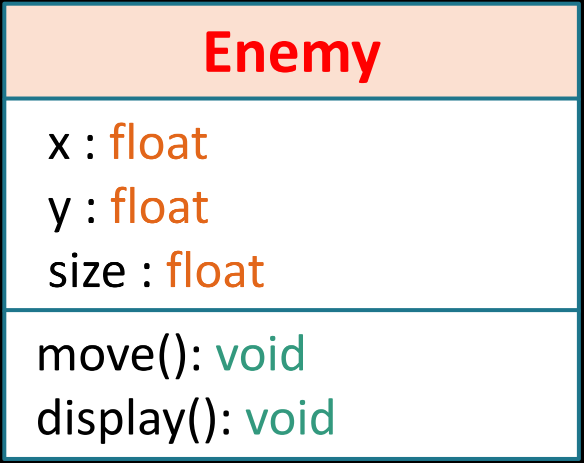
- The Spaceship class is used for describing a spaceship object. It uses the same attributes and functions from our game example.



```
class Spaceship {
 //attributes
 float x = 0 , y = 375;
 //behavior
 void move(){
   x = mouseX;
 }
 void display(){
   triangle(x,y,x+10,y+20,x-10,y+20);
 }
}
```

Enemy Class

- The Enemy class is used for describing an enemy object. It uses the same attributes and functions from our game example.



Enemy

x : float
y : float
size : float

move(): void
display(): void

```
class Enemy {
 //attributes
 float x = 0 , y = 375, size = 40;
 //behavior
 void move(){
   y+=0.3;
   x=200+100*sin(map(y,0,height,0,8*PI));
 }
 void display(){
   ellipse(x,y,size,size);
 }
}
```

Bullet Class

- The Bullet class is used for describing a bullet object. It uses the same attributes and functions from our game example.

Bullet
x : float y : float len : float isActive : boolean
move(): void display(): void

```
class Bullet {
 //attributes
 float x = 0 , y = 0, len = 10;
 boolean isActive = false;
 //behavior
 void move(Spaceship ship){
   if(isActive){
    y -= 6;
    if(y<0) isActive = false;
  }else{ x = ship.x;  y = ship.y; }
 }
 void display(){
    line(x, y, x, y+len);
 }
}
```

Object Oriented SpaceShooter Game

```
int score = 0;
Spaceship ship = new Spaceship();
Enemy enemy    = new Enemy();
Bullet bullet  = new Bullet();

void setup(){
  size(400,400); stroke(255); strokeWeight(3);
}

void draw(){
  background(100);
  text("Score: " + score, 20,20);
  //game loop
  ship.move();
  enemy.move();
  bullet.move(ship);
  detectCollisions();
  ship.display();
  enemy.display();
  bullet.display();
}
void detectCollisions(){
  if(dist(bullet.x, bullet.y , enemy.x, enemy.y) < enemy.size/2)
       score++;
}
void mouseReleased(){
  bullet.isActive = true;
}
```

Create objects here!

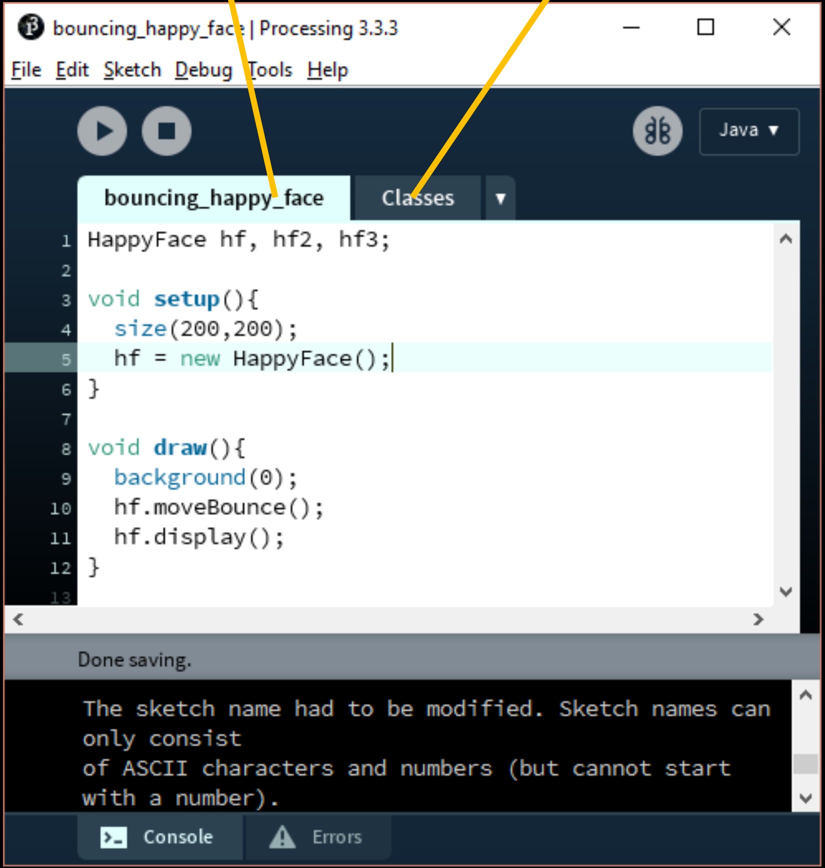
Use the objects in the functions!

Remember Sketchbook Tabs?

- As the program gets larger, you will need to find a way to organize the code so that it is easy to follow.
- One way to do this is to separate code blocks using Sketchbook Tabs in the PDE.
- For example, you can put the HappyFace class you just created in its own tab instead of putting it below the draw() method.

Write the code for the main program here

Create more tabs to hold the code for your classes.


bouncing_happy_face | Processing 3.3.3
File Edit Sketch Debug Tools Help
Java
bouncing_happy_face
Classes
Done saving.
Console
Errors

```
HappyFace hf, hf2, hf3;

void setup(){
  size(200,200);
  hf = new HappyFace();
}

void draw(){
  background(0);
  hf.moveBounce();
  hf.display();
}
```

```
The sketch name had to be modified. Sketch names can
only consist
of ASCII characters and numbers (but cannot start
with a number).
```

Object-Oriented Terminology

- An ***object*** is an instance of a class that has its own attributes and functions. Attributes and functions define what the object is and what it can do. *Each object has its own area in memory.*

- A ***class*** is a generic template (blueprint) for creating an object. All objects of a class have the same functions and attributes (although the attribute values can be different).

- An ***attribute*** (or ***property***, or ***instance variable***) is an attribute of an object.

- A ***function*** (or a ***method***) is a set of statements that performs an action.

- A ***parameter*** is data passed into a method for it to use.

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COSC 123

Computer Creativity

Practice with Object Oriented Programming

Okanagan

Slides courtesy of Dr. Abdallah Mohamed.

