# Variables

```
/** Print out the conversion formula (version 2) */
    public void printFormula () {
        String formula;
        formula = "Celsius = (Fahrenheit - 32) *5/9" ;
        UI.println( formula );
    }
```

"  "

Use a variable whenever you need the computer to remember something temporarily.

- A variable is a place in memory that can hold a value.
  - Must specify the **type** of value that can be put in the variable
    ⇒ "Declare" the variable.
  - Must put a value into a variable before you can use it
    ⇒ "assign" to the variable
  - Can *use* the value by specifying the variable's name
  - Can change the value in a variable
    (unlike mathematical variable)

Asking for a place

# Assignment Statements

```
/** Print out the conversion formulas (version 2) */
    public void printFormula () {
        String formula;
        formula = "Celsius = (Fahrenheit - 32) *5/9" ;
        UI.println( formula );
    }
```

"  "

Putting a value into a variable

- Assignment Statement:

*where* = *what* ;

⟨variable⟩ → **=** → ⟨expression⟩ → **;**

*name-of-place* = *specification-of-value* ;

formula = " Celsius = (Fahrenheit - 32) *5/9"

Meaning: Compute the value and put it in the place

# Expressions

```
/** Convert from fahrenheit to Celsius */
public void doFahrenheitToCelsius(){
    double fahrenheit = UI.askDouble("Fahrenheit:" );
    double celsius = (fahrenheit – 32.0) * 5.0 / 9.0;
    UI.println(fahrenheit  + “F is " + celsius + “ C");
}
```

Version 2: combined into a single method that asks, computes and prints.

+ for Strings: "concatenates" the Strings

- Expressions describe how to compute a value.
- Expressions are constructed from
  - values
  - variables
  - operators (+, -, *, /, etc)
  - method calls that return a value
  - sub-expressions, using (… )
  - …

# Method Calls and variables: a metaphor

## Method Definition: Like a pad of worksheets

```
public void doFahrenheitToCelsius(){
    double fahrenheit = UI.askDouble("Fahrenheit:");
    double celsius  = (fahrenheit – 32.0) * 5.0 / 9.0;
    UI.println(fahrenheit + " is " + celsius + " C");
}
```

Fahrenheit: 86

86.0F is 30.0C

86 0

30 0

## Calling a Method:

tempCalc1.fahrenheitToCelsius();

⇒ get a "copy" of the method worksheet

⇒ perform each action in the body.

⇒ throw the worksheet away (losing all the information on it)

# Method Definitions: Parameters

```
/** Convert from fahrenheit to centigrade */
    public void printCelsius(double temp){
        double celsius = (temp – 32.0) * 5.0 / 9.0;
        UI.println(temp +  " F -> " + celsius + " C");
    }
```

A parameter specifies

- the type of a value the method needs
- a name for the place where the value will be put when the method is called
  (a kind of variable, but special)

- Parameters are in defined in the headers of method definitions

# Method Calls

Method Definition: Like a pad of worksheets

```
public void printCelsius(double temp){
    double celsius = (temp – 32.0) * 5.0 / 9.0;
    UI.println(temp + " F -> " + celsius + " C");
}
```

Calling a Method:

tempConv1.printCelsius(86);

⇒ get a "copy" of the method worksheet

⇒ copy the argument(s) into the parameters(s)

⇒ perform the actions in the body.

# Summary of Java program structure

- A Class specifies a type of object
  - TemperatureCalculator.class describes TemperatureCalculator objects
- A Class contains a constructor
  - Constructor specifies what to do when objects are created
- A Class contains a collection of methods
  - Each method is an action the objects can perform.
  - TemperatureCalculator objects can do celsiusToFahrenheit, fahrenheitToCelsius, printFormula
  - If you have an object, you can call its methods on it.
- A constructor/method definitions contains statements
  - Each statement specifies one step of performing the action
  - Method call statements
  - Declaration and Assignment statements

# What can the UI do?

- UI is a predefined object
- Has methods for
  - text input from the user

    eg `UI.askString("What is your name?");` `UI.askDouble ("How tall are you") ;`
  - text output

    eg `UI.println(" *  " + name + "  * " );`
  - graphical output

    eg `UI.drawRect(100, 100, 300, 150);`
  - making buttons, sliders, etc
    - eg `UI.addButton("Quit", UI::quit);`
- How do you find out about all the methods?
- How do your find out what arguments you need to provide?

# Read the Documentation!

- Full documentation for all the standard Java library code
  (the "API" : Application Programming Interface)

- Version of Java API documentation on course web site:
  - "Java Documentation" in side bar
  - http://ecs.victoria.ac.nz/foswiki/pub/Main/JavaResources/javaAPI-102.html

- Tailored for Comp 102
  - Includes documentation of the ecs100 library: (UI, Trace, etc,)
  - puts most useful classes at the top of the list.

- Use the documentation while you are programming!
  - Control-space in Bluej brings up the options plus documentation.

