Java Building Elements

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Core Java Technology

Table of contents

Outline of Presentation

Console Input and Output

- Any program takes some input and produces some output
- Java associates System.out with display and System.in with keyboard
- Earlier, we have seen that we can generate output in Java program using System.out.println(). We will also learn formated output.
- Java program can take input in two ways:
  - Command-line arguments (before the program starts execution)
  - Input at runtime (while program is executing)

Console Input using Command-line Arguments

Java program: Greetings.java

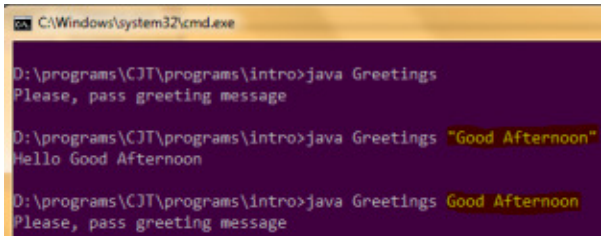
```
1 class Greetings{
2    public static void main(String[] args){
3       if(args.length!=1)
4          System.out.println("Please, pass
               greeting message");
5       else{
6          System.out.println("Hello "+args[0]);
7       }
8    }
9 }
```


Console Input using Command-line Arguments

Java program: Greetings.java

We test our program with three cases

1. No command-line arguments
2. One command-line argument
3. More than one command-line arguments



Console Input at Runtime

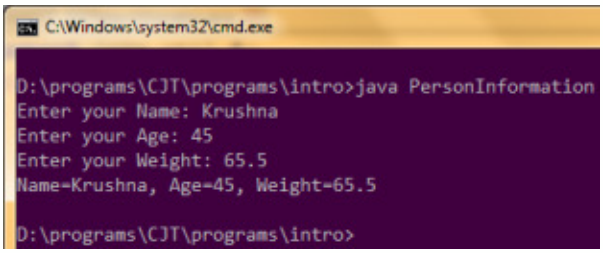
Java program: PersonInformation.java

```
1  import java.util.*;
2  class PersonInformation{
3     public static void main(String[] args){
4        String name;
5        int age;
6        float weight;
7        Scanner input = new Scanner(System.in);
8        System.out.print("Enter your Name: ");
9        name = input.next();
10       System.out.print("Enter your Age: ");
11       age = input.nextInt();
12       System.out.print("Enter your Weight: ");
13       weight = input.nextFloat();
14       System.out.println("Name="+name+",
            Age="+age+", Weight="+weight);
15    }
16 }
```


Console Input at Runtime, Running the Program

Java program: PersonInformation.java

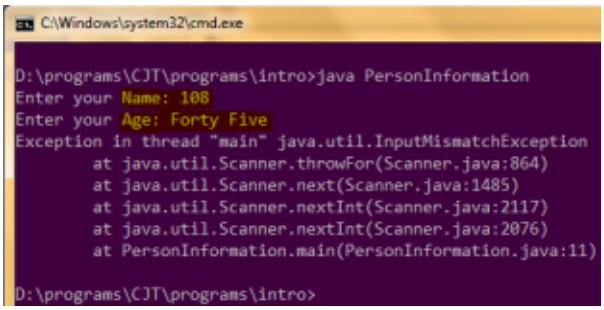
We run the program and input all correct values.



Console Input at Runtime, Running the Program

Java program: PersonInformation.java

We run the program and input values in wrong data type.



Console Input Methods

```
1 Scanner input = new Scanner(System.in);
2 int intValue = input.nextInt();
3 long longValue = input.nextLong();
4 double doubleValue = input.nextDouble();
5 float floatValue = input.nextFloat();
6 String string = input.next();
```

- In earlier version of Java, Scanner class was not available. We had to use java.io package for keyboard input (Will be discussed in Input/Output)
- Java has added Scanner utility class for console input. Available in java.util package
- What is a package?
  - Package is a grouping concepts, in which we can place related classes under one group.

