Elementary Programming

CSE 114: Introduction to Object-Oriented Programming

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Contents

- Identifiers
- Variables
  - Declaring Variables and Data Types (Java's Primitive Types)
  - Assignments and Assignment Compatibility
- Type Casting
- Arithmetic Operators
  - Pre and Post Increment and Decrement Operators
- Scientific Notation and "double-precision" values
- Constants
- Character Data Type and Unicode
- Classes, Methods and the main Method
  - HelloWorld.java, ComputeArea.java, ChangeMaker.java
- Reading Input from the Console and Packages in Java
- Software engineering basics

Identifiers

- What's an Application Programming Interface (API)?
  - a library of code identifiers/names to use
- What are identifiers/names used for?
  - For Variables, Classes, and Methods
  - They come from 2 sources:
    - the Oracle (or someone else's) Java API
    - your own classes, variables, and methods
  - Identifiers (Names) – Why name them?
    - they are your data and commands, and you'll need to reference them elsewhere in your program

```
int myVariable = 5; // Declaration
myVariable = myVariable + 1; // Using the variable
```

Rules for Identifiers

- Should contain only letters, numbers, & '_'
  - '$' is allowed, but only for special use
- Cannot begin with a digit!
- Although it is legal, do not begin with '_' (underscore)
- Uppercase and lowercase letters are considered to be different characters (Java is case-sensitive)
- Examples:
  - Legal: **`myVariable, my_class, my4Var`**
  - Illegal: **`4myVariable, my class, my!Var, @#$myClass`**

Common Java Naming Conventions

- Variables & Methods start with lower case letters: **`radius`**, **`getRadius`**
- Classes start with upper case letters: **`Circle`**
- Variables and Class identifiers should generally be nouns: **`radius`**, **`Circle`**
- Method identifiers should be verbs: **`getRadius`**
- Use Camel notation: **`GeometricObject`**, **`getRadius`**
- Use descriptive names: **`Circle`**, **`radius`**, **`area`**

```
area = PI * radius * radius;
```

Variables

- In a program, the variables store data
- All Java variables must have a declared type

```
type variable;
```

  - A variable's type determines:
    - what kind of value the variable can hold
    - how much memory to reserve for that variable

```
char letter;
int i;
double area;
String s;
Object o;
```

Data Types

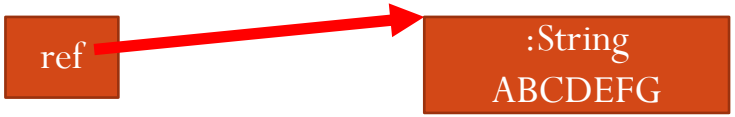
- There are 2 categories of types in Java (and most other modern programming languages):
  - Primitive type variables store single pieces of data:

```
int i = 1;
```


```
char letter = 'A';
```

  - Object or reference type variables store the reference (i.e., address) to an object that has multiple pieces of data (ex: a **`String`** is a sequence of potentially multiple characters):

```
String text = "ABCDEFG";
```



Java's 8 Primitive Types

- Integers (whole numbers):
  - **`byte`**–represented in 1 byte (8 bits) (-128 to 127)
  - **`short`** –2 bytes (-32,768 to 32,767)
  - **`int`**–4 bytes (-2,147,483,648 to 2,147,483,647) – default for integer constants in the program
  - **`long`**–8 bytes (-9223372036854775808 to 9223372036854775807)
- Real Numbers:
  - **`float`**–4 bytes
  - **`double`**–8 bytes - default for real constants in the program
- **`char`**–represented in 2 bytes to store a single character (Unicode2/UTF16 variable encoding)
- **`boolean`**–stores **`true`** or **`false`** (uses 1-bit)

Assignments

- A variable gets a value in an assignment statement:

```
Variable = some_value or
           an expression ;
```

Examples:

```
double salary;
salary = 20000.0;
char grade;
grade = 'A';
```

Assignments

- Variables can be declared and initialized at once:

```
char yesChar = 'y';
String word = "Hello!";
char initial3 = 'T';
boolean completed = false;
```

- We can declare and (optionally) assign multiple variables in one statement:

```
double total, count=0, avg = 0.0,
  stdDev, his = 0.0;
```

Assignments

- The Assignment Statement

```
variable = expression;
```

What does it do?