# Some UI methods

## Text:

UI.clearText()

UI.print(*anything* )

UI.println(*anything* )

UI.printf( *format-string*, *values*…)

UI.askString(*prompt-string* )

UI.askToken(*prompt-string* )

UI.askDouble(*prompt-string* )

UI.askInt(*prompt-string* )

UI.askBoolean(*prompt-string* )

## Graphics:

Eg: Color.red

UI.clearGraphics()

UI.setColor(*color* )

UI.setLineWidth(*width* )

UI.drawRect(*left, top, wd, ht* )

UI.fillRect(*left, top, wd, ht* )

UI.drawOval(*left, top, wd, ht* )

UI.fillOval(*left, top, wd, ht* )

UI.drawLine($x_1$, $y_1$, $x_2$, $y_2$ )

UI.drawImage(*file, left, top* )

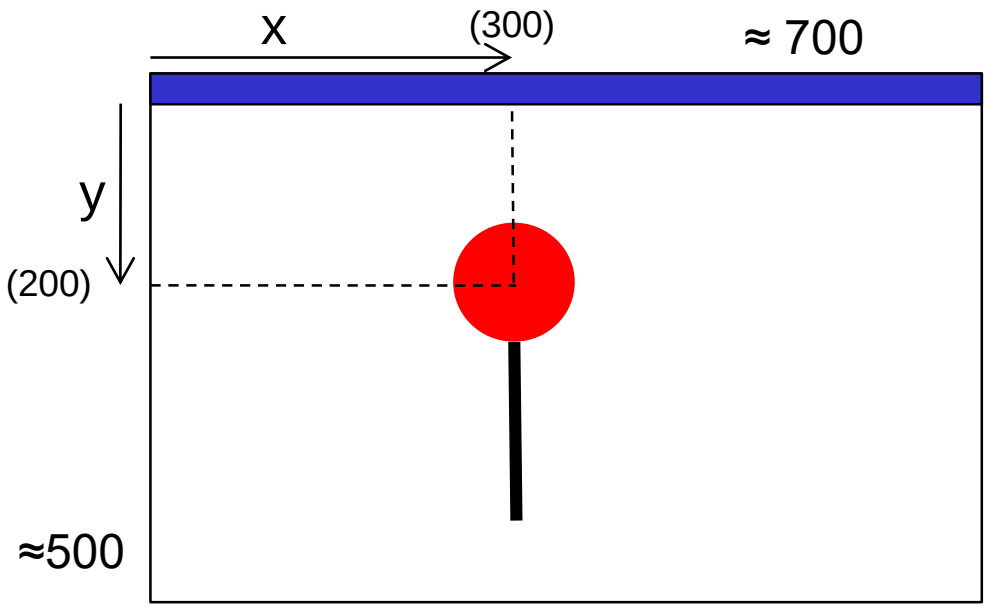
……

# Lollipop program

Design:

Method drawLollipop():

- set line width to 10
- draw line
- set line width back to 1
- set color to red
- fill oval




- Must work out the coordinates:
  - line:
  - oval:

# Programs with graphics output

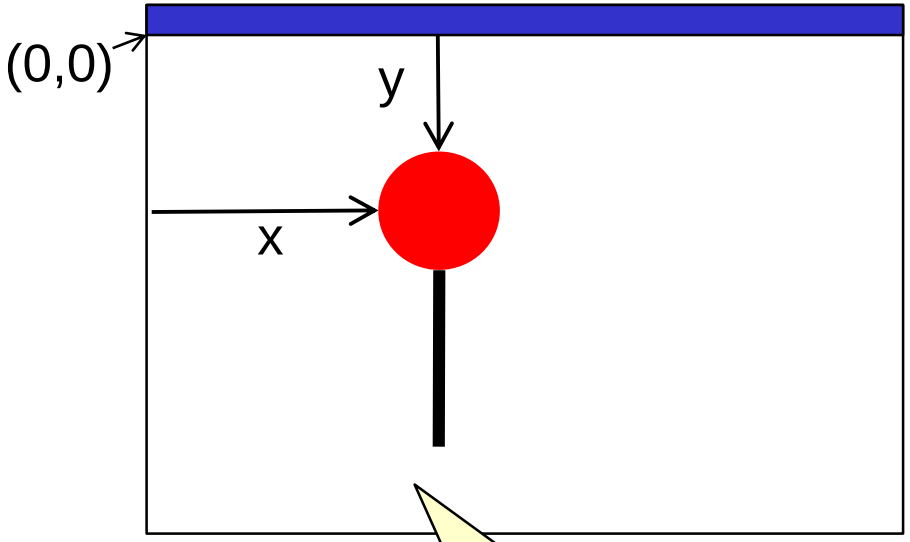
- Write a program to draw a lollipop:

Design

- What shapes can we draw?
  - UI has methods to draw rectangles, ovals, lines, arcs,…

⇒ Draw
one thick black line
one red oval,

Shapes are drawn on top of previous shapes




Coordinates measured from left and top

- How do we draw them?
  Need to set the color first (initially black)
  then call the draw/fill methods:
  - must specify the positions and size
    - rectangles/ovals: left, top, width, height
    - lines: x and y of each end.