Console Output: Formatted Output

- Sometimes, we need display/rendering of data in a desired format.
- Examples:
  - Number as right justified to make digits on multiple lines aligned
  - Amount in Rs. (float or double value) has only two digits after decimal point
  - Percentage value has only two digits after decimal point
- In C language (procedural language), this formating is provided by printf() function
- In Java printf() is available as System.out.printf() (as 100% object oriented, the printf() method is not standalone)
- The printf() in Java is similar to the printf() in C.

Method for Formatted Output

- The syntax of printf() function is as follows:

```
1 System.out.printf(format, item1, item2, ...,
     itemK);
```

- Where the format is a string that may have substrings and format specifiers
- A format specifier specifies how an item should be displayed.
- An item could be
  - a numeric (int, long, float, or double)
  - a Boolean value
  - a character
  - a string

Format Specifiers

- A simple specifier has percentage sign (%) followed by one letter character code for the type of data.

Specifier	Output	Example
%b	a Boolean value	true or false
%c	a character	a
%d	a decimal integer	108
%e	a number in scientific notation	3.2320000e+01
%f	a floating point number	32.320000
%s	a string	Java is powerful

Program on Formatting output

```
1 class FormattedOutput{
2     public static void main(String[] args){
3         int rollNo = 1;
4         float percent = 78.333333f;
5         System.out.printf("Roll No. %d has %f
              percentage",rollNo,percent);
6     }
7 }
```

- The items must match the specifiers in order, in number, and in type.
- By default, floating-point number is displayed with six digits after decimal point.

```
D:\programs\CJT\programs\intro>javac FormattedOutput.java

D:\programs\CJT\programs\intro>java FormattedOutput
Roll No. 1 has 78.333336 percentage
```


Specifying Width and Precision

- We can specify width (number of characters to be displayed) for an item to be displayed
- For floating-point number, we can also specify precision (number of digits after decimal point).
- In general, width indicates at least how many characters to be displayed:
  - If number of characters in the item is less than the width, extra whites-space characters are added at the front
  - Otherwise, the width is increased to accommodate the characters of the item.
- Examples:
  - %5c: character with total width 5, i.e., add four spaces
  - %6b: boolean with total width 6, i.e., add one space for false and two spaces for true.
  - %12s: string of at least 12 characters
  - %10.2f: total width of floating-point at least 10 and precision 2

Program on Formatting output: width and precision

```
1  class FormattedOutputWidthPrecision{
2      public static void main(String[] args){
3          String name = "Kisan";
4          char gender = 'M';
5          int age = 45;
6          float amount = 48000.9900999f;
7          boolean futureVisit = false;
8          System.out.println("# # # # # # # # # #
               # # #");
9          System.out.printf("Name:%10s\n",name);
10         System.out.printf("Gender:%3c
               Age:%3d\n",gender,age);
11         System.out.printf("Paid
               Amount:%10.2f\n",amount);
12         System.out.printf("To visit in
               future:%6b\n",futureVisit);
13     }
14 }
```


Program on Formatting output: width and precision

```
D:\programs\CJT\programs\intro>javac FormattedOutputWidthPrecision.java

D:\programs\CJT\programs\intro>java FormattedOutputWidthPrecision
# # # # # # # # # # # #
Name:     Kisan
Gender:  M   Age: 45
Paid Amount:  48000.99
To visit in future: false
```


Outline of Presentation

Identifiers

- Every entity in the real world is identifiable with a name.

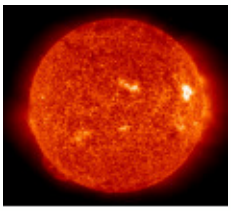


Figure : Sun

Figure : Krushna

- In program also we have to choose names for things/entities that we want to refer.
- Programming languages use special symbols, called identifiers, for naming programming entities.