Key Points

1) Object Oriented Thinking
2) Old Problems Revisited
3) Exercises

Object Oriented Thinking

- Many of the programs we did before can be written using OOP
- You need apply ***Object-Oriented Thinking***. Instead of focusing on designing functions, you need to focus on how to group ***data (attributes)*** and ***functions (actions)*** together into objects.
  1. ***Identify the items*** needed in your animation and create a class for each category of items (i.e. items that share the same design).
  2. ***Create objects*** in your game, initialize their attributes, and ask them to *act* (by calling their functions)
- You can even create **objects for non-physical objects**. For example, to detect collisions in our space-shooter game, you can create an object, ***CollisionDetector***, whose sole purpose is to monitor the game and detect any collisions.
  - Note that this can also be done using a function detectCollision() as we did in the previous program.

Old Programs REVISTED

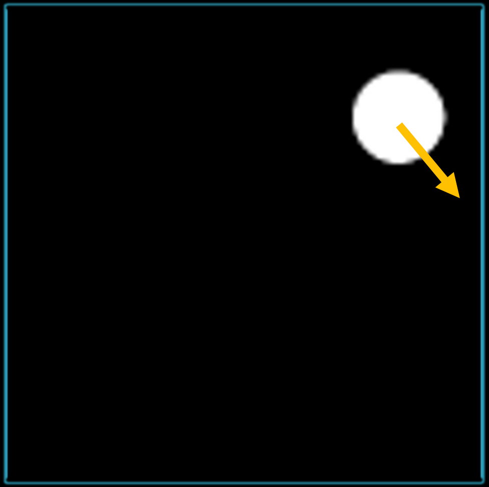
- Let's try to convert some of the programs we wrote so far to Object-Oriented Programs
  - Bouncing Ball
  - Spaceship
  - Buttons
    - *important as it facilitates creating GUIs*

Bouncing Ball WITHOUT OOP

This is the code we wrote before without OOP.

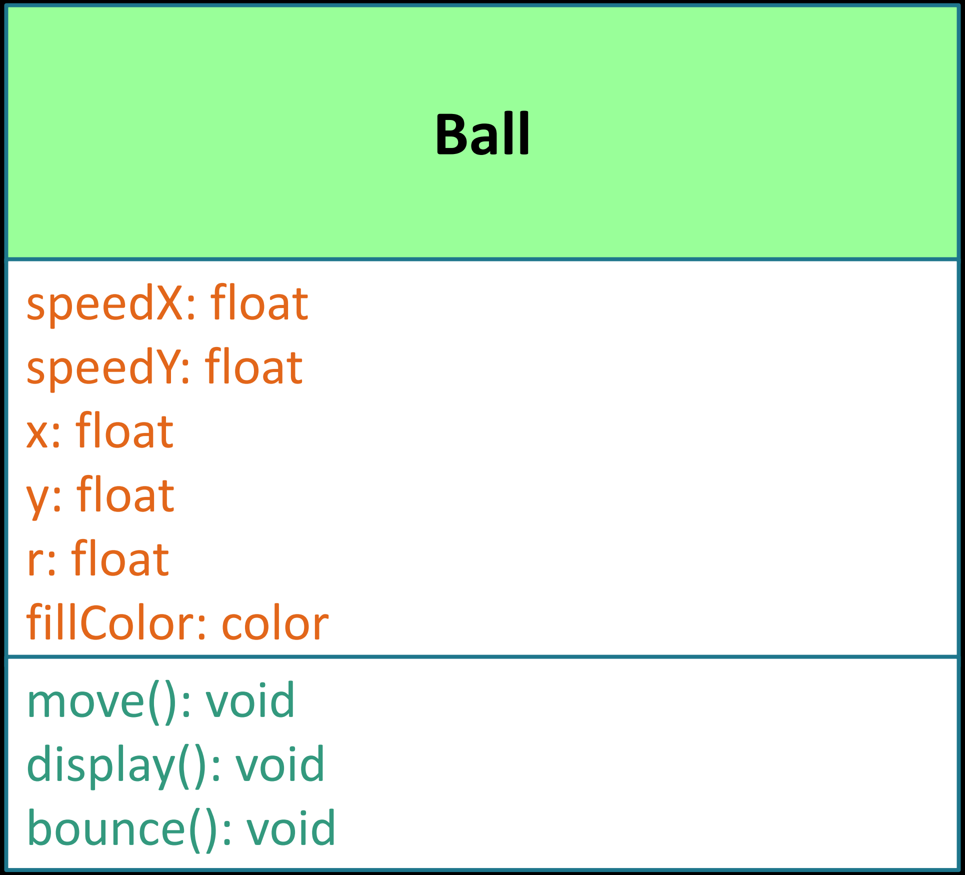
In order to re-think the code in OOP:

1. Identify items in animation → ball
2. Identify item's attributes → x, y, speedX, speedY, and r
3. Identify item's behavior → move(), bounce(), and display()



```
float speedX = 1, speedY = 2;
float x=20, y=100, r = 20;
void setup(){
  size(200,200);
}
void draw(){
  background(0);
  ellipse(x,y,2*r,2*r);
  //increment x
  x += speedX;
  //if ball at edge, reverse direction
  if( x > width-r || x < r )
     speedX = -speedX;
  //increment y. reverse when at edge
  y += speedY;
  if(y > height-r || y < r)
     speedY = -speedY;
}
```

Bouncing Ball Class



Ball

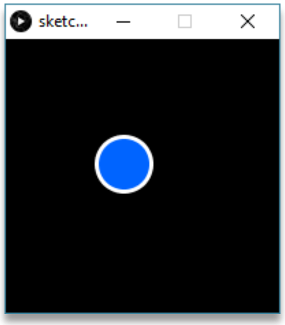
speedX: float
speedY: float
x: float
y: float
r: float
fillColor: color

move(): void
display(): void
bounce(): void

OOP Bouncing Ball – basic design

```
Ball ball;
void setup(){
  size(200,200);
  //create ball object
  ball = new Ball();
  //initialize ball object
  ball.x = width/2;
  ball.y = height/2;
  ball.speedX = 2;
  ball.speedY = 3;
  ball.r = 20;
}
void draw(){
  background(0);
  ball.move();
  ball.bounce();
  ball.display();
}
```

```
class Ball {
 //attributes
 float x,y,r,speedX,speedY;
 //behavior
 void move() {
  x = x + speedX;
  y = y + speedY;
 }
 void bounce() {
  if (x<r||x>width-r) speedX = -speedX;
  if (y<r||y>height-r)speedY = -speedY;
 }
 void display() {
  fill(0,100,255);
  stroke(255);
  strokeWeight(r/7);
  ellipse(x, y, 2*r, 2*r);
 }
}
```



should be part of the ball attributes?

