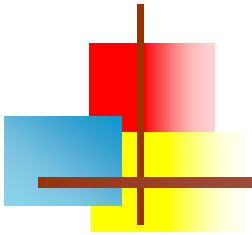
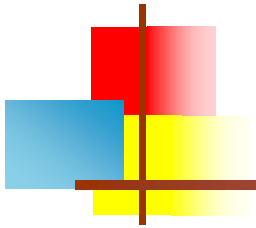
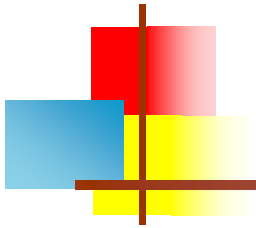


Condensed Java



Python and Java

- Python and Java are both object-oriented languages
  - Conceptually, the languages are very similar
  - The syntax, however, is quite different, and Java syntax is much more complicated
  - Now that you understand the concepts of object-oriented languages, we'll spend a lot of time on Java syntax
- Java and Python are both popular languages
  - For technical reasons, Java can be much faster than Python

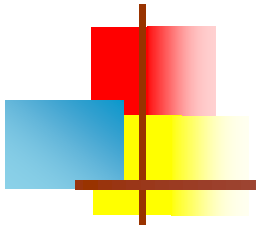


Structure of a Java program

- A program, or project, consists of one or more packages
  - Package = directory = folder
- A package contains one or more classes
- A class contains one or more fields and methods
  - A method contains declarations and statements
- Classes and methods may also contain comments
- We'll begin by looking at the "insides" of methods

Project:

- packages
  - classes
    - fields
    - methods
      - declarations
      - statements

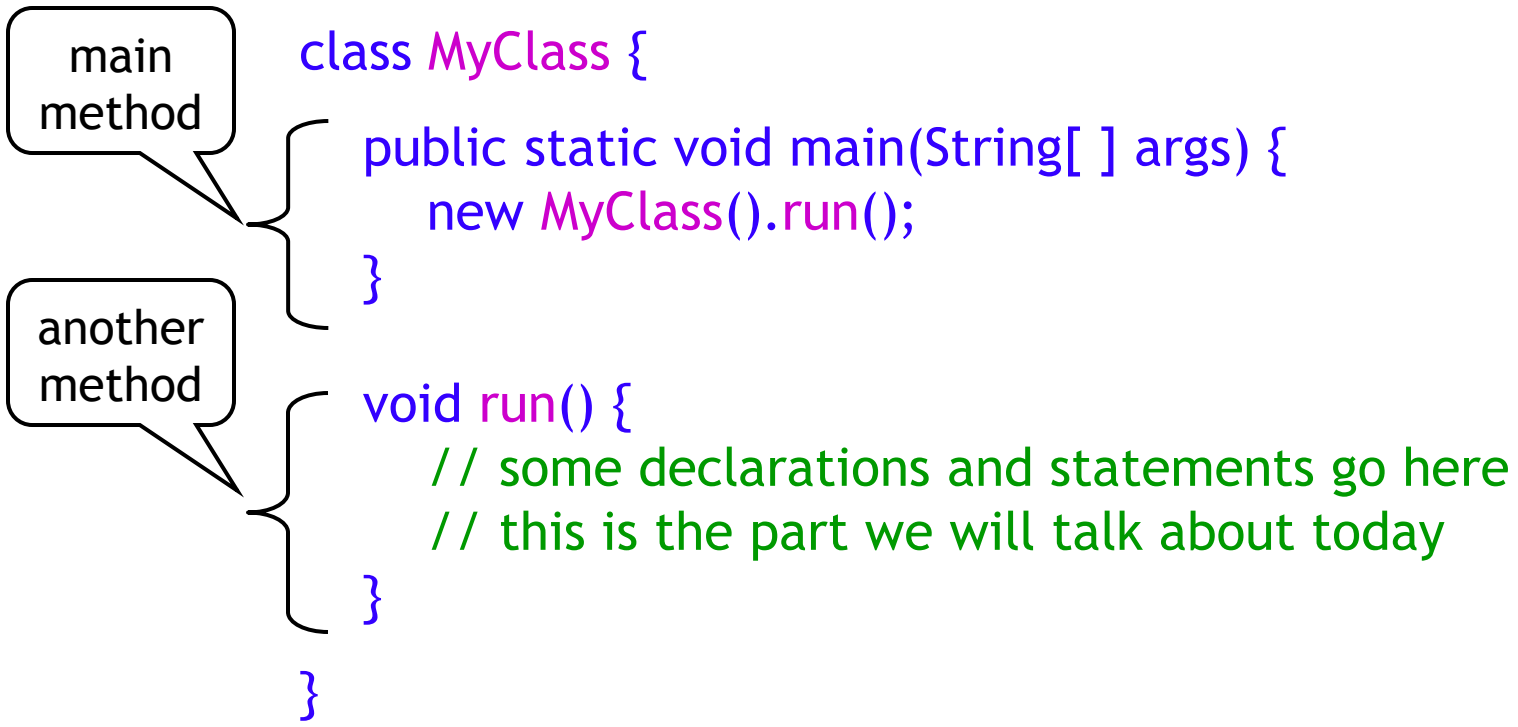


Java structure and Eclipse

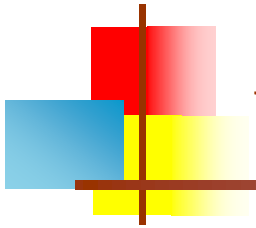
- A workspace is where Eclipse keeps projects
- When you use Eclipse to create a project (a single "program"), it creates a directory with that name in your workspace
- Within the project, you next create a package
- Finally, you create a class in that package

