Basic Computation (Savitch, Chapter 2)

TOPICS

- Variables and Data Types
- Expressions and Operators
- Integers and Real Numbers
- Characters and Strings
- Input and Output

Variables

- Variables store information
  - You can think of them like boxes
  - They "hold" values
  - The value of a variable is its current contents
- Note that this differs from variable in math
  - In math, a variable is an "unknown"
    - It has a fixed value (or set of values)
    - Solving an equation reveals its value
    - They don't actually "vary"
  - In programming, variables change values
    - Their current value is always known
    - The program changes their values to achieve a goal

Data Types

- Variables are like boxes: they hold values
  - But you can't put an elephant in a shoe box
  - Different boxes hold different types of things
- Therefore, variables have *data types*
  - The data type describes the set of values a variable might contain
  - The value of a variable is a member of the set defined by its data type
  - Examples: int, char, double, boolean, String

Creating Variables

- You create new variables through *declarations*
  - Examples:

```
int daysPerYear;
char vowel;
```

- You assign values using =
  - Examples:

```
daysPerYear = 365;
vowel = 'a';
```

More about Variables

- An uninitialized variable is useless
  - So it's good practice to initialize when declaring variables, can be done with one statement:

```
int daysPerYear = 365;
```

- Variables can be re-used:

```
int daysPerYear = 365;
// random code here
daysPerYear = 110;
```


Literals

- Literals are values that are directly recognized by Java:
  - numbers

    `237, 10, 9, 1.5, 5.8, 99.999`
  - characters

    `'a', 'Z', '0', '$'`
  - strings

    `"hello", "there"`

Java Identifiers

- An identifier is a name, such as the name of a variable.
- Identifiers may contain only
  - Letters
  - Digits (0 through 9)
  - The underscore character (_)
  - And the dollar sign symbol ($) which has a special meaning
- The first character cannot be a digit.

Java Identifiers

- Identifiers may not contain any spaces, dots (.), asterisks (*), or other characters:

  7-11 netscape.com util.* (not allowed)
- Identifiers can be arbitrarily long.
- Since Java is case sensitive, stuff, Stuff, and STUFF are different identifiers.

Keywords or Reserved Words

- Words such as if are called keywords or reserved words and have special, predefined meanings.
  - Cannot be used as identifiers.
  - See Appendix 1 for a complete list of Java keywords.
- Example keywords: **int**, **public**, **class**

Naming Conventions

- Class types begin with an uppercase letter (e.g. String).
- Primitive types begin with a lowercase letter (e.g. int).
- Variables of both class and primitive types begin with a lowercase letters (e.g. myName, myBalance).
- Multiword names are "punctuated" using uppercase letters.

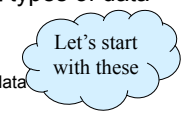
Where to Declare Variables

- Declare a variable
  - Just before it is used or
  - At the beginning of the section of your program that is enclosed in {}:

```
public static void main(String[] args)
{
   /* declare variables here */
   . . .
   /* code starts here */
   . . .
}
```


Java Types

- In Java, there are two different types of data types:
  - Primitive data types
    - Hold a single, indivisible piece of data
    - Pre-defined by the language
    - Examples: int, char, double, boolean
  - Classes
    - Hold complex combinations of data
    - Programs may define new classes
    - Examples: String, System



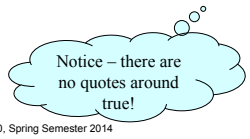
Primitive Types

- Integer types: byte, short, int, and long
  - int is most common
- Floating-point types: float and double
  - double is more common
- Character type: char
- Boolean type: boolean

Primitive Data Types

- The 4 most common primitive data types

Data Type	Description	Example
int	- integer values	5
double	- floating-point values	3.14
char	- characters	'J'
boolean	- either true or false	true