OOP Bouncing Ball – adding color attributes

```
Ball ball;
void setup(){
  size(200,200);
  //create & initialize ball
  ball = new Ball();
  ball.x = width/2;
  ball.y = height/2;
  ball.speedX = 2;
  ball.speedY = 3;
  ball.r = 20;
  ball.fillColor =color(0,100,255);
  ball.strokeColor = color(255);
}
void draw(){
  background(0);
  ball.move();
  ball.bounce();
  ball.display();
}
```

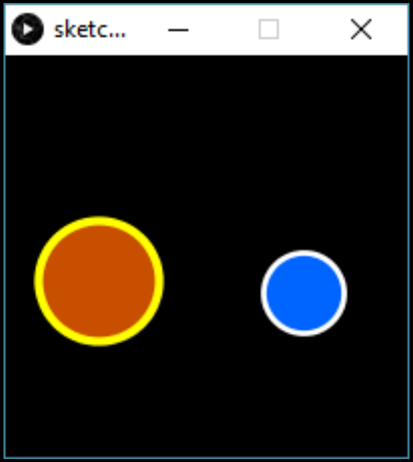
```
class Ball {
 //attributes
 float x,y,r,speedX,speedY;
 color fillColor, strokeColor;
 //behavior
 void move() {...}
 void bounce() {...}
 void display() {
  fill(fillColor);
  stroke(strokeColor);
  strokeWeight(r/7);
  ellipse(x, y, 2*r, 2*r);
 }
}
```

Same as previous slide, except we created attributes for the colors

Example

OOP: Many bouncing balls!

- Now, we can create several bouncing balls using the same Ball class



```
Ball b1, b2;
void setup(){
  size(200,200);
  b1 = new Ball();
  b1.x = width/2;  b1.y = height/2;
  b1.speedX = 2;   b1.speedY = 3;
  b1.r = 20;
  b1.fillColor = color(0,100,255);
  b1.strokeColor = color(255);
  b2 = new Ball();
  b2.x = width/2;  b2.y = height/2;
  b2.speedX = -3;   b2.speedY = -2;
  b2.r = 30;
  b2.fillColor = color(255,100,0,200);
  b2.strokeColor = color(255,255,0);
}
void draw(){
  background(0);
  b1.move(); b1.bounce(); b1.display();
  b2.move(); b2.bounce(); b2.display();
}

class Ball {
 same as before
}
```

Example

Advanced Ball!

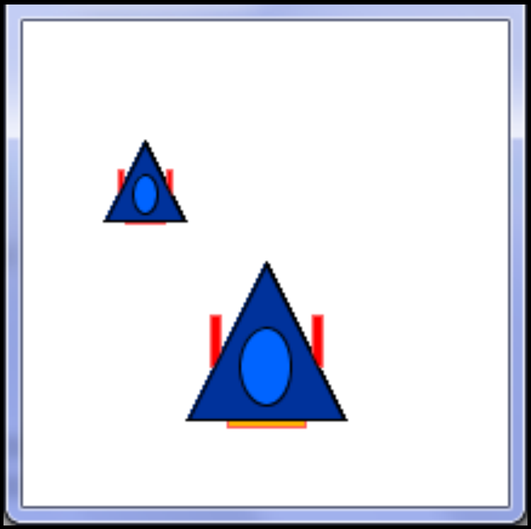
- This design if for a ball that
  - can move, bounce off the edges, and wrap around the sketch
  - Initializes its attributes to some random values

```
Ball b1, b2;
void setup(){
  size(200,200);
  b1 = new Ball(); b2 = new Ball();
}
void draw(){
  background(0);
  b1.move();  b1.bounce();  b1.display();
  b2.move();  b2.wrap();    b2.display();
}

class Ball {
  //attributes
  float x=random(20,80), y=random(20,80), r = 20;
  float speedX = random(-2,2), speedY = random(-2,2);
  color filling=color(random(255), random(255),random(255));
  color outline=color(255);
  //methods (actions)
  void move(){
     x += speedX;y += speedY;
  }
  void bounce(){
    if( x > width-r || x < r ) speedX = -speedX;
    if(y > height-r || y < r)  speedY = -speedY;
  }
  void wrap(){
    if(x > width+r)    x = -r;
    else if(x < -r)    x = width + r ;
    if(y > height+r)   y = -r;
    else if(y < -r)    y = height + r ;
  }
  void display(){
      fill(filling); stroke(outline);
      ellipse(x,y,2*r,2*r);
  }
}
```

Example

Spaceships WITHOUT OOP

1. Items in animation → spaceship
2. item's attributes → location and size
3. item's behavior → move and display



```
void setup(){
  size(300,300);
}
void draw() {
 drawSpaceship(mouseX,mouseY,64);
 drawSpaceship(50,50,32);
}
void drawSpaceship(int x, int y, int size) {
 // draw side guns
 rectMode(CENTER);
 stroke(255, 90, 90);
 strokeWeight(1);
 fill(255, 0, 0);
 rect(x-size/3, y+size/2, size/15, size/3);
 rect(x+size/3, y+size/2, size/15, size/3);
 // draw jet engine
 fill(255, 180, 0);
 rect(x, y+size, size/2, size/10);
 // draw main body
 stroke(0);
 fill(0, 50, 155);
 triangle(x,y,x+size/2,y+size,x-size/2, y+size);
 fill(0, 100, 255);
 ellipse(x, y+2*size/3, size/3, size/2);
}
```

Example

OOP Spaceship

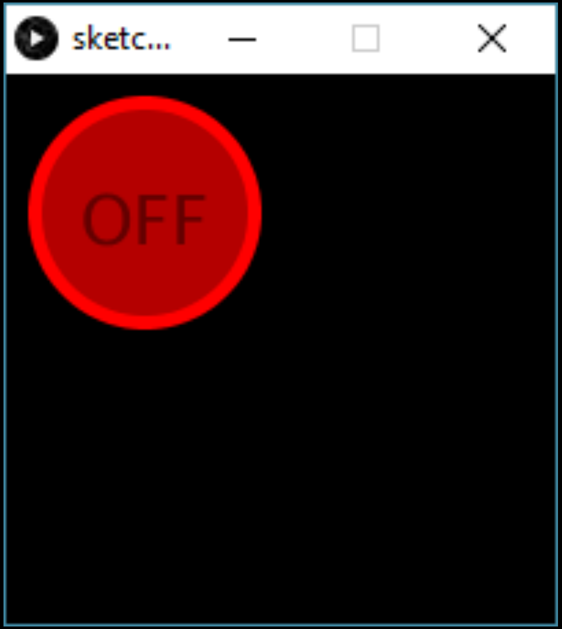
```
Spaceship s1, s2;
void setup(){
  size(300,300);
  s1 = new Spaceship();
  s1.size=64;
  s2 = new Spaceship();
  s2.size=32;
}

void draw() {
  background(0);
  s1.moveTo(mouseX,mouseY);
  s2.moveTo(50,50);
  s1.display();
  s2.display();
}
```

```
class Spaceship {
  float x, y, size;
  void moveTo(int x1,int y1){
    x = x1;
    y = y1;
  }
  void display() {
    rectMode(CENTER);
    stroke(255, 90, 90);
    strokeWeight(1);
    fill(255, 0, 0);
    rect(x-size/3, y+size/2, size/15, size/3);
    rect(x+size/3, y+size/2, size/15, size/3);
    // draw jet engine
    fill(255, 180, 0);
    rect(x, y+size, size/2, size/10);
    // draw main body
    stroke(0);
    fill(0, 50, 155);
    triangle(x,y,x+size/2,y+size,x-size/2,y+size);
    fill(0, 100, 255);
    ellipse(x, y+2*size/3, size/3, size/2);
  }
}
```