- For the simplest program, you need only a single package, and only one (or a very few) classes

Simple program outline

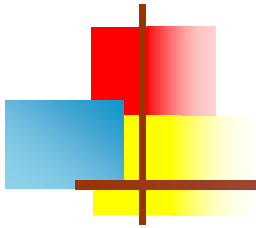


- Notes:
  - The class name (MyClass) must begin with a capital
  - main and run are methods (the name main is special; the name run isn't)
  - This is the form we will use for now
    - Once you understand all the parts, you can vary things



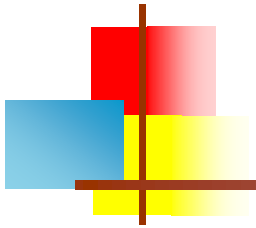
What you need to know

- You need to be able to:
  - Read in data (for now, numbers)
    - We will use a Scanner for this
  - Save numbers in variables
    - We will use declarations to create variables
  - Do arithmetic on numbers to get new numbers
    - We will use assignment statements
  - Test whether or not to do something
    - We will use if statements
  - Do something repeatedly
    - We will use while statements
  - Print output
    - We will use System.out.print and System.out.println
  - Use methods
    - A "method" is a function that belongs to a class



Declarations, statements, comments

- A declaration gives **type** information to the computer
  - You must declare:
    - The type of value (int, String, etc.) each variable can hold
    - The type of every parameter to a method
    - The type returned by every method
- A statement tells the computer to do something
  - Statements should really be called "commands"
  - Statements may only occur within methods
- Comments are ignored by the compiler
  - As in Python, there are different comments for people who use your methods, and those who read your code

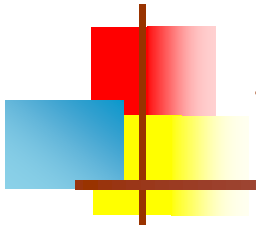


Comments

- Python: Single-line comments start with `#`
- Java: Single-line comments start with `//`

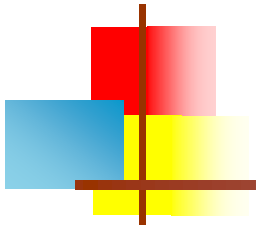
- Java: Multi-line comment start with `/*` and end with `*/`

- Python: Documentation comments are enclosed in triple quotes, and are put right after the `def` line
- Java: Documentation comments start with `/**` and end with `*/`, and are put just *before* the definition of a variable, method, or class
  - Documentation comments are more heavily used in Java, and there are much better tools for working with them



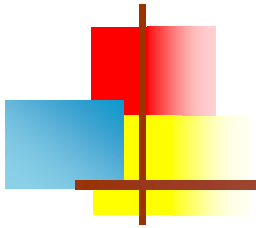
Variables

- Every variable has a name
  - Examples: name, age, address, isMarried
  - Variables start with a lowercase letter
  - Multiword variables are written using "camelCase"
- Every variable has a type of value that it can hold
  - For example,
    - name might be a variable that holds a String
    - age might be a variable that holds an int
    - isMarried might be a variable that holds a boolean
      - Boolean constants are true and false (not True and False)
  - The type of a variable *cannot be changed*
    - However, you might have a different variable with the same name somewhere else in the program



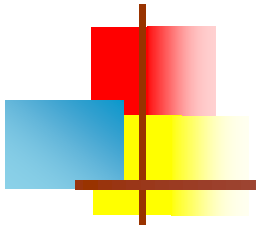
Some Java data types

- In Java, the most important primitive (simple) types are:
  - int variables hold integer values
  - double variables hold floating-point numbers (numbers containing a decimal point)
  - boolean variables hold a true or false value
- Other primitive types are
  - char variables hold single characters
  - float variables hold less accurate floating-point numbers
  - byte, short and long hold integers with fewer or more digits
- Another important type is the String
  - A String is an Object, not a primitive type
  - A String is composed of zero or more chars



Declaring variables

- In Python, a variable may hold a value of any type
- Every variable that you use in a program must be declared (in a declaration)
  - The declaration specifies the type of the variable
  - The declaration *may* give the variable an initial value
- Examples:
  - int age;
  - int count = 0;
  - double distance = 37.95;
  - boolean isReadOnly = true;
  - String greeting = "Welcome to CIT 591";
  - String outputLine;

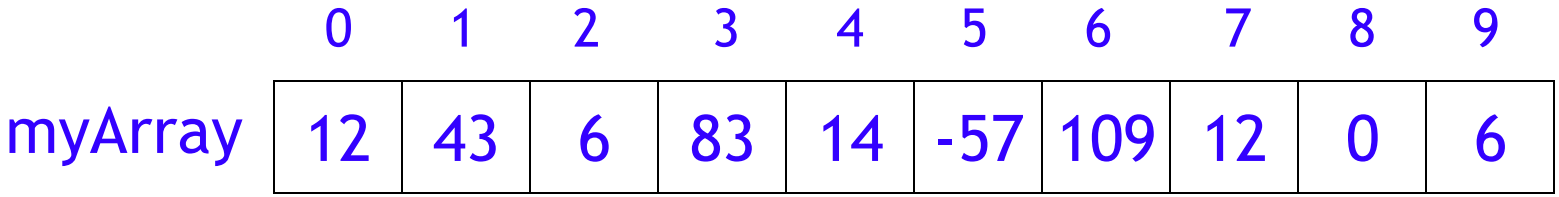


Multiple values

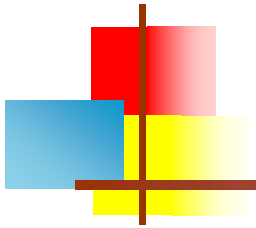
- An array lets you associate one name with a fixed (but possibly large) number of values
- Arrays are like Python's lists, but much less flexible
- All values must have the same type
- The values are distinguished by a numerical index between 0 and array size minus 1