Primitive Types

Type Name	Kind of Value	Memory Used	Range of Values
byte	Integer	1 byte	–128 to 127
short	Integer	2 bytes	–32,768 to 32,767
int	Integer	4 bytes	–2,147,483,648 to 2,147,483,647
long	Integer	8 bytes	–9,223,372,036,8547,75,808 to 9,223,372,036,854,775,807
float	Floating-point	4 bytes	$\pm 3.40282347 \times 10^{+38}$ to $\pm 1.40239846 \times 10^{-45}$
double	Floating-point	8 bytes	$\pm 1.79769313486231570 \times 10^{+308}$ to $\pm 4.94065645841246544 \times 10^{-324}$
char	Single character (Unicode)	2 bytes	All Unicode values from 0 to 65,535
boolean		1 bit	True or false

Assignment Statements

- An assignment statement is used to assign a value to a variable.

```
answer = 42;
```

- The "equal sign" is called the *assignment operator.*
- We say, "The variable named `answer` is assigned a value of 42," or more simply, "`answer` is assigned 42."

Operators

- Operators act on primitive data types
- You have already seen =
  - No, it does not test for equality
  - The '=' operator assigns a value to a variable
  - Example: int x = 7;
- The other operators are more intuitive:
  - '+' adds two numbers
  - '*' multiplies two numbers
  - '-' subtracts two numbers
  - '/' divides two numbers
  - '==' tests for equality

Expressions

- A program is a sequence of expressions
  - Well, it also needs a header
  - But the program body lists expressions
- A simple expression looks like:

data_type var1 = var2 op var3;

  - Where 'var1', 'var2' and 'var3' are variables
  - 'op' is any operator (e.g. +, -, *)
  - If var1 is a new variable, then 'data_type' is the type of the new value

Variations on Expressions

- Note that variables can be re-used across expressions:

```
int x = 7;
x = x + 1;
```

- Variables can be re-used within expressions:

```
x = x + x;
```


More variations on expressions

- The *right hand side* of an assignment can be any mathematical expression:

```
int y = x + (2 * z);
```

- When more than one operator appears
  - Parenthesis disambiguate
    - See above
  - Without parenthesis, operator precedence rules apply
    - E.g. multiply before add, left before right
    - Better to rely on parentheses

Example Problem

- How would you write a program to print all the numbers from 1 to 100, one per line?
  - You could write 100 println(…) commands, but that would be a long program!
  - Or could use one variable and keep incrementing it…

Example

```
// Simple example of loop in Java

public class SimpleExample {

    public static void main(String[] args) {

        int counter = 1;
        while (counter <= 100) {
            System.out.println(counter);
            counter = counter + 1;
        }
    }
}
```


Integers

- Numbers without fractional parts

3, 47, -12

- Variables store integers with an assignment statement

```
int size = 7;
```

- Integer variables may be used like integer literals (i.e., number), e.g.,

```
size = size + 1;
```


Integer Arithmetic Operations

Symbol	Operation	Example	Evaluates to
+	Addition	45 + 5	50
-	Subtraction	657 – 57	600
*	Multiplication	7000 * 3	21000
/	Division	13 / 7	1
%	Remainder	13 % 7	6

Remainder Reminder

- **%** determines what is left after integer division.
- For integers, x % y or x / y

$$x = qy + r$$

where r = x % y and q = x / y

Integer Math

```
int i = 10/3;
```

- What's i = ? 3

```
int j = 10 % 3;
```

- What's j = ? 1

```
int k = 13 % 5 / 2;
```

- What's k = ? 1

Additional Integer Operators

- Self-assignment

```
int temperature = 32;
temperature = temperature + 10;
```

What is temperature? 42

- Increment

`cent++;` equivalent to `cent = cent + 1;`

- Decrement

`cent--;` equivalent to `cent = cent - 1;`

Specialized Assignment Operators

- Assignment operators can be combined with arithmetic operators including `-, *, /, %`.

```
amount = amount + 5;
```

can be written as

```
amount += 5;
```

yielding the same results.

