Elementary Programming

CSE 114: Introduction to Object-Oriented Programming
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http://www.cs.stonybrook.edu/~cse114
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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

```java
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`

\[
\text{area} = \pi \times \text{radius} \times \text{radius};
\]
Variables

• In a program, the **variables store data**

• All Java variables must have a **declared type**

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

```java
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:
    ```java
    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):
    ```java
    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:

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

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

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

- The Assignment Statement
  \[\text{variable} = \text{expression};\]

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?

```java
int x = 5;
x = x + x + 10;
System.out.println(x);  // 20
```
Variables

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

```java
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:**

  ```java
  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**:

```java
class Example {
    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.

```java
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:**

```c
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):
  
  \[ (\text{type}_\text{name})\text{expression} \]

- **Example**:
  
  ```java
  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)

```java
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):
  - $8.0/3.0 = 2.666666666666667$
  - $8.0/3 = 2.666666666666667$
  - $8/3.0 = 2.666666666666667$
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 (+-)

  ```java
  int x = 5;
  int y = 10;
  int z = 2;
  int num1 = x + y * z;
  System.out.println(num1);  // Output: 25
  ```

  ```java
  int r2d2c3po = 3 * 4 + 5 / 6;  // Output: 12
  int r2d2c3po2 = (3 * (4 + 5)) / 6;  // Output: 4
  ```

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

- The modulo/remainder % operator
- Produces division remainders

```java
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

```java
int x = 5, y = 15, z = 25;
x = x + 1;
y++;
z += 1;
System.out.println(x);  // 6
System.out.println(y);  // 16
System.out.println(z);  // 26
```
Pre and Post Increment and Decrement Operators

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

Same effect as

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

Results in: $i = 11$

```java
int newNum = 10 * (++i);
i = i + 1;
```

Results in: $\text{newNum} = 110$

```
Results in: 
\text{newNum} = 100

\text{i} = 11
```
Pre and Post Increment

```java
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](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);

    0.700000001
Constants

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

- Examples:
  ```java
  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)
char letter = 'A';
char numChar = '4';
Character Data Type

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

```java
cchar letter = '\u0041'; // Unicode for 'A'
cchar 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

```java
int i = 'a'; // Same as int i = (int)'a';
    // i is 97
char c = 97; // Same as char c = (char)97;
    // c is 'a'
```
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`:
  
  ```java
  char ch = 'a';
  System.out.println(++ch);
  ```
## Escape Sequences for Special Characters

<table>
<thead>
<tr>
<th>Description</th>
<th>Escape Sequence</th>
<th>Unicode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tab</td>
<td>\</td>
<td>\u0009</td>
</tr>
<tr>
<td>Linefeed</td>
<td>\n</td>
<td>\u000A</td>
</tr>
<tr>
<td>Backslash</td>
<td>\</td>
<td>\u005C</td>
</tr>
<tr>
<td>Single Quote</td>
<td>'</td>
<td>\u0027</td>
</tr>
<tr>
<td>Double Quote</td>
<td>&quot;</td>
<td>\u0022</td>
</tr>
</tbody>
</table>
Classes

A program is defined by using one or more classes

```java
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.

```java
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.

```java
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!"
    }
}

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Computing the Area of a Circle:

```java
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);
    }
}
```
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);
    }
}
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);
    }
}
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);
    }
}
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);
    }
}
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);
    }
}
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," + 
                         ns + " nickels and" + 
                         ps + " pennies");
    }
}
Reading Input from the Console

1. Create a Scanner object

\[
\text{Scanner input} = \text{new Scanner(System.in);}
\]

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,

\[
\text{System.out.println("Enter a double value: ");}
\text{Scanner input} = \text{new Scanner(System.in);}
\text{double d} = \text{input.nextDouble();}
\]

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

\[
\text{import java.util.Scanner;}
\]
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:

    ```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
    
    ```java
    import java.util.Scanner;
    ```
  • Import the member's entire package
    ```java
    import java.util.*;
    ```
  • Refer to the member by its fully qualified name
    ```java
    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:
    ```java
    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:
  ```bash
  %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
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
3. Design an algorithm

- How many quarters?
  - subtract the maximum number of quarters $\times 25c$ from the total
- How many dimes?
  - subtract the maximum number of dimes $\times 10c$ from remaining total
- How many nickels?
  - subtract the maximum number of nickels $\times 5c$ from remaining total
- How many pennies?
  - the remaining total
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
```
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");
    }
}
Suppose amount is 11.56

```java
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;
```
Suppose amount is 11.56

```c
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;
```
Suppose amount is 11.56

```java
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;
```
Suppose amount is 11.56

```java
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 numberOfOneQuarters = 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
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;