Identifiers

- We assign names to the following programming entities:
  - variables
  - constants
  - methods
  - classes
  - interfaces
  - packages

Rules for Naming Identifiers

There are rules for naming identifiers, like we have rules for naming persons or objects

- An identifier must start with a letter (a-z,A-Z), an underscore (_), or a dollar sign ($).
- An identifier cannot contain operators, such as +, -, *, etc.
- An identifier cannot be a reserved word
- An identifier cannot be true, false, or null
- An identifier can be of any length

Valid and Invalid Identifiers

Valid identifiers

- $2, _age, newAge
- Char, α (unicode letter allowed)
- X, x (both are different, Java is case sensitive)
- ____2_w, _$
- is_umbrella_open_during_rain

Invalid identifiers

- -d, :b, e#
- 1rank, .com
- new, float, class, private, public, protected
- is#umbrella#open#during#rain

Variables

- Variables are used to store data for input, output, and intermediate result.
- Declaring a variable
  - Before using a variable, we have to declare it
  - We need to specify both name and data type for the variable
  - The syntax is dataType variableName;
  - Example: int x;
- Assignment Statements
  - After a variable is declared, we can assign some value to it
  - The syntax is variableName = value; or variableName = expression;, where expression could be any valid expression or a method call
  - Example: area = radius*radius*3.14;
- Combining declaration and initialization
  - We can combine variable declaration and value assignment in a single step
  - Example: int age = 50;

Constants

- The value of a variable can change during the execution of the program.
- However, the value of a constant, cannot change once assigned
- Example: final int ENTRY_AGE = 5;
- Constants declared as class members are made static.
- Example: static final int ENTRY_AGE = 5;

Numerical Data Types

- Each data type has a domain(range) of valid values
- The compiler allocates memory to a variable or constant based on its data type
- Java provides several primitive data types for numerical values, characters, and boolean values

Data type	Domain	Storage size
byte	-2^7 to 2^7+1	8-bit signed
short	-2^{15} to $2^{15}+1$	16-bit signed
int	-2^{31} to $2^{31}+1$	32-bit signed
long	-2^{63} to $2^{63}+1$	64-bit signed
float	$-3.4E38$ to $+3.4E38$ (6 to 7 significant digits of accuracy)	32-bit IEEE 754
double	$-1.7E308$ to $+1.7E308$ (14 to 15 significant digits of accuracy)	64-bit IEEE 754

Use of Numeric Data Types

```
1 int i1 = 22 + 1;          // i1 becomes 23
2 float d1 = 22.0f - 0.1f;  // d1 becomes 21.9
3 long i2 = 300*30 ;        // i2 becomes 9000
4 double d2 = 1.0/2.0;      // d2 becomes 0.5
5 int i3 = 1/2;             // i3 becomes 0
6 byte i4 = 21%2;           // i4 becomes 1
```


Numerical Literals

- A literal is a primitive type value that directly appears in the program.
- For example, 23, 1000000, and 10.0 are literals

```
1    int i = 23;
2    long l = 1000000;
3    double d = 10.0;
```

- By default floating point number (with decimal point) is considered as a double number.
- We can indicate a number literal as float by appending f or F, and double by appending d or D.

```
1    float ff = 23.0f;
2    double dd = 10.0D;
```


Numeric Type Conversion

- In an expression $a+b$, a and b are called operands and $+$ is called operator.
- It is possible that operands are of different data types.
- Java automatically converts different types into unifying type.
- Java chooses unifying type in the following order: double, float, long, int, short, and byte.
- For example, if one of operands is of type double, the unifying type will be double.

```
1    byte bVar = 108;
2    long lVar = i * 3 + 4;
3    double dVar = i * 3.1 + 1/2;
```