# Writing the program

- Need import statements
- Need a class (with a descriptive comment)
- Need a constructor
- Need a method (with a descriptive comment)

```
import  ecs100.*;
import  java.awt.Color;

/** Draws little shapes on the graphics pane */
public class  Drawer {

    /** Constructor: Set up interface */
    public  Drawer() {
        UI.addButton("Draw it",  this::drawLollipop);
    }

    /** Draw an red lollipop with a stick */
    public void drawLollipop() {
        // actions
    }
}
```

Button that will call the drawLollipop method of this class

Write the method body as comments first

# Writing the program: using comments

```
import  ecs100.*;
import java.awt.Color ;

/** Draws little pictures on the graphics pane */
public class  Drawer {
    public  Drawer() {
        UI.addButton("Draw it",  this::drawLollipop);
    }

    /** Draw an red lollipop on a stick */
    public void drawLollipop() {
        // set line width to 10
        // draw line          (300,200)  to  (300, 400)
        // set line width to 1
        //  set color to red
        // fill oval          @(260,160)   80x80
    }
}
```

Do it in BlueJ!

Now express each comment in Java (look up documentation as necessary)

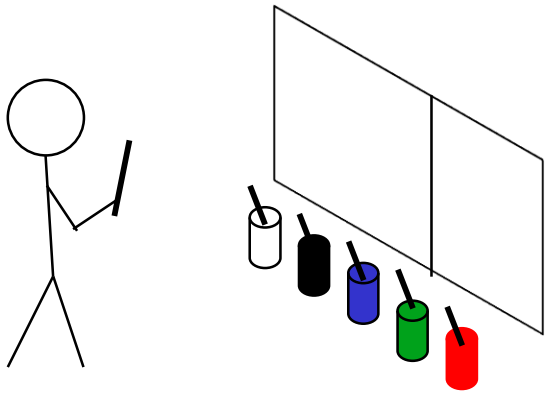
# Writing the program

```
import ecs100.*;
import java.awt.Color ;

/** Draws little pictures on the graphics pane */
public class  Drawer {
    public  Drawer() {
        UI.addButton("Draw it",  this::drawLollipop);
    }
    /** Draw a lollipop */
    public void drawLollipop() {
        UI.setLineWidth(10);                    // set line width to 10
        UI.drawLine(300, 200, 300, 400);        // draw line
        UI.setLineWidth(1);                     // set line width back to 1
        UI.setColor(Color.red);                 // set color to red
        UI.fillOval(260, 160, 80, 80);          // draw blob
    }
}
```

Now compile and run the program

# A model/metaphor for the computer

- If you are giving instructions to someone/something, it helps to understand how they think and what they can do!
- Your program is run by the "Java Virtual Machine"
- The JVM is like a clerk
  - with Alzheimer's – only remembers what he writes down
  - with a clipboard for the worksheets with the instructions he is currently working on
  - looking at the back of the UI window which he can write/paint on,
    but the writing/painting only appears on the outside – he can't see what he has written/drawn
  - can see a stream of characters that the user types on the keyboard



# Improving the design

- This program is very inflexible:
- What if
  - We want the lollipop to be in a different position?
  - We want the lollipop to be bigger or smaller?
  - We want the stick to be longer?
  - ….
  - We want to draw two of them?
- Current design is filled with <u>literal values</u>

  ⇒ difficult to understand

  ⇒ difficult to change
  (have to find all the places and redo all the arithmetic

# Move or resize the Lollipop.

```
import ecs100.*;
import java.awt.Color ;

/** Draws little pictures on the graphics pane */
public class  Drawer {

    /** Constructor:  Set up the interface with one button */
    public  Drawer() {
        UI.addButton("Draw it",  this::doDrawLollipop);
    }

    /** Draw a lollipop */
    public void doDrawLollipop() {
        UI.setColor(Color.black);                    // set color to black
        UI.setLineWidth(10);                         // set line width to 10
        UI.drawLine(300, 200, 300, 400);             // draw line
        UI.setLineWidth(1);                          // set line width back to 1
        UI.setColor(Color.red);                      // set color to red
        UI.fillOval(260, 160, 80, 80);               // draw blob
    }
}
```

