Turtle graphics

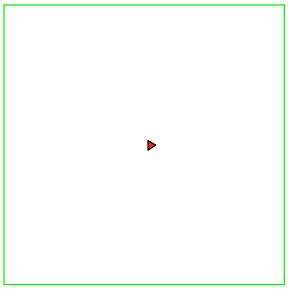
TurtleWorld as an object example

CS111 Computer Programming

Department of Computer Science
Wellesley College

TurtleWorld revisited

- Buggles' smaller, more carefree cousins return to teach an object lesson.
- Recall that Turtles are born centered, pointing EAST, brushDown (red).
- In this lecture, we design and implement a world for Turtles.



A world sophisticate enough to spiral

```
public class SpiralWorld extends TurtleWorld
{
     public void run()
     {
          SpiralMaker spiro = new SpiralMaker();
          spiro.spiral(4, 90, 0, 3)
     }
}
class SpiralMaker extends Turtle
{
     public void spiral(int steps, int angle, int length, int increment)
     {
          if (steps <= 0) {
               // do nothing
          } else {
               fd(length);
               lt(angle);
               spiral(steps-1, angle, length+increment, increment);
          }
     }
}
```

Overrides the run() method in TurtleWorld

Or grow trees

```
public class TreeWorld extends TurtleWorld
{
     public void run()
     {
          TreeMaker tina = new TreeMaker();
          tina.tree(4, 100, 45, 0.6);
     }
}
public class TreeMaker extends Turtle
{
     public void tree(int levels, double length, double angle, double shrink)
     {
          if (levels <= 0) {
               // do nothing
          } else {
               fd(length);
               rt(angle);
               tree(levels-1, length*shrink, angle, shrink);
               lt(2*angle);
               tree(levels-1, length*shrink, angle, shrink);
               rt(angle);
               bd(length);
          }}}
```

Also overrides run() method in TurtleWorld

In other words, we implement the Turtle contract

`public void fd(double n)`
Moves this turtle forward by length `n` in the direction of its current heading.

`public void bd (double n)`
Moves this turtle backward by length `n` in the direction of its current heading.

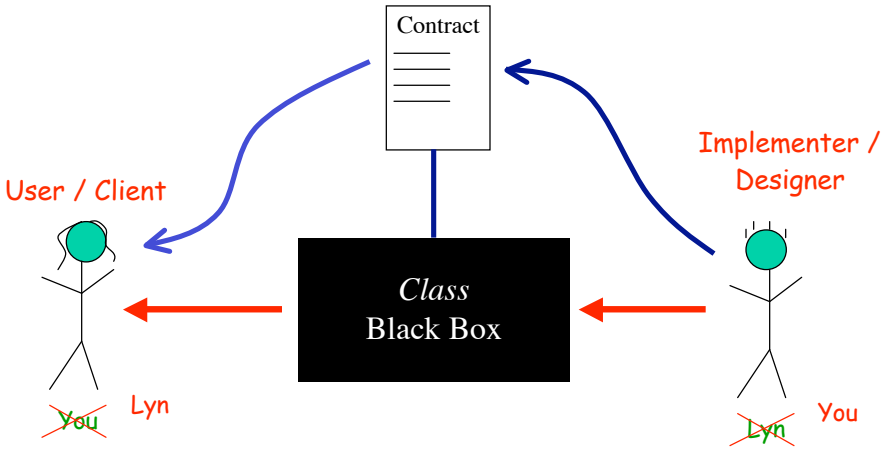
`public void lt (double angle)`
Turns this turtle left by `angle` degrees.

`public void rt (double angle)`
Turns this turtle right by `angle` degrees.

`public void pu ()`
Raises this turtle's pen. When the pen is raised, the turtle leaves no trail when it moves.

