Elementary Programming

CSE160: Computer Science A: Honors
Paul Fodor
Stony Brook University

http://www.cs.stonybrook.edu/~cse160
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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

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
  • 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;                   i
    char letter = 'A';          letter
    ```
  • **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";     text
    ```
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

```java
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?

```java
int x = 5;
x = x + x + 10;
System.out.print(x);  // Output: 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);
}
```

```java
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
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);

    // Syntax ERROR
    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:

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

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

• What about these?

```java
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)

```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):
  
  ```plaintext
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);  // 25
```

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

```java
int r2d2c3po = 3 * 4 + 5 / 6;  // 12
int r2d2c3po2 = (3 * (4 + 5)) / 6;  // 4
```
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
* Fast multiply
/ Fast divide

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

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

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

Same effect as

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

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

Results in: i=11

newNum = 110

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

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

Same effect as

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

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

Results in: newNum = 100

i=11
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.

```java
System.out.println(1 - 0.1 - 0.1 - 0.1);
0.70000001
```
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)
Character Data Type

```c
char letter = 'A';
char numChar = '4';
```
Character Data Type

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

```java
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 65536 characters.

- Examples:

  Unicode \u03b1 \u03b2 \u03b3 for three Greek letters
Casting between char and Numeric Types

```c
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>\t</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>
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:

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);
  }
}

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);
  }
}
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");
    }
}
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,

   ```java
   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:

   ```java
   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.cse160;
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:
    ```
    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
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 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
3. Design an algorithm (cont.)

- **Pseudocode:** Use div and mod (remainder operator)

  ```plaintext
  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

```java
import java.util.Scanner;

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");
    }
}
```
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
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 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

updated
Suppose amount is 11.56

```cpp
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 numberOfOneDimes = remainingAmount / 10;
remainingAmount = remainingAmount % 10;

// Find the number of nickels in the remaining amount
int numberOfOneNickels = remainingAmount / 5;
remainingAmount = remainingAmount % 5;

// Find the number of pennies in the remaining amount
int numberOfOnePennies = 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;
```