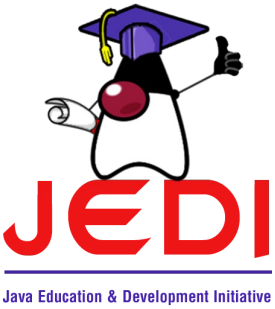

Introduction to Programming I

Student's Manual

Version 1.3
June 2006

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Requirements For the Laboratory Exercises

Supported Operating Systems

The NetBeans IDE 5.5 runs on operating systems that support the Java VM.

- Microsoft Windows XP Professional SP2 or newer
- Mac OS X 10.4.5 or newer
- Red Hat Fedora Core 3
- Solaris™ 10 Operating System Update 1 (SPARC® and x86/x64 Platform Edition)

NetBeans Enterprise Pack is also known to run on the following platforms:

- Microsoft Windows 2000 Professional SP4
- Solaris™ 8 OS (SPARC and x86/x64 Platform Edition) and Solaris 9 OS (SPARC and x86/x64 Platform Edition)
- Various other Linux distributions

Minimum Hardware Configuration

Note: The NetBeans IDE's minimum screen resolution is 1024x768 pixels.

Operating System	Processor	Memory	Disk Space
Microsoft Windows	500 MHz Intel Pentium III	512 MB	850 MB of free disk space
Linux	500 MHz Intel Pentium III workstation or equivalent	512 MB	450 MB of free disk space
Solaris OS (SPARC)	UltraSPARC II 450 MHz	512 MB	450 MB of free disk space
Solaris OS (x86/x64 Platform Edition)	AMD Opteron 100 Series 1.8 GHz	512 MB	450 MB of free disk space
Macintosh OS X operating system	PowerPC G4	512 MB	450 MB of free disk space

Recommended Hardware Configuration

Operating System	Processor	Memory	Disk Speed
Microsoft Windows	1.4 GHz Intel Pentium III workstation or equivalent	1 GB	1 GB of free disk space
Linux	1.4 GHz Intel Pentium III workstation or equivalent	1 GB	850 MB of free disk space
Solaris OS (SPARC)	UltraSPARC IIIi 1 GHz	1 GB	850 MB of free disk space
Solaris OS (x86/x64 Platform Edition)	AMD Opteron 100 Series 1.8 GHz	1 GB	850 MB of free disk space
Macintosh OS X operating system	PowerPC G5	1 GB	850 MB of free disk space

Required Software

NetBeans Enterprise Pack 5.5 Early Access runs on the Java 2 Platform Standard Edition Development Kit 5.0 Update 1 or higher (JDK 5.0, version 1.5.0_01 or higher), which consists of the Java Runtime Environment plus developer tools for compiling, debugging, and running applications written in the Java language. Sun Java System Application Server Platform Edition 9 has been tested with JDK 5.0 update 6.

- For **Solaris**, **Windows**, and **Linux**, you can download the JDK for your platform from http://java.sun.com/j2se/1.5.0/download.html
- For **Mac OS X**, Java 2 Platform Standard Edition (J2SE) 5.0 Release 4, is required. You can download the JDK from Apple's Developer Connection site. Start here: http://developer.apple.com/java (you must register to download the JDK).

For more information, please visit:
http://www.netbeans.org/community/releases/40/relnotes.html

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Revision History

For Version 1.3
June 2006

Section	Details
Appendix A and B, Chapter 3:Getting to know your programming environment	Switch to Netbeans 5.5 Beta Version
Appendix A, Chapter 3:Getting to know your programming environment	Switch from Redhat Linux to Ubuntu Dapper
Appendix F: Additional Exercises	Added (Teacher's manual)-c/o JEDI member school teachers

For Version 1.2
January 2006

Section	Details
Version Number	Change from 1.1 to 1.2
Chapter 3: Gettting to know your programming environment Appendix A	Change Netbeans/netbeans to **NetBeans**
Chapter 4: Programming Fundamentals	List of Java keywords
Chapter 10: Creating your own classes	Coding guidelines: filenames should have the same name as the **public** class name
Master Documents	Added to list of references

For Version 1.1
August 2005

Section	Details
Version Number	Change from 1.0 to 1.1
Revision History	Added
Appendix E: Hands-on Lab Exercises	Added (c/o Sang)
Chapter 10: Creating Your own classes	Added subsection on How to set classpath at packages section

Section	Details

Chapter 11: Inheritance, Interfaces and Polymorphism	Polymorphism section
	• Added example that uses another class whose method can receive a reference variable
	
	Interface
	• Added sections
	  • Why do we use Interfaces?
	  • Interface vs. Abstract Class
	  • Interface vs. Class
	  • Relationship of an Interface to a Class
	  • Inheritance among Interfaces

1 Introduction to Computer Programming

1.1 Objectives

In this section, we will be discussing the basic components of a computer, both hardware and software. We will also be giving a brief overview of programming languages and the program development life cycle. Finally, different number systems and conversions from one type to another will be discussed.

At the end of the lesson, the student should be able to:

- Identify the different components of a computer
- Know about programming languages and their categories
- Understand the program development life cycle and apply it in problem solving
- Learn the different number systems and their conversions

1.2 Introduction

A computer is a machine that performs a variety of tasks according to specific instructions. It is a data processing machine which accepts data via an ***input device*** and its ***processor*** manipulates the data according to a ***program***.

The computer has two major components. The first one is the **Hardware** which is the tangible part of the computer. It is composed of electronic and mechanical parts.

The second major component is the **software** which is the intangible part of a computer. It consists of data and the computer programs.

1.3 Basic Components of a Computer

1.3.1 Hardware

1.3.1.1 The Central Processing Unit

The processor is the "brain" of the computer. It contains millions of extremely tiny electrical parts. It does the fundamental computing within the system. Examples of processors are Pentium, Athlon and SPARC.

1.3.1.2 Memory

The memory is where data and instructions needed by the CPU to do its appointed tasks can be found. It is divided into several storage locations which have corresponding addresses. The CPU accesses the memory with the use of these addresses.

1. Main Memory

The main memory is very closely connected to the processor. It is used to hold programs and data, that the processor is actively working with. It is not used for long-term storage. It is sometimes called the RAM (Random Access Memory).

The computer's main memory is considered as ***volatile*** storage. This means that once the computer is turned off, all information residing in the main memory is erased.

2. The Secondary Memory

The secondary memory is connected to main memory. It is used to hold programs and data for long term use. Examples of secondary memory are hard disks and cd-rom.

Secondary memory is considered as ***non-volatile*** storage. This means that information residing in secondary memory is not erased after the computer is turned off.

Main Memory	***Secondary Memory***	***Property***
Fast	Slow	Speed
Expensive	Cheap	Price
Low	High	Capacity
Yes	No	Volatile

Table 1: Comparison between main memory and secondary memory

1.3.1.3 Input and Output Devices

Input and output devices allows a computer system to interact with the outside world by moving data into and out of the system.

Examples of input devices are keyboards, mice and microphones. Examples of output devices are monitors, printers and speakers.

1.3.2 Software

A software is the program that a computer uses in order to function. It is kept on some hardware device like a hard disk, but it itself is intangible. The data that the computer uses can be anything that a program needs. Programs acts like instructions for the processor.

Some Types of Computer Programs:

1. Systems Programs

- Programs that are needed to keep all the hardware and software systems running together smoothly

- Examples:
  - Operating Systems like Linux, Windows, Unix, Solaris, MacOS

2. Application Programs

- Programs that people use to get their work done

- Examples:
  - Word Processor
  - Game programs
  - Spreadsheets

3. Compilers

- The computer understands only one language: machine language. Machine language is in the form of ones and zeros. Since it is highly impractical for people to create programs out of zeros and ones, there must be a way of translating or converting a language which we understand into machine language, for this purpose, there exists compilers.

1.4 Overview of Computer Programming Languages

1.4.1 What is a Programming Language?

A programming language is a standardized communication technique for expressing instructions to a computer. Like human languages, each language has its own syntax and grammar.

Programming languages enable a programmer to precisely specify what data a computer will act upon, how these data will be stored/transmitted, and precisely what actions to take under various circumstances.

There are different types of programming languages that can be used to create programs, but regardless of what language you use, these instructions are translated into machine language that can be understood by computers.

1.4.2 Categories of Programming Languages

1. High-level Programming Languages

- A high-level programming language is a programming language that is more user-friendly, to some extent platform-independent, and abstract from low-level computer processor operations such as memory accesses. A programming statement may be translated into one or several machine instructions by a **compiler**.

- Examples are Java, C, C++, Basic, Fortran

2. Low-level Assembly Language

- Assembly languages are similar to machine languages, but they are much easier to program in because they allow a programmer to substitute names for numbers. Assembly languages are available for each CPU family, and each assembly instruction is translated into one machine instruction by an **assembler** program.

Note: The terms "high-level" and "low-level" are inherently relative. Originally, assembly language was considered low-level and COBOL, C, etc. were considered high-level. Many programmers today might refer to these latter languages as low-level.

1.5 The Program Development Life Cycle

Programmers do not sit down and start writing code right away when trying to make a computer program. Instead, they follow an organized plan or methodology, that breaks the process into a series of tasks.

Here are the basic steps in trying to solve a problem on the computer:

1. Problem Definition
2. Problem Analysis
3. Algorithm design and representation (Pseudocode or flowchart)
4. Coding and debugging

In order to understand the basic steps in solving a problem on a computer, let us define a single problem that we will solve step-by-step as we discuss the problem solving methodologies in detail. The problem we will solve will be defined in the next section.

1.5.1 Problem Definition

A programmer is usually given a task in the form of a problem. Before a program can be designed to solve a particular problem, the problem must be well and clearly defined first in terms of its input and output requirements.

A clearly defined problem is already half the solution. Computer programming requires us to define the problem first before we even try to create a solution.

Let us now define our example problem:

"Create a program that will determine the number of times a name occurs in a list."

1.5.2 Problem Analysis

After the problem has been adequately defined, the simplest and yet the most efficient and effective approach to solve the problem must be formulated.

Usually, this step involves breaking up the problem into smaller and simpler sub-problems.

Example Problem:
Determine the number of times a name occurs in a list

Input to the program:
list of names, name to look for

Output of the program:
the number of times the name occurs in a list

1.5.3 Algorithm design and representation

Once our problem is clearly defined, we can now set to finding a solution. In computer programming, it is normally required to express our solution in a step-by-step manner.

An **Algorithm** is a clear and unambiguous specification of the steps needed to solve a problem. It may be expressed in either **Human language** (English, Tagalog), through a graphical representation like a **flowchart** or through a **pseudocode**, which is a cross between human language and a programming language.

Now given the problem defined in the previous sections, how do we express our general solution in such a way that it is simple yet understandable?

Expressing our solution through Human language:

1. Get the list of names
2. Get the name to look for, let's call this the keyname
3. Compare the keyname to each of the names in the list
4. If the keyname is the same with a name in the list, add 1 to the count
5. If all the names have been compared, output the result

Expressing our solution through a flowchart:

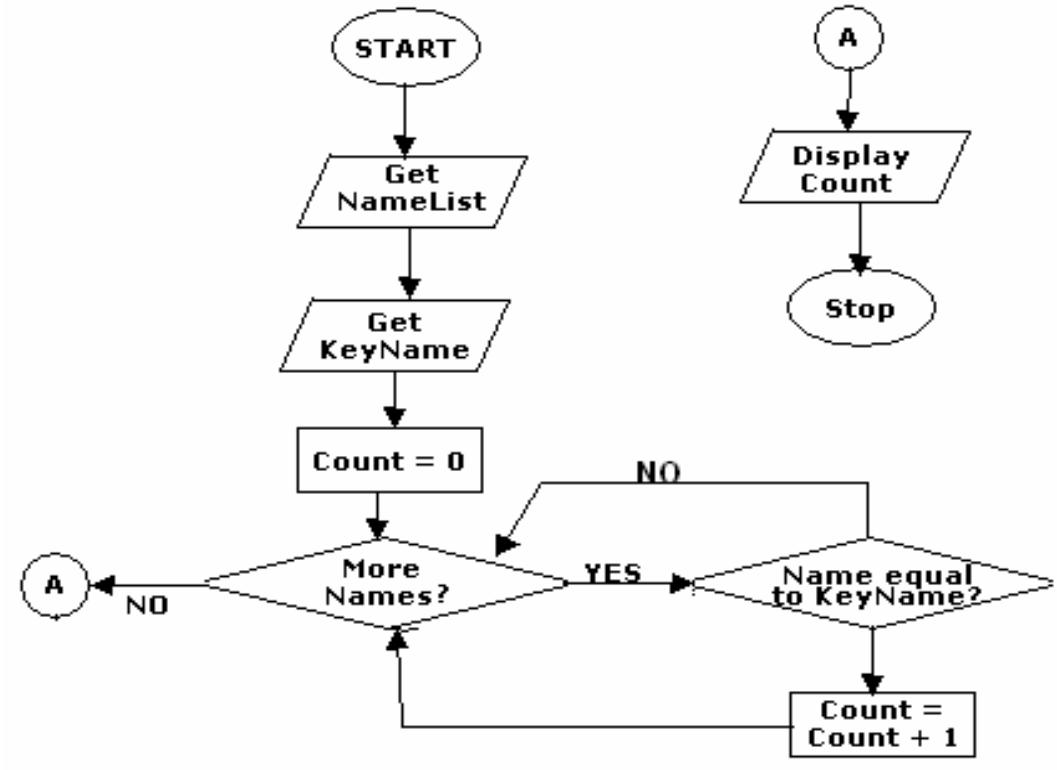


Figure 1.1: Example of a flow chart

Expressing our solution through pseudocode:

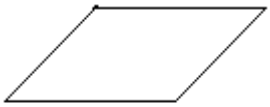
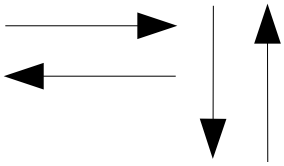
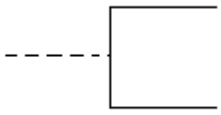
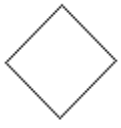
```
Let nameList = List of Names
Let keyName = the name to be sought
Let Count = 0
For each name in NameList do the following
if name == keyName
Count = Count + 1
Display Count
```

Figure 1.2: Example of a pseudocode

1.5.3.1 Flowcharting Symbols and their meanings

A flowchart is a design tool used to graphically represent the logic in a solution. Flowcharts typically do not display programming language commands. Rather, they state the concept in English or mathematical notation.

Here are some guidelines for commonly used symbols in creating flowcharts. You can use any symbols in creating your flowcharts, as long as you are consistent in using them.

Symbol	*Name*	*Meaning*
	**Process Symbol**	Represents the process of executing a defined operation or groups of operations that results in a change in value, form, or location of information. Also functions as the default symbol when no other symbol is available.
	**Input/Output (I/O) Symbol**	Represents an I/O function, which makes data available for processing (input) or displaying (output)of processed information.
	**Flowline Symbol**	Represents the sequence of available information and executable operations.The lines connect other symbols, and the arrowheads are mandatory only for right-to-left and bottom-to-top flow.
	**Annotation Symbol**	Represents the addition of descriptive information, comments, or explanatory notes as clarification. The vertical line and the broken line may be placed on the left, as shown, or on the right.
	**Decision Symbol**	Represents a decision that determines which of a number of alternative paths is to be followed.
	**Terminal Symbol**	Represents the beginning, the end, or a point of interruption or delay in a program.

Symbol	Name	Meaning
	**Connector Symbol**	Represents any entry from, or exit to, another part of the flowchart. Also serves as an off-page connector.
	**Predefined Process Symbol**	Represents a named process consisting of one or more operations or program steps that are specified elsewhere.

Table 2: Flowchart Symbols

1.5.4 Coding and Debugging

After constructing the algorithm, it is now possible to create the source code. Using the algorithm as basis, the source code can now be written using the chosen programming language.

Most of the time, after the programmer has written the program, the program isn't 100% working right away. The programmer has to add some fixes to the program in case of errors (also called bugs) that occurs in the program. This process of is called **debugging**.

There are two types of errors that a programmer will encounter along the way. The first one is compile-time error, and the other is runtime error.

Compile-Time Errors occur if there is a syntax error in the code. The compiler will detect the error and the program won't even compile. At this point, the programmer is unable to form an executable that a user can run until the error is fixed.

Forgetting a semi-colon at the end of a statement or misspelling a certain command, for example, is a compile-time error. It's something the compiler can detect as an error.

Compilers aren't perfect and so can't catch all errors at compile time. This is especially true for logic errors such as infinite loops. This type of error is called ***runtime error.***

For example, the actual syntax of the code looks okay. But when you follow the code's logic, the same piece of code keeps executing over and over again infinitely so that it loops. In such a case, compilers aren't really smart enough to catch all of these types of errors at compile-time, and therefore, the program compiles fine into an executable file. However, and unfortunately, when the end-user runs the program, the program (or even their whole computer) freezes up due to an infinite loop. Other types of run-time errors are when an incorrect value is computed, the wrong thing happens, etc.

1.6 Number Systems and Conversions

Numbers can be represented in a variety of ways. The representation depends on what is called the **BASE**. The following are the four most common representations.

1.6.1 Decimal

We normally represent numbers in their decimal form. Numbers in decimal form are in base 10. This means that the only digits that appear are 0-9. Here are examples of numbers written in decimal form:

126_{10} (normally written as just 126)
11_{10} (normally written as just 11)

1.6.2 Binary

Numbers in binary form are in base 2. This means that the only legal digits are 0 and 1. We need to write the subscript $_2$ to indicate that the number is a binary number. Here are examples of numbers written in binary form:

1111110_2
1011_2

1.6.3 Octal

Numbers in octal form are in base 8. This means that the only legal digits are 0-7. We need to write the subscript $_8$ to indicate that the number is an octal number. Here are examples of numbers written in octal form:

176_8
13_8

1.6.4 Hexadecimal

Numbers in hexadecimal form are in base 16. This means that the only legal digits are 0-9 and the letters A-F (or a-f, lowercase or uppercase does not matter). We need to write the subscript $_{16}$ to indicate that the number is a hexadecimal number. Here are examples of numbers written in hexadecimal form:

$7E_{16}$
B_{16}

Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Decimal Equivalent	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Table 3: Hexadecimal Numbers and their Equivalence to decimal numbers

Decimal	Binary	Octal	Hexadecimal
126_{10}	1111110_2	176_8	$7E_{16}$
11_{10}	1011_2	13_8	B_{16}

Table 4: Summary of Examples

1.6.5 Conversions

1.6.5.1 Decimal to Binary / Binary to Decimal

To convert a decimal number to binary, continuously divide the number by 2 and get the remainder (which is either 0 or 1), and get that number as a digit of the binary form of the number. Get the quotient and divide that number again by 2 and repeat the whole process until the quotient reaches 0 or 1. We then get all the remainders starting from the last remainder, and the result is the binary form of the number.
NOTE: For the last digit which is already less than the divisor (which is 2) just copy the value to the remainder portion.

For Example:
126_{10} = ? $_2$

	Quotient	***Remainder***
126 / 2 =	63	0
63 / 2 =	31	1
31 / 2 =	15	1
15 / 2 =	7	1
7 / 2 =	3	1
3 / 2 =	1	1
1 / 2 =	→	1

Write it this way

So, writing the remainders from the bottom up, we get the binary number 1111110_2

To convert a binary number to decimal, we multiply the binary digit to "2 raised to the position of the binary number". We then add all the products to get the resulting decimal number.

For Example:
1111110_2 = ? $_{10}$

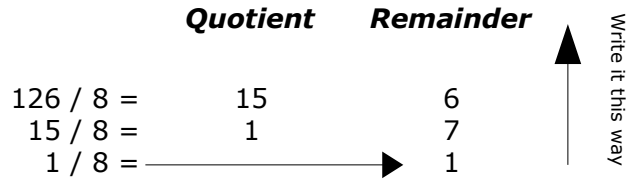
Position	*6*	*5*	*4*	*3*	*2*	*1*	*0*
Binary Digits	**1**	**1**	**1**	**1**	**1**	**1**	**0**

$0 \times 2^0 = 0$
$1 \times 2^1 = 2$
$1 \times 2^2 = 4$
$1 \times 2^3 = 8$
$1 \times 2^4 = 16$
$1 \times 2^5 = 32$
$1 \times 2^6 = 64$
TOTAL: 126

1.6.5.2 Decimal to Octal (or Hexadecimal)/Octal (or Hexadecimal) to Decimal

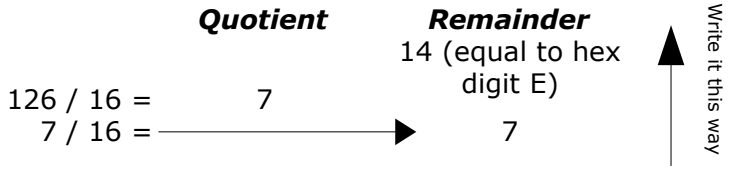
Converting decimal numbers to Octal or hexadecimal is basically the same as converting decimal to binary. However, instead of having 2 as the divisor, you replace it with 8(for octal) or 16 (for hexadecimal).