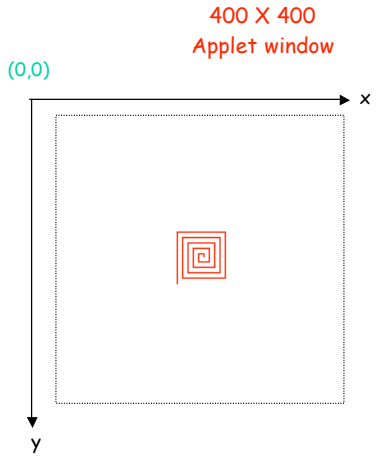
`public void pd ()`
Lowers this turtle's pen. When the pen is lowered, the turtle leaves a trail when it moves.

Big idea number 1: Abstraction



First, Turtle's box

- TurtleWorld is an Applet whose contract contains exactly one method `public void run().`
- We use a Graphics object, to draw the Turtle's art.



Turtle World

```
import java.awt.*;
public class TurtleWorld extends Applet
{
     public static TurtleWorld currentWorld;
     private Graphics turtleGraphics;

     public void init()
     {
          currentWorld = this;
          turtleGraphics = currentWorld.getGraphics();
     }
     public Graphics getTurtleGraphics ()
     {
          return turtleGraphics;
     }
     public void paint(Graphics g)
     {
          this.run();
     }
     public void run()
     {
          // Method intended to be overridden
     }
}
```

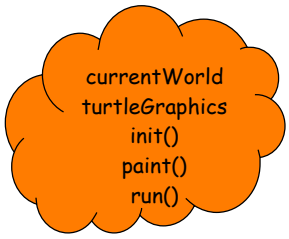
Refers to instance of TurtleWorld created when the Applet is run

Returns the lean, mean graphics machine associated with Applet window

A TurtleWorld object

```
import java.awt.*;
public class TurtleWorld extends Applet
{
     public static TurtleWorld currentWorld;
     private Graphics turtleGraphics;

     public void init()
     {
          currentWorld = this;
          turtleGraphics = currentWorld.getGraphics(`
     }
     public Graphics getTurtleGraphics ()
     {
          return turtleGraphics;
     }
     public void paint(Graphics g)
     {
          this.run();
     }
     public void run()
     {
          // Method intended to be overridden by subclass
     }
}
```

TurtleWorld

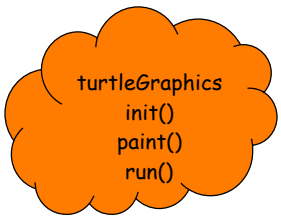


Paint method called automatically after init()

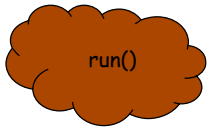
A SpiralWorld object

```
public class SpiralWorld extends TurtleWorld
{
     public void run()
     {
          SpiralMaker spiro = new SpiralMaker();
          spiro.spiral(4, 90, 0, 3)
     }
}
class SpiralMaker extends Turtle
{
     public void spiral(int steps, int angle, int length, int increment)
     {
          if (steps <= 0) {
               // do nothing
          } else {
               fd(length);
               lt(angle);
               spiral(steps-1, angle, length+increment, increment);
          }
     }
}
```

TurtleWorld

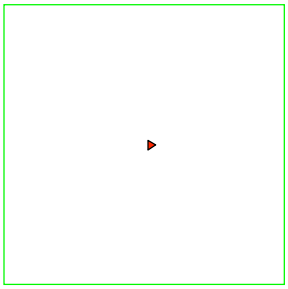


SpiralWorld



Now for the main event

```
import java.awt.*;    // Import Abstract Window Toolkit

public class Turtle
{
     // Instance variables?

          private or public?

     // Constructor methods?



     // Instance methods?


}
```