Parentheses and Precedence

- Parentheses can communicate the order in which arithmetic operations are performed
- examples:

```
(cost + tax) * discount
 cost + (tax * discount)
```

- Without parentheses, an expressions is evaluated according to the *rules of precedence.*

Precedence Rules

- Figure 2.2 Precedence Rules

Highest Precedence

First: the unary operators +, -, !, ++, and --

Second: the binary arithmetic operators *, /, and %

Third: the binary arithmetic operators + and –

Lowest Precedence

Precedence Rules

- The *binary* arithmetic operators `*, /,` and `%`, have *lower precedence* than the *unary* operators `+, -, ++, --,` and `!`, but have *higher precedence* than the binary arithmetic operators `+` and `-`.
- When binary operators have equal precedence, the operator on the left acts before the operator(s) on the right.

Sample Expressions

Ordinary Math	Java (Preferred Form)	Java (Parenthesized)
$rate^2 + delta$	`rate * rate + delta`	`(rate * rate) + delta`
$2(salary + bonus)$	`2 * (salary + bonus)`	`2 * (salary + bonus)`
$\frac{1}{time + 3mass}$	`1 / (time + 3 * mass)`	`1 / (time + (3 * mass))`
$\frac{a-7}{t+9v}$	`(a - 7) / (t + 9 * v)`	`(a - 7) / (t + (9 * v))`

Real Numbers

- Also called floating-point numbers
- Numbers with fractional parts

3.14159, 7.12, 9.0, 0.5e001, -16.3e+002

- Declared using the data type `double`

```
double pricePerPound = 3.99,
       taxRate       = 0.05,
       shippingCost  = 5.55;
double pctProfit = 12.997;
```


`double` Arithmetic Operations

Symbol	Operation	Example
+	Addition	45.0 + 5.30
-	Subtraction	657.0 – 5.7
*	Multiplication	70.0 * 3.0
/	Division	96.0 / 2.0

Numbers in Java

- `int` is of fixed size;
  a value that is too large to be stored in an `int` variable will not match the mathematical value.
  - Example:

```
int x = 100000 * 100000;
out.println( x );
```

Will print: 1410065408

Numerical overflow!

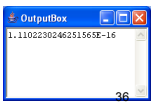
No warning messages!

Numbers in Java

- It is not always possible to test `double` expressions for equality and obtain a correct result because of rounding errors (called “floating point error”).

```
public class ProblemDoublePrecision
{
  public static void main( String[ ] args )
  {
        double val = 1.0/5.0+1.0/5.0+1.0/5.0-0.6;
        System.out.println( val );
  }
}
```

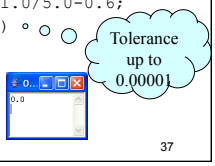
Should be zero!



Numbers in Java

- How should you handle “floating point error”?
  - Test to see if the value is within a margin of error

```
public class CheckDoubleEquality
{
  public static void main( String[ ] args )
  {
        double val = 1.0/5.0+1.0/5.0+1.0/5.0-0.6;
        if ( Math.abs(val) < 0.00001 )
              val = 0;
        System.out.println( val );
  }
}
```



Assignment Compatibilities

- Java is said to be strongly typed.
  - You can't, for example, assign a floating point value to a variable declared to store an integer.
- Sometimes conversions between numbers are possible …

```
doubleVariable = 7;
```

- … is possible even if doubleVariable is of type double, for example.

Assignment Compatibilities

- A value of one type can be assigned to a variable of a type further to the right:

  byte --> short --> int --> long --> float --> double
  - But not to a variable of any type further to the left.
- You can assign a value of type char to a variable of type int.

Type Casting

- A type cast temporarily changes the value of a variable from the declared type to some other type.
- For example,

```
double distance;
distance = 9.0;
int points;
points = (int)distance;
```

- Illegal without (int)

Type Casting

- The value of (int)distance is 9,
- The value of distance, both before and after the cast, is 9.0.
- Any nonzero value to the right of the decimal point is truncated rather than rounded.