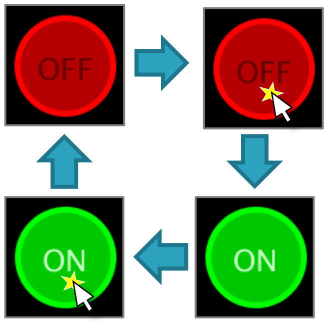
We can also use coordinate translation

Example

Toggle Button WITHOUT OOP

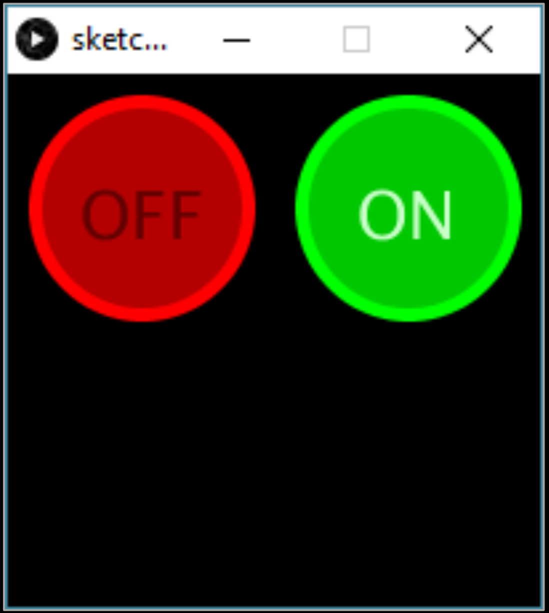


```
boolean active = false;       // button attributes
int x = 50, y = 50, r = 40;
void setup() {
  size(200, 200);
}
void draw() {
 background(0);
  strokeWeight(5);
  textSize(25);   textAlign(CENTER,CENTER);
 if(active) {
  fill(0, 200, 0);  stroke(0,255,0);
  ellipse(x,y,2*r,2*r);
  fill(200,255,200);text("ON",x,y);
 }else{
  fill(180, 0, 0);  stroke(255,0,0);
  ellipse(x,y,2*r,2*r);
  fill(100,0,0);    text("OFF",x,y);
 }
}
void mousePressed() {
 if(dist(mouseX,mouseY,x,y)<r) active = ! active;
}
```



Example

TWO toggle buttons WITHOUT OOP

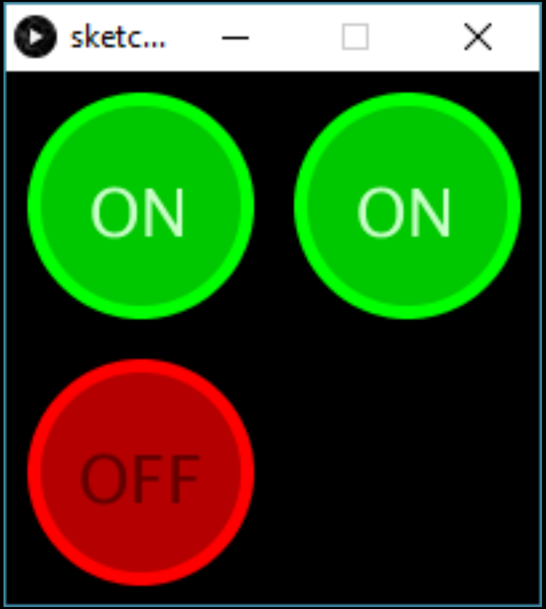


```
boolean active1 = false; // button1
int x1 = 50, y1 = 50, r1 = 40;
boolean active2 = false; // button2
int x2 = 150, y2 = 50, r2 = 40;
void setup() {
  size(200, 200);
}
void draw() {
 background(0);
  strokeWeight(5);
  textSize(25);   textAlign(CENTER,CENTER);
 //button1
 if(active1) {
  fill(0, 200, 0);  stroke(0,255,0); ellipse(x1,y1,2*r1,2*r1);
  fill(200,255,200);text("ON",x1,y1);
 }else{
  fill(180, 0, 0);  stroke(255,0,0); ellipse(x1,y1,2*r1,2*r1);
  fill(100,0,0);    text("OFF",x1,y1);
 }
 //button2
 if(active2) {
  fill(0, 200, 0);  stroke(0,255,0); ellipse(x2,y2,2*r1,2*r2);
  fill(200,255,200);text("ON",x2,y2);
 }else{
  fill(180, 0, 0);  stroke(255,0,0); ellipse(x2,y2,2*r1,2*r2);
  fill(100,0,0);    text("OFF",x2,y2);
 }
}
void mousePressed() {
 if(dist(mouseX,mouseY,x1,y1)<r1) active1 = ! active1;
 if(dist(mouseX,mouseY,x2,y2)<r2) active2 = ! active2;
}
```

Copy/paste code

Example

FOUR toggle buttons WITHOUT OOP



What if we have 10 buttons ?? Or 20?? How about a 100?

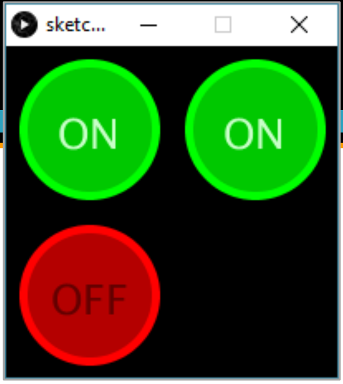
What if we decided to make a change to the button design?

```
boolean active1 = false; // button1
int x1 = 50, y1 = 50, r1 = 40;
boolean active2 = false; // button2
int x2 = 150, y2 = 50, r2 = 40;
boolean active3 = false; // button3
int x3 = 150, y3 = 50, r3 = 40;
void setup() {
  size(200, 200);
}
void draw() {
 background(0);
  strokeWeight(5);
  textSize(25);   textAlign(CENTER,CENTER);
 //button1
 if(active1) {
  fill(0, 200, 0);  stroke(0,255,0); ellipse(x1,y1,2*r1,2*r1);
  fill(200,255,200);text("ON",x1,y1);
 }else{
  fill(180, 0, 0);  stroke(255,0,0); ellipse(x1,y1,2*r1,2*r1);
  fill(100,0,0);    text("OFF",x1,y1);
 }
 //button2
 if(active2) {
  fill(0, 200, 0);  stroke(0,255,0); ellipse(x2,y2,2*r2,2*r2);
  fill(200,255,200);text("ON",x2,y2);
 }else{
  fill(180, 0, 0);  stroke(255,0,0); ellipse(x2,y2,2*r2,2*r2);
  fill(100,0,0);    text("OFF",x2,y2);
 }
 //button3
 if(active3) {
  fill(0, 200, 0);  stroke(0,255,0); ellipse(x2,y2,2*r3,2*r3);
  fill(200,255,200);text("ON",x3,y3);
 }else{
  fill(180,0,0);    stroke(255,0,0); ellipse(x3,y3,2*r3,2*r3);
  fill(100,0,0);    text("OFF",x3,y3);
 }
}
void mousePressed() {
 if(dist(mouseX,mouseY,x1,y1)<r1) active1 = ! active1;
 if(dist(mouseX,mouseY,x2,y2)<r2) active2 = ! active2;
 if(dist(mouseX,mouseY,x3,y3)<r3) active3 = ! active3;
}
```

More copy/paste!!