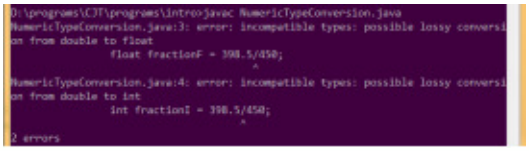

Numeric Type Conversion, Slide - I

- Sometimes, we may want to convert the result of the expression into some desired data type.
- For example, converting double result into float or float result into integer.

```
1 class NumericTypeConversion{
2    public static void main(String[] args){
3       float fractionF = 398.5/450;
4       int fractionI = 398.5/450;
5       System.out.println("Fraction in Integer
           "+fractionI);
6       System.out.println("Fraction in Float
           "+fractionF);
7    }
8 }
```


Numeric Type Conversion, Slide - II

- The program does not compile, and generate the following errors:



Numeric Type Conversion, Slide - III

- We use type casting for converting result of the expression into desired/target data type.
- Syntax $(target - datatype)expression$.

```
1 class NumericTypeConversion{
2    public static void main(String[] args){
3       float fractionF = (float) 398.5/450;
4       int fractionI = (int) 398.5/450;
5       System.out.println("Fraction in Integer
           "+fractionI);
6       System.out.println("Fraction in Float
           "+fractionF);
7    }
8 }
```


Numeric Type Conversion, Slide - IV

- The program now compiles successfully and generates the following output:

```
D:\programs\CJT\programs\intro>javac NumericTypeConversion.java

D:\programs\CJT\programs\intro>java NumericTypeConversion
Fraction in Integer 0
Fraction in Float 0.88555557
```

- The result of the integer fraction is 0 as the fractional part from the result is dropped.

Character Data Type, Slide - I

- The character data type, char, is used to represent a single character.
- A character literal is indicated by enclosing a character in single quotes.

```
1 char grade='A';
2 char position = '3';
```


Character Data Type, Slide - II

- An integer value should not be assigned to a character data type.

```
1 class CharDataType{
2    public static void main(String[] args){
3       char position = 65;
4       System.out.println("Position =
           "+position);
5    }
6 }
```

- The output would not be as expected:

```
D:\programs\CJT\programs\intro>javac CharDataType.java

D:\programs\CJT\programs\intro>java CharDataType
Position = A
```


Unicode Characters, Slide - I

- Java uses Unicode characters
- It is 16-bit encoding scheme established by Unicode Consortium
- Unicode can support interchange, processing, and display of texts of the world languages.
- As Unicode occupies 2 bytes, Java's character occupies 2 bytes
- Unicode literal is indicated using 2-byte hex numbers with \u as prefix.
- Unicode range is '\u0000' to '\uFFFF', in which ASCII code is included in the range '\u0000' to '\u00FF'.
- Unicode can be found at `http://www.unicode.org`

Unicode Characters, Slide - II

```
1 class Unicode{
2    public static void main(String[] args){
3       int h = 72;
4       char charH = (char) h ;
5       char uniH = '\u0048';
6       System.out.println("charH = "+charH+"
           uniH = "+uniH);
7    }
8 }
```

```
D:\programs\CJT\programs\intro>javac Unicode.java

D:\programs\CJT\programs\intro>java Unicode
charH = H uniH = H
```

Boolean Data Type

- The boolean data type is from Boolean algebra
- The domain of boolean type has only two values: true and false, which are used as literals while assigning value.

```
1 boolean isWorking = true;
```


Outline of Presentation

Shortcut Operators, Slide - I

- Many times, we want to update value of a variable by some amount.

```
1    i = i + 20;
```

- We can perform same expression using less characters.

```
1    i += 20;
```

- Here, += is called shortcut operator.