Move it left

Move it down

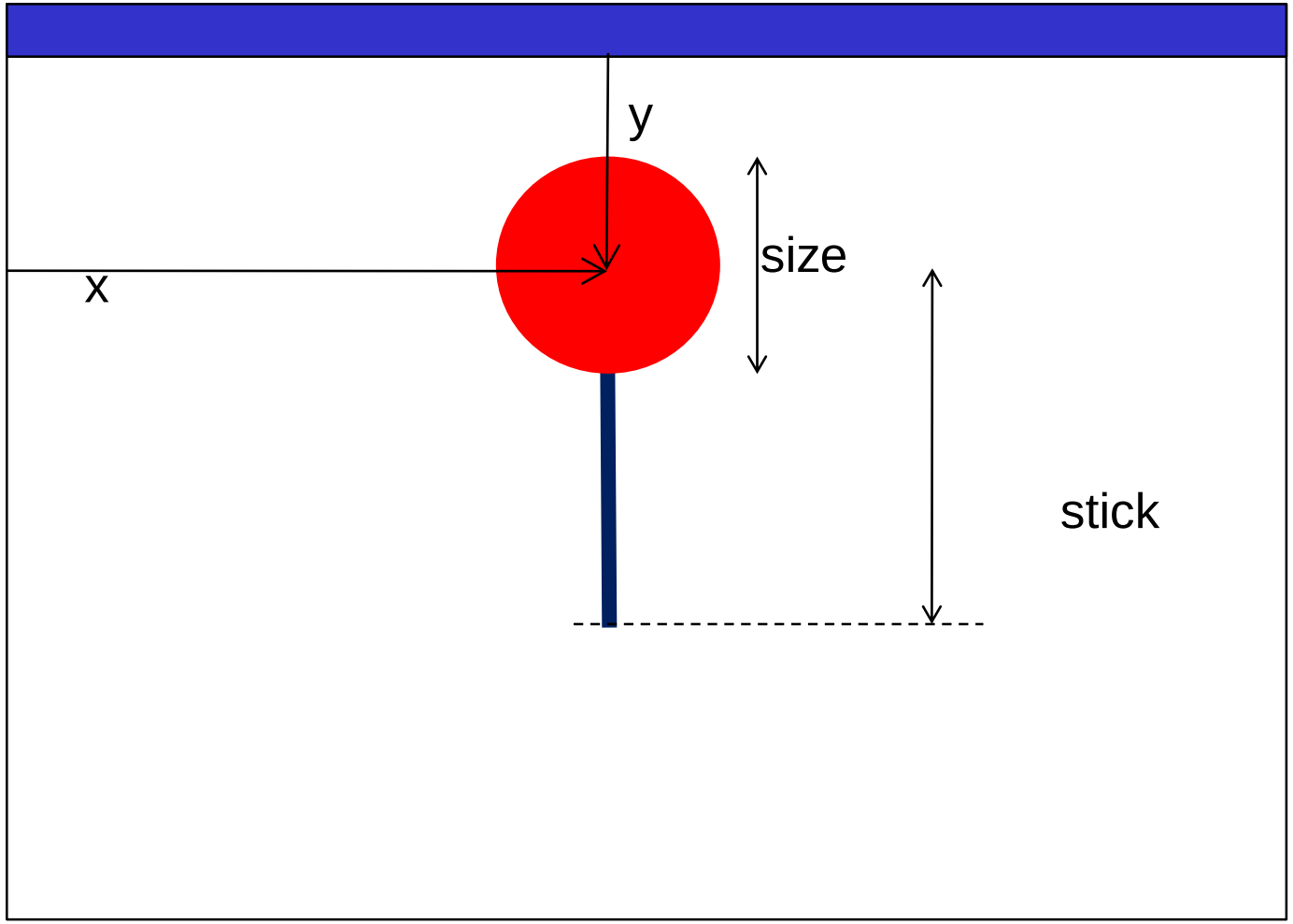
Change blob size

# Improving the design

- Better design: Use named constants and variables
  - ⇒ easier to write and easier to change
  - ⇒ get the computer to do the arithmetic

- Use named constants for values that won't change while the program is running.