1. **First: Solves/evaluates expression!**
2. Assigns resulting value to the left variable!

- Exercise: What's the output if the same variable appear to the left and right of an assignment?

```
int x = 5;
x = x + x + 10;
System.out.print(x);
```

20

Variables

- **A variable must be declared before being assigned values:**

```
public void methodWithGoodDeclaration(){
  double salary;     //GOOD
  salary = 20000.0; //GOOD
  System.out.println("Salary is " + salary);
}
public void methodWithBadDeclaration(){
  salary = 20000.0; // SYNTAX ERROR
  double salary;
  System.out.println("Salary is " + salary);
}
```

Variables

- A local variable must be initialized before being used:

```
public void methodWithGoodReference(){
  double salary = 20000.0; // GOOD
  double raise = salary * 0.05; // 5% raise
  System.out.println("Raise is " + raise);
}
public void methodWithBadReference(){
  double salary; // Salary has no value.
  double raise = salary * 0.05;
   // SYNTAX ERROR because salary has no value
  System.out.println("Raise is " + raise);
}
```

Variables

- **A variable should only be declared once in one block:**

```
public void methodWithGoodDeclaration(){
  double salary = 20000.0;
  System.out.println("Salary is " + salary);
  salary = 60000.0;
  System.out.println("Salary is " + salary);
}
public void methodWithBadDeclaration(){
  double salary = 50000.0;
  System.out.println("Salary is " + salary);
  double salary = 60000.0; //Syntax ERROR
  System.out.println("Salary is " + salary);
 }
```

Variables

- **Local variables can only be used from their declaration until the end of the block where they were declared**

```
public void methodWithGoodScope(){
  double x = 5.0;
  if (x > 0.0){ // x is in scope here
      x = 6.0;  // including in inner blocks
  }
  System.out.println("x " + x); // x is still in scope here
}
public void methodWithBadScope(){
  double y = 100.0;
  if (y > 0.0) {
      double x = 5.0;
  } // no more x
  System.out.println("x " + x); // SYNTAX ERROR
}                               // x is not in scope
```

Compatibility

- **Assignment Compatibility:**
  - The expression should be of compatible type with the variable
    - if not, you may get a compiler error.
  - Examples:

```
int sumGrades, gradeX, gradeY;
gradeX = 1;                    // GOOD
sumGrades = 1473;              // GOOD
sumGrades = 1472 + 1;          // GOOD
sumGrades = 1472 + gradeX; // GOOD
sumGrades = true;              // SYNTAX ERROR
sumGrades = 5.4;               // SYNTAX ERROR
```

Assignment Compatibility

- **What about mixing numeric types?**
- These assignment statements are ok:

```
int x = 5;
long y = x;  // OK
double z = y; // OK
```

because: byte < short < int < long < float < double

- What about these?

```
double a = 6.5;
long b = a; // SYNTAX ERROR
int c = b;  // SYNTAX ERROR
```

  - No assigning big type values to little type variables OR real type values to integer type variables

Assignment Compatibility

- Type Casting: change a data type value to another type (sometimes with some loss):

  (type_name)expression

  - Example:

```
double myReal = 10.5;
int goodInt = (int)myReal;//Good
// goodInt is now 10
```

  - No type casting is allowed to/from boolean

Arithmetic Operators

+	Addition
-	Subtraction
*	Multiplication
/	Division
%	Modulo/Remainder (integer operands only)

```
int x = 5;
int y = 10;
int z = 2;
int num1 = (x + y) * z;
System.out.println(num1);
```

30

Division

- Integer division:
  - 8/3 = 2 (the quotient)
- Double division (if at least an operand is a double):
  - 8.0/3.0 = 2.6666666666666667
  - 8.0/3 = 2.6666666666666667
  - 8/3.0 = 2.6666666666666667