Operator	Example	Equivalent
+=	i+=5;	i = i+5;
-=	f-=5.0;	f = f+5.0;
*=	i*=5;	i = i*5;
/=	i/=5;	i = i/5;
% =	i%=5;	i = i%5;

Shortcut Operators, Slide - II

- There are two more shortcut operators for incrementing or decrementing by 1.
  - ++ is for incrementing by 1
  - -- is for decrementing by 1
- Depending upon where (before or after) they are placed along with variable name, there are two types of operation:
  1. Prefix: ++x
  2. Postfix x++

Example	Equivalent
x++	x = x+1;
++x	x = x+1;
x--	x = x-1;
--x	x = x-1;

Shortcut Operators, Slide - III

- The prefix ++x and suffix or postfix x++ are different when they are in expression.
- The prefix is evaluated before other operators in an expression
- The postfix or suffix is evaluated after entire expression is evaluated.

```
1  class PrefixPostfix{
2     public static void main(String[] args){
3        int i=0, j=0;
4        int valPre, valPost;
5        valPre = ++i + ++i + ++i + ++i;
6        valPost = j++ + j++ + j++ + j++;
7        System.out.println("Values: i = "+i+"
            valPre = "+valPre);
8        System.out.println("Values: j = "+j+"
            valPost = "+valPost);
9     }
10 }
```


Shortcut Operators, Slide - IV

- When we run the program, we get the following output

```
D:\programs\CJT\programs\intro>javac PrefixPostfix.java

D:\programs\CJT\programs\intro>java PrefixPostfix
Values: i = 4 valPre = 10
Values: j = 4 valPost = 6
```

- It can be observed that after evaluation of expressions, values of both i and j become 4; however, values of valPre and valPost are different.

Comparison Operators

- Comparison operators evaluate to boolean value

Operator	Name	Example	Answer
$<$	less than	$21 < 23$	true
$<=$	less than or equal to	$21 <= 21$	true
$>$	greater than	$21 > 23$	false
$>=$	greater than or equal to	$21 >= 21$	true
$==$	equal to	$21 == 23$	false
$!=$	not equal to	$21 != 23$	true

Boolean Operators, Slide - I

- Boolean operators operate on boolean values and result in a new boolean value.

Operator	Name	Description
!	not	logical negation
&&	and	logical conjunction
||	or	logical disjunction
^	exclusive or	logical exclusive

- The not operator (!) is unary operator, whereas other three are binary operators.

Boolean Operators, Slide - II

Table : Truth values for Operator !

Operand	!Operand
true	false
false	true

Table : Truth values for Operator &&

Operand-1	Operand-1	Operand-1 && Operand-2
false	false	false
false	true	false
true	false	false
true	true	true

Boolean Operators, Slide - III

Table : Truth values for Operator ||

Operand-1	Operand-1	Operand-1 || Operand-2
false	false	false
false	true	true
true	false	true
true	true	true

Table : Truth values for Operator ^

Operand-1	Operand-1	Operand-1 ^ Operand-2
false	false	false
false	true	true
true	false	true
true	true	false

Boolean Operators, Slide - IV

- When evaluating b1 && b2, Java first evaluates b1
  - If b1 is false, b2 is not evaluated
  - If b1 is true, then b2 is evaluated
- When evaluating b1 || b2, Java first evaluates b1
  - If b1 is true, b2 is not evaluated
  - If b1 is false, then b2 is evaluated
- Java provides other operators & and |
  - These operators are similar to && and ||
  - The difference is in & and |, second operand is also evaluated irrespective of value of the first operand.

Boolean Operators, Slide - V

```
1  class BooleanOperators{
2     public static void main(String[] args){
3        boolean hungry = true;
4        int eatDish = 0;
5        if(hungry && ++eatDish >= 2)
6           hungry = false;
7        if(hungry && ++eatDish >= 2)
8           hungry = false;
9        if(hungry && ++eatDish >= 2)
10          hungry = false;
11       System.out.println("Now hungry =
            "+hungry+", Consumed dish =
            "+eatDish);
12    }
13 }
```

Boolean Operators, Slide - VI

```
D:\programs\CJT\programs\intro>javac BooleanOperators.java

D:\programs\CJT\programs\intro>java BooleanOperators
Now hungry = false, Consumed dish = 2
```