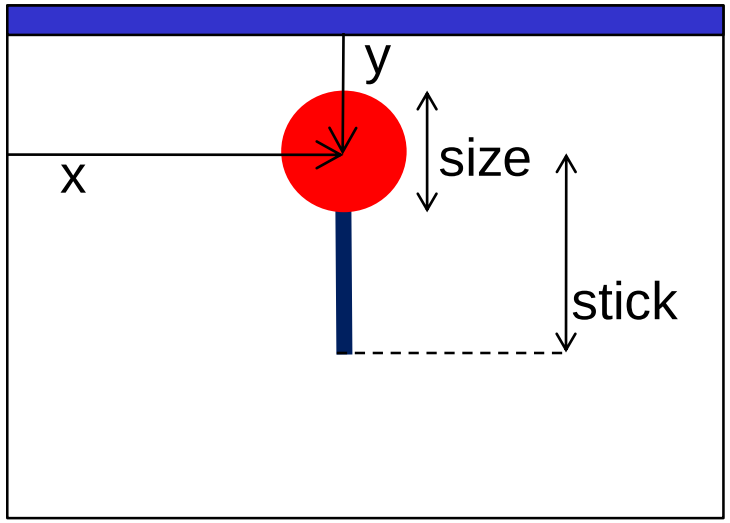
# Values to specify lollipop & stick



# Improving the program: constants

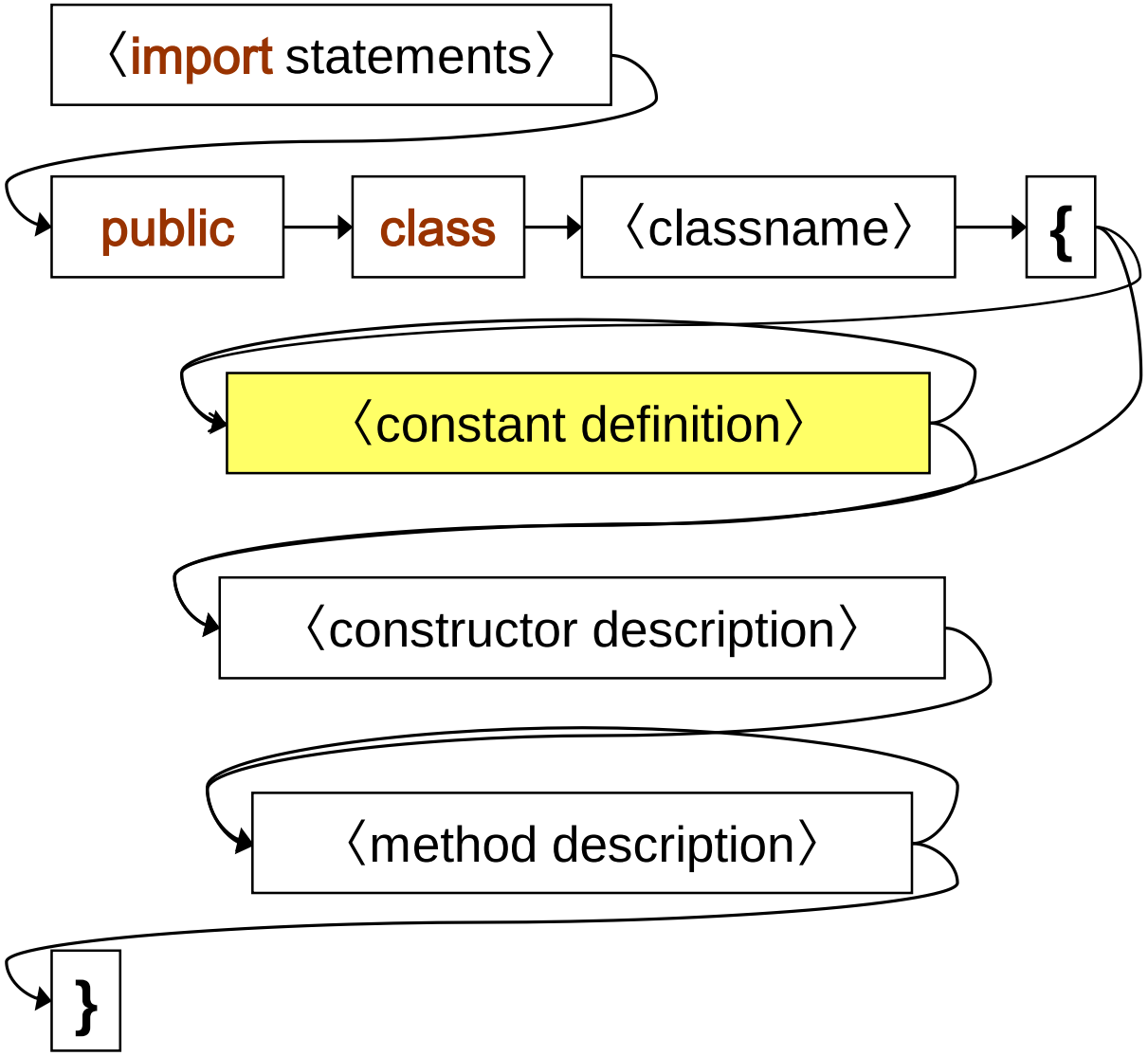
```
import ecs100.*;    import java.awt.Color;
/** Draw a lollipop with a stick */
public class Drawer {
    public static final double x = 300.0;        // horizontal center of lollipop
    public static final double y = 180.0;        // vertical center of lollipop
    public static final double size = 80.0;      // diameter of lollipop
    public static final double stick = 200.0;    // length of lollipop stick
    public Drawer() {
        UI.addButton("Draw it", this::doDrawLollipop);
    }
    /** Draw a lollipop */
    public void doDrawLollipop() {
        UI.setLineWidth(size/8.0);
        UI.drawLine(x, y, x, y+stick);
        UI.setLineWidth(1);
        UI.setColor(Color.red);
        UI.fillOval(x-size/2.0, y-size/2.0, size, size);
    }
}
```

Easy to change: one place!