For Example (Octal):
126_{10} = ? $_8$



So, writing the remainders from the bottom up, we get the octal number 176_8

For Example (Hexadecimal):
126_{10} = ? $_{16}$

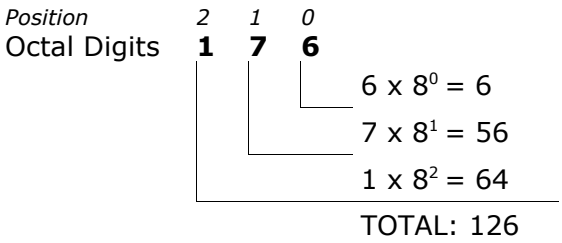


So, writing the remainders from the bottom up, we get the hexadecimal number $7E_{16}$

* * *

Converting octal or hexadecimal numbers is also the same as converting binary numbers to decimal. To do that, we will just replace the base number 2 with 8 for Octal and 16 for hexadecimal.

For Example (Octal):
176_8 = ? $_{10}$



For Example (Hexadecimal):
$7E_{16}$ = ? $_{10}$

Position	*1*	*0*
Hex Digits	**7**	**E**

$14 \times 16^0 = 14$

$7 \times 16^1 = 112$

TOTAL: 126

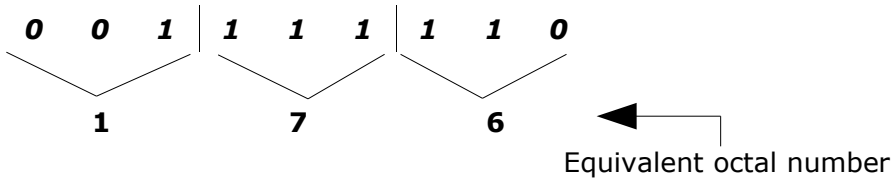
1.6.5.3 Binary to Octal / Octal to Binary

To convert from binary numbers to octal, we partition the binary number into groups of 3 digits (from right to left), and pad it with zeros if the number of digits is not divisible by 3. We then convert each partition into its corresponding octal digit. The following is a table showing the binary representation of each octal digit.

Octal Digit	***Binary Representation***
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

Table 5: Octal Digits and their corresponding binary represenation

For Example:
1111110_2 = ? $_8$



Converting octal numbers to binary is just the opposite of what is given above. Simply convert each octal digit into its binary representation (given the table) and concatenate them. The result is the binary representation.

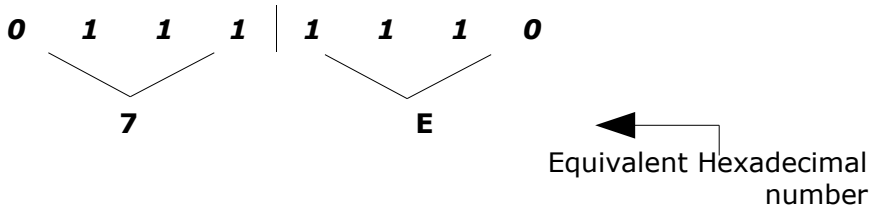
1.6.5.4 Binary to Hexadecimal / Hexadecimal to Binary

To convert from binary numbers to hexadecimal, we partition the binary number into groups of 4 digits (from right to left), and pad it with zeros if the number of digits is not divisible by 4. We then convert each partition into its corresponding hexadecimal digit. The following is a table showing the binary representation of each hexadecimal digit.

Hexadecimal Digit	***Binary Representation***
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

Table 6: Hexadecimal Digits and their corresponding binary represenation

For Example:
$1111110_2 = \underline{?\ _{16}}$



Converting hexadecimal numbers to binary is just the opposite of what is given above. Simply convert each hexadecimal digit into its binary representation (given the table) and concatenate them. The result is the binary representation.

1.7 Exercises

1.7.1 Writing Algorithms

Given the following set of tasks, create an algorithm to accomplish the following tasks. You may write your algorithms using pseudocodes or you can use flowcharts.

1. Baking Bread
2. Logging into your laboratory's computer
3. Getting the average of three numbers

1.7.2 Number Conversions

Convert the following numbers:

1. 1980_{10} to binary, hexadecimal and octal
2. 1001001101_{2} to decimal, hexadecimal and octal
3. 76_{8} to binary, hexadecimal and decimal
4. $43F_{16}$ to binary, decimal and octal

2 Introduction to Java

2.1 Objectives

In this section, we will be discussing a little bit of Java history and what is Java Technology. We will also discuss the phases that a Java program undergoes.

At the end of the lesson, the student should be able to:

- Describe the features of Java technology such as the Java virtual machine, garbage collection and code security
- Describe the different phases of a Java program

2.2 Java Background

2.2.1 A little Bit of History

Java was created in 1991 by James Gosling et al. of Sun Microsystems. Initially called Oak, in honor of the tree outside Gosling's window, its name was changed to Java because there was already a language called Oak.

The original motivation for Java was the need for platform independent language that could be embedded in various consumer electronic products like toasters and refrigerators. One of the first projects developed using Java was a personal hand-held remote control named Star 7.

At about the same time, the World Wide Web and the Internet were gaining popularity. Gosling et. al. realized that Java could be used for Internet programming.

2.2.2 What is Java Technology?

2.2.2.1 A programming language

As a **programming language**, Java can create all kinds of applications that you could create using any conventional programming language.

2.2.2.2 A development environment

As a **development environment**, Java technology provides you with a large suite of tools: a compiler, an interpreter, a documentation generator, a class file packaging tool, and so on.

2.2.2.3 An application environment

Java technology applications are typically general-purpose programs that run on any machine where the **Java runtime environment** (JRE) is installed.

2.2.2.4 A deployment environment

There are **two main deployment environments: First, the JRE** supplied by the Java 2 Software Development Kit (SDK) contains the complete set of class files for all the Java technology packages, which includes basic language classes, GUI component classes, and so on. The other main deployment environment is on your **web browser**. Most commercial browsers supply a Java technology interpreter and runtime environment.

2.2.3 Some Features of Java

2.2.3.1 The Java Virtual Machine

The **Java Virtual Machine** is an imaginary machine that is implemented by emulating software on a real machine. The JVM provides the hardware platform specifications to which you compile all Java technology code. This specification enables the Java software to be platform-independent because the compilation is done for a generic machine known as the JVM.

A **bytecode** is a special machine language that can be understood by the **Java Virtual Machine (JVM)**. The bytecode is independent of any particular computer hardware, so any computer with a Java interpreter can execute the compiled Java program, no matter what type of computer the program was compiled on.

2.2.3.2 Garbage Collection

Many programming languages allows a programmer to allocate memory during runtime. However, after using that allocated memory, there should be a way to deallocate that memory block in order for other programs to use it again. In C, C++ and other languages the programmer is responsible for this. This can be difficult at times since there can be instances wherein the programmers forget to deallocate memory and therefor result to what we call memory leaks.

In Java, the programmer is freed from the burden of having to deallocate that memory themselves by having what we call the **garbage collection thread**. The garbage collection thread is responsible for freeing any memory that can be freed. This happens automatically during the lifetime of the Java program.

2.2.3.3 Code Security

Code security is attained in Java through the implementation of its **Java Runtime Environment (JRE).** The JRE runs code compiled for a JVM and performs class loading (through the class loader), code verification (through the bytecode verifier) and finally code execution.

The **Class Loader** is responsible for loading all classes needed for the Java program. It adds security by separating the namespaces for the classes of the local file system from those that are imported from network sources. This limits any Trojan horse applications since local classes are always loaded first. After loading all the classes, the memory layout of the executable is then determined. This adds protection against unauthorized access to restricted areas of the code since the memory layout is determined during runtime.

After loading the class and layouting of memory, the **bytecode verifier** then tests the format of the code fragments and checks the code fragments for illegal code that can violate access rights to objects.

After all of these have been done, the code is then finally executed.

2.2.4 Phases of a Java Program

The following figure describes the process of compiling and executing a Java program.

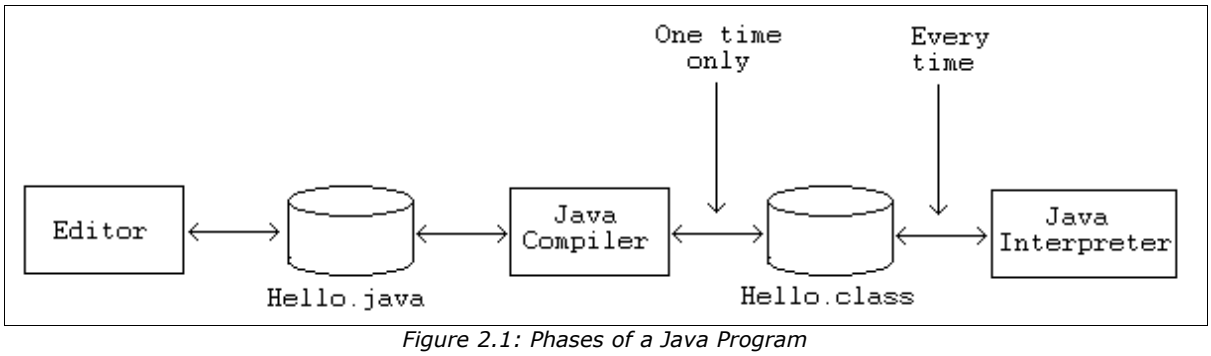


Figure 2.1: Phases of a Java Program

The first step in creating a Java program is by writing your programs in a text editor. Examples of text editors you can use are notepad, vi, emacs, etc. This file is stored in a disk file with the extension `.java`.

After creating and saving your Java program, compile the program by using the Java Compiler. The output of this process is a file of Java **bytecodes** with the file extension `.class`.

The `.class` file is then interpreted by the Java interpreter that converts the bytecodes into the machine language of the particular computer you are using.

Task	*Tool to use*	*Output*
Write the program	Any text editor	File with .java extension
Compile the program	Java Compiler	File with .class extension (Java bytecodes)
Run the program	Java Interpreter	Program Output

Table 7: Summary of Phases of a Java Program

3 Getting to know your Programming Environment

3.1 Objectives

In this section, we will be discussing on how to write, compile and run Java programs. There are two ways of doing this, the first one is by using a console and a text editor. The second one is by using NetBeans which is an **Integrated Development Environment or IDE**.

At the end of the lesson, the student should be able to:

- Create a Java program using text editor and console in the Linux (Ubuntu Dapper) environment
- Differentiate between syntax-errors and runtime errors
- Create a Java program using NetBeans

3.2 Introduction

An IDE is a programming environment integrated into a software application that provides a GUI builder, a text or code editor, a compiler and/or interpreter and a debugger.

This tutorial uses Ubuntu Dapper as the operating system. Make sure that before you do this tutorial, you have installed Java and NetBeans in your system. For instructions on how to install Java and NetBeans, please refer to **Appendix A**. For the Windows XP version of this section, please refer to **Appendix B**.

Before going into details, let us first take a look at the first Java program you will be writing.

3.3 My First Java Program

```
public class Hello
{
    /**
     * My first java program
     */
    public static void main(String[] args) {

      //prints the string "Hello world" on screen
         System.out.println("Hello world!");

    }
}
```

Before we try to explain what the program means, let's first try to write this program in a file and try to run it.

3.4 Using a Text Editor and Console

For this example, we will be using a text editor to edit the Java source code. You will also need to open the Terminal window to compile and execute your Java programs.

Step 1: Start the Text Editor
To start the Text Editor in Linux, click on Applications->Accessories->Text Editor.

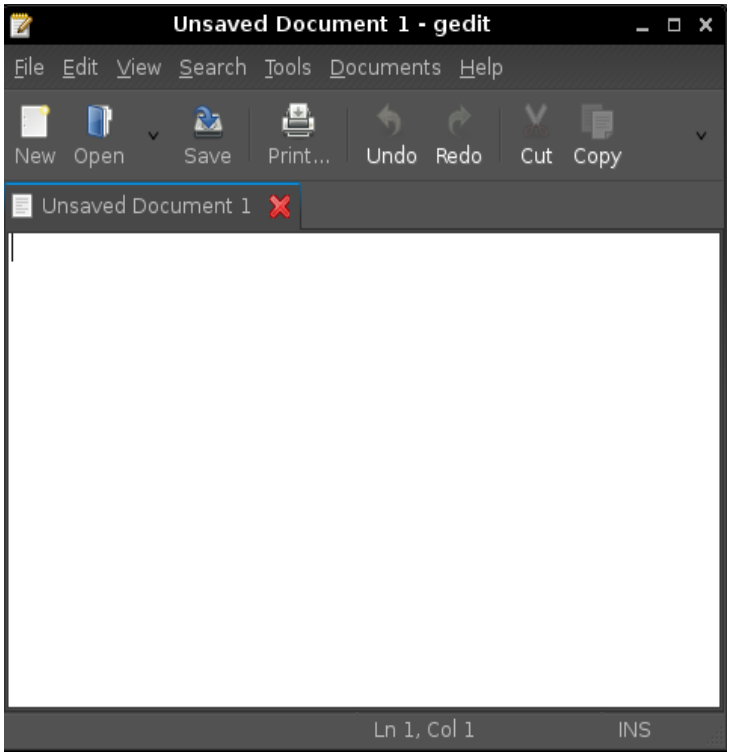


Figure 3.1: Text Editor Application in Linux

Step 2: Open Terminal
To open Terminal in Linux, click on Applications-> Accessories-> Terminal.

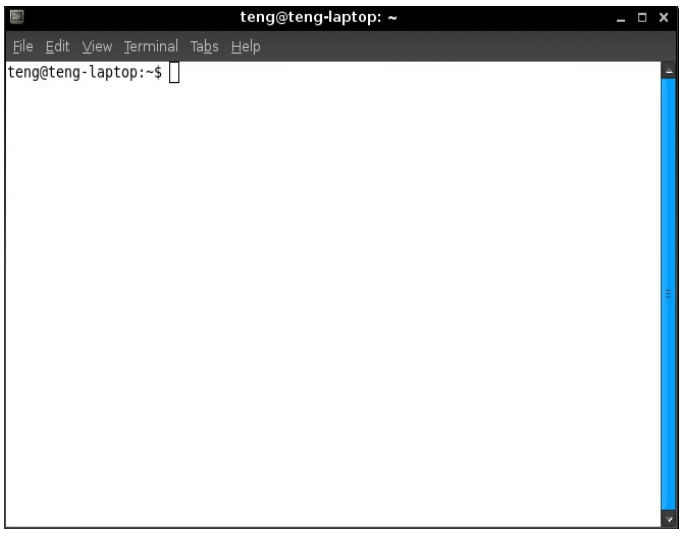


Figure 3.2: Terminal in Linux

Step 3: Write your the source code of your Java program in the Text Editor

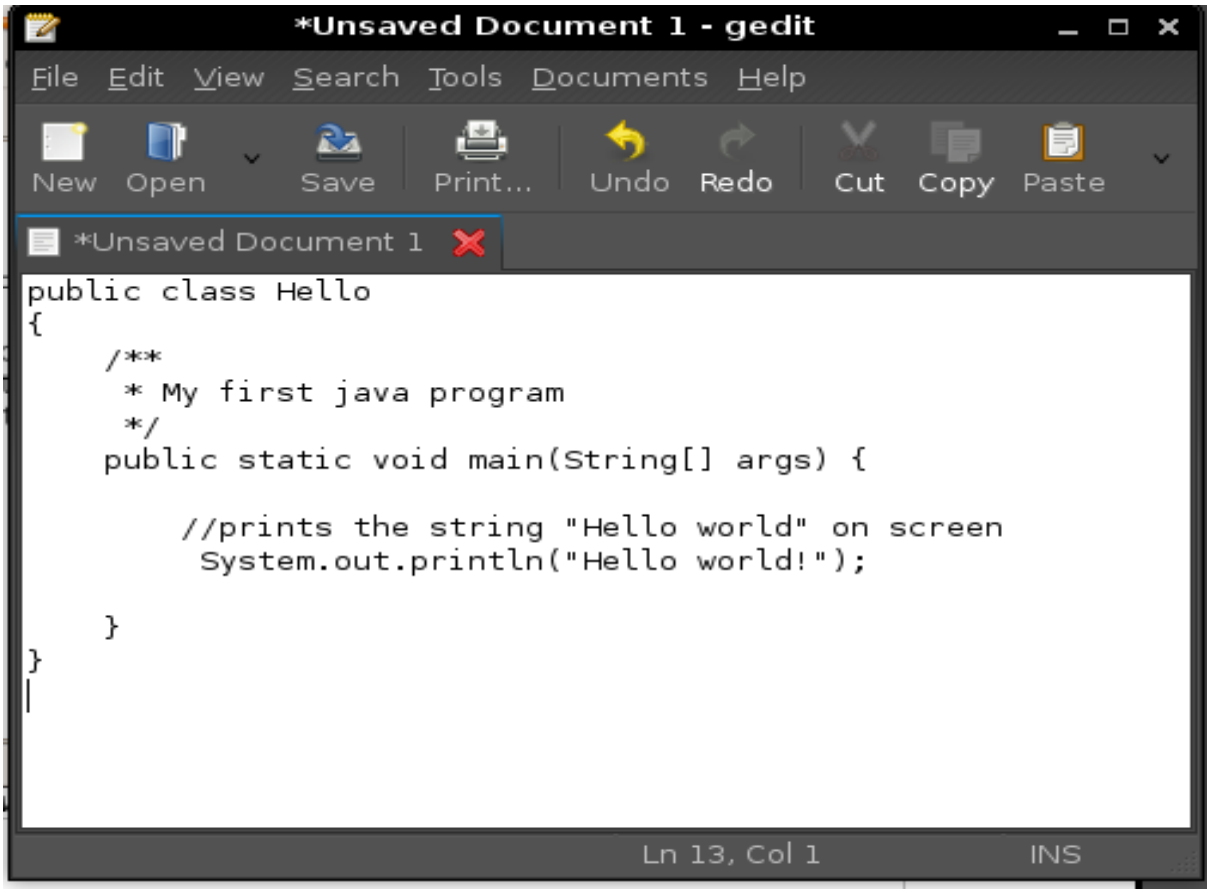


Figure 3.3: Writing the Source Code with the Text Editor

Step 4: Save your Java Program
We will save our program on a file named "Hello.java", and we will be saving it inside a folder named MYJAVAPROGRAMS.

To open the **Save** dialog box, click on the File menu found on the menubar and then click on Save.

After doing the procedure described above, a dialog box will appear as shown in Figure below.