Boolean Operators, Slide - VII

```
1  class BooleanOperators{
2     public static void main(String[] args){
3        boolean hungry = false;
4        int eatDish = 0;
5        if(hungry & ++eatDish >= 2)
6           hungry = false;
7        if(hungry & ++eatDish >= 2)
8           hungry = false;
9        if(hungry & ++eatDish >= 2)
10          hungry = false;
11       System.out.println("Now hungry =
            "+hungry+", Consumed dish =
            "+eatDish);
12    }
13 }
```


Boolean Operators, Slide - VIII

```
D:\programs\CJT\programs\intro>javac BooleanOperators.java

D:\programs\CJT\programs\intro>java BooleanOperators
Now hungry = false, Consumed dish = 3
```

- We should avoid using & and | operators

Operator Precedence, Slide - I

- It is possible to write an arbitrary long expression, containing different operators
- Operator precedence determines the order in which expressions are evaluated.
- Parenthesis has highest priority. In nested parenthesis, the innermost parenthesis has highest priority.

Operator Precedence, Slide - II

Table : Operator precedence from highest to lowest

() parenthesis, () function call, [] array subscript, . member access
++,--, + unary plus, - unary minus, ! unary logical negation, (type) unary casting, new create object
*, /, %
+, -
<, <=, >, >=, instanceof
==, !=
&&
||
?: ternary condition
=, +=, -=, *=, /=, %=

Operator Precedence, Slide - III

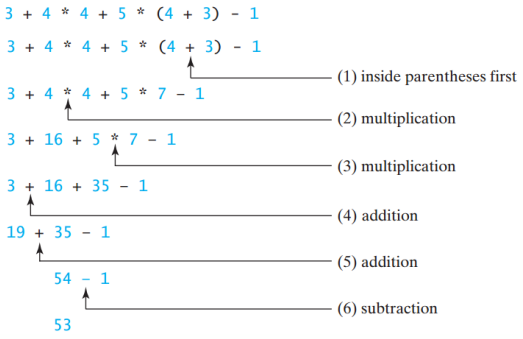


Figure : Example of Precedence [1]

[1] Source: An Introduction to Java Programming, Y. Daniel Liang, Eigth Edition, Prentice Hall

Outline of Presentation

Errors in Program

- Even experienced programmer might make mistakes.
- The errors can be categorized into two:
  1. Compilation Errors
  2. Runtime Errors
- Compilation errors are reported by compiler
- Runtime errors occur while program is running

Compilation Errors, Slide - I

- Errors that occur during compilation are called compilation errors or syntax errors
- These are easy to detect as the compiler tells the location and reason for errors.
- Consider the following program:

```
1 class CompilationError{
2    public static void main(String[] args){
3       i = 100;
4       System.out.println(i+8);
5    }
6 }
```


Compilation Errors, Slide - II

```
D:\programs\CJT\programs\intro>javac CompilationError.java
CompilationError.java:3: error: cannot find symbol
                i = 100;
                ^
  symbol:   variable i
  location: class CompilationError
CompilationError.java:4: error: cannot find symbol
                System.out.println(i+8);
                                   ^
  symbol:   variable i
  location: class CompilationError
2 errors
```

- We can see that the compiler shows errors at two places, where we are accessing variable i.
- The reason for errors is that we have not declared variable i. It should be int i;
- It is possible that for a single error in our program, the compiler shows multiple errors.
- Therefore, we should start troubleshooting from the first error.