Division

- **Division examples (evaluate full expression first, then assignment):**

```
double average = 100.0/8.0;     //12.5
average = 100.0/8;              //12.5
average = 100/8;                //12.0
int sumGrades = 100/8;          //12
sumGrades = 100.0/8.0;          //ERROR
sumGrades = (int)100.0/8.0;     //ERROR
sumGrades = (int)(100.0/8.0); //12
int fifty_percent = 50/100;     //0
double fiftyPercent = 50/100; //0.0
fiftyPercent = 50.0/100.0;      //0.5
```

Rules of precedence

- Standard PEMDAS order of operations:
  - Multiplication and division (*/) have higher precedence over addition and subtraction (+-)

```
int x = 5;
int y = 10;
int z = 2;
int num1 = x + y * z;
System.out.println(num1);
```

25

- **My Advice: avoid rules of precedence and,** whenever in doubt, go with **explicit use of parentheses**.

```
int r2d2c3po = 3 * 4 + 5 / 6;
```

12

```
int r2d2c3po2 = (3 * (4 + 5))/ 6;
```

4

Arithmetic Operators

- **The modulo/remainder % operator**
  - **Produces division remainders**

```
int remainder = 10 % 6;
System.out.println(remainder);
```

```
4
```

Arithmetic Operators

++	Increment by one
--	Decrement by one
+=	Increment by specified amount
-=	Decrement by specified amount
*=	Multiply by specified amount
/=	Divide by specified amount

```
int x = 5, y = 15, z = 25;
x = x + 1;
y++;
z += 1;
System.out.println(x);
System.out.println(y);
System.out.println(z);
```

```
6
16
26
```

Pre and Post Increment and Decrement Operators

```
int i = 10;
int newNum = 10 * (++i);
```

Same effect as

```
i = i + 1;
int newNum = 10 * i;
```

Results in: i=11

newNum = 110

```
int i = 10;
int newNum = 10 * i++;
```

Same effect as

```
int newNum = 10 * i;
i = i + 1;
```

Results in: newNum = 100

i=11

Pre and Post Increment

```
int i = 10;
i = ++i       + i++;
  //(i=11)11 + 11(i=12) = 22
System.out.println(i); // 22
```

```
int i = 10;
i = i++       + i++;
 // 10(i=11) + 11(i=12) = 21
System.out.println(i); // 21
```

```
int y = 5;
y -= y++ - --y;
// y = 5 - (5(y=6) - (y=5)5) = 5 - (5 - 5) = 5 - 0 = 5
System.out.println(y); // 5
```

- **Notes:**

  `y -= val;` **IS** `y = y - val;`

Scientific Notation

- Floating-point literals can also be specified in scientific notation:
  - E (or e) represents an exponent of the base and it can be either in lowercase or uppercase
  - Examples

```
1.23456e+2 = 1.23456e2 = 123.456
1.23456e-2 = 0.0123456
```

"double-precision" values

- **`double`** values are represented internally as 64-bit "double-precision" values, according to the IEEE 754 standard (https://en.wikipedia.org/wiki/IEEE_754-2008_revision):
  - That is, floating point numbers are represented internally as sums of binary (base-2) fractions/negative powers of 2 (e.g., $0.5 = 2^{-1}$, $0.75 = 2^{-1} + 2^{-2}$).
    - But many/most decimal fractions (e.g, 1/10=0.1) cannot be represented exactly as binary fractions, so in many/most cases the internal representation of a floating-point number is an approximation of the actual value.

```
System.out.println(1 - 0.1 - 0.1 - 0.1);
0.70000001
```

Constants

```
final datatype CONSTANTNAME = VALUE;
```

- Examples:

```
final double PI = 3.14159;
final int SIZE; // assignment can be later
SIZE = 3; // GOOD
SIZE = 4; // ILLEGAL if changed again
```

- Convention (i.e., style): UPPERCASE letters are used for constants (because FORTRAN did not have constants, so developers used uppercase only to communicate that the identifier is a constant)

Character Data Type

```
char letter = 'A';
char numChar = '4';
```

Character Data Type

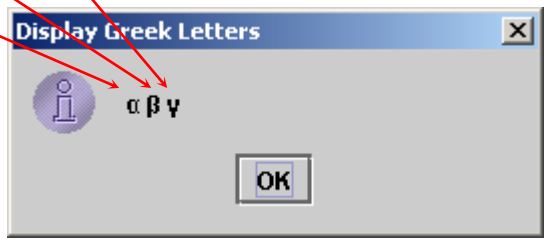
- Java characters use *Unicode* UTF-16 bit encoding
- chars can be assigned Unicode codes:

```
char letter = '\u0041'; // Unicode for 'A'
char numChar = '\u0034'; // Unicode for '4'
```

Unicode takes two bytes preceded by \u, expressed in four hexadecimal numbers that run from '\u0000' to '\uFFFF'. Unicode can represent `65535 + 1 characters`.