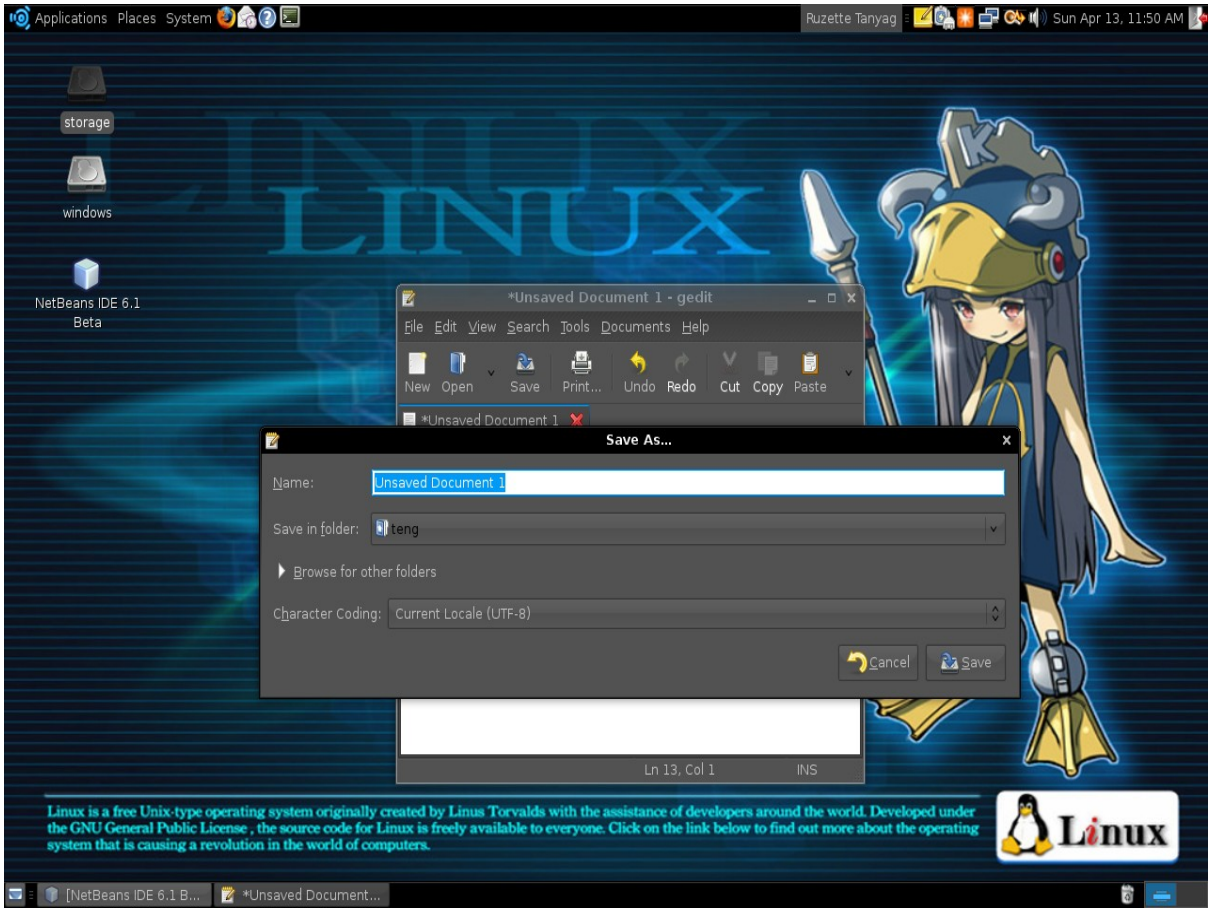
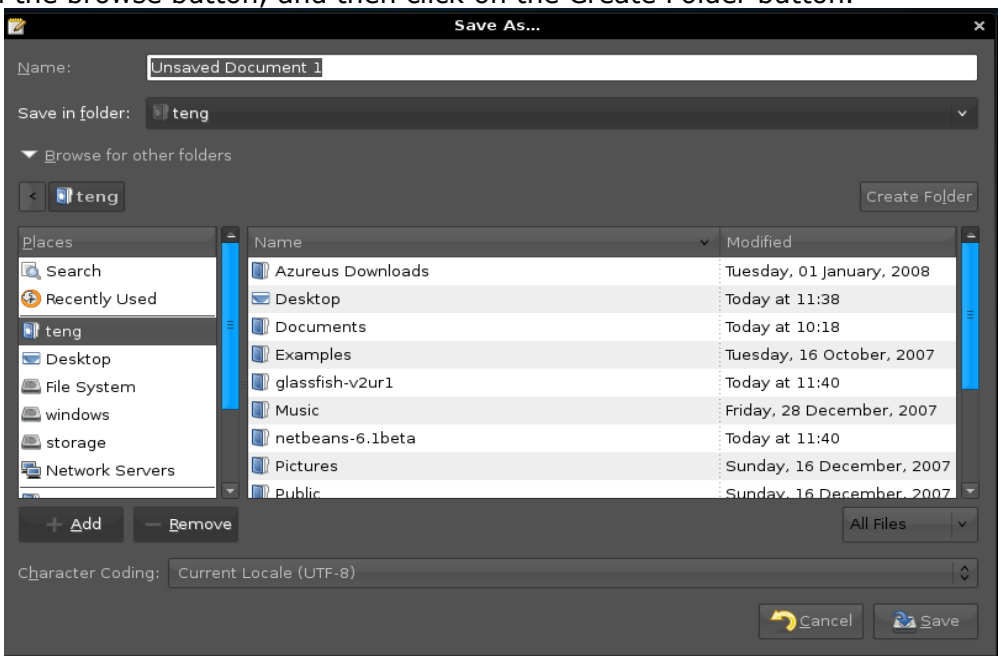
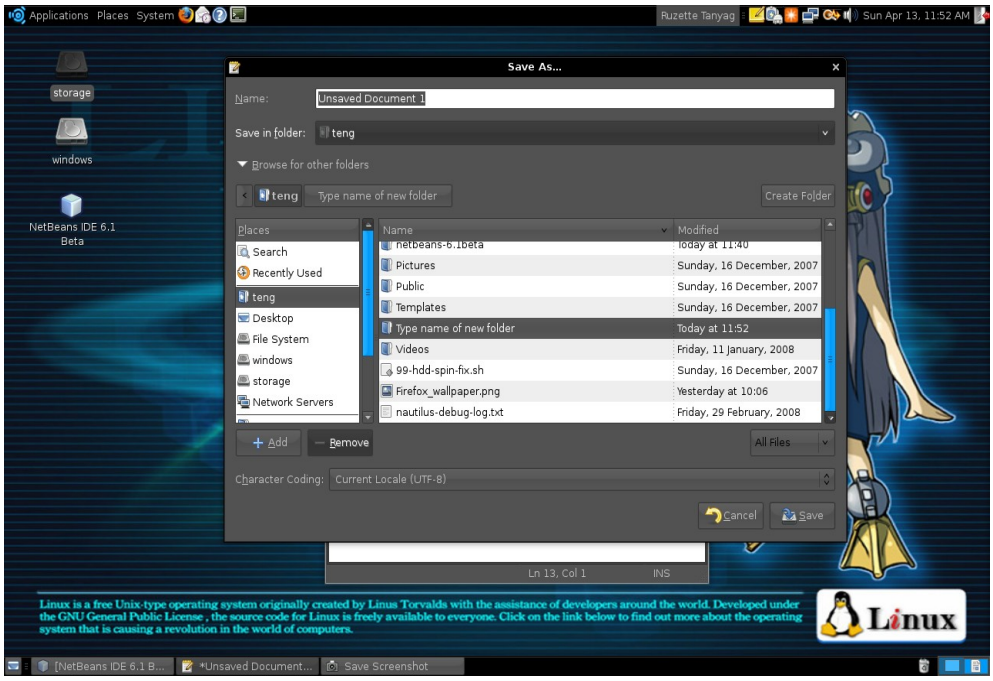


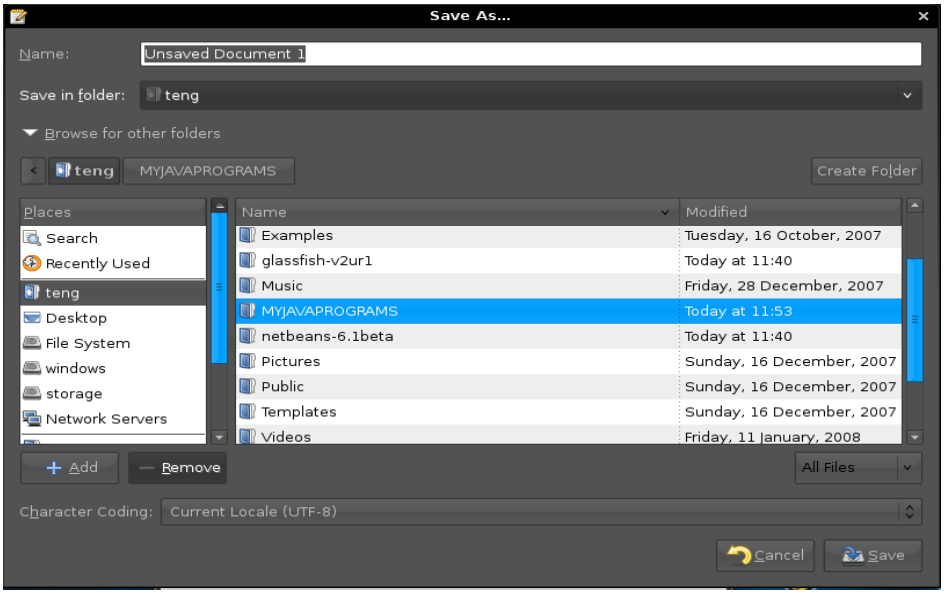
Figure 3.4: Save As Dialog

Click on the browse button, and then click on the Create Folder button.

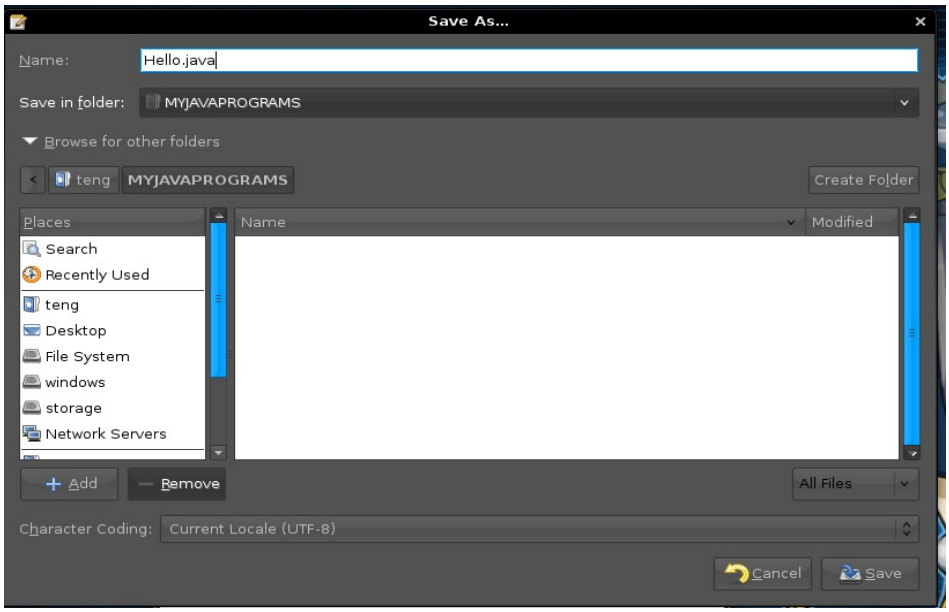




Name the new folder MYJAVAPROGRAMS. Now, click on the MYJAPROGRAMS folder in order to get inside that folder. You will see a similar figure as shown below after you clicked on MYJAVAPROGRAMS. The folder should be empty for now since it's a newly created folder and we haven't saved anything in it yet.



Now, in the Selection textbox, type in the filename of your program, which is "Hello.java", and then click on the SAVE button.



Now that you've saved your file, notice how the title of the frame changes from "Untitled Document 1 (modified) – gedit" to "Hello.java (~/MYJAVAPROGRAMS) - gedit". Take note that if you want to make changes in your file, you can just edit it, and then save it again by clicking on File -> Save.

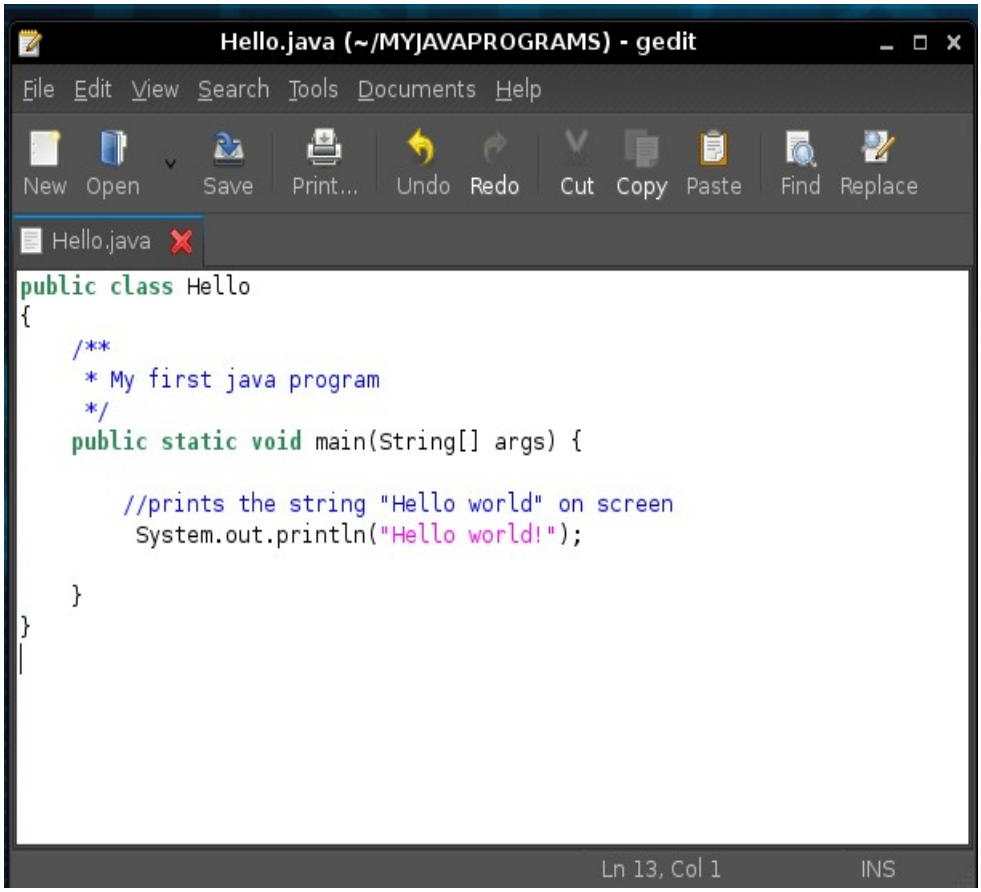


Figure 3.5: New Window After Saving

Step 5: Compiling your program
Now, the next step is to compile your program. Go to the Terminal window we just opened a while ago.

Typically, when you open the terminal window, it opens up and takes you directly to what is called your **home folder**. To see what is inside that home folder, type **ls** and then press ENTER. What you will see is a list of files and folders inside your home folder.

Now, you can see here that there is a folder named "MYJAVAPROGRAMS" which we have created a while ago, and where we saved our Hello.java program. Now let's go inside that directory.

To go inside a directory, you type in the command: **cd [directory name].** The "cd" command stands for, change directory. In this case, since the name of our directory is MYJAVAPROGRAMS, you type in: **cd MYJAVAPROGRAMS**

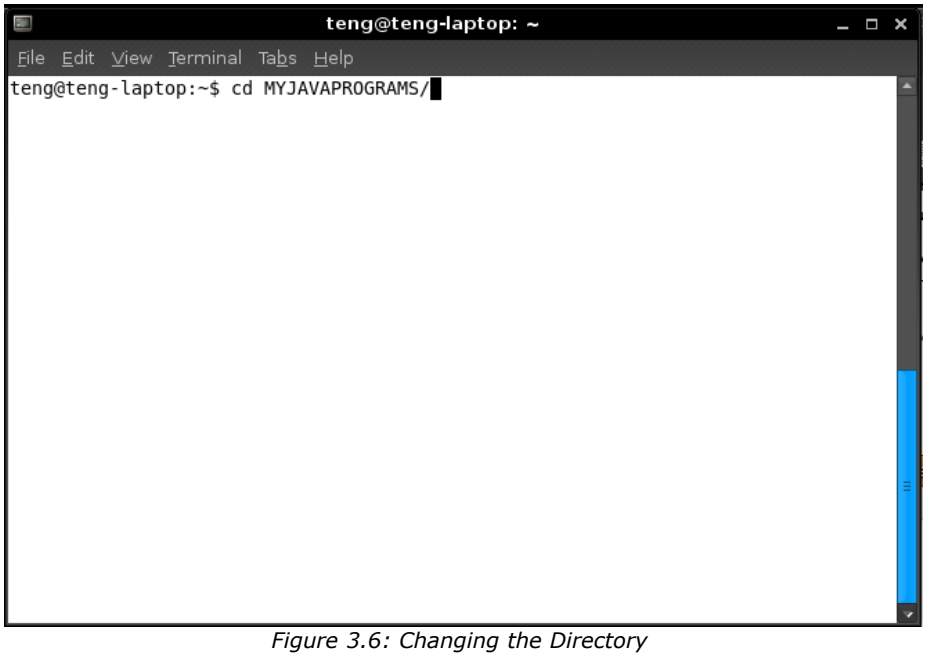


Figure 3.6: Changing the Directory

Once inside the folder where your Java programs are, let us now start compiling your Java program. Take note that, you should make sure that the file is inside the folder where you are in. In order to do that, execute the "ls" command again to see if your file is inside that folder.

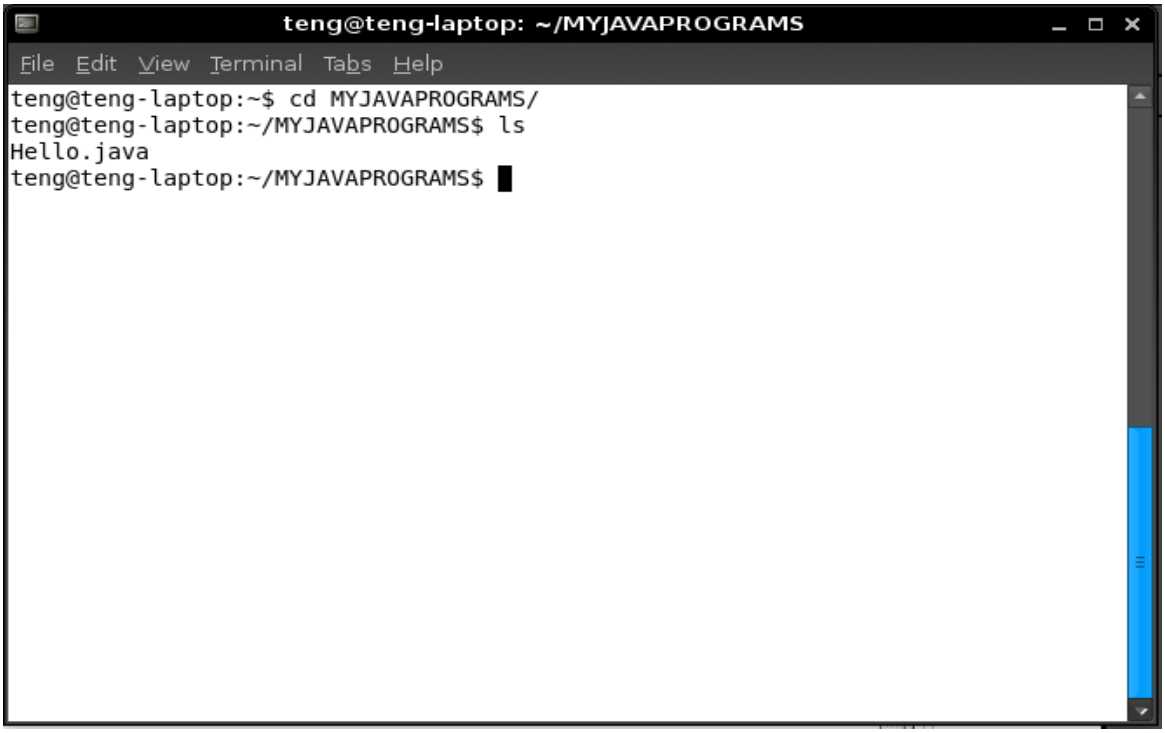


Figure 3.7: List of Files Inside the New Directory

To compile a Java program, we type in the command: **javac [filename]**. So in this case, type in: **javac Hello.java.**

Figure 3.8: Compiling Java File

During compilation, javac adds a file to the disk called **[filename].class,** or in this case, **Hello.class**, which is the actual bytecode.

Step 6: Running the Program
Now, assuming that there are no problems during compilation (we'll explore more of the problems encountered during compilation in the next section), we are now ready to run your program.

To run your Java program, type in the command: **java [filename without the extension]**, so in the case of our example, type in: **java Hello**

You can see on the screen that you have just run your first Java program that prints the message, "Hello world!".

Figure 3.9: Running Class File

3.4.1 Errors

What we've shown so far is a Java program wherein we didn't encounter any problems in compiling and running. However, this is not always the case. As what we have discussed in the first part of this course, we usually encounter errors along the way.

As discussed before, there are two types of errors. The first one is a compile-time error or also called as syntax error. The second one is the runtime error.

3.4.1.1 Syntax Errors

Syntax errors are usually typing errors. You may have misspelled a command in Java or forgot to write a semi-colon at the end of a statement. Java attempts to isolate the error by displaying the line of code and pointing to the first incorrect character in that line. However, the problem may not be at the exact point.

Other common mistakes are in capitalization, spelling, the use of incorrect special characters, and omission of correct punctuation.

Let's take for example, our Hello.java program wherein we intentionally omit the semicolon at one statement and we try to type the incorrect spelling of a command.