	0	1	2	3	4	5	6	7	8	9
myArray	12	43	6	83	14	-57	109	12	0	6

Using array elements

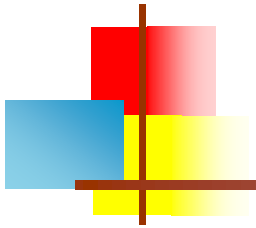


- Examples:
  - x = myArray[1]; // sets x to 43
  - myArray[4] = 99; // replaces 14 with 99
  - m = 5;
    y = myArray[m]; // sets y to -57
  - z = myArray[myArray[9]]; // sets z to 109



Declaration and definition

- To declare an array is to tell its type, but *not* its size
  - Example: `int[] scores;`
- To define an array is to give its size
  - Example: `scores = new int[40];`
- Declaration and definition can be combined
  - Example: `int[] scores = new int[40];`
- The initial content of an array is zero (for numbers), `false` (for booleans), or `null` (for objects)



Two ways to declare arrays

- You can declare more than one variable in the same declaration:

```
int a[ ], b, c[ ], d;   // notice position of brackets
```

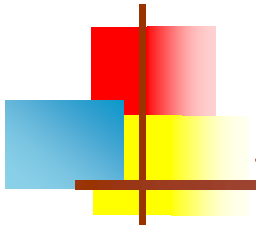
  - a and c are int arrays
  - b and d are just ints

- Another syntax:

```
int [ ] a, b, c, d;      // notice position of brackets
```

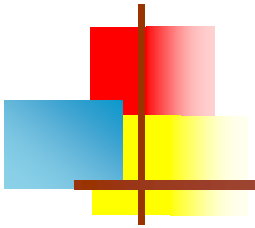
  - a, b, c and d are int arrays
  - When the brackets come before the first variable, they apply to *all* variables in the list

- But...
  - In Java, we typically declare each variable separately



Arrays of arrays

- The elements of an array can themselves be arrays
- Once again, there is a special syntax
- Declaration: `int[ ][ ] table;` (or `int table[ ][ ];`)
- Definition: `table = new int[10][15];`
- Combined: `int[ ][ ] table = new int[10][15];`
- The first index (10) is usually called the row index; the second index (15) is the column index
- An array like this is called a two-dimensional array



Reading in numbers

- First, import the Scanner class:

```
import java.util.Scanner;
```

- Create a scanner and assign it to a variable:

```
Scanner scanner = new Scanner(System.in);
```

  - The name of our scanner is `scanner`
  - `new Scanner(...)` says to make a new one
  - `System.in` says the scanner is to take input from the keyboard
- Next, it's polite to tell the user what is expected:

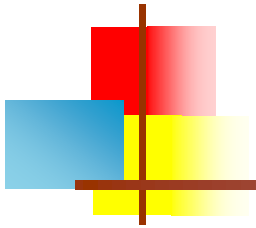
```
System.out.print("Enter a number:  ");
```

- Finally, read in the number:

```
myNumber = scanner.nextInt();
```

- If you haven't previously declared the variable `myNumber`, you can do it when you read in the number:

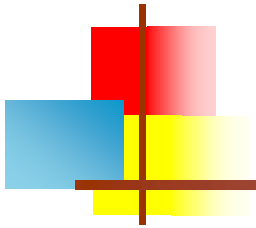
```
int myNumber = scanner.nextInt();
```



Printing

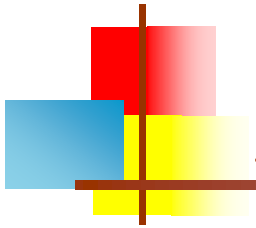
- There are two methods you can use for printing:
  - System.out.println(something);
    - This prints something and ends the line
  - System.out.print(something);
    - This prints something and *doesn't* end the line (so the next thing you print will go on the same line)
- These methods will print any **one** thing, but only one at a time
- You can concatenate Strings with the + operator
- Anything concatenated with a String is automatically converted to a String
  - Example:

```
System.out.println("There are " + appleCount +
                   " apples and " + orangeCount +
                   " oranges.");
```



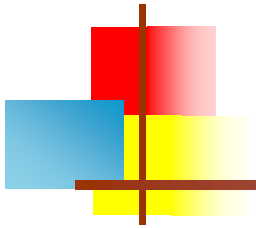
Program to double a number

```
import java.util.Scanner;

public class Doubler {

    public static void main(String[] args) {
        new Doubler().run();
    }

    private void run() {
        Scanner scanner;
        int number;
        int doubledNumber;

        scanner = new Scanner(System.in);
        System.out.print("Enter a number: ");
        number = scanner.nextInt();
        doubledNumber = 2 * number;
        System.out.println("Twice " + number + " is " + doubledNumber);
    }
}
```