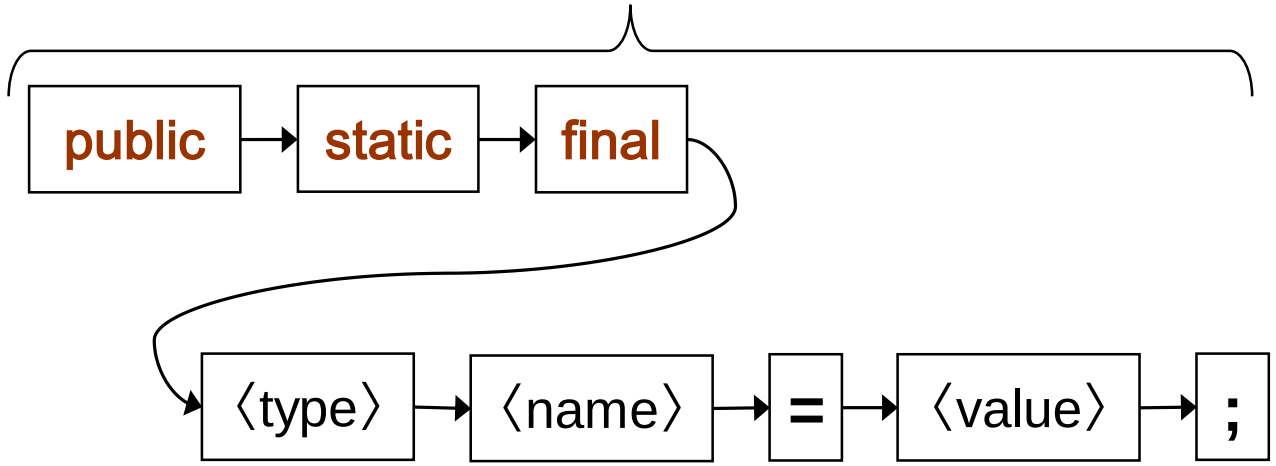


# Syntax rules: Program structure

- 2nd version




Defining a constant

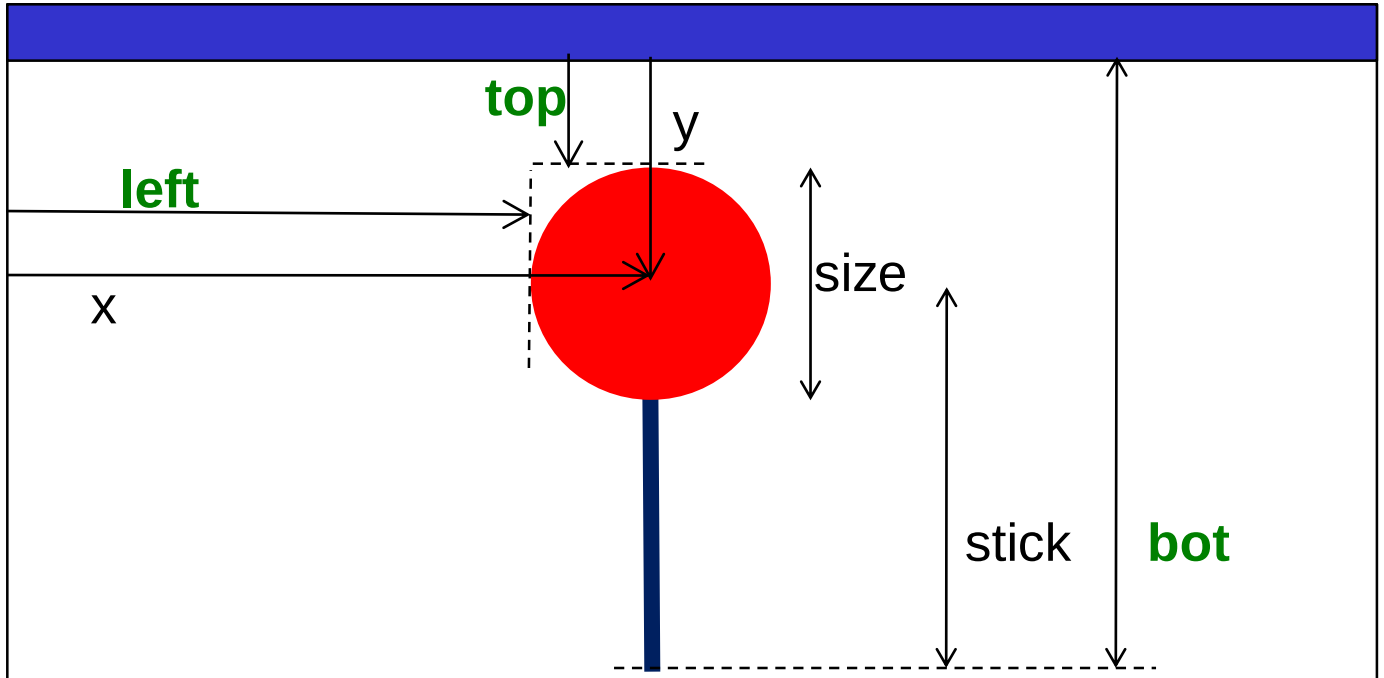


# Improving the program: more names

```
public static final double x = 300.0;          // horizontal center of lollipop
public static final double y = 180.0;          // vertical center of lollipop
public static final double size = 80.0;        // diameter of lollipop
public static final double stick =  200.0;     // length of lollipop stick

/** Constructor:  Set up the interface with one button */
public  Drawer() {
    UI.addButton("Draw it",  this::doDrawLollipop);
}

/** Draw a lollipop */
public void doDrawLollipop() {
    UI.setLineWidth(10);
    UI.drawLine(x, y, x, y+stick);
    UI.setLineWidth(1);
    UI.setColor(Color.red);
    UI.fillOval(x-size/2.0, y-size/2.0, size, size);
}
```

Still have a problem:
What do these expressions mean?

# Values to specify lollipop & stick




Useful to have more named values!