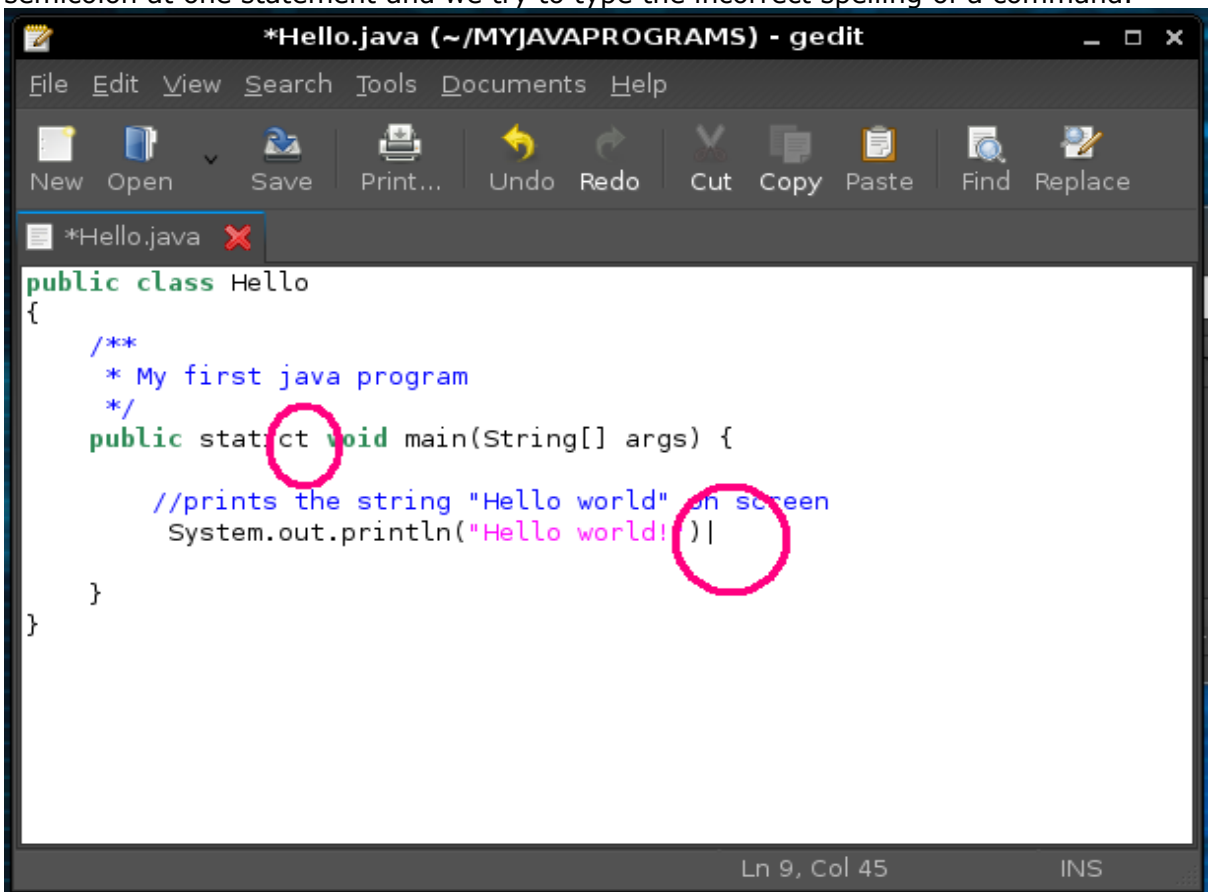


Figure 3.10: Source Code With Errors

See the error messages generated after compiling the program. The first error message suggests that there is an error in line 6 of your program. It pointed to the next word after the **statict**, which should be spelled as static.

The second error message suggests that there is a missing semicolon after your statement.

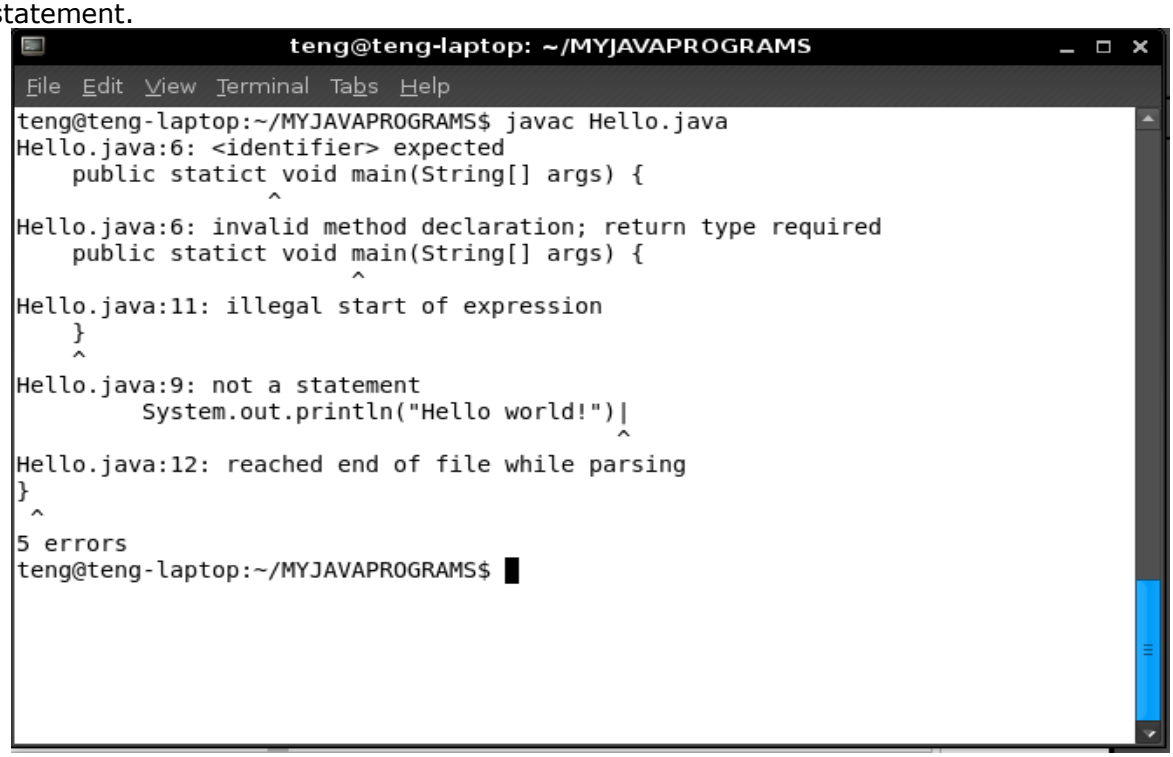


Figure 3.11: Compiling the Source Code with Errors

As a rule of thumb, if you encounter a lot of error messages, try to correct the first mistake in a long list, and try to compile the program again. Doing so may reduce the total number of errors dramatically.

3.4.1.2 Run-time Errors

Run-time errors are errors that will not display until you run or execute your program. Even programs that compile successfully may display wrong answers if the programmer has not thought through the logical processes and structures of the program.

3.5 Using NetBeans

Now that we've tried doing our programs the complicated way, let's now see how to do all the processes we've described in the previous sections by using just one application.

In this part of the lesson, we will be using **NetBeans**, which is an **Integrated Development Environment or IDE**. An IDE is a programming environment integrated into a software application that provides a GUI builder, a text or code editor, a compiler and/or interpreter and a debugger.

Step 1: Run NetBeans
To Run NetBeans, is by clicking on the shortcut icon found on your Desktop.

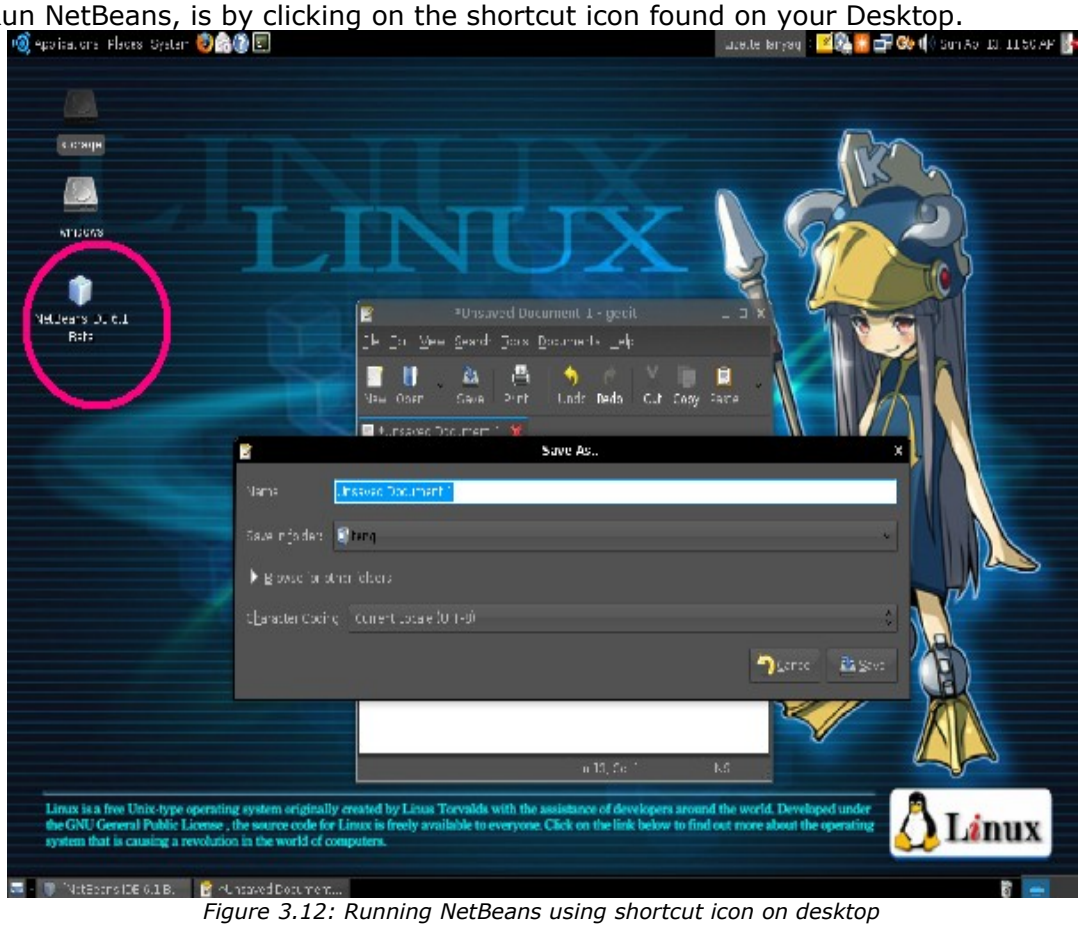


Figure 3.12: Running NetBeans using shortcut icon on desktop

After you've open NetBeans IDE, you will see a graphical user interface (GUI) similar to what is shown below.

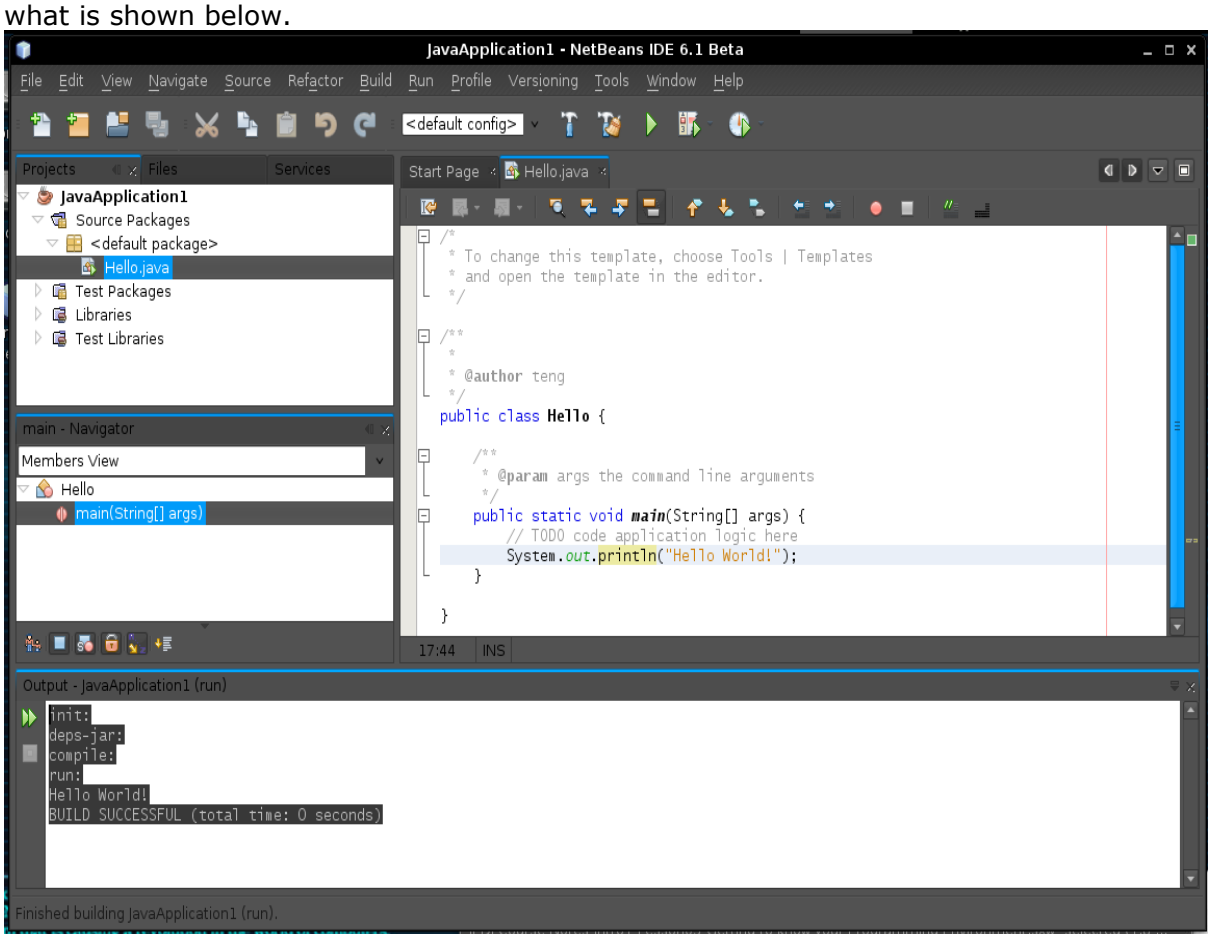


Figure 3.13: Window After Openning NetBeans

Step 2: Make a project
Now, let's first make a project. Click on File-> New Project. After doing this, a New Project dialog will appear. Now click on Java Application and click on the NEXT button.

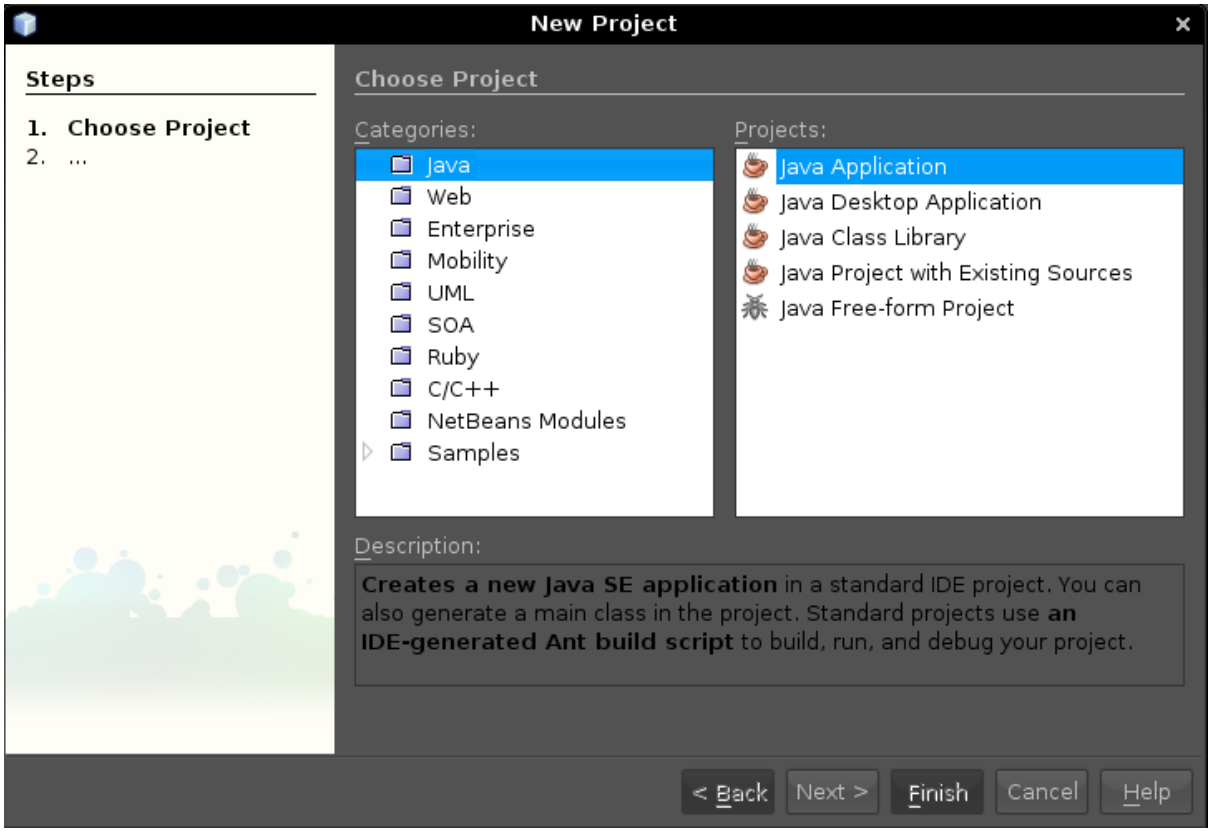


Figure 3.14: Choosing Project Type

Now, a New Application dialog will appear.

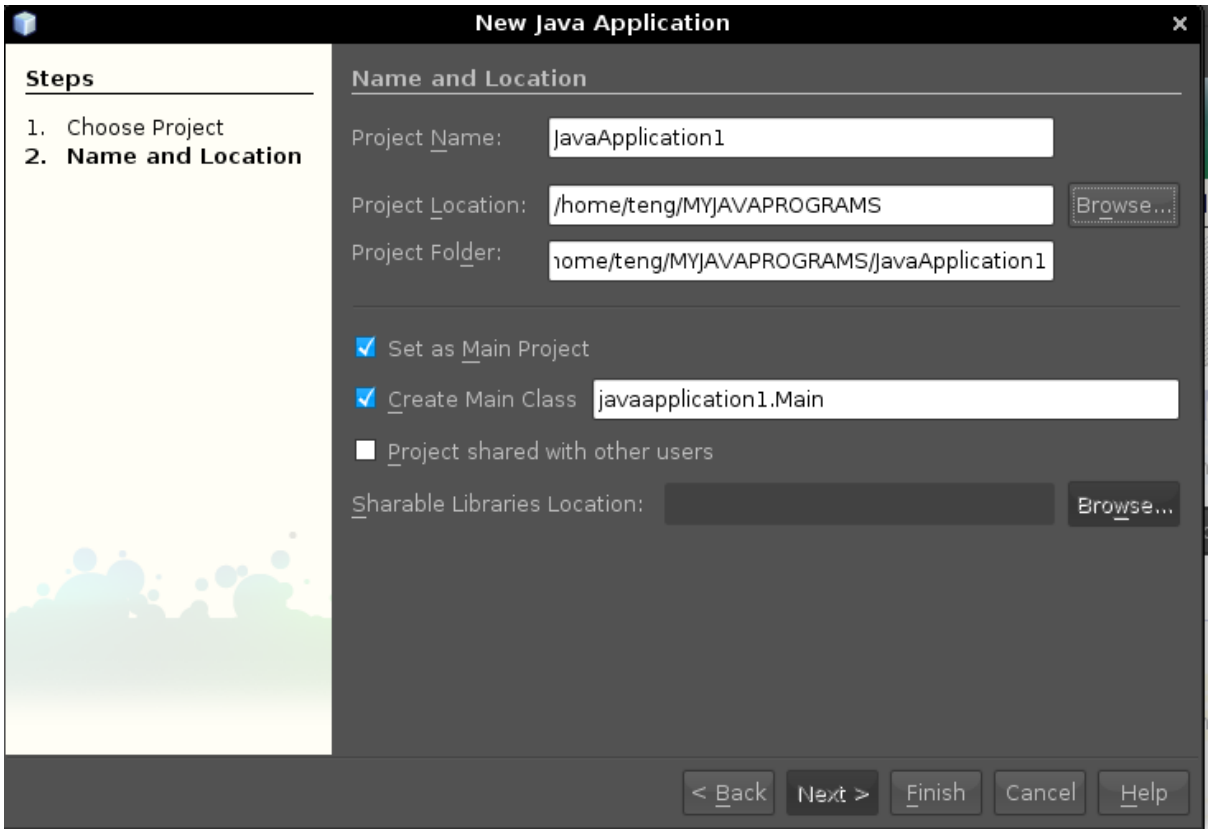


Figure 3.15: Setting the Project Information

Now try to change the Application Location, by clicking on the BROWSE button. A Project Location dialog will then appear. Double-click on your home folder.