- Examples:

  Unicode \u03b1 \u03b2 \u03b3 for three Greek letters



Casting between char and Numeric Types

```
int i = 'a'; // Same as int i = (int)'a';
   // i is 97
char c = 97; // Same as char c = (char)97;
   // c is 'a'
```

Character Data Type

The increment and decrement operators can also be used on char variables to get the next or preceding Unicode character.

- the following statements display character **b**:

```
char ch = 'a';
System.out.println(++ch);
```

Escape Sequences for Special Characters

Description	*Escape Sequence*	*Unicode*
Tab	`\t`	`\u0009`
Linefeed	`\n`	`\u000A`
Backslash	`\\`	`\u005C`
Single Quote	`\'`	`\u0027`
Double Quote	`\"`	`\u0022`

Classes

A program is defined by using one or more classes

```
public class ClassName {
      // implementation
}
```

A **class** is also a template or blueprint for **objects** (we will see that later in Objects and Classes)

Methods

A method is a sequence of statements that performs a sequence of operations.

```
public static void print(String arg) {
  // implementation
}
```

-It is used by invoking the method with arguments.

```
System.out.print("Welcome to Java!");
```

The main Method

- The main method provides the control of program flow.

```
public class ClassName {
    public static void main(String[] args) {
        // ClassName PROGRAM'S POINT OF ENTRY
        // THIS PROGRAM'S INSTRUCTIONS
        // START HERE
    }
}
```

  - ***ClassName*** is executable because it has a main method
    - we can compile and then run it
  - Not all classes require main methods
    - only those classes that initiate program execution require a main method

Example programs: HelloWorld.java

```
/**
* HelloWorld is a Java application
* that simply displays "Hello World!" in the
* Java console.
*/
public class HelloWorld {
  public static void main(String[] args) {
      System.out.println("Hello, World!");
      // Statement above displays "Hello, World!"
  }
}
```

Computing the Area of a Circle:

```
public class ComputeArea {
  public static void main(String[] args) {
    double radius; // Declare radius
    double area; // Declare area
    // Assign a radius
    radius = 20; // New value is radius
    // Compute area
    area = radius * radius * 3.14159;
    // Display results
    System.out.println("The area for the circle"
      + " of radius " + radius + " is " + area);
  }
}
```

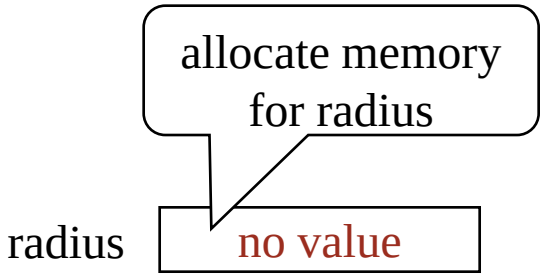
Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```



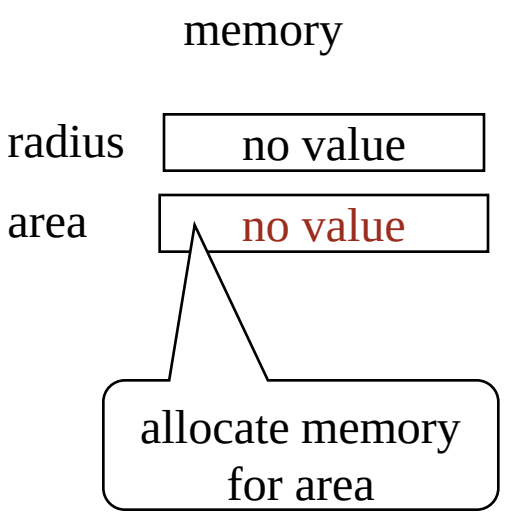
Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```