Assignment statements

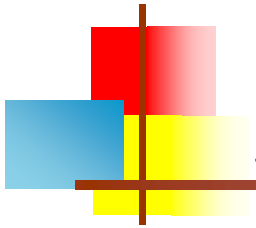
- Values can be assigned to variables by assignment statements
  - The syntax is: *variable* = *expression*;
  - The expression must be of the same type as the variable *or* a type that can be converted without loss of precision
  - The expression may be a simple value or it may involve computation
  - Examples:
    - `name = "Dave";`
    - `count = count + 1;`
    - `area = (4.0 / 3.0) * 3.1416 * radius * radius;`
    - `isReadOnly = false;`
- When a variable is assigned a value, the old value is discarded and totally forgotten



Organization of a class

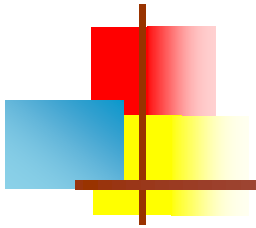
- A class may contain data declarations and methods (and constructors, which are like methods), but **not** statements
- A method may contain (temporary) data declarations and statements
- A common error:

```
class Example {
    int variable ;                  // simple declaration is OK
    int anotherVariable= 5;   // declaration with initialization is OK
    yetAnotherVariable = 5;   // statement! This is a syntax error

    void someMethod( ) {
        int yetAnotherVariable;  //declaration is OK
        yetAnotherVariable = 5;  // statement inside method is OK
    }
}
```



Arithmetic expressions

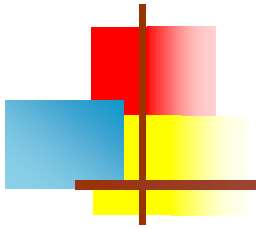
- Arithmetic expressions may contain:
  - `+` to indicate addition
  - `-` to indicate subtraction
  - `*` to indicate multiplication
  - `/` to indicate division
  - `%` to indicate remainder of a division (integers only)
  - Sorry, no exponentiation
  - parentheses `( )` to indicate the order in which to do things
  - Exponentiation is done with the method **`Math.pow(`***base*`,` *exponent*`)`**
- An operation involving two `int`s results in an `int`
  - When dividing one `int` by another, the fractional part of the result is thrown away: `14 / 5` gives `2`
- Any operation involving a `double` results in a `double`:
  `14.0 / 5` gives approximately `2.8`



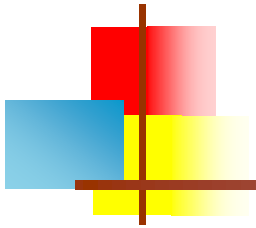
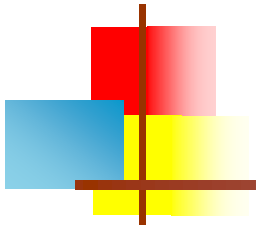
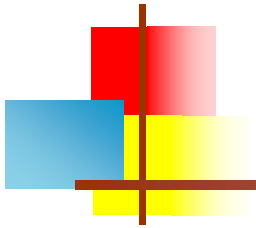
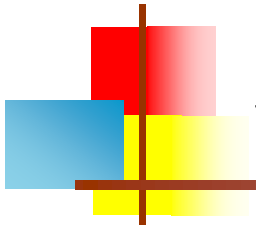
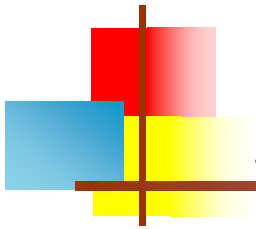
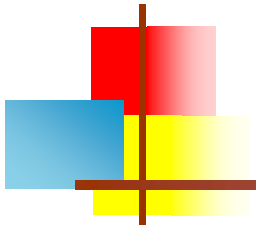
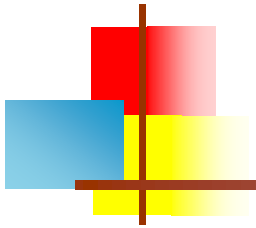
Boolean expressions

- Arithmetic comparisons result in a boolean value of true or false
  - There are six comparison operators:
    - `<` less than
    - `<=` less than or equals
    - `>` greater than
    - `>=` greater than or equals
    - `==` equals
    - `!=` not equals
- There are three boolean operators:
  - `&&` "and"--true only if both operands are true
  - `||` "or"--true if either operand is true
  - `!` "not"--reverses the truth value of its one operand
- Example:

  `(x > 0) && !(x > 99)`
  - "x is greater than zero and is not greater than 99"

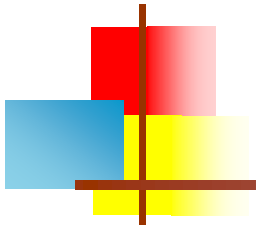
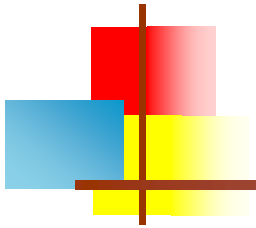
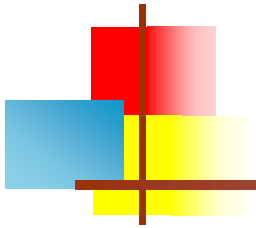
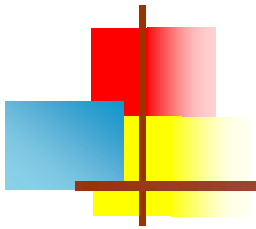
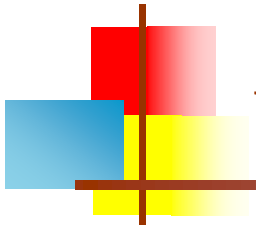
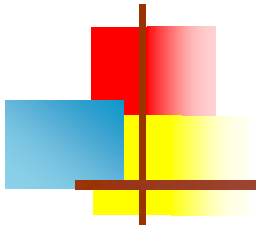