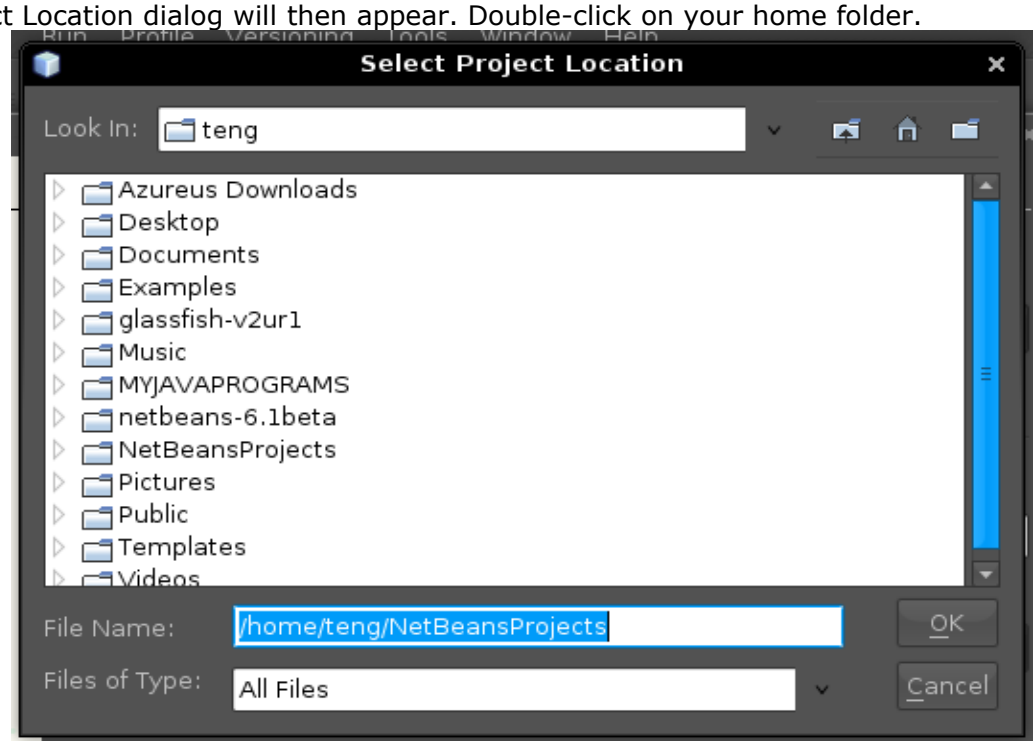
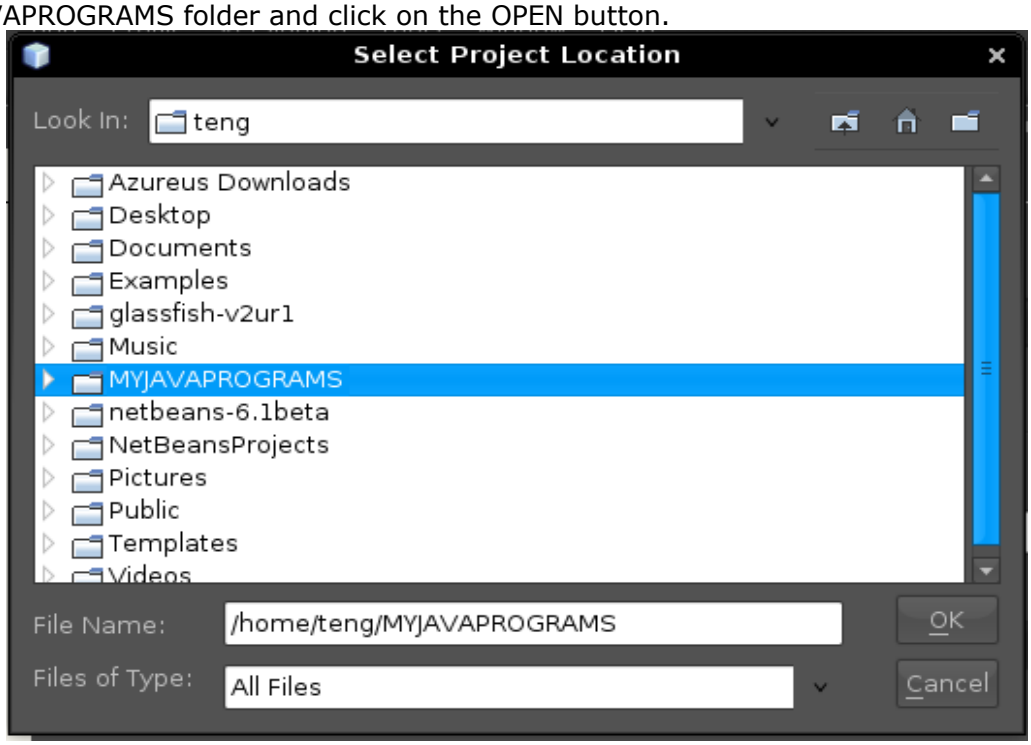


Figure 3.16: Setting the Project Location

The contents of the root folder is then displayed. Now double-click on the MYJAVAPROGRAMS folder and click on the OPEN button.



See now that the Project Location and Project Folder is changed to /home/<user>/MYJAVAPROGRAMS.

Finally, on the Create Main Class textfield, type in Hello as the main class' name, and then click on the FINISH button.

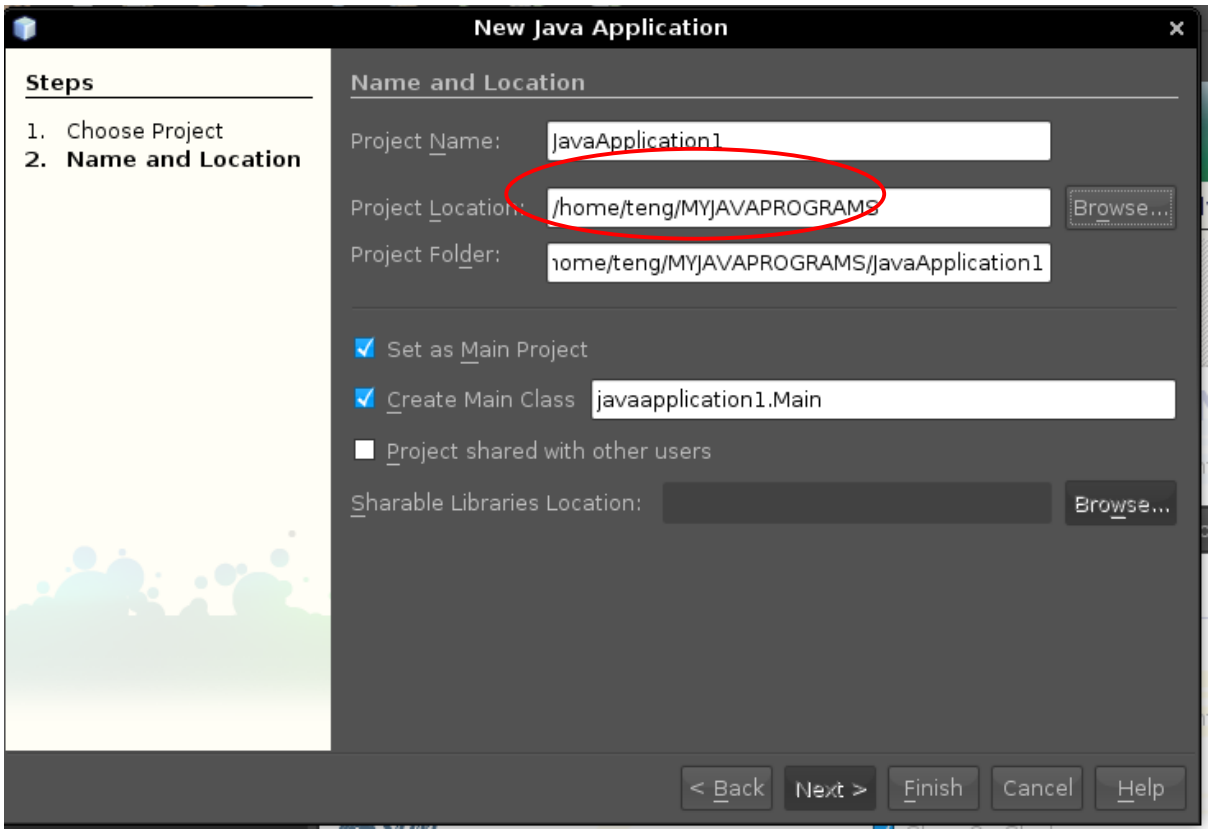


Figure 3.17: Window after Setting the Project Location to MYJAVAPROGRAMS/Setting the Main Class of the Project to Hello

Step 3: Type in your program
Before typing in your program, let us first describe the main window after creating the project.

As shown below, NetBeans automatically creates the basic code for your Java program. You can just add your own statements to the generated code. On the left side of the window, you can see a list of folders and files that NetBeans generated after creating the project. This can all be found in your MYJAVAPROGRAMS folder, where you set the Project location.

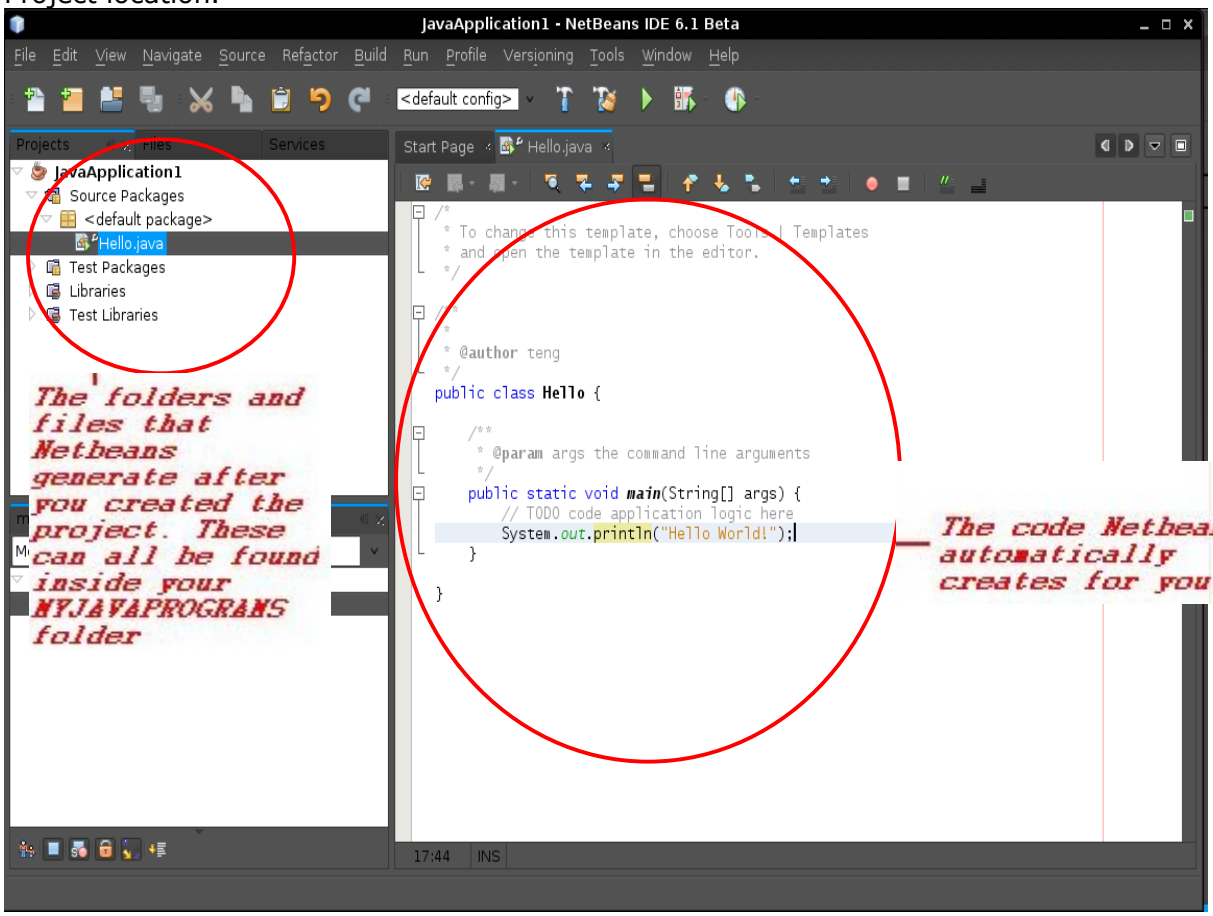


Figure 3.18: View of the Created Project

Now, try to modify the code generated by NetBeans. Ignore the other parts of the program for now, as we will explain the details of the code later. Insert the code:

```
System.out.println("Hello world!");
```

after the statement, //TODO code application logic here.

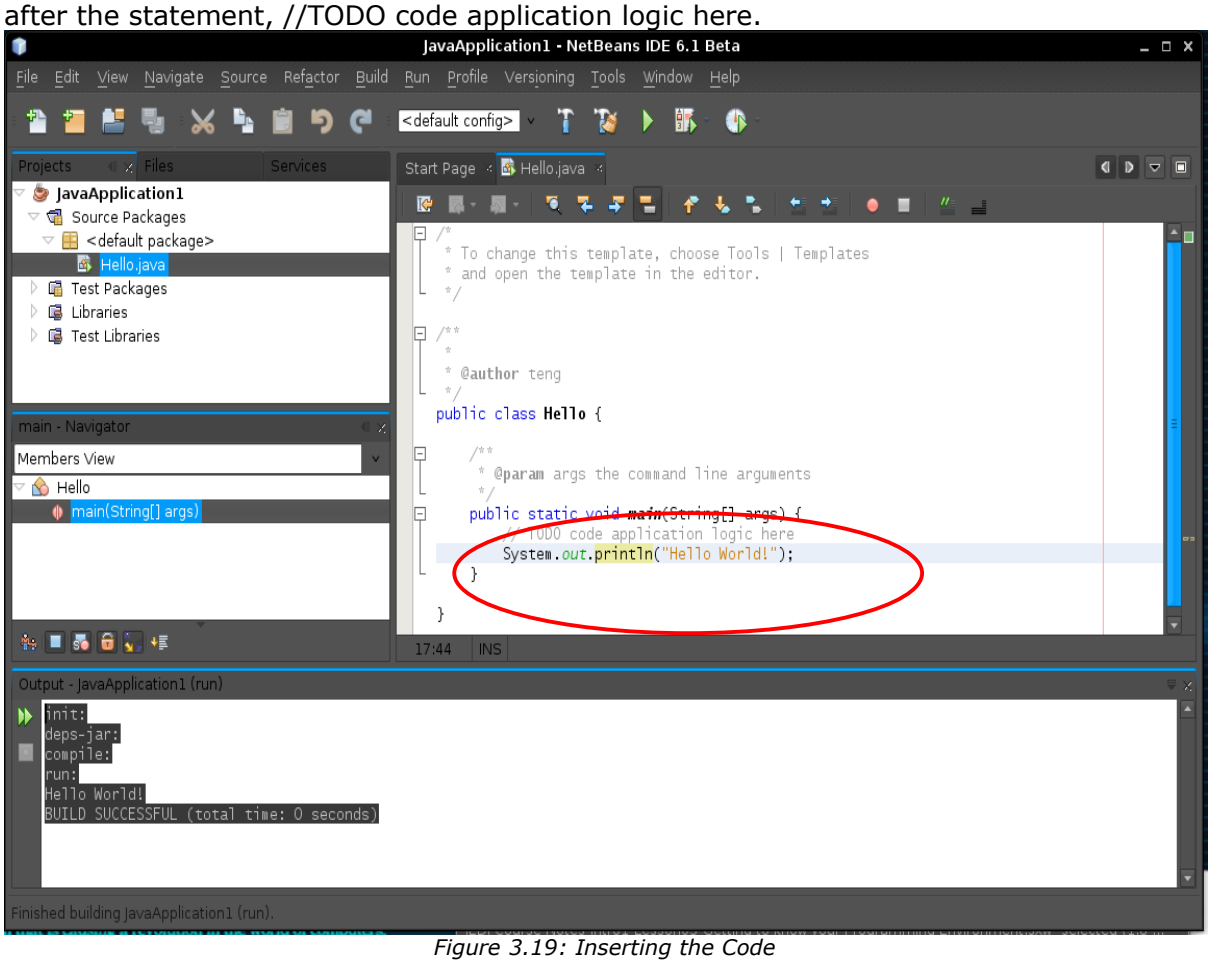
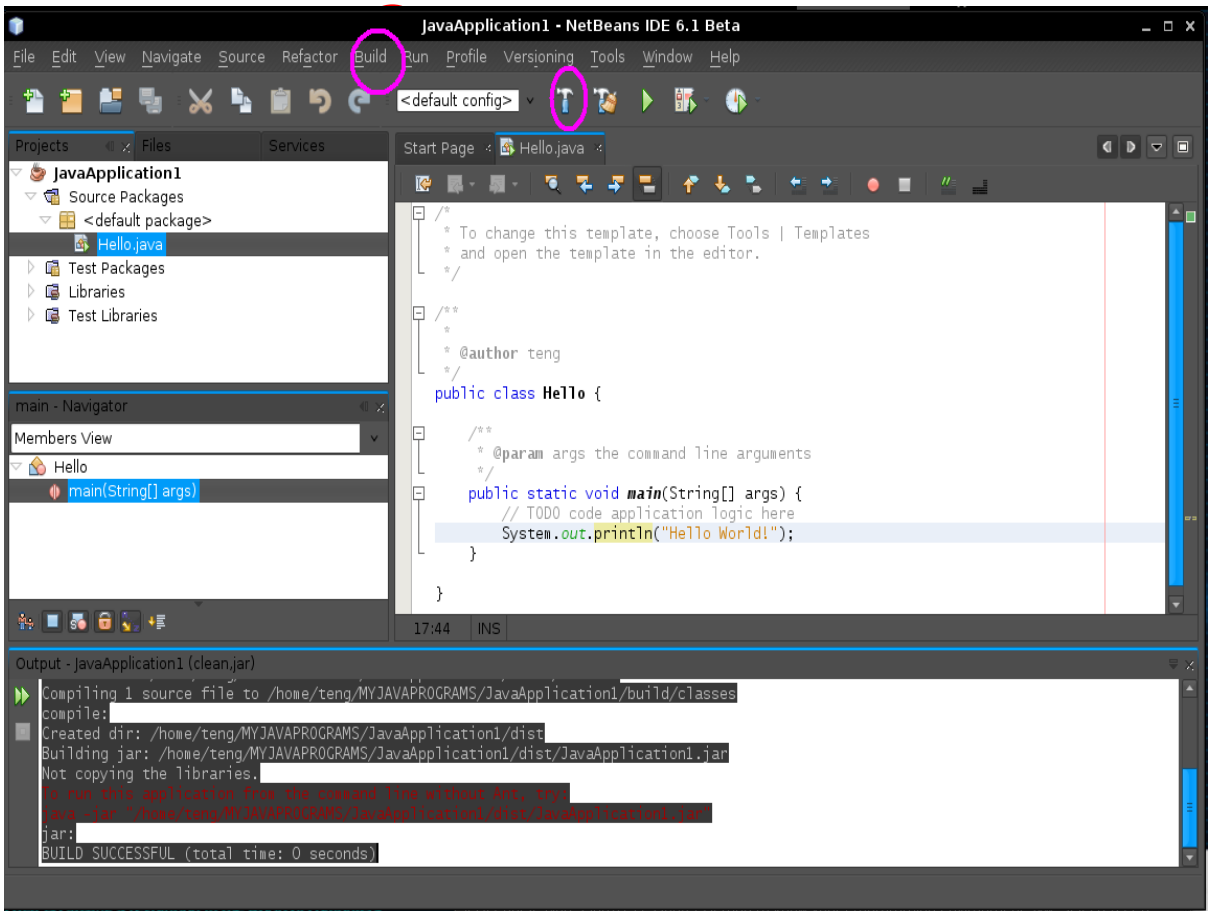


Figure 3.19: Inserting the Code

Step 4: Compile your program

Now, to compile your program, just click on Build -> Build Main Project. Or, you could also use the shortcut button to compile your code.



If there are no errors in your program, you will see a build successful message on the output window.