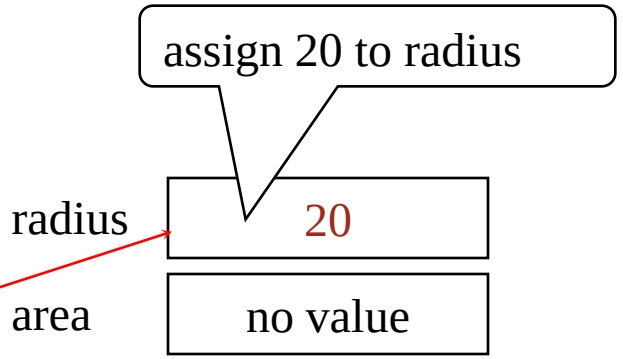
Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```



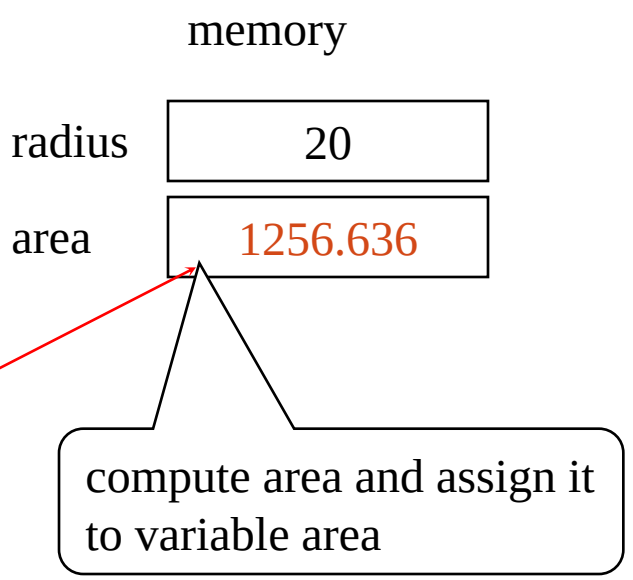
Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```



Trace a Program Execution

```
public class ComputeArea {
  /** Main method */
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area for the circle of radius " +
      radius + " is " + area);
  }
}
```

memory

radius	20
area	1256.636

print a message to the console

ChangeMaker.java

```
import java.util.Scanner;

public class ChangeMaker {
  public static void main(String[] args) {
      int change, rem, qs, ds, ns, ps;
      System.out.print("Input change amount (1-99): ");
      Scanner input = new Scanner(System.in);
      change = input.nextInt();
      qs = change / 25;
      rem = change % 25;
      ds = rem / 10;
      rem = rem % 10;
      ns = rem / 5;
      rem = rem % 5;
      ps = rem;
      System.out.print(qs + " quarters,"
            + ds + " dimes,");
      System.out.println(ns + " nickels and"
            + ps + " pennies");
  }
}
```

Reading Input from the Console

1. Create a Scanner object

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

2. Use the methods **`nextByte()`**, **`nextShort()`**, **`nextInt()`**, **`nextLong()`**, **`nextFloat()`**, **`nextDouble()`**, **`nextBoolean()`** or **`next()`** to obtain a **`byte`**, **`short`**, **`int`**, **`long`**, **`float`**, **`double`**, **`boolean`** or **`String`** (up to the first white space) value. For example,

```
System.out.print("Enter a double value: ");
Scanner input = new Scanner(System.in);
double d = input.nextDouble();
```

Scanner is in the Java package java.util
- start your program with:

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

Packages in Java

- To make types easier to find and use, to avoid naming conflicts, and to control access, programmers bundle groups of related types into packages.
- The types that are part of the Java platform are members of various packages that bundle classes by function: fundamental classes are in *java.lang*, classes for reading and writing (input and output) are in *java.io* and *java.util*, and so on.
  - You can put your types in packages too.
    - To create a package, you choose a name for the package and put a package statement with that name at the top of *every source file* that contains the types (e.g., classes, interfaces). In file Circle.java:

```
package edu.stonybrook.cse114;
public class Circle {
    ...
}
```