Example

OOP Toggle Buttons (3 buttons)

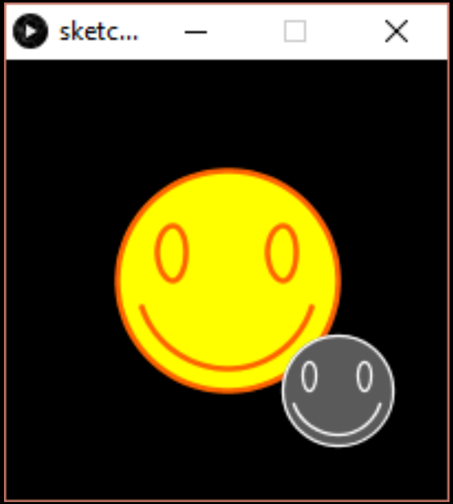


```
Button b1, b2, b3;
void setup() {
  size(200, 200);
  b1 = new Button();
  b1.x = 50; b1.y = 50;
  b2 = new Button();
  b2.x = 150; b2.y = 50;
  b3 = new Button();
  b3.x = 50; b3.y = 150;
}
void draw() {
 background(0);
 b1.display();
 b2.display();
 b3.display();
}
void mousePressed(){
 b1.checkClicked();
 b2.checkClicked();
 b3.checkClicked();
}
```

```
class Button{
  boolean active = false;
  int x = 50, y = 50, r = 40;
  void display(){
    strokeWeight(5);
    textSize(25);   textAlign(CENTER,CENTER);
    if(active) {
      fill(0, 200, 0);  stroke(0,255,0);
      ellipse(x,y,2*r,2*r);
      fill(200,255,200);text("ON",x,y);
    }else{
      fill(180, 0, 0);  stroke(255,0,0);
      ellipse(x,y,2*r,2*r);
      fill(100,0,0);    text("OFF",x,y);
    }
  }
  void checkClicked(){
   if(dist(mouseX,mouseY,x,y)<r) active=!active;
  }
}
```

Happy Face Class Definition

- Implement a class `HappyFace`:
  - A HappyFace has position x, y and radius r, all of float type.
  - A HappyFace has fill color and outline color.
  - Write a function display() that draws the face centered at (x, y).
    - The mouth is an arc with a diameter equal to $1.6\,r$.
    - The eyes are ellipses with dimensions $\frac{r}{2} \times \frac{r}{4}$
    - The outline's thickness is $\frac{r}{20}$
- Use the HappyFace class to create two different faces and display them on the sketch.
  - Use the **dot operator** to set the attributes. E.g.:
    - `face1.x = width/2;`
    - `face1.y = height/2;`
    - `face1.r = width/4.`
    - `face1.fillColor = color(255,255,0);`
    - `…etc`



- Add code to move the faces and bounce them off the sketch edges

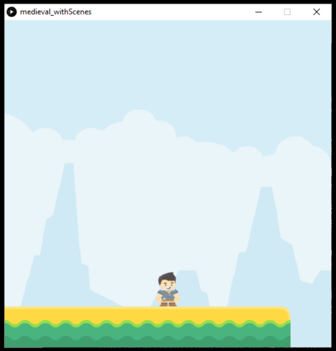
Hint: code for drawing 1 happy face

- Here is the non-OOP code

```
float x = 50, y = 50, r = 20;

fill(255,255,0);

stroke(255,155,0);

strokeWeight(r/20);

ellipse(x,y,2*r,2*r);

//face

arc(x,y,1.6*r,1.6*r,.1*PI,.9*PI); //mouth

ellipse(x+r/2,y-r/4,r/4,r/2);     //right eye

ellipse(x-r/2,y-r/4,r/4,r/2);     //left eye
```