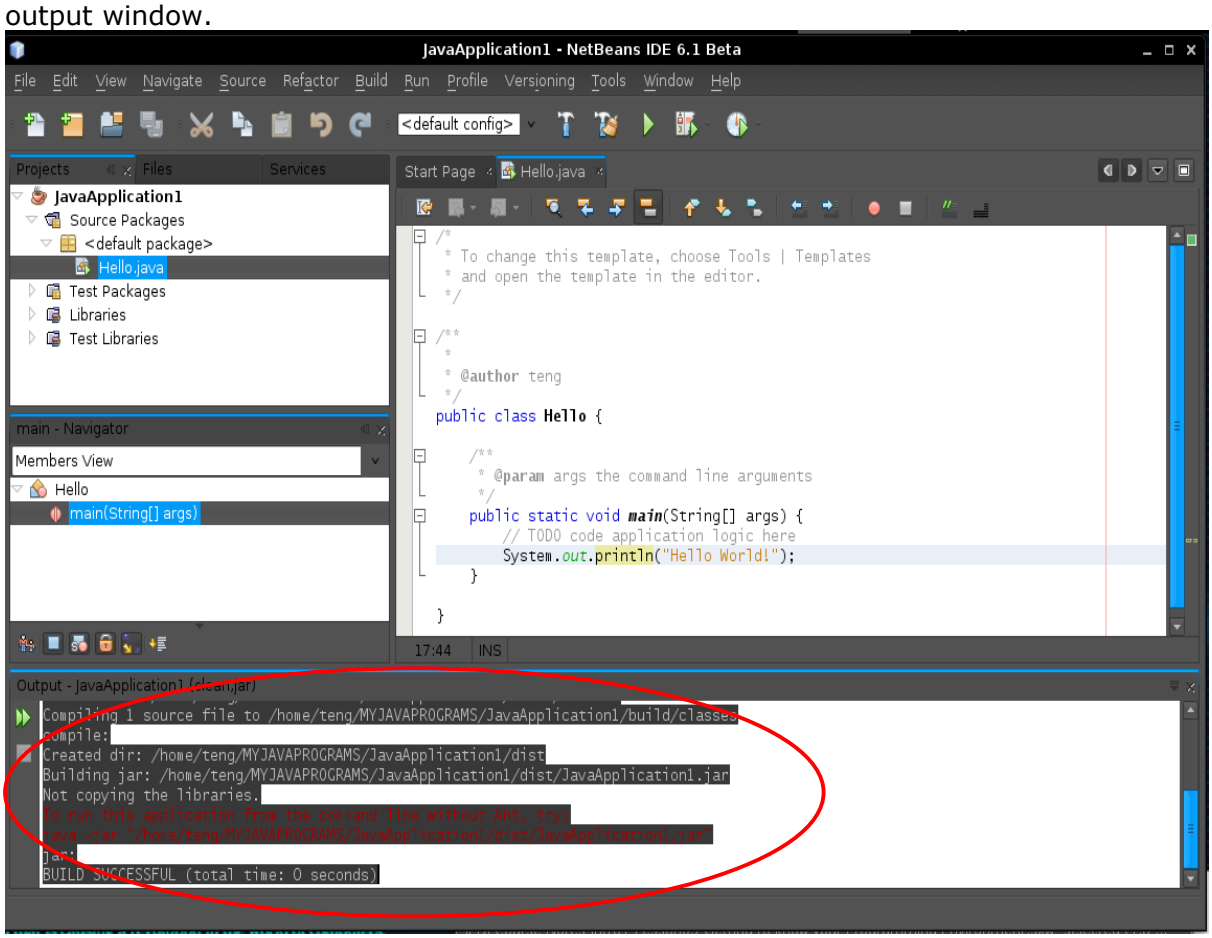


Figure 3.20: View after a Successful Compilation

Step 5: Run your program

To run your program, click on Run-> Run Main Project. Or you could also use the shortcut button to run your program.

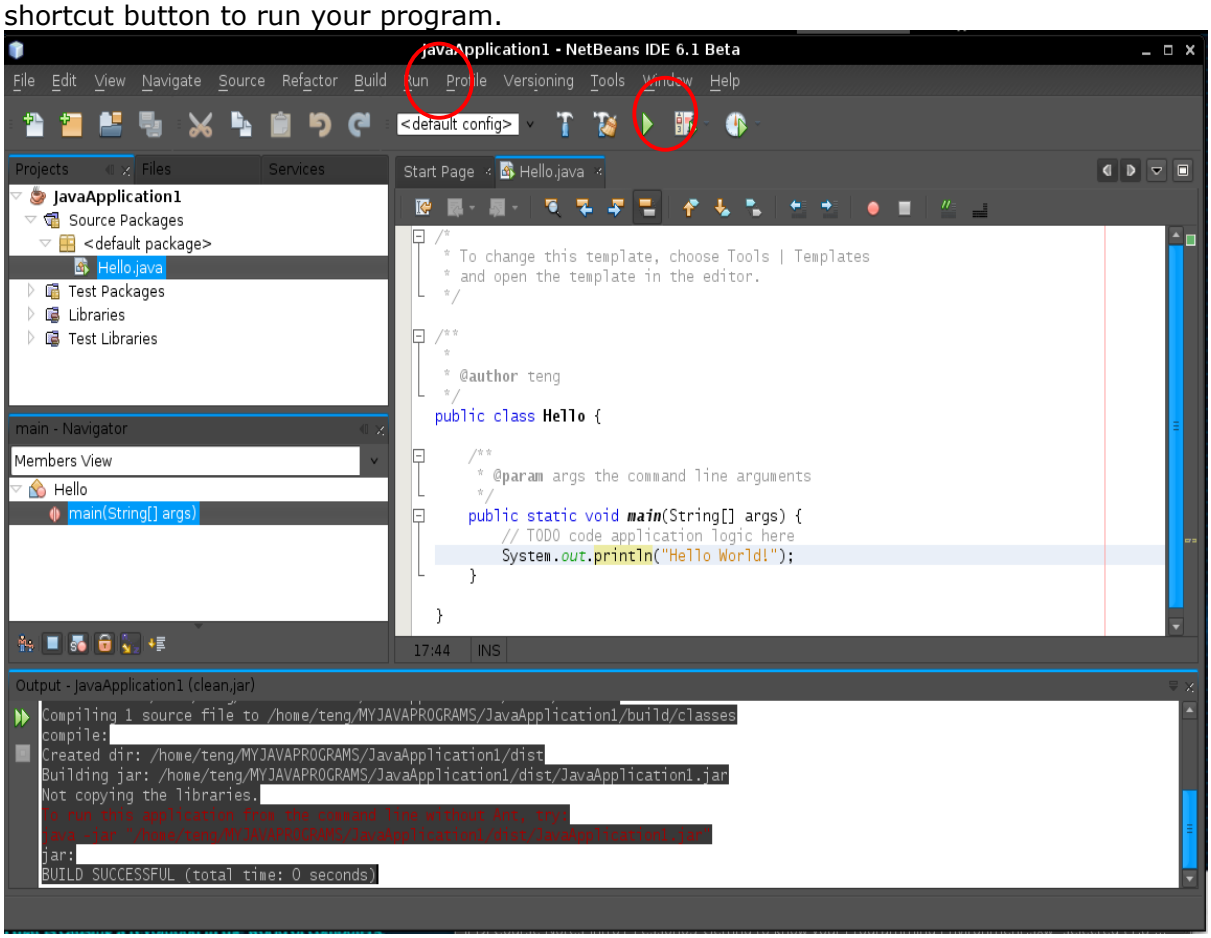


Figure 3.21: Running with NetBeans

The output of your program is displayed in the output window.

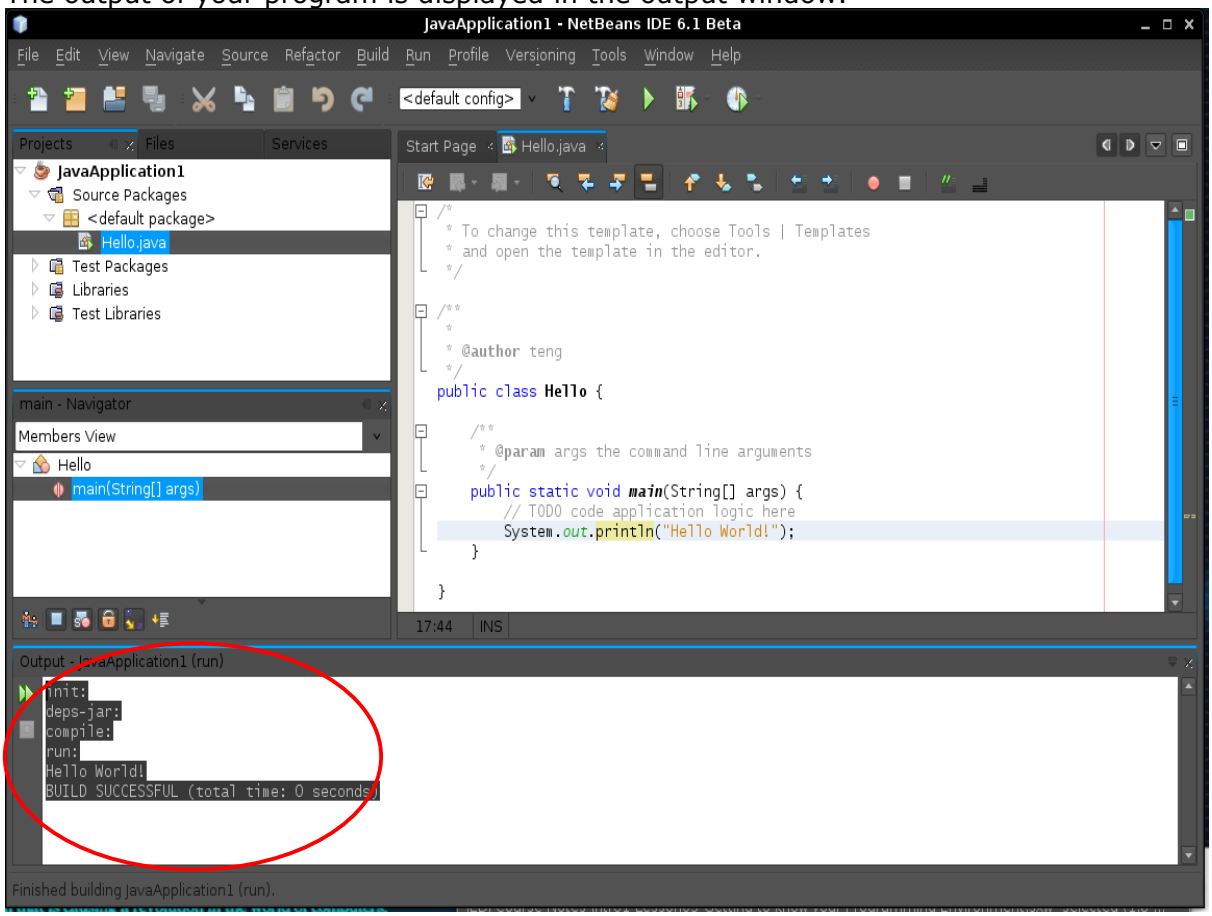


Figure 3.22: View after a Successful Run

3.6 Exercises

3.6.1 Hello World!

Using NetBeans, create a class named: [YourName]. The program should output on the screen:

```
Welcome to Java Programming [YourName]!!!
```

3.6.2 The Tree

Using NetBeans, create a class named: **TheTree**. The program should output the following lines on the screen:

```
I think that I shall never see,
a poem as lovely as a tree.
A tree whose hungry mouth is pressed
Against the Earth's sweet flowing breast.
```

4 Programming Fundamentals

4.1 Objectives

In this section, we will be discussing the basic parts of a Java program. We will start by trying to explain the basic parts of the Hello.java program introduced in the previous section. We will also be discussing some coding guidelines or code conventions along the way to help in effectively writing readable programs.

At the end of the lesson, the student should be able to:

- Identify the basic parts of a Java program
- Differentiate among Java literals, primitive data types, variable types ,identifiers and operators
- Develop a simple valid Java program using the concepts learned in this chapter

4.2 Dissecting my first Java program

Now, we'll try to the dissect your first Java program:

```
public class Hello
{
    /**
     * My first java program
     */
    public static void main(String[] args) {

      //prints the string "Hello world" on screen
         System.out.println("Hello world!");
    }
}
```

The first line of the code,

```
public class Hello
```

indicates the name of the class which is **Hello.** In Java, all code should be placed inside a class declaration. We do this by using the **class** keyword. In addition, the class uses an *access specifier* **public,** which indicates that our class in accessible to other classes from other packages (packages are a collection of classes). We will be covering packages and access specifiers later.

The next line which contains a curly brace { indicates the start of a block. In this code, we placed the curly brace at the next line after the class declaration, however, we can also place this next to the first line of our code. So, we could actually write our code as:

```
public class Hello
{
```

or

```
public class Hello {
```

The next three lines indicates a Java comment. A comment is something used to document a part of a code. It is not part of the program itself, but used for documentation purposes. It is good programming practice to add comments to your code.

```
/**
* My first java program
*/
```

A comment is indicated by the delimiters "**/***" and "***/***". Anything within these delimiters are ignored by the Java compiler, and are treated as comments.
The next line,

```
public static void main(String[] args) {
```

or can also be written as,

```
public static void main(String[] args)
{
```

indicates the name of one method in **Hello** which is the **main** method. The **main** method is the starting point of a Java program. All programs except Applets written in Java start with the **main** method. Make sure to follow the exact signature.

The next line is also a Java comment,

```
//prints the string "Hello world" on screen
```

Now, we learned two ways of creating comments. The first one is by placing the comment inside /* and */, and the other one is by writing // at the start of the comment.

The next line,

```
System.out.println("Hello world!");
```

prints the text "Hello World!" on screen. The command System.out.println(), prints the text enclosed by quotation on the screen.

The last two lines which contains the two curly braces is used to close the **main** method and **class** respectively.

Coding Guidelines:

1. *Your Java programs should always end with the **.java** extension.*
2. *Filenames should **match** the name of your public class. So for example, if the name of your public class is **Hello,** you should save it in a file called **Hello.java**.*
3. *You should write comments in your code explaining what a certain class does, or what a certain method do.*

4.3 Java Comments

Comments are notes written to a code for documentation purposes. Those text are not part of the program and does not affect the flow of the program.

Java supports three types of comments: C++-style single line comments, C-style multiline comments and special javadoc comments.

4.3.1 C++-Style Comments

C++ Style comments starts with //. All the text after // are treated as comments. For example,

```
// This is a C++ style or single line comments
```

4.3.2 C-Style Comments

C-style comments or also called multiline comments starts with a /* and ends with a */. All text in between the two delimeters are treated as comments. Unlike C++ style comments, it can span multiple lines. For example,

```
/* this is an exmaple of a
    C style or multiline comments */
```

4.3.3 Special Javadoc Comments

Special Javadoc comments are used for generating an HTML documentation for your Java programs. You can create javadoc comments by starting the line with /** and ending it with */. Like C-style comments, it can also span lines. It can also contain certain tags to add more information to your comments. For example,

```
/**
 This is an example of special java doc comments used for \n
 generating an html documentation. It uses tags like:
 @author Florence Balagtas
 @version 1.2
*/
```

4.4 Java Statements and blocks

A **statement** is one or more lines of code terminated by a semicolon. An example of a single statement is,

```
System.out.println(“Hello world”);
```

A **block** is one or more statements bounded by an opening and closing curly braces that groups the statements as one unit. Block statements can be nested indefinitely. Any amount of white space is allowed. An example of a block is,

```
public static void main( String[] args ){
      System.out.println("Hello");
      System.out.println("world");
}
```

Coding Guidelines:

1. *In creating blocks, you can place the opening curly brace in line with the statement, like for example,*

   public static void main(String[] args){

   or you can place the curly brace on the next line, like,

   public static void main(String[] args)
   {

2. *You should indent the next statements after the start of a block,for example,*

   ```
   public static void main( String[] args ){
         System.out.println("Hello");
         System.out.println("world");
   }
   ```

4.5 Java Identifiers

Identifiers are tokens that represent names of variables, methods, classes, etc. Examples of identifiers are: Hello, main, System, out.

Java identifiers are case-sensitive. This means that the identifier: **Hello** is not the same as **hello**. Identifiers must begin with either a letter, an underscore "_", or a dollar sign "$". Letters may be lower or upper case. Subsequent characters may use numbers 0 to 9.

Identifiers cannot use Java keywords like class, public, void, etc. We will discuss more about Java keywords later.

Coding Guidelines:

1. *For names of classes, capitalize the first letter of the class name. For names of methods and variables, the first letter of the word should start with a small letter.For example:*
   ***T**his**I**s**A**n**E**xample**O**f**C**lass**N**ame*
   ***t**his**I**s**A**n**E**xample**O**f**M**ethod**N**ame*

2. *In case of multi-word identifiers, use capital letters to indicate the start of the word except the first word. For example, charArray, fileNumber, ClassName.*

3. *Avoid using underscores at the start of the identifier such as _read or _write.*

4.6 Java Keywords

Keywords are predefined identifiers reserved by Java for a specific purpose. You cannot use keywords as names for your variables, classes, methods …etc. Here is a list of the Java Keywords.

abstract	continue	for	new	switch
assert***	default	goto*	package	synchronized
boolean	do	if	private	this
break	double	implements	protected	throw
byte	else	import	public	throws
case	enum****	instanceof	return	transient
catch	extends	int	short	try
char	final	interface	static	void
class	finally	long	strictfp**	volatile
const*	float	native	super	while

* not used
** added in 1.2
*** added in 1.4
**** added in 5.0

Figure 4.1: Java Key Words

We will try to discuss all the meanings of these keywords and how they are used in our Java programs as we go along the way.

Note: `true`, `false`, and `null` are not keywords but they are reserved words, so you cannot use them as names in your programs either

4.7 Java Literals

Literals are tokens that do not change or are constant. The different types of literals in Java are: Integer Literals, Floating-Point Literals, Boolean Literals, Character Literals and String Literals.

4.7.1 Integer Literals

Integer literals come in different formats: **decimal** (base 10), **hexadecimal** (base 16), and **octal** (base 8). In using integer literals in our program, we have to follow some special notations.

For decimal numbers, we have no special notations. We just write a decimal number as it is. For hexadecimal numbers, it should be preceeded by "0x" or "0X". For octals, they are preceeded by "0".

For example, consider the number **12**. It's decimal representation is **12**, while in hexadecimal, it is **0xC**, and in octal, it is equivalent to **014**.

Integer literals default to the data type **int**. An int is a signed 32-bit value. In some cases, you may wish to force integer literal to the data type **long** by appending the "l" or "L" character. A long is a signed 64-bit value. We will cover more on data types later.

4.7.2 Floating-Point Literals

Floating point literals represent decimals with fractional parts. An example is 3.1415. Floating point literals can be expressed in standard or scientific notations. For example, 583.45 is in standard notation, while 5.8345e2 is in scientific notation.

Floating point literals default to the data type **double** which is a 64-bit value. To use a smaller precision (32-bit) **float**, just append the "f" or "F" character.

4.7.3 Boolean Literals

Boolean literals have only two values, **true** or **false**.

4.7.4 Character Literals

Character Literals represent single Unicode characters. A Unicode character is a 16-bit character set that replaces the 8-bit ASCII character set. Unicode allows the inclusion of symbols and special characters from other languages.

To use a character literal, enclose the character in single quote delimiters. For example, the letter **a**, is represented as **'a'**.

To use special characters such as a newline character, a backslash is used followed by the character code. For example, '\n' for the newline character, '\r' for the carriage return, '\b' for backspace.

4.7.5 String Literals

String literals represent multiple characters and are enclosed by double quotes. An example of a string literal is, **"Hello World".**

4.8 Primitive data types

The Java programming language defines eight primitive data types. The following are, boolean (for logical), char (for textual), byte, short, int, long (integral), double and float (floating point).

4.8.1 Logical - boolean

A boolean data type represents two states: true and false. An example is,

```
boolean result = true;
```

The example shown above, declares a variable named **result** as **boolean** type and assigns it a value of **true**.

4.8.2 Textual – char

A character data type (char), represents a single Unicode character. It must have its literal enclosed in single quotes(' '). For example,

```
'a'   //The letter a
'\t'  //A tab
```

To represent special characters like ' (single quotes) or " (double quotes), use the escape character \. For example,

```
'\''  //for single quotes
'\"'  //for double quotes
```

Although, String is not a primitive data type (it is a Class), we will just introduce String in this section. A String represents a data type that contains multiple characters. It is **not a primitive data type, it is a class.** It has it's literal enclosed in double quotes("").

For example,

```
String message="Hello world!"
```

4.8.3 Integral – byte, short, int & long

Integral data types in Java uses three forms – decimal, octal or hexadecimal. Examples are,

```
2     //The decimal value 2
077   //The leading 0 indicates an octal value
0xBACC      //The leading 0x indicates a hexadecimal value
```

Integral types has int as default data type. You can define its long value by appending the letter l or L. Integral data type have the following ranges:

Integer Length	***Name or Type***	***Range***
8 bits	byte	-2^7 to 2^7-1
16 bits	short	-2^{15} to $2^{15}-1$
32 bits	int	-2^{31} to $2^{31}-1$
64 bits	long	-2^{63} to $2^{63}-1$

Table 8: Integral types and their ranges

Coding Guidelines:
In defining a long value, a lowercase L is not recommended because it is hard to distinguish from the digit 1.

4.8.4 Floating Point – float and double

Floating point types has double as default data type. Floating-point literal includes either a decimal point or one of the following,

```
E or e //(add exponential value)
F or f //(float)
D or d //(double)
```

Examples are,

```
3.14        //A simple floating-point value (a double)
6.02E23           //A large floating-point value
2.718F            //A simple float size value
123.4E+306D       //A large double value with redundant D
```

In the example shown above, the 23 after the E in the second example is implicitly positive. That example is equivalent to 6.02E+23. Floating-point data types have the following ranges:

Float Length	***Name or Type***	***Range***
32 bits	float	-2^{31} to $2^{31}-1$
64 bits	double	-2^{63} to $2^{63}-1$

Table 9: Floating point types and their ranges

4.9 Variables

A **variable** is an item of data used to store state of objects.