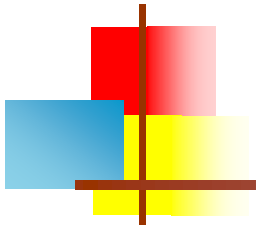
String concatenation

- You can concatenate (join together) Strings with the + operator
  - Example: `fullName = firstName + "  " + lastName;`
- In fact, you can concatenate any value with a String and that value will automatically be turned into a String
  - Example:
    ```
    System.out.println("There are " + count + " apples.");
    ```
- Be careful, because + also still means addition
  - ```
    int x = 3;
    int y = 5;
    System.out.println(x + y + " != " + x + y);
    ```
    - The above prints `8 != 35`
    - "Addition" is done left to right--use parentheses to change the order
    ```



if statements

- An if statement lets you choose whether or not to execute one statement, based on a *boolean* condition
  - Syntax: `if (`*boolean_condition*`) {`
    statement`;`
    `}`
  - Example:

```
if (x < 100) { // adds 1 to x, but only if x is less than 100
   x = x + 1;
}
```

  - Python programmers: The parentheses are required
  - C programmers:
    - The condition *must* be boolean
    - The braces, { }, should be on the lines as shown above. *Do not* insist on using C conventions in Java!



if-else statements

- An if statement may have an optional else part, to be executed if the boolean condition is false
  - Syntax:

```
if (boolean_condition) {
    statement;
} else {
    statement;
}
```

  - Example:

```
if (x >= 0 && x < limit) {
    y = x / limit;
} else {
    System.out.println("x is out of range: " + x);
}
```

- Java has no equivalent to Python's elif (just use else if instead)



Compound statements

- Multiple statements can be grouped into a single statement by surrounding them with braces, { }
- Example:

```
if (score > 100) {
    score = 100;
    System.out.println("score has been adjusted");
}
```

- Unlike other statements, there is no semicolon after a compound statement
- Braces can also be used around a single statement, or no statements at all (to form an “empty” statement)
- Indentation and spacing should be as shown in the above example



while loops

- A while loop will execute the enclosed statement as long as a boolean condition remains true
  - Syntax: while (*boolean_condition*) {
    statement;
    }
  - Example:

```
n = 1;
while (n < 4) {
    System.out.println(n + " squared is " + (n * n));
    n = n + 1;
}
```

  - Result:

```
1 squared is 1
2 squared is 4
3 squared is 9
```

  - Python programmers: The parentheses are required
  - C programmers: The condition *must* be boolean
- Danger: If the condition never becomes false, the loop never exits, and the program never stops



A complete program

```
public class SquareRoots {
    // Prints the square roots of numbers 1 to 10
    public static void main(String args[]) {
        int n = 1;
        while (n <= 10) {
            System.out.println(n + "  " + Math.sqrt(n));
            n = n + 1;
        }
    }
}
```

```
1  1.0
2  1.4142135623730951
3  1.7320508075688772
4  2.0
5  2.23606797749979
```

etc.



The do-while loop

- The syntax for the do-while is:

```
do {
    …any number of statements…
} while (condition) ;
```

- The while loop performs the test first, before executing the statement
- The do-while statement performs the test *afterwards*
- As long as the test is true, the statements in the loop are executed again



The increment operator

- ++ adds 1 to a variable
  - It can be used as a statement by itself
  - It can be used as part of a larger expression, but this is very bad style (see next slide)
  - It can be put *before* or *after* a variable
    - If before a variable (preincrement), it means to add one to the variable, then use the result
    - If put after a variable (postincrement), it means to use the current value of the variable, then add one to the variable
    - When used as a statement, preincrement and postincrement have identical results

Examples of ++

```
int a = 5;
a++;
// a is now 6

int b = 5;
++b;
// b is now 6

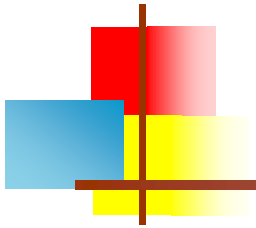
int c = 5;
int d = ++c;
// c is 6, d is 6
```

```
int e = 5;
int f = e++;
// e is 6, f is 5

int x = 10;
int y = 100;
int z = ++x + y++;
// x is 11, y is 101, z is 111
```

Confusing code is bad code, so this is very poor style



The decrement operator

- `--` subtracts 1 from a variable
  - It acts just like `++`, and has all the same problems



The for loop

- The for loop is complicated, but *very* handy
- Syntax:

  for (*initialize* ; *test* ; *increment*) *statement* ;

  - Notice that there is no semicolon after the *increment*
- Execution:
  - The *initialize* part is done first and only once
  - The *test* is performed; as long as it is true,
    - The *statement* is executed
    - The *increment* is executed



Parts of the for loop

- *Initialize:* In this part you define the loop variable with an assignment statement, or with a declaration and initialization
  - Examples: `i = 0` `int i = 0` `i = 0, j = k + 1`
- *Test, or condition:* A boolean condition
  - Just like in the other control statements we have used
- *Increment:* An assignment to the loop variable, or an application of `++` or `--` to the loop variable
  - This may be the *only* good use of `++` and `--` !



Example for loops

- Print the numbers 1 through 10, and their squares:

```
for (int i = 1; i < 11; i++) {
    System.out.println(i + "  " + (i * i));
}
```

- Print the squares of the first 100 integers, ten per line:

```
for (int i = 1; i < 101; i++) {
    System.out.print("  " + (i * i));
    if (i % 10 == 0) System.out.println();
}
```

Example: Multiplication table

```
public static void main(String[] args) {
      for (int i = 1; i < 11; i++) {
         for (int j = 1; j < 11; j++) {
            int product = i * j;
            if (product < 10)
                  System.out.print("   " + product);
            else System.out.print("  " + product);
         }
         System.out.println();
      }
   }
```



When do you use each loop?

- Use the for loop if you know ahead of time how many times you want to go through the loop
  - Example: Stepping through an array
  - Example: Print a 12-month calendar
- Use the while loop in almost all other cases
  - Example: Compute the next step in an approximation until you get close enough
- Use the do-while loop if you must go through the loop at least once before it makes sense to do the test
  - Example: Ask for the password until user gets it right



The break statement

- Inside any loop, the break statement will immediately get you out of the loop
  - If you are in nested loops, break gets you out of the *innermost* loop
- It doesn't make any sense to break out of a loop unconditionally—you should do it only as the result of an if test
- Example:
  - ```
    for (int i = 1; i <= 12; i++) {
        if (badEgg(i)) break;
    }
    ```
- break is not the normal way to leave a loop
  - Use it when necessary, but don't overuse it
    ```



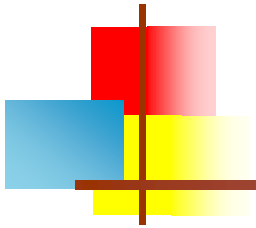
The continue statement

- Inside any loop, the continue statement will start the next pass through the loop
  - In a while or do-while loop, the continue statement will bring you to the test
  - In a for loop, the continue statement will bring you to the increment, *then* to the test



Multiway decisions

- The if-else statement chooses one of two statements, based on the value of a boolean expression
- The switch statement chooses one of several statements, based on the value on an integer (int, byte, short, long, or enum) or a char expression



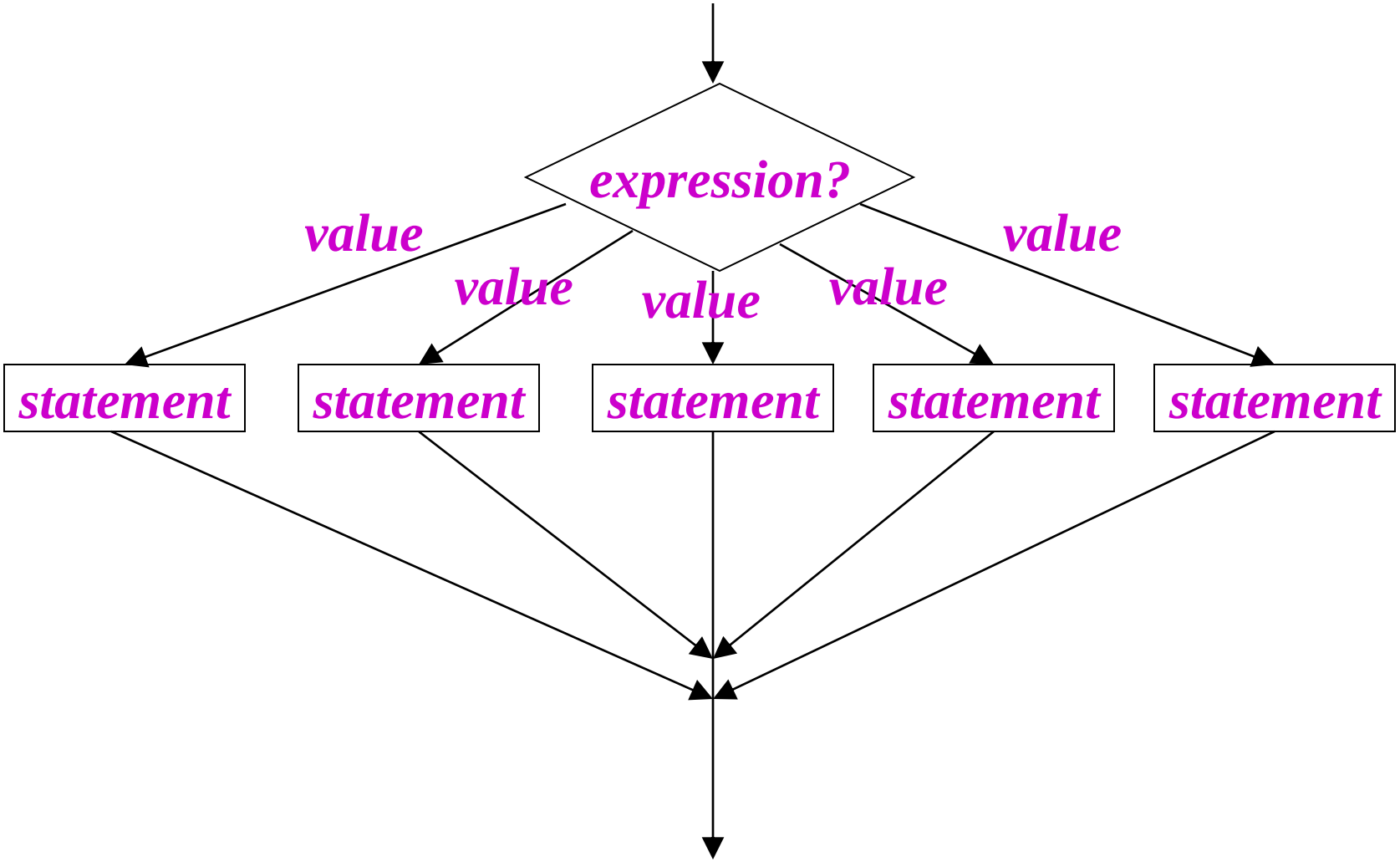
Syntax of the switch statement

- The syntax is:

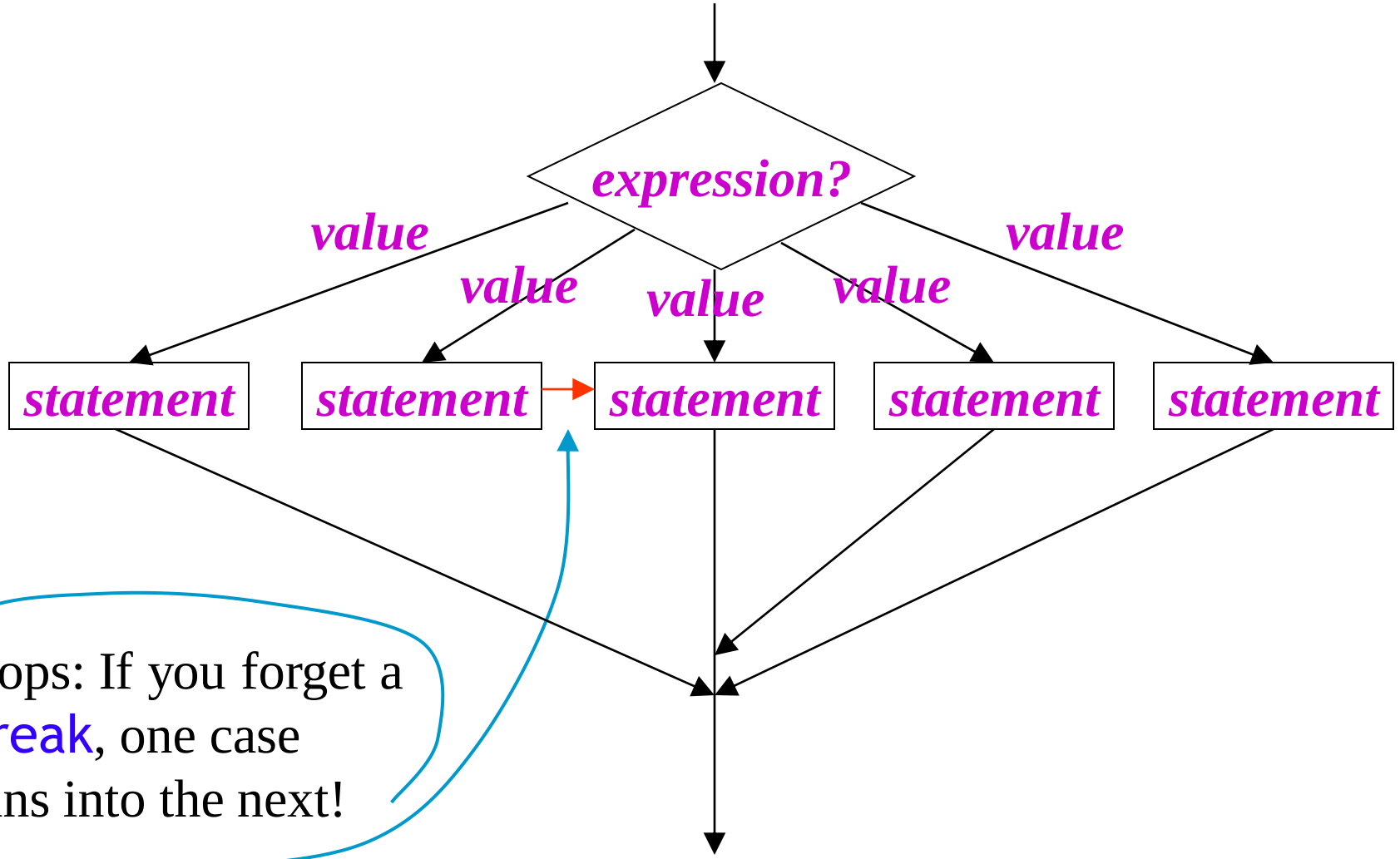
```
switch (expression) {
   case value1 :
      statements ;
      break ;
   case value2 :
      statements ;
      break ;
    ...(more cases)...
   default :
      statements ;
     break ;
}
```

- The *expression* must yield an integer or a character
- Each *value* must be a literal integer or character
- Notice that colons (:) are used as well as semicolons
- The last statement in every case should be a break;
  - I even like to do this in the *last* case
- The default: case handles every value not otherwise handled

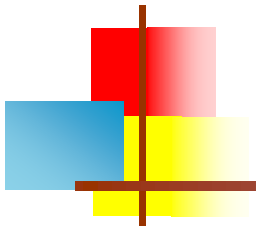
Flowchart for switch statement



Flowchart for switch statement

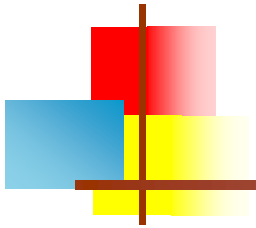


Oops: If you forget a break, one case runs into the next!