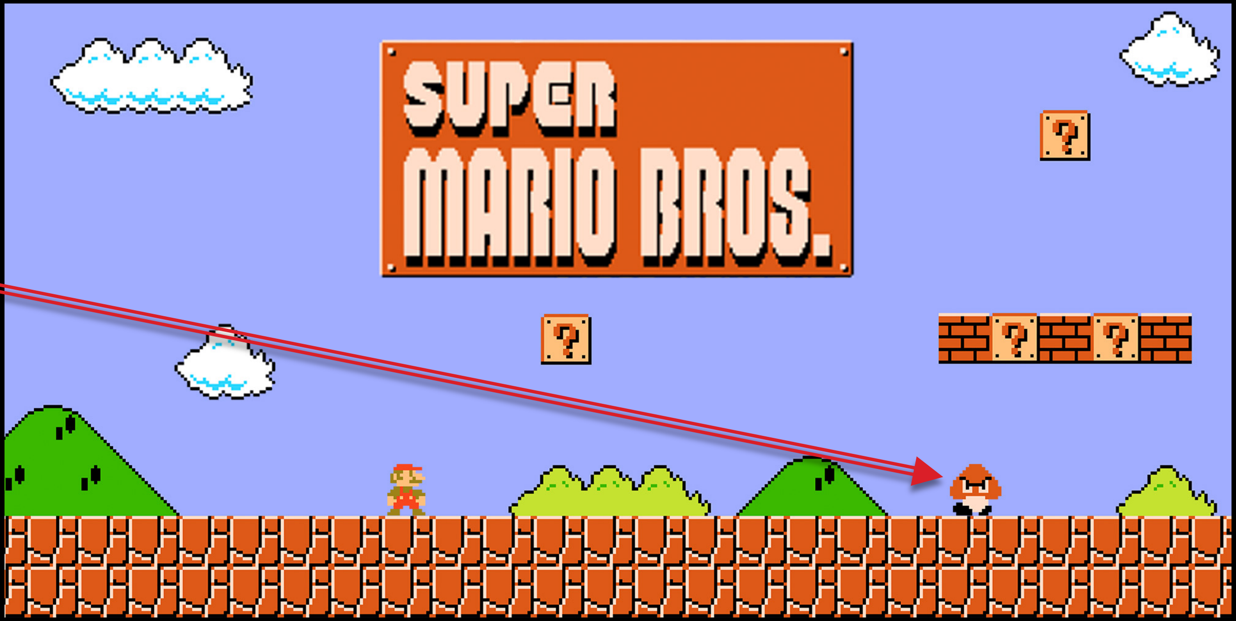
Update your game

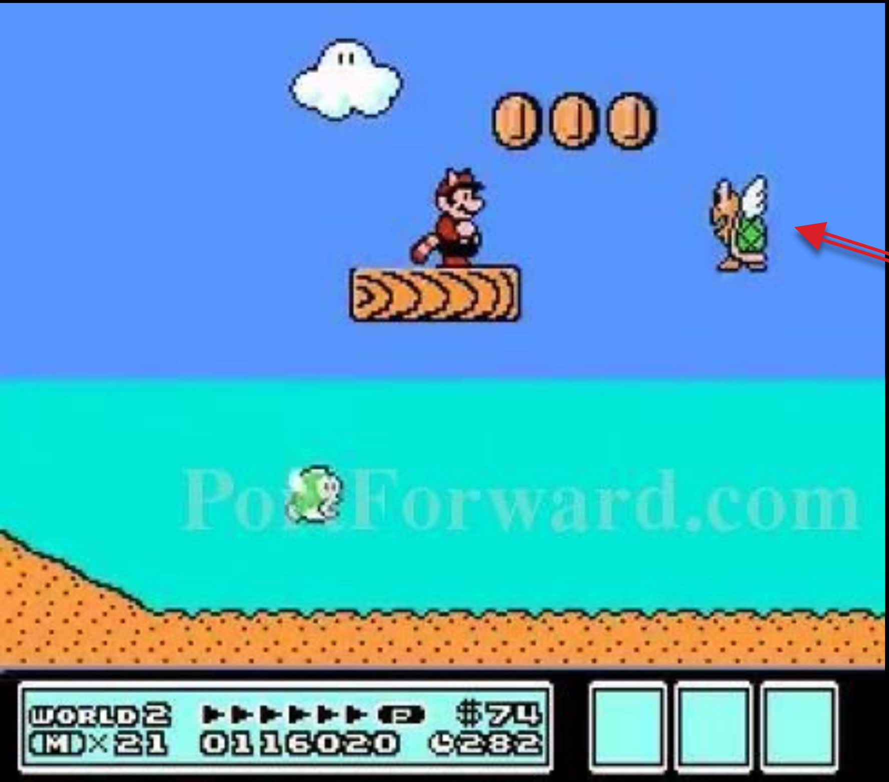
1. Start with your game from Lecture Activity 8
2. Copy the code to Lecture Activity 9 (cp)
3. If you haven't already, organize your code so it uses tabs



4. Use object-oriented programming to create two classes:
   1. Ground Enemies (or Goombas from the original Mario)
   2. Flying Enemies (or Paratroopa from the original Mario)
5. Add 3 ground enemies and 5 flying enemies; they should all have different names, and be of different colours; flying enemies should be restricted to the air, and ground enemies cannot fly.
6. Remember that the original names and images are probably copyrighted, so you will have to find your own!

“Goomba”





“Paratooper”

01000011 01001111 01010011 01000011 01111011

COSC 123

Computer Creativity

Object Oriented Programming II

Okanagan

Slides courtesy of Dr. Abdallah Mohamed.

Key Points

1) Using constructors to initialize objects as they are created.

2) Object references

3) Advanced: The `this` keyword

4) Advanced: Garbage collection and Object’s lifetime

Constructors

- A ***constructor*** is a special function that is **called when the object is first created to initialize** its attributes.
    - A constructor may have parameters like any other function.

```
Ball b = new Ball();
```

Calling the constructor

- Unlike other functions, a constructor:
    - 1) has a name that is the same as the class name.
    - 2) can not have a return type.
    - 3) is called only when we create the object using the new keyword.
- *IF* you do *not* supply a constructor for a class, Processing will use a ***default constructor*** which has no parameters which looks like this:

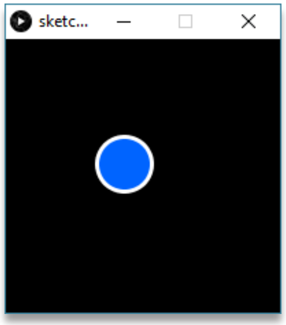
```
Ball(){ }; //attributes are set some default values
```

Example

Ball Class WITHOUT a Constructor

```
Ball ball;
void setup(){
  size(200,200);
  //create & initialize ball
  ball = new Ball();
  ball.x = 100;
  ball.y = 100;
  ball.speedX = 2;
  ball.speedY = 3;
  ball.r = 20;
}
void draw(){
  background(0);
  ball.moveBounce();
  ball.display();
}
```

```
class Ball {
 //attributes
 float x,y,r,speedX,speedY;
 //behavior
 void moveBounce() {
  x = x + speedX;
  y = y + speedY;
  if (x<r||x>width-r) speedX = -speedX;
  if (y<r||y>height-r)speedY = -speedY;
 }
 void display() {
  fill(0,100,255);
  stroke(255);
  strokeWeight(r/7);
  ellipse(x, y, 2*r, 2*r);
 }
}
```



Using Constructors

- Wouldn't it be nice to initialize the attributes of an object as we create it?

```
// create a ball object
Ball ball = new Ball();
// initialize attributes
ball.x = 100;
ball.y = 100;
ball.speedX = 2;
ball.speedY = 3;
ball.r = 20;
```

$\Downarrow$

```
// create a ball object and initialize it
Ball  ball=new Ball(100,100,2,3,20);
```

Example

Ball Class WITH a Constructor

```
Ball ball;
void setup(){
  size(200,200);
  //create & initialize a ball
  ball=new Ball(100,100,2,3,20);
}
void draw(){
  background(0);
  ball.moveBounce();
  ball.display();
}
```

```
class Ball {
 //attributes
 float x,y,r,speedX,speedY;
 //constructor
 Ball(float a, float b, float sx, float sy, float r1){
   x = a; y = b; r = r1;
   speedX = sx; speedY = sy;
 }
 //behavior
 void moveBounce() {
  x = x + speedX;
  y = y + speedY;
  if (x<r||x>width-r) speedX = -speedX;
  if (y<r||y>height-r)speedY = -speedY;
 }
 void display() {
  fill(0,100,255);
  stroke(255);
  strokeWeight(r/7);
  ellipse(x, y, 2*r, 2*r);
 }
}
```