A variable has a **data type** and **a name**. The **data type** indicates the type of value that the variable can hold. The **variable name** must follow rules for identifiers.

4.9.1 Declaring and Initializing Variables

To declare a variable is as follows,

```
<data type> <name> [=initial value];
```

Note: Values enclosed in <> are required values, while those values enclosed in [] are optional.

Here is a sample program that declares and initializes some variables,

```
public class VariableSamples
{
    public static void main( String[] args ){
        //declare a data type with variable name
        // result and boolean data type
        boolean   result;

        //declare a data type with variable name
        // option and char data type
        char      option;
        option = 'C';   //assign 'C' to option

        //declare a data type with variable name
        //grade, double data type and initialized
        //to 0.0
        double    grade = 0.0;
    }
}
```

Coding Guidelines:

1. *It always good to **initialize** your variables as you declare them.*
2. *Use **descriptive** names for your variables. Like for example, if you want to have a variable that contains a grade for a student, name it as, **grade** and not just some random letters you choose.*
3. *Declare one variable per line of code. For example, the variable declarations,*

```
double exam=0;
double quiz=10;
double grade = 0;
```

is preferred over the declaration,

```
double exam=0, quiz=10, grade=0;
```

4.9.2 Outputting Variable Data

In order to output the value of a certain variable, we can use the following commands,

```
System.out.println()
System.out.print()
```

Here's a sample program,

```
public class OutputVariable
{
    public static void main( String[] args ){
        int value = 10;
        char x;
        x = 'A';

        System.out.println( value );
        System.out.println( "The value of x=" + x );
    }
}
```

The program will output the following text on screen,

```
10
The value of x=A
```

4.9.3 System.out.println() vs. System.out.print()

What is the difference between the commands System.out.println() and System.out.print()? The first one appends a newline at the end of the data to output, while the latter doesn't.

Consider the statements,

```
System.out.print("Hello ");
System.out.print("world!");
```

These statements will output the following on the screen,

```
Hello world!
```

Now consider the following statements,

```
System.out.println("Hello ");
System.out.println("world!");
```

These statements will output the following on the screen,

```
Hello
world!
```

4.9.4 Reference Variables vs. Primitive Variables

We will now differentiate the two types of variables that Java programs have. These are **reference variables** and **primitive variables**.

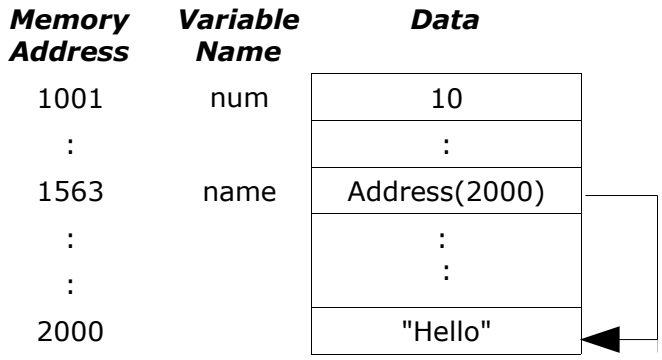
Primitive variables are variables with primitive data types. They store data in the actual memory location of where the variable is.

Reference variables are variables that stores the address in the memory location. It points to another memory location of where the actual data is. When you declare a variable of a certain ***class***, you are actually declaring a reference variable to the object with that certain class.

For example, suppose we have two variables with data types int and String.

```
int num = 10;
String name = "Hello"
```

Suppose, the illustration shown below is the actual memory of your computer, wherein you have the address of the memory cells, the variable name and the data they hold.



As you can see, for the primitive variable num, the data is on the actual location of where the variable is. For the reference variable name, the variable just holds the address of where the actual data is.

4.10 Operators

In Java, there are different types of operators. There are arithmetic operators, relational operators, logical operators and conditional operators. These operators follow a certain kind of precedence so that the compiler will know which operator to evaluate first in case multiple operators are used in one statement.

4.10.1 Arithmetic operators

Here are the basic arithmetic operators that can be used in creating your Java programs,

Operator	Use	Description
+	op1 + op2	Adds op1 and op2
*	op1 * op2	Multiplies op1 by op2
/	op1 / op2	Divides op1 by op2
%	op1 % op2	Computes the remainder of dividing op1 by op2
-	op1 - op2	Subtracts op2 from op1

Table 10: Arithmetic operations and their functions

Here's a sample program in the usage of these operators:

```
public class ArithmeticDemo
{
    public static void main(String[] args)
   {

        //a few numbers
        int i = 37;
        int j = 42;
        double x = 27.475;
        double y = 7.22;
        System.out.println("Variable values...");
        System.out.println("    i = " + i);
        System.out.println("    j = " + j);
        System.out.println("    x = " + x);
        System.out.println("    y = " + y); //adding numbers
        System.out.println("Adding...");
        System.out.println("    i + j = " + (i + j));
        System.out.println("    x + y = " + (x + y));

        //subtracting numbers
        System.out.println("Subtracting...");
        System.out.println("    i - j = " + (i - j));
        System.out.println("    x - y = " + (x - y));

        //multiplying numbers
        System.out.println("Multiplying...");
        System.out.println("    i * j = " + (i * j));
        System.out.println("    x * y = " + (x * y));
     //dividing numbers
        System.out.println("Dividing...");
        System.out.println("    i / j = " + (i / j));
        System.out.println("    x / y = " + (x / y));

       //computing the remainder resulting from dividing
numbers
        System.out.println("Computing the remainder...");
        System.out.println("    i % j = " + (i % j));
        System.out.println("    x % y = " + (x % y));

        //mixing types
        System.out.println("Mixing types...");
        System.out.println("    j + y = " + (j + y));
        System.out.println("    i * x = " + (i * x));
    }
}
```

Here is the output of the program,

```
Variable values...
    i = 37
    j = 42
    x = 27.475
    y = 7.22
Adding...
    i + j = 79
    x + y = 34.695
Subtracting...
    i - j = -5
    x - y = 20.255
Multiplying...
    i * j = 1554
    x * y = 198.37
Dividing...
    i / j = 0
    x / y = 3.8054
Computing the remainder...
    i % j = 37
    x % y = 5.815
Mixing types...
    j + y = 49.22
    i * x = 1016.58
```

Note: When an integer and a floating-point number are used as operands to a single arithmetic operation, the result is a floating point. The integer is implicitly converted to a floating-point number before the operation takes place.

4.10.2 Increment and Decrement operators

Aside from the basic arithmetic operators, Java also includes a unary increment operator (++) and unary decrement operator (--). Increment and decrement operators increase and decrease a value stored in a number variable by 1.

For example, the expression,

```
count = count + 1;      //increment the value of count by 1
```

is equivalent to,

```
count++;
```

Operator	*Use*	*Description*
++	op++	Increments op by 1; evaluates to the value of op before it was incremented
++	++op	Increments op by 1; evaluates to the value of op after it was incremented
--	op--	Decrements op by 1; evaluates to the value of op before it was decremented
--	--op	Decrements op by 1; evaluates to the value of op after it was decremented

Table 11: Increment and Decrement operators

The increment and decrement operators can be placed before or after an operand.

When used **before** an operand, it causes the variable to be incremented or decremented by 1, and then the new value is used in the expression in which it appears. For example,

```
int i = 10,
int j = 3;
int k = 0;

k = ++j + i; //will result to k = 4+10 = 14
```

When the increment and decrement operators are placed after the operand, the old value of the variable will be used in the expression where it appears. For example,

```
int i = 10,
int j = 3;
int k = 0;

k = j++ + i; //will result to k = 3+10 = 13
```

Coding Guideline:
Always keep expressions containing increment and decrement operators simple and easy to understand.

4.10.3 Relational operators

Relational operators compare two values and determines the relationship between those values. The output of evaluation are the **boolean values** true or false.

Operator	*Use*	*Description*
>	op1 > op2	op1 is greater than op2
>=	op1 >= op2	op1 is greater than or equal to op2
<	op1 < op2	op1 is less than op2
<=	op1 <= op2	op1 is less than or equal to op2
==	op1 == op2	op1 and op2 are equal
!=	op1 != op2	op1 and op2 are not equal

Table 12: Relational Operators

Here's a sample program that uses relational operators,

```
public class RelationalDemo
{
    public static void main(String[] args) {
        //a few numbers
        int i = 37;
        int j = 42;
        int k = 42;
        System.out.println("Variable values...");
        System.out.println("    i = " + i);
        System.out.println("    j = " + j);
        System.out.println("    k = " + k);

   //greater than
        System.out.println("Greater than...");
        System.out.println("    i > j = " + (i > j)); //false
        System.out.println("    j > i = " + (j > i)); //true
        System.out.println("    k > j = " + (k > j)); //false

   //greater than or equal to
        System.out.println("Greater than or equal to...");
        System.out.println("    i >= j = " + (i >= j)); //false
        System.out.println("    j >= i = " + (j >= i)); //true
        System.out.println("    k >= j = " + (k >= j)); //true

   //less than
        System.out.println("Less than...");
        System.out.println("    i < j = " + (i < j)); //true
        System.out.println("    j < i = " + (j < i)); //false
        System.out.println("    k < j = " + (k < j)); //false
   //less than or equal to
        System.out.println("Less than or equal to...");
        System.out.println("    i <= j = " + (i <= j)); //true
        System.out.println("    j <= i = " + (j <= i)); //false
        System.out.println("    k <= j = " + (k <= j)); //true

   //equal to
        System.out.println("Equal to...");
        System.out.println("    i == j = " + (i == j)); //false
        System.out.println("    k == j = " + (k == j)); //true

   //not equal to
        System.out.println("Not equal to...");
        System.out.println("    i != j = " + (i != j)); //true
        System.out.println("    k != j = " + (k != j)); //false

    }
}
```

Here's the output from this program:

```
Variable values...
    i = 37
    j = 42
    k = 42
Greater than...
    i > j = false
    j > i = true
    k > j = false
Greater than or equal to...
    i >= j = false
    j >= i = true
    k >= j = true
Less than...
    i < j = true
    j < i = false
    k < j = false
Less than or equal to...
    i <= j = true
    j <= i = false
    k <= j = true
Equal to...
    i == j = false
    k == j = true
Not equal to...
    i != j = true
    k != j = false
```

4.10.4 Logical operators

Logical operators have one or two boolean operands that yield a boolean result. There are six logical operators: && (logical AND), & (boolean logical AND), || (logical OR), | (boolean logical inclusive OR), ^ (boolean logical exclusive OR), and ! (logical NOT).

The basic expression for a logical operation is,

```
x1 op x2
```

where x1, x2 can be boolean expressions, variables or constants, and op is either &&, &, ||, | or ^ operator. The truth tables that will be shown next, summarize the result of each operation for all possible combinations of x1 and x2.

4.10.4.1 && (logical AND) and & (boolean logical AND)

Here is the truth table for && and &,

x1	*x2*	*Result*
TRUE	TRUE	TRUE
TRUE	FALSE	FALSE
FALSE	TRUE	FALSE
FALSE	FALSE	FALSE

Table 13: Truth table for & and &&

The basic difference between && and & operators is that && supports **short-circuit evaluations** (or partial evaluations), while & doesn't. What does this mean?

Given an expression,

```
exp1 && exp2
```

&& will evaluate the expression exp1, and immediately return a false value is exp1 is false. If exp1 is false, the operator never evaluates exp2 because the result of the operator will be false regardless of the value of exp2. In contrast, the & operator always evaluates both exp1 and exp2 before returning an answer.

Here's a sample source code that uses logical and boolean AND,

```
public class TestAND
{
      public static void main( String[] args ){

            int   i     = 0;
            int   j     = 10;
            boolean test= false;

            //demonstrate &&
            test = (i > 10) && (j++ > 9);
            System.out.println(i);
            System.out.println(j);
            System.out.println(test);

            //demonstrate &
            test = (i > 10) & (j++ > 9);
            System.out.println(i);
            System.out.println(j);
            System.out.println(test);
      }
}
```

The output of the program is,

```
0
10
false
0
11
false
```

Note, that the j++ on the line containing the && operator is not evaluated since the first expression (i>10) is already equal to false.

4.10.4.2 || (logical OR) and | (boolean logical inclusive OR)

Here is the truth table for || and |,

x1	*x2*	*Result*
TRUE	TRUE	TRUE
TRUE	FALSE	TRUE
FALSE	TRUE	TRUE
FALSE	FALSE	FALSE

Table 14: Truth table for | and ||

The basic difference between || and | operators is that || supports short-circuit evaluations (or partial evaluations), while | doesn't. What does this mean?

Given an expression,

```
exp1 || exp2
```

|| will evaluate the expression exp1, and immediately return a true value is exp1 is true. If exp1 is true, the operator never evaluates exp2 because the result of the operator will be true regardless of the value of exp2. In contrast, the | operator always evaluates both exp1 and exp2 before returning an answer.

Here's a sample source code that uses logical and boolean OR,

```
public class TestOR
{
      public static void main( String[] args ){

            int   i     = 0;
            int   j     = 10;
            boolean test= false;

            //demonstrate ||
            test = (i < 10) || (j++ > 9);
            System.out.println(i);
            System.out.println(j);
            System.out.println(test);

            //demonstrate |
            test = (i < 10) | (j++ > 9);
            System.out.println(i);
            System.out.println(j);
            System.out.println(test);
      }
}
```

The output of the program is,

```
0
10
true
0
11
true
```

Note, that the j++ on the line containing the || operator is not evaluated since the first expression (i<10) is already equal to true.

4.10.4.3 ^ (boolean logical exclusive OR)

Here is the truth table for ^,

x1	*x2*	*Result*
TRUE	TRUE	FALSE
TRUE	FALSE	TRUE
FALSE	TRUE	TRUE
FALSE	FALSE	FALSE

Table 15: Truth table for ^

The result of an exclusive OR operation is TRUE, if and only if one operand is true and the other is false. Note that both operands must always be evaluated in order to calculate the result of an exclusive OR.

Here's a sample source code that uses the logical exclusive OR operator,

```
public class TestXOR
{
      public static void main( String[] args ){

            boolean val1 = true;
            boolean val2 = true;
            System.out.println(val1 ^ val2);

            val1 = false;
            val2 = true;
            System.out.println(val1 ^ val2);

            val1 = false;
            val2 = false;
            System.out.println(val1 ^ val2);

            val1 = true;
            val2 = false;
            System.out.println(val1 ^ val2);
      }
}
```

The output of the program is,

```
false
true
false
true
```

4.10.4.4 ! (logical NOT)

The logical NOT takes in one argument, wherein that argument can be an expression, variable or constant. Here is the truth table for !,

x1	*Result*
TRUE	FALSE
FALSE	TRUE

Table 16: Truth table for !

Here's a sample source code that uses the logical NOT operator,

```
public class TestNOT
{
      public static void main( String[] args ){

            boolean val1 = true;
            boolean val2 = false;
            System.out.println(!val1);
            System.out.println(!val2);
      }
}
```

The output of the program is,

```
false
true
```

4.10.5 Conditional Operator (?:)

The conditional operator **?:** is a ternary operator. This means that it takes in three arguments that together form a conditional expression. The structure of an expression using a conditional operator is,

```
exp1?exp2:exp3
```

wherein exp1 is a boolean expression whose result must either be true or false.

If exp1 is true, exp2 is the value returned. If it is false, then exp3 is returned.

For example, given the code,

```
public class ConditionalOperator
{
      public static void main( String[] args ){

            String      status = "";
            int   grade = 80;

            //get status of the student
            status = (grade >= 60)?"Passed":"Fail";

            //print status
            System.out.println( status );
      }
}
```

The output of this program will be,

```
Passed
```

Here is the flowchart of how ?: works,

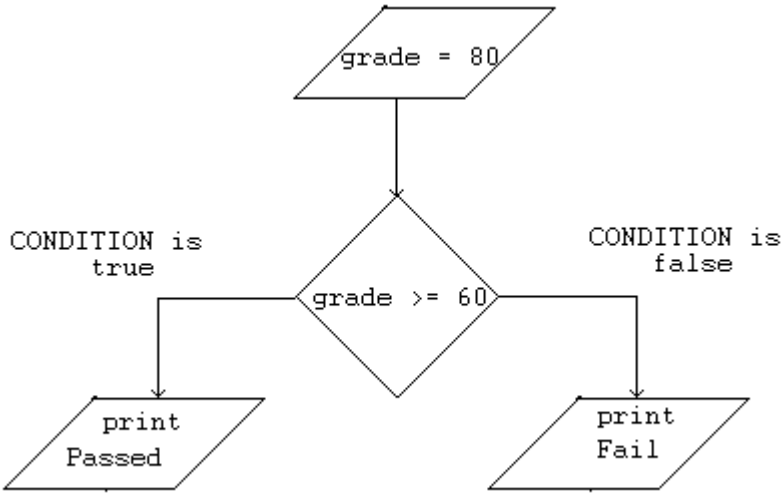


Figure 4.2: Flowchart using the ?: operator

Here is another program that uses the ?: operator,

```
class ConditionalOperator
{
      public static void main( String[] args ){

            int   score = 0;
            char  answer = 'a';

            score = (answer == 'a') ? 10 : 0;
            System.out.println("Score = " + score );
      }
}
```

The output of the program is,

```
Score = 10
```

4.10.6 Operator Precedence

Operator precedence defines the compiler's order of evaluation of operators so as to come up with an unambiguous result.

The following is the list of Java operators from highest to lowest precedence:

.	[ ]	( )	
++	--	!	~
*	/	%	
+	-		
<<	>>	>>>	<<<
<	>	<=	>=
==	!=		
&	|		
^			
&&			
||			
?:			
=			

The highest precedence is on the top row and the lowest is on the bottom row.

Figure 4.3: Operator Precedence

Given a complicated expression,

```
6%2*5+4/2+88-10
```

we can re-write the expression and place some parenthesis base on operator precedence,

```
((6%2)*5)+(4/2)+88-10;
```

Coding Guidelines
To avoid confusion in evaluating mathematical operations, keep your expressions simple and use parenthesis.

4.11 Exercises

4.11.1 Declaring and printing variables

Given the table below, declare the following variables with the corresponding data types and initialization values. Output to the screen the variable names together with the values.

Variable name	*Data Type*	*Initial value*
number	integer	10
letter	character	a
result	boolean	true
str	String	hello

The following should be the expected screen output,

```
Number = 10
letter = a
result = true
str = hello
```

4.11.2 Getting the average of three numbers

Create a program that outputs the average of three numbers. Let the values of the three numbers be, 10, 20 and 45. The expected screen output is,

```
number 1 = 10
number 2 = 20
number 3 = 45
Average is = 25
```

4.11.3 Output greatest value

Given three numbers, write a program that outputs the number with the greatest value among the three. Use the conditional ?: operator that we have studied so far (**HINT**: You will need to use two sets of **?:** to solve this). For example, given the numbers 10, 23 and 5, your program should output,

```
number 1 = 10
number 2 = 23
number 3 = 5
The highest number is = 23
```

4.11.4 Operator precedence

Given the following expressions, re-write them by writing some parenthesis based on the sequence on how they will be evaluated.
1. a / b ^ c ^ d – e + f – g * h + i
2. 3 * 10 *2 / 15 – 2 + 4 ^ 2 ^ 2
3. r ^ s * t / u – v + w ^ x – y++

5 Getting Input from the Keyboard

5.1 Objectives

Now that we've studied some basic concepts in Java and we've written some simple programs, let's make our programs more interactive by getting some input from the user. In this section, we'll be discussing two methods of getting input, the first one is through the use of the BufferedReader class and the other one involves a graphical user interface by using JOptionPane.

At the end of the lesson, the student should be able to:

- Create an interactive Java program that gets input from the keyboard
- Use the BufferedReader class to get input from the keyboard using a console
- Use the JOptionPane class to get input from the keyboard using a graphical user interface

5.2 Using BufferedReader to get input

In this section, we will use the `BufferedReader` class found in the `java.io` package in order to get input from the keyboard.

Here are the steps to get input from the keyboard:

1. Add this at the top of your code:

   import java.io.*;

2. Add this statement:

```
BufferedReader dataIn = new BufferedReader(
                        new InputStreamReader( System.in) );
```

3. Declare a temporary String variable to get the input, and invoke the readLine() method to get input from the keyboard. You have to type it inside a try-catch block.

```
try{
    String temp = dataIn.readLine();
}
catch( IOException e ){
    System.out.println("Error in getting input");
}
```

Here is the complete source code:

```
import java.io.BufferedReader;
import java.io.InputStreamReader;
import java.io.IOException;


public class GetInputFromKeyboard
{
    public static void main( String[] args ){

      BufferedReader dataIn = new BufferedReader(new
            InputStreamReader( System.in) );

      String name = "";


      System.out.print("Please Enter Your Name:");

      try{
            name = dataIn.readLine();
            }catch( IOException e ){
            System.out.println("Error!");
      }

      System.out.println("Hello " + name +"!");
    }
}
```

Now let's try to explain each line of code:

The statements,

```
import java.io.BufferedReader;
import java.io.InputStreamReader;
import java.io.IOException;
```

indicate that we want to use the classes **`BufferedReader`**, **`InputStreamReader`** and **`IOException`** which is inside the **`java.io`** **package**. The Java Application Programming Interface (API) contains hundreds of predefined classes that you can use in your programs. These classes are organized into what we call **packages.**

Packages contain classes that have related purpose. Just like in our example, the **`java.io`** package contains classes that allow programs to input and output data. The statements can also be rewritten as,

```
import java.io.*;
```

which will load all the classes found in the package, and then we can use those classes inside our program.