Runtime Errors

- Runtime errors occur while program is running
- These errors generally cause programs to terminate abnormally
- There are three main reasons for runtime errors:
  1. Input errors
  2. System software or hardware errors
  3. Logical errors

Runtime Errors

Input Errors

- An input error occurs when the user enters an unexpected input value and the program cannot handle it.
- For example, in our earlier program on PersonInformation, when we enter unexpected value for age, we get runtime error

```
C:\Windows\system32\cmd.exe

D:\programs\CJT\programs\intro>java PersonInformation
Enter your Name: 100
Enter your Age: Forty Five
Exception in thread "main" java.util.InputMismatchException
        at java.util.Scanner.throwFor(Scanner.java:864)
        at java.util.Scanner.next(Scanner.java:1485)
        at java.util.Scanner.nextInt(Scanner.java:2117)
        at java.util.Scanner.nextInt(Scanner.java:2076)
        at PersonInformation.main(PersonInformation.java:11)

D:\programs\CJT\programs\intro>
```

- We should provide informative message to the user. For example, "Enter your age (integer value)".

Runtime Errors

System Software or Hardware Errors

- System errors are rarely encountered.
- However, sometimes, unreliable system software and hardware malfunctions can cause a program to abort.
- System errors are beyond programmer's control
- For mission-critical applications, system reliability should be achieved using fault tolerance system

Runtime Errors

Logical Errors

- Logical errors either generate incorrect results or terminate the program abnormally.
- These errors are called bugs.
- The process of finding logical errors (bugs) is called debugging.
- Finding logical errors is a difficult task
- IDEs are equipped with debugger, which can be used for step-by-step execution and watching/inspecting values of variables.
- A common approach is to locate code region generating logical errors and then to reach at the precise cause point.

Outline of Presentation

Programming Style and Documentation

- Programming style deals with the appearance of the program.
- It is possible to write the whole program on just one line.
- However, it is difficult to read and understand; therefore, it is a bad programming style.
- Programming Style and Documentation are as important as coding
- There are some guidelines for Java programming style and documentation.

Appropriate Comments

- We should place summary at the beginning of the program.
- The summary can include major information about
  - key features
  - supporting data structures
  - unique/special logic or algorithm it uses
- We should write comments before each major step in a long program
- We should write comments for each complicated or complex part or logic
- The comments should be concise and easy to read.

Proper Indentation I

- An unindented program is difficult to read
- Using indentation, we can show structural relationships among the program's components or statements.

```
1 class Greetings{
2 public static void main(String[] args){
3 if(args.length!=1)
4 System.out.println("Please, pass greeting
    message");
5 else{
6 System.out.println("Hello "+args[0]);
7 }
8 }
9 }
```

Proper Indentation II

- The following is the same program, but properly indented
- The program is very easy to read and understand

```
1 class Greetings{
2    public static void main(String[] args){
3       if(args.length!=1)
4          System.out.println("Please, pass
               greeting message");
5       else{
6          System.out.println("Hello "+args[0]);
7       }
8    }
9 }
```


Naming Conventions - I

- Classes and interfaces
  - The first letter should be capitalized
  - If several words are linked together to form the name, the first letter of the inner words should be uppercase
  - This format is sometimes called camelCase
  - Examples:
    - Person
    - Account
    - PrintWriter
- Methods:
  - The first letter should be lowercase
  - Then normal camelCase rules should be used
  - the names should typically be verb-noun pairs
  - Examples:
    - getBalance

Naming Conventions - II

    - doCalculation
    - setCustomerName
- Variables:
  - similar to methods, the camelCase format should be used (the first letter is lower case)
  - Short and meaningful names are recommended
  - Examples:
    - buttonWidth
    - accountBalance
    - myString
- Constants:
  - Java constants are created by marking variables static and final
  - They should be named using uppercase letters with underscore characters as separators
  - Examples:
    - MIN_HEIGHT
    - MAX_MARKS

Summary of key terms

- Scanner (Console input), Command-line arguments
- Identifiers, variables, constants, numerical data types, character data type, Unicode, Boolean data type
- Operators: shortcut, comparison, boolean (logical), precedence
- Error handling: compilation, runtime
- Indentation, naming convention, comments

References

- An Introduction to Java Programming, Y. Daniel Liang, PHI
- An Introduction to Java Programming, Y. Daniel Liang, Eigth Edition, Prentice Hall