Packages in Java

- To use a public package member from outside its package, you must do one of the following:
  - Import the package member

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

  - Import the member's entire package

```
import java.util.*;
```

  - Refer to the member by its fully qualified name

```
java.util.Scanner input =
  new java.util.Scanner(System.in);
```

Packages in Java

- Packages appear to be hierarchical, but they are not.
  - Importing **`java.awt.*`** imports all of the types in the java.awt package, but it does not import **`java.awt.color`**, **`java.awt.font`**, or any other **`java.awt.xxxx`** packages.
  - If you plan to use the classes and other types in **`java.awt.color`** as well as those in **`java.awt`**, you must import both packages with all their files:

```
import java.awt.*;
import java.awt.color.*;
```

Setting the CLASSPATH System Variable

- In Windows: **`set CLASSPATH=C:\users\george\java\classes`**
- In Unix-based OS:

```
%CLASSPATH=/home/george/java/classes;
export CLASSPATH
```

Software engineering basics

- Software engineering waterfall model:
  1. Understand and define the problem
  2. Determine the required input and output
  3. Design an algorithm to solve the problem by computer
  4. Implement (code) the solution
  5. Debug and test the software
  6. Maintain and update the software

Example: ChangeMaker

- Problem:
  - you have to give someone change
  - what coins do you give that person?
- Requirements:
  - takes user input
  - displays the change breakdown as output

ChangeMaker

1. Understand and Define the Problem

- ask user for input
- US coins (quarter, dime, nickel, penny)
- max change: 99¢
- display the minimum number of coins (output)

- What's involved?
  - interview users
    - What are their expectations?
    - What data do they need to access?
  - write a requirements analysis report

ChangeMaker

2. Determine Input and Output

- Typed input by user: amount of change requested (an integer between 1 and 99)
- Printed output:
  - Number of quarters given
  - Number of dimes given
  - Number of nickels given
  - Number of pennies given

ChangeMaker

3. Design an algorithm

- How many quarters?
  - subtract the maximum number of quarters X 25c from the total
- How many dimes?
  - subtract the maximum number of dimes X 10c from remaining total
- How many nickels?
  - subtract the maximum number of nickels X 5c from remaining total
- How many pennies?
  - the remaining total

ChangeMaker

3. Design an algorithm (cont.)

- Pseudocode: Use div and mod (remainder operator)

```
User Inputs originalAmount
numQuarters=originalAmount div 25
remainder =originalAmount mod 25
numDimes =remainder div 10
remainder =remainder mod 10
numNickels = remainder div 5
remainder =remainder mod 5
numPennies =remainder
Output numQuarters
Output numDimes
Output numNickels
Output numPennies
```

4. Implement (code) the solution

```
import java.util.Scanner;
public class ChangeMaker {
  public static void main(String[] args) {
        int change, rem, qs, ds, ns, ps;
        System.out.print("Input change amount (1-99): ");
        Scanner input = new Scanner(System.in);
        change = input.nextInt();
        qs = change / 25;
        rem = change % 25;
        ds = rem / 10;
        rem = rem % 10;
        ns = rem / 5;
        rem = rem % 5;
        ps = rem;
        System.out.print(qs + " quarters," + ds + " dimes,");
        System.out.println(ns + " nickels and" + ps + " pennies");
  }
}
```

Extend ChangeMaker to include dollars

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);
```

remainingAmount 1156

remainingAmount initialized

```
// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;
// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

Trace / Debug

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;
// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