Mixing Numeric Data Types

- *Widening conversion* Java will automatically convert `int` expressions to `double` values without loss of information
  - `int i = 5;`

```
double x = i + 10.5;
```

  - `double y = i;`

Arithmetic promotion of i to largest data type double

assignment promotion of i

- *Narrowing conversion* To convert `double` expressions to `int` requires a *typecasting* operation and truncation will occur

```
i = (int) (10.3 * 2)
```

i = **20** : the .6 is truncated

- To *round-up* instead of truncating add 0.5

```
i = (int) (10.3 * x + 0.5)
```


Characters

- Any key you type on the keyboard generates a character which may or may not be displayed on the screen (e.g., *nonprinting* characters)
- Characters are a primitive type in Java and are not equivalent to Strings
- Examples

```
char vitamin = 'A',
     chromosome = 'y',
     middleInitial = 'N';
```


Important Literal Characters

`'A', … ,'Z'`	Uppercase letters
`'a', … ,'z'`	Lowercase letters
`'0', … , '9'`	Digits
`'.', ',', '!','"',etc.`	Punctuation Marks
`' '`	Blank
`'\n'`	New line
`'\t'`	Tab
`'\\'`	Backslash
`'\''`	Single Right Quote

The other meta-type: Classes

- A *primitive* data type is indivisible
  - They have no meaningful subparts
  - The primitives are defined by the language
    - int, char, double, etc.
- A *class* is a data type that contains many bits of information
  - For example, Strings (many primitive chars)
  - Many classes defined by the language
    - You can also define new ones…

Classes

- Classes have data & methods
  - The data may be primitives or other classes.
  - Used instead of operators
- The period (‘.’) accesses methods of a class:

```
String greeting = “hello”;
char c = greeting.charAt(0);
// c now equals ‘h’
```


More about Strings

- `String` is defined in the `java.lang` package
  - **The java.lang package is automatically included in all programs, so you do not need to import it.*
- String literals are defined in double-quotes “string”
- Examples

```
String t1 = “To be ”;
String t2 = “or not to be”;
System.out.println(t1.concat(t2));
// prints To be or not to be
```


String Methods

Name	Description
`int length()`	Returns the length of this string
`int indexOf(String s)`	Returns the index within the string of the first occurrence of the string s.
`String substring (int beginx, int endx)`	Returns the substring beginning at index beginx and ending at index endx-1
`String toUpperCase()`	Converts all characters of the string to uppercase
`String concat(String s)`	Concatenates the new string to the end of the original string
`char charAt(int index)`	Returns the character at the index, which must be between 0 and length of string - 1

Syntax: primitives vs classes

- Operators act on primitive variables
  - Examples: +. -, *, %
  - Standard math in-fix notation
    - x + y;
    - y / 7;
- Methods act on class variables
  - Example: length()
  - Notation: class.method(arguments)
    - String s1 = “foo”;
    - int x = s1.length();

String Method Examples

```
import java.util.Scanner;

// Simple string program in Java

public class SimpleString {

    public static void main(String[] args) {

        // Keyboard input example
        String string1;
        Scanner keyboard = new Scanner(System.in);
        System.out.print("String: ");
        string1 = keyboard.nextLine();
        System.out.println(string1);

        // Using String methods
        String string2 = "Here is a test string";
        System.out.println(string2.charAt(2));      // prints "r"
        System.out.println(string2.indexOf("s"));   // prints 6
        System.out.println(string2.indexOf("x"));   // prints -1
        System.out.println(string2.length());       // prints 21
        System.out.println(string2.substring(8,14)); // prints ‘a test’
    }
}
```


Object Examples

- Scanner instance is an object (not primitive)
- Methods for the Scanner class include
  - nextInt ← returns next sequence as integer
  - nextDouble ← returns next sequence as double
  - next ← returns next sequence of chars
    - read until the next whitespace (spaces, tabs, end of line)
  - nextLine ← returns next line up until enter key
    - reads