# Improving the program: variables

```
public static final double x = 300.0;          // horizontal center of lollipop
public static final double y = 180.0;          // vertical center of lollipop
public static final double size = 80.0;        // diameter of lollipop
public static final double stick =  200.0;     // length of lollipop stick

public  Drawer() {
    UI.addButton("Draw it",  this::doDrawLollipop);
}
/** Draw a lollipop */
public void doDrawLollipop() {
    double left = x – size/2.0;          // left of lollipop
    double top = y – size/2.0;           // top of lollipop
    double bot =  y + stick;             // bottom of stick
    UI.setLineWidth(10);
    UI.drawLine(x, y, x, bot);
    UI.setLineWidth(1);
    UI.setColor(Color.red);
    UI.fillOval(left, top, size, size);
}
```

# Principle of good design

- Use well named constants or variables wherever possible, rather than literal values

  ⇒ easier to understand

  ⇒ easier to get right

  ⇒ much easier to modify

- Choosing the *right* constants or variables is an art!!
  - why did I choose "x" instead of "left" ?
  - why did I choose "y" instead of stick bottom?
- We have effectively *parameterised* the drawing
  - Four values (x, y, size, stick) control the whole thing.

# Even better design: parameters

- Every time we want a lollipop of a different size or in a different position, we have to modify the code.
- How come we don't have to do that with drawRect?
- drawRect has four parameters:

Definition of drawRect:

```
public void drawRect(double left, double top, double wd, double ht) {……}
```

Parameters

In the library files

Calling drawRect:

```
UI.drawRect(200, 150, 50, 80);
UI.drawRect(200, 150, 50, 80);
```

Arguments

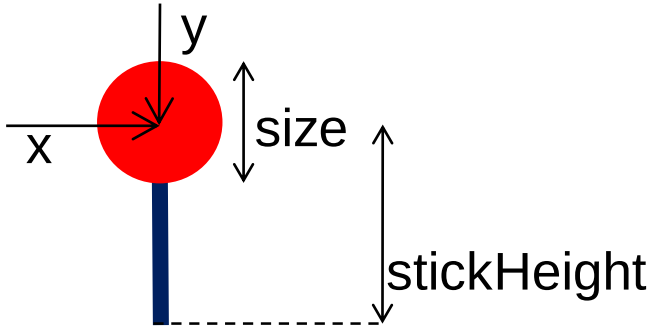
In our program

⇒ drawRect can make many different rectangles.

Why can't we do that with lollipop?

# Improving the program: using parameters

```
/** Draw a lollipop at  (300, 180), asking the user for its size */
public void doDrawLollipop() {
    double size = UI.askDouble("Diameter:");
    double stickHeight =  UI.askDouble("Stick height");
    this.drawLollipop(300, 180, size, stickHeight);
}

public void drawLollipop(double x, double y, double size, double stick) {
    double left = x – size/2.0;          // left of lollipop
    double top = y – size/2.0;           // top of lollipop
    double bot =  y + stick;             // bottom of stick
    UI.setLineWidth(10);
    UI.drawLine(x, y, x, bot);
    UI.setLineWidth(1);
    UI.setColor(Color.red);
    UI.fillOval(left, top, size, size);
}
```