More than One Constructor

- We can have more than one constructor in the same class as long as their parameters are different
- In this example, the `Ball` class defines two constructors:
  - a zero-argument constructor that sets the attributes to some default values.
  - A five-argument constructor that sets the attributes to given values.

```
class Ball {
 //attributes
 float x,y,r,speedX,speedY;
 //constructors
 Ball(){
   x = 50; y = 50; r = 20;
   speedX=2; speedY=2;
 }
 Ball(float x1, float y1, float sx, float sy, float r1){
   x = x1; y = y1; r = r1;
   speedX=sx; speedY=sy;
 }
 //behavior
 void moveBounce() {
  x = x + speedX;  y = y + speedY;
  if (x<r||x>width-r) speedX = -speedX;
  if (y<r||y>height-r)speedY = -speedY;
 }
 void display() {
  fill(0,100,255);
  stroke(255); strokeWeight(r/7);
  ellipse(x, y, 2*r, 2*r);
 }
}
```

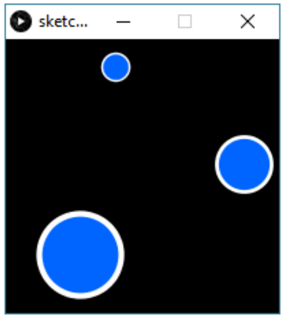
Example

SEVERAL Balls

```
Ball b1,b2,b3;
void setup(){
  size(200,200);
  //create & initialize a ball
  b1 = new Ball(100,100,2,3,20);
  b2 = new Ball();
  b3 = new Ball(80,70,2,-3,30);
}
void draw(){
  background(0);
  b1.moveBounce(); b1.display();
  b2.moveBounce(); b2.display();
  b3.moveBounce(); b3.display();
}
```

Q: How would the code look like if we don't use constructors?

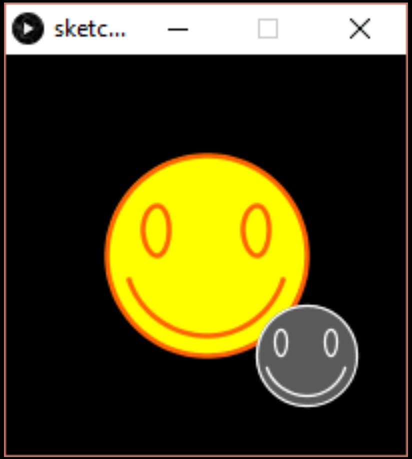
```
class Ball {
 //attributes
 float x,y,r,speedX,speedY;
 //constructor
 Ball(){
   x = 50; y = 50; r = 20;
   speedX=2; speedY=2;
 }
 Ball(float x1,float y1,float sx,float sy,float r1){
   x = x1; y = y1; r = r1;
   speedX=sx; speedY=sy;
 }
 //behavior
 void moveBounce() {
  x = x + speedX;
  y = y + speedY;
  if (x<r||x>width-r) speedX = -speedX;
  if (y<r||y>height-r)speedY = -speedY;
 }
 void display() {
  fill(0,100,255);
  stroke(255);
  strokeWeight(r/7);
  ellipse(x, y, 2*r, 2*r);
 }
}
```



Add Constructors to HappyFace Class

1) Modify your HappyFace class from previous unit so that it has two constructors:

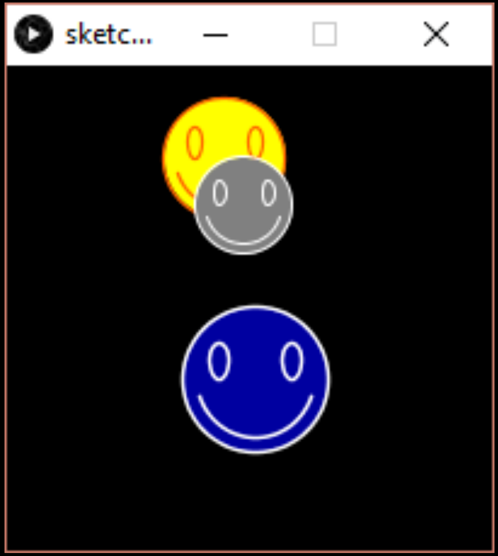
- A zero-arg constructor that sets the radius to 50, the (x,y) position to (radius,radius), speedX and speedY to 0, fill color to yellow, outline color to orange.
- A seven-arg constructor that sets the attributes to given values.



Bouncing Happy-Face(s)

2) Create three bouncing happy-faces with different positions, size and speed, and then move, bounce, and display them in the draw() function.

- Notice how easy it is to create many objects now of the same class and use them in your program.



```
HappyFace f1, f2, f3;

void setup(){
  size(200,200);
  f1 = new HappyFace(...);
  //do the same for f2,f3
}

void draw(){
  background(0);
  f1.move;  f1.bounce(); f1.display();
  //do the same for f2,f3
}

class HappyFace{...}
```

Object References

Object References

- It is important to realize the difference between an object and an object reference.

- When you declare an object variable, you are actually declaring an object reference to that particular object type.
  - Until you create an object using `new`, there is no object in memory which is pointed to by the object reference.

- An object is the physical memory representation of the data.
  - An object has a location in memory and a type (class).
    - Each object has its own memory space and attribute values.

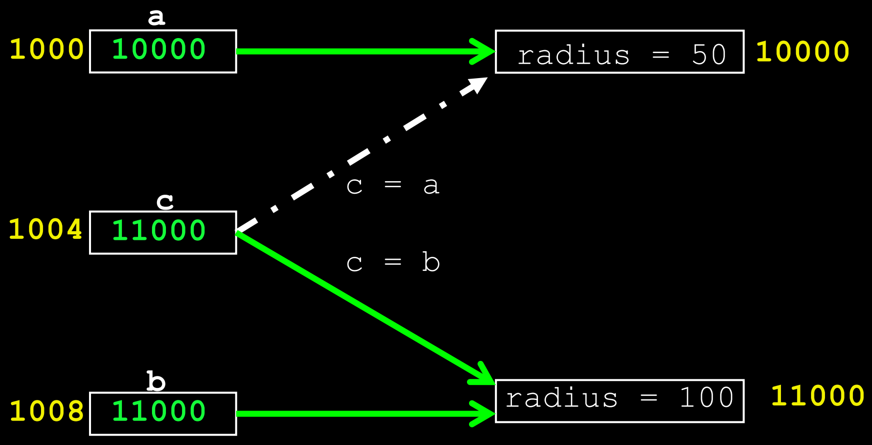
Changing Object References

- Object references are pointers to objects in memory that can be assigned to the same value as another reference using '**=**' or assigned to **null** (which means they refer to nothing).