Input/Output

- From util package
  `import java.util.Scanner;`
- Create a new instance:
  `Scanner in = new Scanner( System.in );`
- Input *(depends on data type reading in)*
  - `String input = in.next( );`
  - `String line = in.nextLine( );`
  - `int intVal = in.nextInt( );`
  - `double dblVal = in.nextDouble( );`

System.in refers to the keyboard

Reading Integers

```
import java.util.*;

public class getInput
{
        public static void main( String[ ] args )
        {
                Scanner in;
                int intVal;

                in = new Scanner( System.in );
                System.out.println("Enter an integer: ");
                intVal = in.nextInt( );

                System.out.println( intVal );
        }
}
```


Reading `double` Numbers

```
import java.util.*;

public class getDoubleInput
{
        public static void main( String[ ] args )
        {
                Scanner in;
                double temp;

                in = new Scanner( System.in );
                System.out.println("Enter a real number: ");
                temp = in.nextDouble( );
        }
}
```


Reading Strings

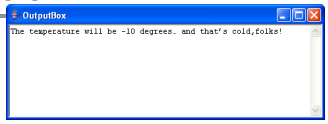
```
import java.util.*;

public class getStringInput
{
        public static void main( String[ ] args )
        {
                Scanner in;
                String name;

                in = new Scanner( System.in );
                System.out.println("Enter your name: ");
                name = in.next( );

                System.out.println( name );
        }
}
```


Printing Integers




```
public class Forecast
{
    public static void main (String args[])
    {
        System.out.print("The temperature will be ");
        System.out.print(-10);
        System.out.print(" degrees…");
        System.out.println(" and that's
cold,folks!");
    }
}
```

What happens if you use println each time?

Formatting Decimal Values

- Use DecimalFormat class
  - Leading zeros (e.g. money: $0.25)
    - "0.##"
  - Trailing zeros (e.g. money: $5.30)
    - "#.00"
  - Round to 3 decimal values
    - "#.###"
  - Add comma for thousands
    - "#,###"

Formatting Decimal Values

- Import package

```
import  java.text.*;
```

- Create the object

```
DecimalFormat  fmt = new DecimalFormat( "#.##" );
```

- Specify which numbers to format when printing by calling format method

```
System.out.println( fmt.format( 45.6789 ) );
```


Formatting Decimal Values

Examples

- DecimalFormat fmt = new DecimalFormat("#.##");

```
System.out.println( \fmt.format( 45.6789 ) );   45.68
System.out.println( fmt.format( 345.6 ) );      345.6
System.out.println( fmt.format( 67.0 ) );       67
```

- DecimalFormat fmt2 = new DecimalFormat("000.00");

```
System.out.println( fmt2.format( 45.6789 ) );   045.68
System.out.println( fmt2.format( 5.6 ) );       005.60
```

- DecimalFormat fmt6 = new DecimalFormat("#,###");

```
System.out.println( fmt6.format( 12345 ) );     12,345
```


What could go wrong?

- If you mis-type a variable name or a data type…
  - When you try to compile & run it in Eclipse
    1. Eclipse will tell you there was an error
    2. The editor will put a red 'x' at the left of the line with the error
  - This is an example of a compile-time error

What else could go wrong?

- You can specify an illegal operation
  - E.g. try to divide a string by a string
  - Again, a compile-time error with a red ‘x’
- You can forget a ; or a }
  - Same as above

More Errors

- Capitalization errors
  - Java is case sensitive, identifier names must use the same capitalization rules each time
- Logic Errors
  - Program appears to run correctly, but on closer inspection the wrong output is displayed

Debugging Hints

- Let Eclipse help you!
  - Gives suggestions on methods to use
  - Provides warning and error messages as you type… even provides suggestions of how to fix the problem.
- Add debugging statements to check the computation

```
System.out.println(…);
```