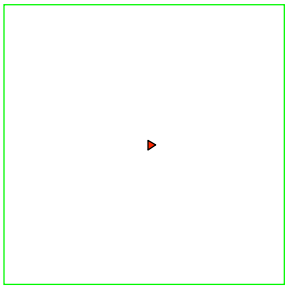


Now for the main event

```
import java.awt.*;       // Import Abstract Window Toolkit

public class Turtle
{
     // Instance variables
     private double x;          // x position of turtle
     private double y;          // y position of turtle
     private double heading;    // heading in degrees
     private boolean pendown;   // is turtle in drawing mode?
     private Color color;       // Red is the default
     private Graphics gfx;      // graphics w/ which turtle draws
     private Rectangle bounds; // bounds of drawing surface

     // some more stuff
}
```

Constructor methods

```
import java.awt.*;    // Import Abstract Window Toolkit

public class Turtle
{
     private double x;
     private double y;
     private double heading;
     private boolean pendown;
     private Color color;
     private Graphics gfx;
     private Rectangle bounds

     // Constructor methods?

             private or public?

     // Instance methods?
}
```

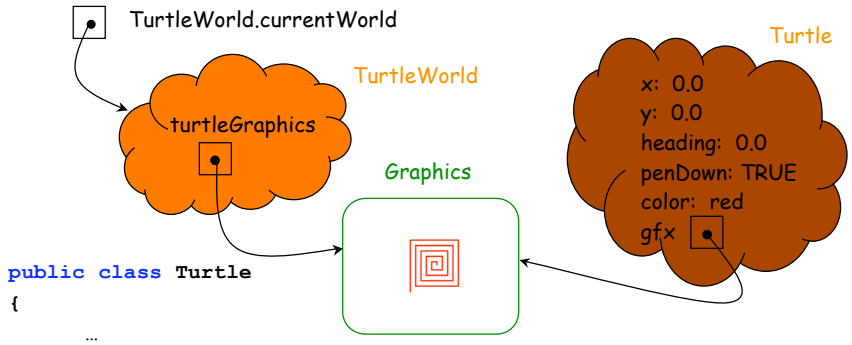


Birth of a Turtle

```
public class Turtle
{
     private double x;          // x position of turtle
     private double y;          // y position of turtle
     private double heading;    // heading in degrees
     private boolean pendown;   // is turtle in drawing mode?
     private Color color;       // Red is the default
     private Graphics gfx;      // graphics w/ which turtle draws
     private Rectangle bounds; // bounds of drawing surface

     public Turtle()
     {
          this.color = Color.red;
          this.x = 0.0;
          this.y = 0.0;
          this.heading = 0.0;
          this.pendown = true;
          this.gfx = TurtleWorld.currentWorld.getTurtleGraphics();
          this.bounds = gfx.getClipRect();
     }
     // Instance methods?
}
```

New Turtle obtains TurtleWorld's Graphics object

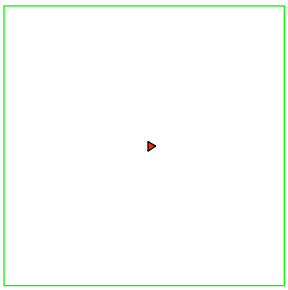
Draw picture of relationships …




```
public class Turtle
{
        …
        private Graphics gfx;
        public Turtle()
        {
              …
             this.gfx = TurtleWorld.currentWorld.getTurtleGraphics();
        }
}
```


Instance methods*

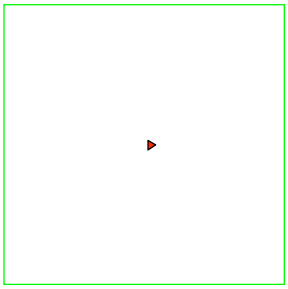
```
public class Turtle
{
      // Instance variables and
      // Constructor methods
      // (been there, done that)

      // Instance methods?

          private or public?

}
```



*How do you decide what these should be?