Example:

```
// "a" is an object reference to a Ball object
Ball a = new Ball(50);
// "b" is an object reference to a Ball object
Ball b = new Ball(100);
// "c" is an object reference (no objects created)
Ball c;

c = b;                // c points to b
println(c.radius);    // 100
c = a;                // c points to a
println(c.radius);    // 50
```

```
class Ball {
    float radius;
    Ball(float r){ radius = r; }
}
```



- Each ***object has its own space in memory*** AND each ***object reference*** also has its ***own memory space***.
- Object references point to objects and can be changed

`null` *Object References*

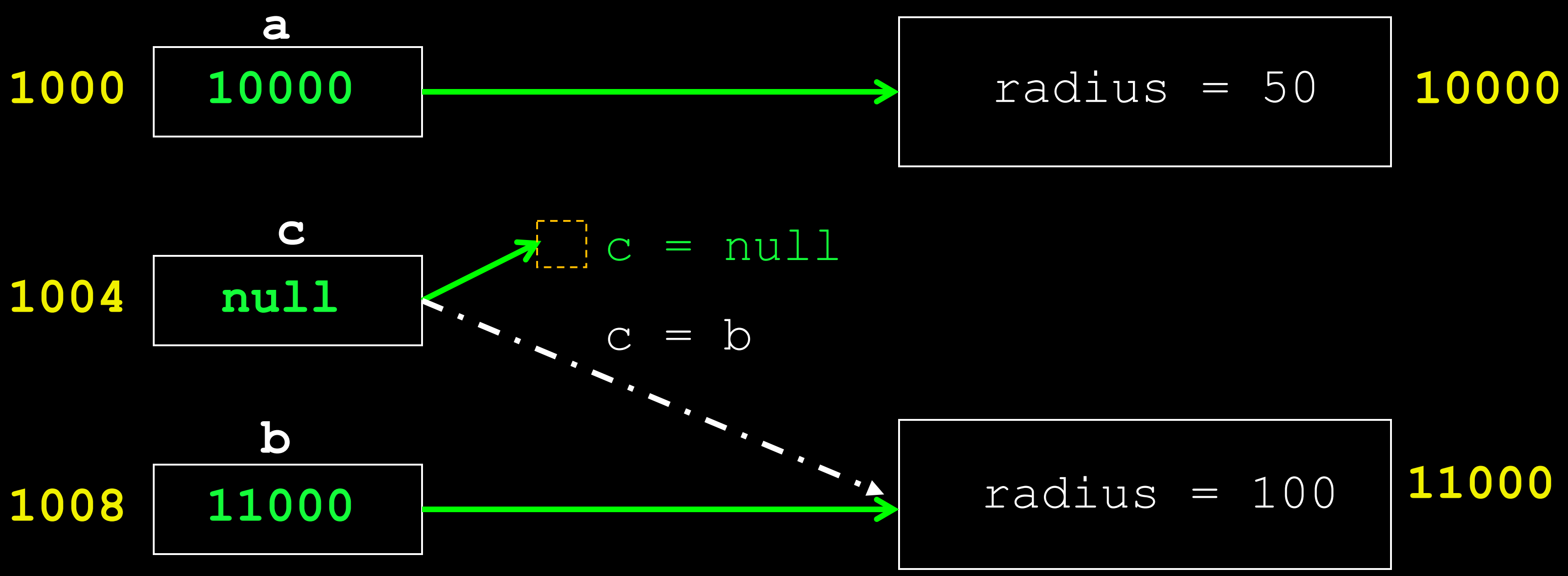
- Sometimes a programmer wants an object reference to point to ***nothing***. To make an object reference refer to nothing, you assign it a value of `null`.
- Example:

```
Ball a = new Ball(50);
Ball b = new Ball(100);
Ball c;

c = b;                  // c points to b
println(c.radius);      // 100
c = null;               // c now points to null
println(c.radius);      // Error!
```

`null` *Object References Example*

- A null reference effectively stores the address of **0**. Since this is not a valid memory address for the program, your program will generate a **run-time error** during execution.
  - The compiler does not check `null` references for you!

- Example:



Question

Objects and Object References

How many objects are created by this code?

```
Ball a, b, c;

a = new Ball();
c = a;
b = new Ball();
```

A. 1

B. 2

C. 3

D. 4

Objects and Object References

What is the radius of the ball referenced by `d`?

```
Ball a, b, c, d;

a = new Ball(50);    // radius = 50
c = a;
b = new Ball(100);   // radius = 100
a = b;
d = c;
```

A. unknown

B. 50

C. 100

D. undefined

Advanced: using this

- When an object function is called, we tell Processing which object to use based on an object reference.
- This object reference is then accessible within an object functions as the **this** reference.

```
class Ball {
  // attributes
  float x, y, r
  float speedX,speedY;
  // constructors
  Ball(){
    this.x = 50; this.y = 50;     this.r = 20;
    this.speedX = 2;   this.speedY = 3;
  }
  Ball(float x,float y,float r,float speedX,float speedY){
    this.x = x;    this.y = y;     this.r = r;
    this.speedX=speedX;   this.speedY=speedY;
  }
  // behavior
  void moveBounce() {
    x = x + speedX;
    y = y + speedY;
    if (x<r||x>width-r) speedX = -speedX;
    if (y<r||y>height-r)speedY = -speedY;
  }
  void display() {
  Ball fill(0,100,255);
    stroke(255);
    strokeWeight(r/7);
    ellipse(x, y, 2*r, 2*r);
  }
}
```

must use this to distinguish between function parameters and object attributes as they have same name.

Advanced: using this

- the **this** reference can be used to call a constructor **from another constructor** in the **same class**

```
class Ball {
  // attributes
  float x, y, r
  float speedX,speedY;
  // constructors
  Ball(){
    this(50, 50, 20, 2, 3);
  }
  Ball(float x,float y,float r,float speedX,float speedY){
    this.x = x;     this.y = y;     this.r = r;
    this.speedX=speedX;   this.speedY=speedY;
  }
  // behavior
  void moveBounce() {
    x = x + speedX;
    y = y + speedY;
    if (x<r||x>width-r) speedX = -speedX;
    if (y<r||y>height-r)speedY = -speedY;
  }
  void display() {
  Ball fill(0,100,255);
    stroke(255);
    strokeWeight(r/7);
    ellipse(x, y, 2*r, 2*r);
  }
}
```

Advanced: Garbage Collection

- Have you ever wondered what happens to objects that you no longer need after you created them using **`new`**?
  - Unlike some other languages, a Java programmer is not responsible for deleting or destroying objects that you no longer use.
  - When an object has no valid references to it, Java may delete the object in memory in a process called ***garbage collection***.

Advanced: Object's Lifetime in Memory

- The lifetime of an object in memory:
  1) The object is created using `new` and a reference to its location in memory is created.
  2) The object may have multiple object references during the program execution.
  3) When all object reference variables go out of scope, the object has no more references and is marked for deletion.
  4) Java periodically scans memory and deletes objects.

Conclusion

- Key object-oriented terminology:
  - ***Object*** – an instance of a class.
  - ***Class*** – an object template with methods and properties.
  - ***Function (or Method)*** – a set of statements that performs an action.
  - ***Parameter*** – data passed into a method.
  - ***Properties*** – are attributes of objects.
- Object references point to objects in memory. Use **`new`** to create objects. Functions are called using an object reference.
- The scope and lifetime of a variable depends on its type (instance, static, local, parameter).