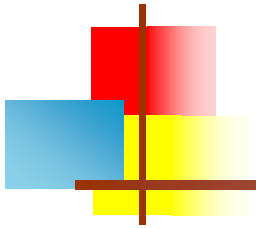
Example switch statement

```
switch (cardValue) {
    case 1:
        System.out.print("Ace");
        break;
    case 11:
        System.out.print("Jack");
        break;
    case 12:
        System.out.print("Queen");
        break;
    case 13:
        System.out.print("King");
        break;
    default:
        System.out.print(cardValue);
        break;
}
```



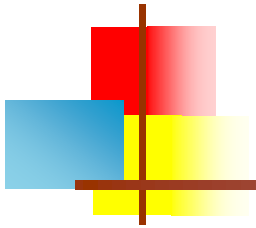
The assert statement

- The purpose of the assert statement is to document something you believe to be true
- There are two forms of the assert statement:
  1. assert ***booleanExpression***;
     - This statement tests the boolean expression
     - It does nothing if the boolean expression evaluates to true
     - If the boolean expression evaluates to false, this statement throws an AssertionError
  2. assert ***booleanExpression*** : ***expression***;
     - This form acts just like the first form
     - In addition, if the boolean expression evaluates to false, the second expression is used as a detail message for the AssertionError
     - The second expression may be of any type except void



Enabling assertions

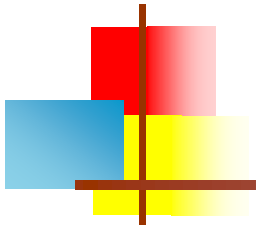
- By default, Java has assertions *disabled*—that is, it *ignores* them
  - This is for efficiency
  - Once the program is completely debugged and given to the customer, nothing more will go wrong, so you don't need the assertions any more
    - Yeah, right!
- You can change this default
  - Open Window → Preferences → Java → Installed JREs
  - Select the JRE you are using (probably 1.7.*something*)
  - Click Edit…
  - For Default VM Arguments, enter -ea (enable assertions)
  - Click OK (twice) to finish



How to define a method

- A method is a "function" that belongs to a class
- The syntax for a method is

  returnType name(*type parameter*, ..., *type parameter*) {
  declarations and statements
  return *value;*
  }
- The *returnType* may be void, meaning nothing is returned
  - In this case, the return statement is unnecessary and, if used, must not provide a value
  - return statements may occur anywhere within the method, but the best style is to have only one, at the end
- Types are specified when the method is defined, *not* when it is called
- You *may* prefix instance variables with this. , but it's seldom necessary



How to define a method

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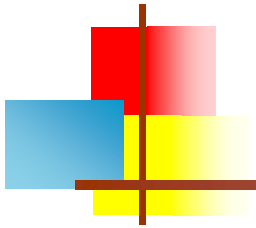
- The syntax for a method is

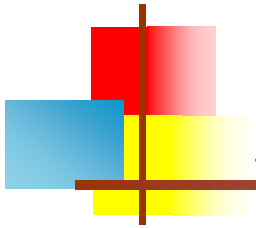
  returnType name(*type parameter*, ..., *type parameter*) {
  declarations and statements
  return *value;*
  }

  - You must declare the types of parameters and the return type
    - A return type of void means nothing is returned
    - If a method returns void (nothing), you *may* use return; statements in it
    - If you reach the end a void method, it automatically returns
  - Java's keyword "this" is the same as Python's variable "self"
    - In Java, never write this (or self) as the first parameter—it's always available



How to "call" a method

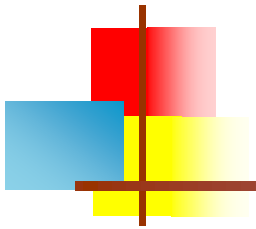
- A method call is a request to an object to do something, or to compute a value
  - `System.out.print(`***expression***`)` is a method call; you are asking the `System.out` object to evaluate and display the ***expression***
- When you call a method, do *not* specify parameter types
  - You must provide parameters of the type specified in the method definition
- Any method call may be used as a statement
  - Example: `System.out.print(2 * pi * radius);`
  - If the method returns a value, the value is ignored
- Methods that return a value may be used as part of an expression
  - Example: `h = Math.sqrt(a * a + b * b);`
  - To use the correct technical jargon, we don't "call" methods; we send a message to the object that holds the method



Another program, with methods

```
import java.util.Random;

public class RandomWalk {
    int x = 0;
    int y = 0;
    Random rand = new Random();

    public static void main(String[] args) {
        new RandomWalk().run();
    }

    void run() {
        double distance = 0;
        while (distance < 10) {
            step(3);
            System.out.println("Now at " + x + ", " + y);
            distance = getDistance();
        }
    }
```

```
    void step(int maxStep) {
        x += centerAtZero(maxStep);
        y += centerAtZero(maxStep);
    }

    int centerAtZero(int maxStep) {
        int r = rand.nextInt(2 * maxStep + 1);
        return r - maxStep;
    }

    double getDistance() {
        return Math.sqrt(x * x + y * y);
    }
}
```



The End

"I think there is a world market for maybe five computers."

—Thomas Watson, Chairman of IBM, 1943

"There is no reason anyone would want a computer in their home."

—Ken Olsen, president/founder of Digital Equipment Corporation, 1977