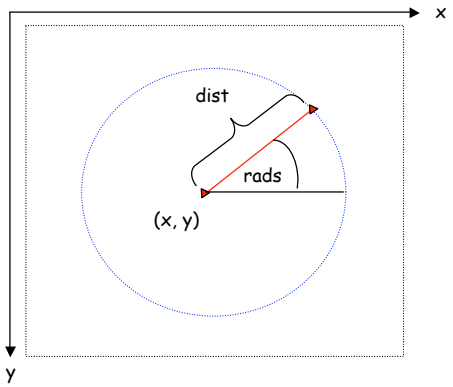
A few methods to implement

```
public class Turtle
{
     // Instance variables and constructor methods
     public void fd(double dist)
     {     …
     }
     public void bd(double dist)
     {     …
     }
     public void lt (double degrees)
     {     …
     }
     public void rt(double angle)
     {     …
     }
     public void pu()
     {     …
     }
     public void pd()
     {     …
     }
}
```

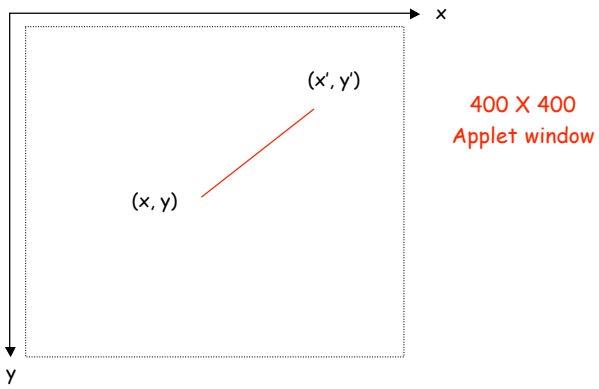


fd(double dist)

```
public void fd(double dist)
{
     double rads = degreesToRadians(this.heading);
     this.moveTo(x + dist*Math.cos(rads), y + dist*Math.sin(rads));
}
```



drawLine(int x1, int y1, int x2, int y2)



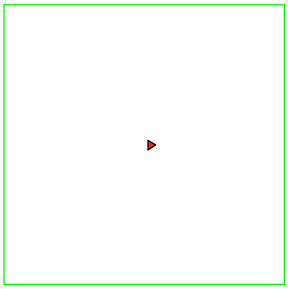

```
this.gfx.setColor(Color.red);
this.gfx.drawLine(x, y, x', y');
```


moveTo(double newx, double newy)

```
public void moveTo(double newx, double newy)
{
     if (pendown) {
          this.gfx.setColor(color);
          this.gfx.drawLine(screenX(x),     screenY(y),
                            screenX(newx), screenY(newy));
     }
     x = newx;
     y = newy;
}
private int screenX(double xcoord)
{
     return (int) Math.round(bounds.x + (bounds.width/2) + xcoord);
}
private int screenY(double ycoord)
{
     return (int) Math.round(bounds.y + (bounds.height/2) - ycoord);
}
```

The rest are a piece of cake

```
public class Turtle
{
     // Instance variables and constructor methods
     // fd() method as above

     public void bd(double dist)
     {
     }
     public void lt (double degrees)
     {
     }
     public void rt(double angle)
     {
     }
     public void pu()
     {
     }
     public void pd()
     {
     }
}
```



There is a problem

```
public class SpiralWorld extends TurtleWorld
{
     public void run()
     {
          SpiralMaker spiro = new SpiralMaker();
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class SpiralMaker extends Turtle
{
     public void spiral(int steps, int angle, int length, int increment)
     {
          if (steps <= 0) {
               // do nothing
          } else {
               fd(length);
               lt(angle);
               spiral(steps-1, angle, length+increment, increment);
          }
     }
}
```

Overloading methods


```
public class Turtle
{
     // Instance variables and constructor methods
     // fd() method as above

     // Backward
    public void bd(double dist)
    {
         this.fd(- dist);
     }
     public void bd (int dist)
     {
          bd((double) dist);
     }
     // Left
     public void lt(double degrees)
     {
          this.heading = heading + degrees;
     }
     public void lt (int degrees)
     {
          lt((double) degrees);
     }
}
```

casting ints into doubles