remainingAmount	1156
numberOfOneDollars	11

numberOfOneDollars assigned

Trace / Debug

Suppose amount is 11.56

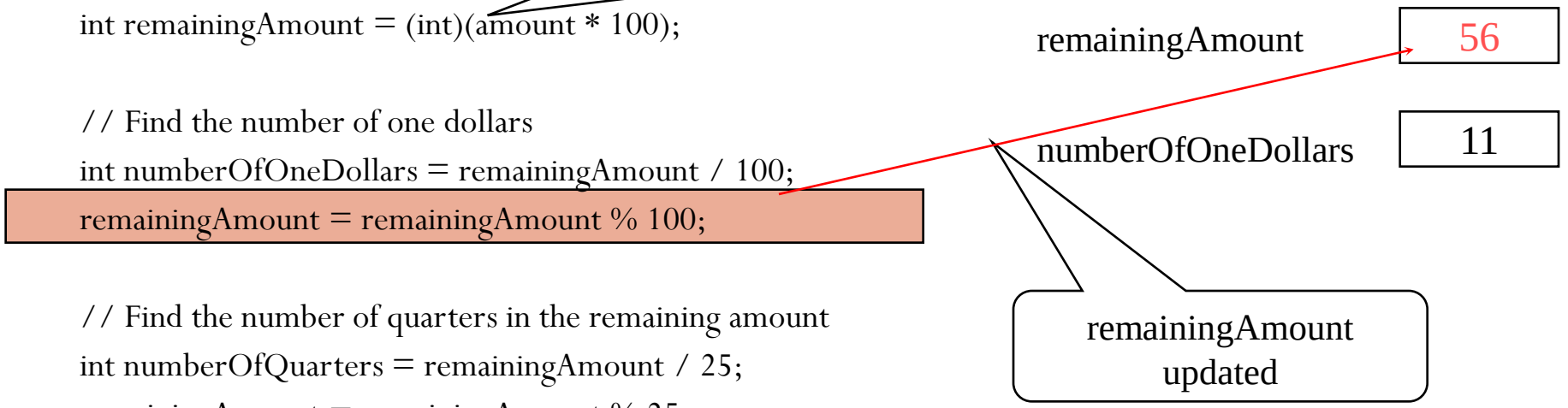
```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;
// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```



Trace / Debug

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;
// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

remainingAmount	56
numberOfOneDollars	11
numberOfOneQuarters	2

numberOfOneQuarters assigned

Trace / Debug

Suppose amount is 11.56

```
int remainingAmount = (int)(amount * 100);

// Find the number of one dollars
int numberOfOneDollars = remainingAmount / 100;
remainingAmount = remainingAmount % 100;

// Find the number of quarters in the remaining amount
int numberOfQuarters = remainingAmount / 25;
remainingAmount = remainingAmount % 25;

// Find the number of dimes in the remaining amount
int numberOfDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;
// Find the number of pennies in the remaining amount
int numberOfPennies = remainingAmount;
```

remainingAmount	6
numberOfOneDollars	11
numberOfQuarters	2

remainingAmount updated

extending ChangeMaker

```
import java.util.Scanner;

public class ChangeMaker {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);
    // read a price, e.g., $73.28
    // read an amount, e.g., $100
    // compute the change=amount-price, e.g., $100-$73.29=$26.72
    // use bills and coins to cover that change
    System.out.print("Input the price: $");
    double price = input.nextDouble();
    System.out.print("Input the paid amount: $");
    double amount = input.nextDouble();

    double change = amount - price;
    System.out.println("Change: $" + change);

    int rem = (int)(change * 100);

    int hundreds = rem / 10000;
    rem = rem % 10000;
    if(hundreds > 0)
      System.out.println(hundreds + " x $100 bills");
```

```
int fifties = rem / 5000;
rem = rem % 5000;
if(fifties > 0)
  System.out.println(fifties + " x $50 bills");

int twenties = rem / 2000;
rem = rem % 2000;
if(twenties > 0)
  System.out.println(twenties + " x $20 bills");

int tens = rem / 1000;
rem = rem % 1000;
if(tens > 0)
  System.out.println(tens + " x $10 bills");

int fives = rem / 500;
rem = rem % 500;
if(fives > 0)
  System.out.println(fives + " x $5 bills");

int ones = rem / 100;
rem = rem % 100;
if(ones > 0)
  System.out.println(ones + " x $1 bills");
```

extending ChangeMaker

```
    int qs = rem / 25;
    rem = rem % 25;
    if(qs > 0)
      System.out.println(qs + " x 25c");

    int ds = rem / 10;
    rem = rem % 10;
    if(ds > 0)
      System.out.println(ds + " x 10c");

    int ns = rem / 5;
    rem = rem % 5;
    if(ns > 0)
      System.out.println(ns + " x 5c");

    if(rem > 0)
      System.out.println(rem + " x 1c");

  }
}
```