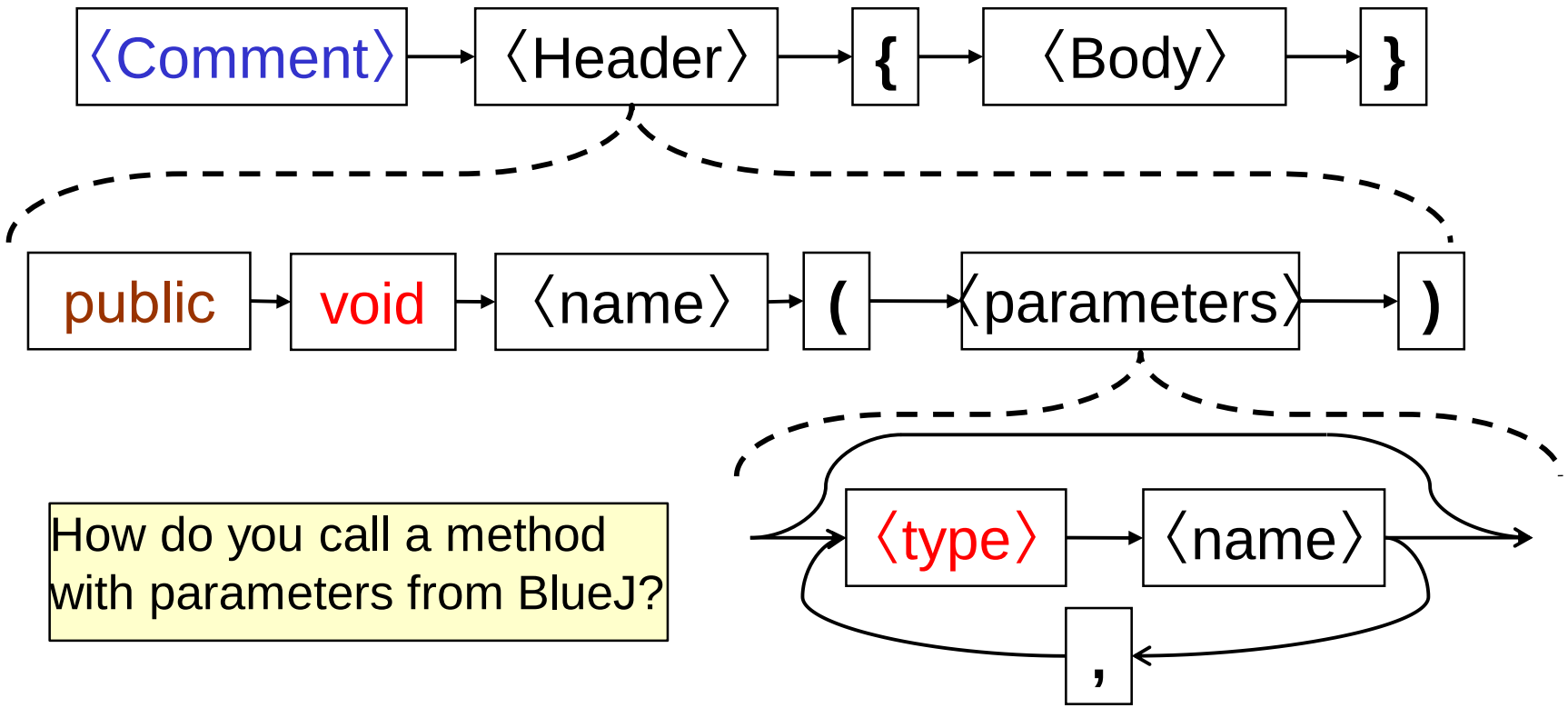

Parameters

Special variables which are given values each time the method is called.

Body of method can use the values in the parameters

# Syntax: Method Definitions (v2)

```
/** Draw a lollipop on a stick */
public void drawLollipop(double x, double y, double size, double stick ){
    double left = x – size/ 2.0;
        :
```




How do you call a method with parameters from BlueJ?

# Method Calls with parameters

## Method Definition: Like a pad of worksheets

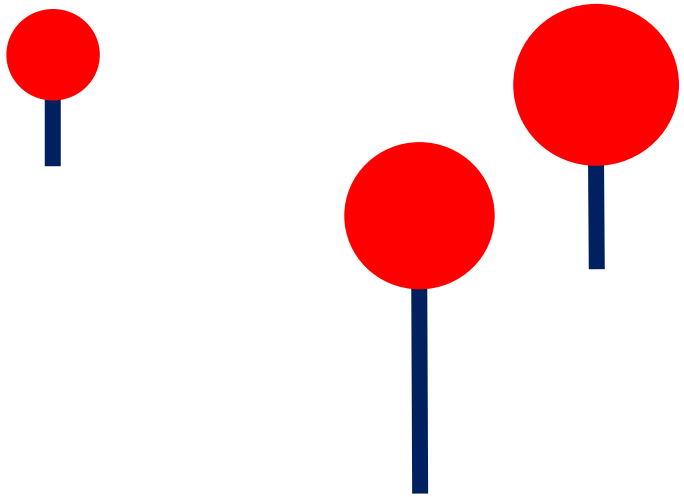
```
public void drawLollipop( double x, double y, double size, double stick){

    double left  =   x – size / 2.0;
    double top  =   y – size / 2.0;
      :
          UI.fillOval(left, top, size, size);
}
```

## Calling a Method:

this.drawLollipop(300, 100, 75, 95);

- ⇒ get a “copy” of the method worksheet
- ⇒ copy the arguments to the parameter places
- ⇒ perform each action in the body
- ⇒ throw the worksheet away (losing all the information on it)

# Calling drawLollipop



```
public class  Drawer {
    public void doDrawLollipops() {
        double diam = UI.askDouble("diameter:");
        this.drawLollipop(300, 180, diam, 200);
        this.drawLollipop(50, 60, diam/2.0, 90);
        this.drawLollipop(400, 100, diam, 70);
    }
    /** Draw a lollipop */
    public void drawLollipop(double x, double y, double size, double stick) {
        double left = x – size/2.0;          // left of lollipop
        double top = y – size/2.0;           // top of lollipop
        double bot =  y + stick;             // bottom of stick
        UI.setLineWidth(10);
        UI.drawLine(x, y, x, bot);
        UI.setLineWidth(1);
        UI.setColor(Color.red);
        UI.fillOval(left, top, size, size);
    }
```

# Principle of good design

- Parameterising a method makes it more flexible and general
  - Allows us to call the same method with different arguments to do the same thing in different ways
  - Allows us to reuse the same bit of code

# Arithmetic in Java

- normal arithmetic operators: + – * and /
  - on **doubles**, operators work as expected
    length / 2.5 =>

    length: 10.0

  - on **Strings**, (or a String and another value):
    - turns other value to a String,
    - Concatenates them together
      "Size is " + length + "cm" =>

  - on **integers**,
    - does "primary school" arithmetic
    - / (division) gives a whole number
    - % gives the remainder

    numDoors: 3

    numWalls: 8

    15 / 4 => 15 % 4 => 15 / 30 =>

    numDoors / numWalls => 1.0 * numDoors / numWalls =>