The next two statements,

```
public class GetInputFromKeyboard
{
    public static void main( String[] args ){
```

were already discussed in the previous lesson. This means we declare a class named `GetInputFromKeyboard` and we declare the `main` method.

In the statement,

```
BufferedReader dataIn = new BufferedReader(new
            InputStreamReader( System.in) );
```

we are declaring a variable named **dataIn** with the class type **BufferedReader**. Don't worry about what the syntax means for now. We will cover more about this later in the course.

Now, we are declaring a String variable with the identifier `name`,

```
String name = "";
```

This is where we will store the input of the user. The variable name is initialized to an empty String "". It is always good to initialize your variables as you declare them.

The next line just outputs a String on the screen asking for the user's name.

```
System.out.print("Please Enter Your Name:");
```

Now, the following block defines a try-catch block,

```
try{
    name = dataIn.readLine();
}catch( IOException e ){
    System.out.println("Error!");
}
```

This assures that the possible exceptions that could occur in the statement

```
name = dataIn.readLine();
```

will be catched. We will cover more about exception handling in the latter part of this course, but for now, just take note that you need to add this code in order to use the readLine() method of BufferedReader to get input from the user.

Now going back to the statement,

```
name = dataIn.readLine();
```

the method call, `dataIn.readLine()`, gets input from the user and will return a String value. This value will then be saved to our `name` variable, which we will use in our final statement to greet the user,

```
System.out.println("Hello " + name + "!");
```

5.3 Using JOptionPane to get input

Another way to get input from the user is by using the `JOptionPane` class which is found in the `javax.swing` package. `JOptionPane` makes it easy to pop up a standard dialog box that prompts users for a value or informs them of something.

Given the following code,

```
import javax.swing.JOptionPane;

public class GetInputFromKeyboard
{

     public static void main( String[] args ){
        String name = "";
        name = JoptionPane.showInputDialog("Please enter your
                                        name");

        String msg = "Hello " + name + "!";

        JOptionPane.showMessageDialog(null, msg);

     }
}
```

This will output,

Figure 5.1: Getting Input Using JOptionPane

Figure 5.2: Input florence on the JOptionPane

Figure 5.3: Showing Message Using JOptionPane

The first statement,

```
import javax.swing.JOptionPane;
```

indicates that we want to import the class `JOptionPane` from the `javax.swing` package.

We can also write this as,

```
import javax.swing.*;
```

The statement,

```
name = JOptionPane.showInputDialog("Please enter your name");
```

creates a `JOptionPane` input dialog, which will display a dialog with a message, a textfield and an OK button as shown in the figure. This returns a String which we will save in the `name` variable.

Now we create the welcome message, which we will store in the `msg` variable,

```
String msg = "Hello " + name + "!";
```

The next line displays a dialog which contains a message and an OK button.

```
JOptionPane.showMessageDialog(null, msg);
```

5.4 Exercises

5.4.1 Last 3 words (BufferedReader version)

Using BufferedReader, ask for three words from the user and output those three words on the screen. For example,

```
Enter word1:Goodbye
Enter word2:and
Enter word3:Hello

Goodbye and Hello
```

5.4.2 Last 3 words (JOptionPane version)

Using JOptionPane, ask for three words from the user and output those three words on the screen. For example,

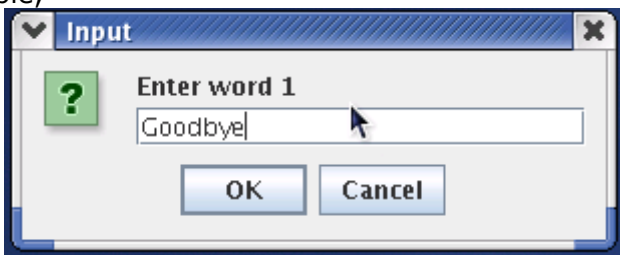


Figure 5.4: First Input

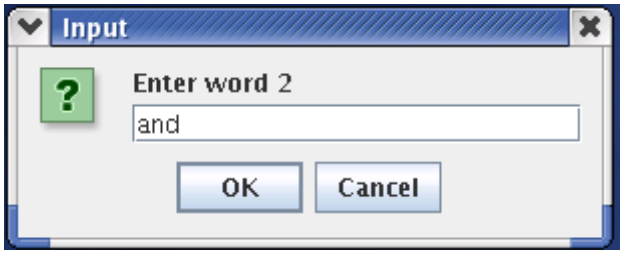


Figure 5.5: Second Input

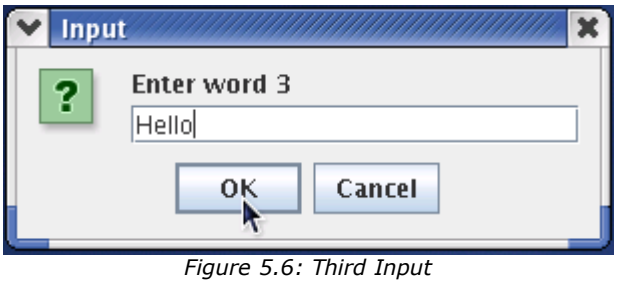


Figure 5.6: Third Input

Figure 5.7: Show Message

6 Control Structures

6.1 Objectives

In the previous sections, we have given examples of sequential programs, wherein statements are executed one after another in a fixed order. In this section, we will be discussing control structures, which allows us to change the ordering of how the statements in our programs are executed.

At the end of the lesson, the student should be able to:

- Use decision control structures (if, else, switch) which allows selection of specific sections of code to be executed
- Use repetition control structures (while, do-while, for) which allow executing specific sections of code a number of times
- Use branching statements (break, continue, return) which allows redirection of program flow

6.2 Decision Control Structures

Decision control structures are Java statements that allows us to select and execute specific blocks of code while skipping other sections.

6.2.1 if statement

The if-statement specifies that a statement (or block of code) will be executed *if and only if a certain boolean statement is true.*

The if-statement has the form,

```
if( boolean_expression )
      statement;
```

or

```
if( boolean_expression ){
      statement1;
      statement2;
      . . .
}
```

where, boolean_expression is either a boolean expression or boolean variable.

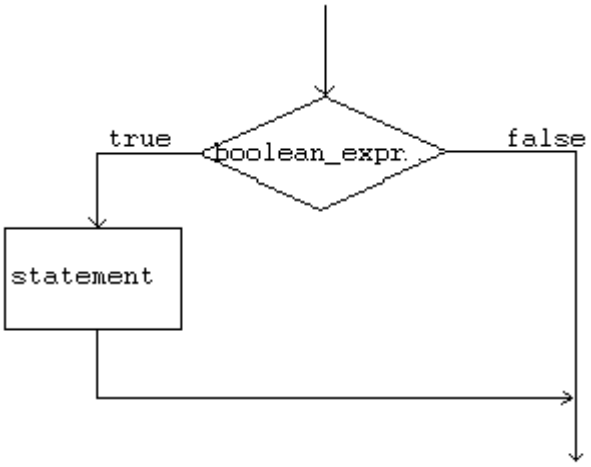


Figure 6.1: Flowchart of If-Statement

For example, given the code snippet,

```
int grade = 68;

if( grade > 60 ) System.out.println("Congratulations!");
```

or

```
int grade = 68;

if( grade > 60 ){
      System.out.println("Congratulations!");
      System.out.println("You passed!");
}
```

Coding Guidelines:

1. *The **boolean_expression** part of a statement should evaluate to a boolean value. That means that the execution of the condition should either result to a value of **true** or a **false**.*
2. *Indent the statements inside the if-block.For example,*

```
if( boolean_expression ){
    //statement1;
    //statement2;
}
```

6.2.2 if-else statement

The if-else statement is used when we want to execute a certain statement if a condition is true, and a different statement if the condition is false.

The if-else statement has the form,

```
if( boolean_expression )
      statement;
else
      statement;
```

or can also be written as,

```
if( boolean_expression ){
      statement1;
      statement2;
      . . .
}
else{
      statement1;
      statement2;
      . . .
}
```

For example, given the code snippet,

```
int grade = 68;

if( grade > 60 )   System.out.println("Congratulations!");
else        System.out.println("Sorry you failed");
```

or

```
int grade = 68;

if( grade > 60 ){
      System.out.println("Congratulations!");
      System.out.println("You passed!");
}
else{
      System.out.println("Sorry you failed");
}
```

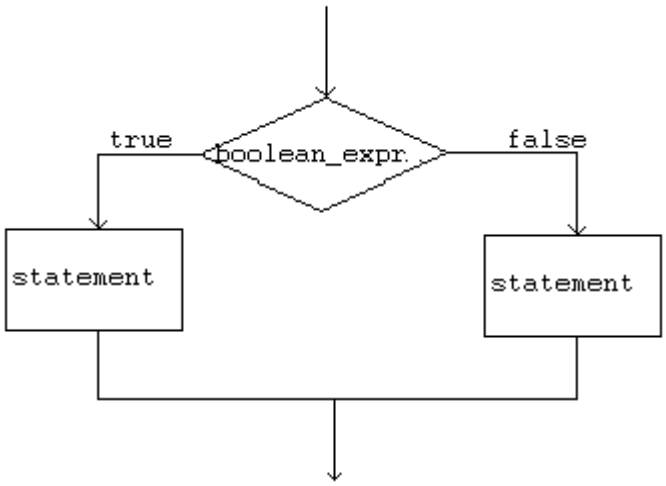


Figure 6.2: Flowchart of If-Else Statement

Coding Guidelines:

1. *To avoid confusion, always place the statement or statements of an if or if-else block inside brackets {}.*
2. *You can have nested if-else blocks. This means that you can have other if-else blocks inside another if-else block.For example,*

```
if( boolean_expression ){
        if( boolean_expression ){
                . . .
        }
}
else{ . . .
}
```

6.2.3 if-else-if statement

The statement in the else-clause of an if-else block can be another if-else structures. This cascading of structures allows us to make more complex selections.

The if-else if statement has the form,

```
if( boolean_expression1 )
      statement1;
else if( boolean_expression2 )
      statement2;
else
      statement3;
```

Take note that you can have many else-if blocks after an if-statement. The else-block is optional and can be omitted. In the example shown above, if boolean_expression1 is true, then the program executes statement1 and skips the other statements. If boolean_expression2 is true, then the program executes statement 2 and skips to the statements following statement3.

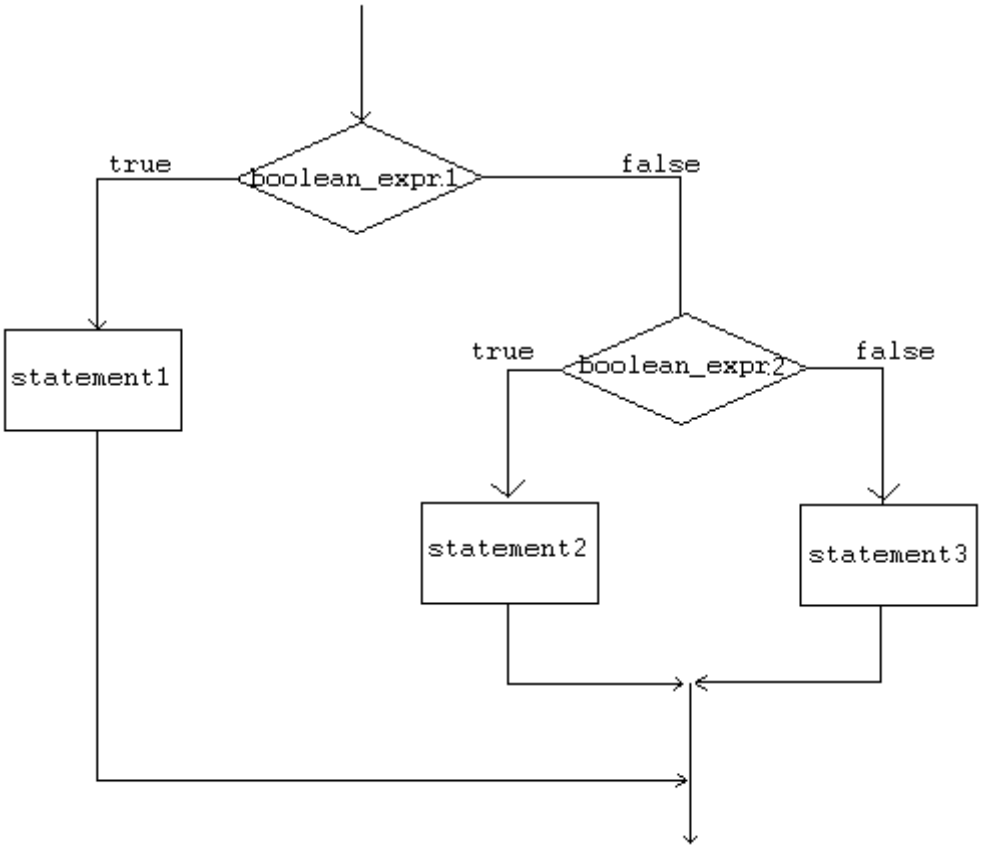


Figure 6.3: Flowchart of If-Else-If Statement

For example, given the code snippet,

```
int grade = 68;

if( grade > 90 ){
      System.out.println("Very good!");
}
else if( grade > 60 ){
      System.out.println("Very good!");
}
else{
      System.out.println("Sorry you failed");
}
```

6.2.4 Common Errors when using the if-else statements:

1. The condition inside the if-statement does not evaluate to a boolean value. For example,

```
//WRONG
int number = 0;
if( number ){
      //some statements here
}
```

The variable number does not hold a Boolean value.

2. Using = instead of == for comparison. For example,

```
//WRONG
int number = 0;
if( number = 0 ){
      //some statements here
}
```

This should be written as,

```
//CORRECT
int number = 0;
if( number == 0 ){
      //some statements here
}
```

3. Writing **elseif** instead of **else if**.

6.2.5 Example for if-else-else if

```
public class Grade
{
    public static void main( String[] args )
    {
        double grade = 92.0;

        if( grade >= 90 ){
               System.out.println( "Excellent!" );
        }
        else if( (grade < 90) && (grade >= 80)){
               System.out.println("Good job!" );
        }
        else if( (grade < 80) && (grade >= 60)){
               System.out.println("Study harder!" );
        }
        else{
               System.out.println("Sorry, you failed.");
        }
    }
}
```

6.2.6 switch statement

Another way to indicate a branch is through the **switch** keyword. The switch construct allows branching on multiple outcomes.

The switch statement has the form,

```
switch( switch_expression ){
      case case_selector1:
            statement1; //
            statement2; //block 1
            . . .       //
            break;

      case case_selector2:
            statement1; //
            statement2; //block 2
            . . .       //
            break;
      . . .
      default:
            statement1; //
            statement2; //block n
            . . .       //
            break;
}
```

where, switch_expression is an **integer** or **character** expression and, case_selector1, case_selector2 and so on, are unique integer or character constants.

When a switch is encountered, Java first evaluates the switch_expression, and jumps to the case whose selector matches the value of the expression. The program executes the statements in order from that point on until a break statement is encountered, skipping then to the first statement after the end of the switch structure.

If none of the cases are satisfied, the default block is executed. Take note however, that the default part is optional. A switch statement can have no default block.

NOTES:

- Unlike with the **if** statement, the multiple statements are executed in the switch statement without needing the curly braces.
- When a case in a switch statement has been matched, all the statements associated with that case are executed. Not only that, the statements associated with the succeeding cases are also executed.
- To prevent the program from executing statements in the subsequent cases, we use a **break** statement as our last statement.

Coding Guidelines:

1. *Deciding whether to use an if statement or a switch statement is a judgment call. You can decide which to use, based on readability and other factors.*
2. *An if statement can be used to make decisions based on ranges of values or conditions, whereas a switch statement can make decisions based only on a single integer or character value. Also, the value provided to each case statement must be unique.*

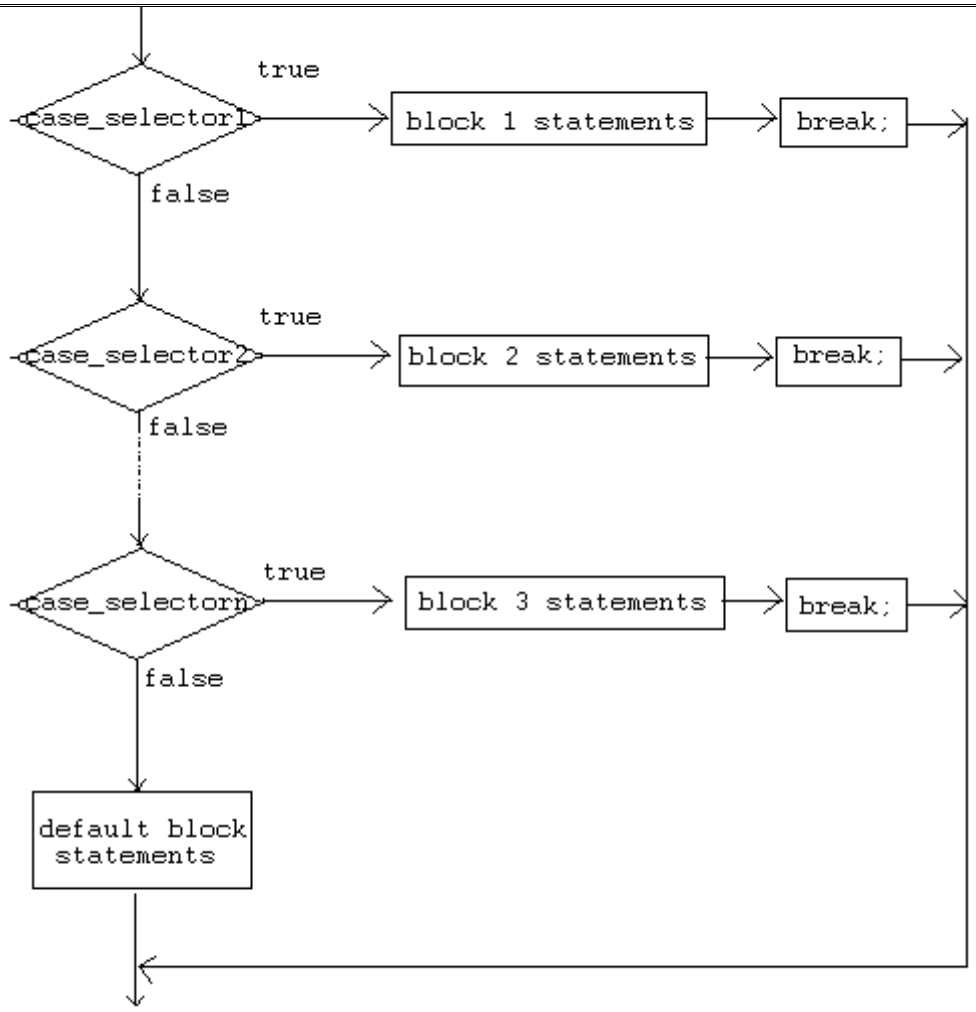


Figure 6.4: Flowchart of Switch Statements

6.2.7 Example for switch

```
public class Grade
{
    public static void main( String[] args )
    {
        int grade = 92;

        switch(grade){
      case 100:
                System.out.println( "Excellent!" );
                break;
      case 90:
                System.out.println("Good job!" );
                break;
      case 80:
                System.out.println("Study harder!" );
                break;
      default:
                System.out.println("Sorry, you failed.");
        }
    }
}
```

6.3 Repetition Control Structures

Repetition control structures are Java statements that allows us to execute specific blocks of code a number of times. There are three types of repetition control structures, the while, do-while and for loops.

6.3.1 while loop

The while loop is a statement or block of statements that is repeated as long as some condition is satisfied.

The while statement has the form,

```
while( boolean_expression ){
      statement1;
      statement2;
      . . .
}
```

The statements inside the while loop are executed as long as the boolean_expression evaluates to true.

For example, given the code snippet,

```
int i = 4;
while ( i > 0 ){
      System.out.print(i);
      i--;
}
```

The sample code shown will print `4321` on the screen. Take note that if the line containing the statement `i--;` is removed, this will result to an **infinite loop**, or a loop that does not terminate. Therefore, when using while loops or any kind of repetition control structures, make sure that you add some statements that will allow your loop to terminate at some point.

The following are other examples of while loops,

Example 1:

```
int x = 0;
while (x<10)
{
      System.out.println(x);
      x++;
}
```

Example 2:

```
//infinite loop
while(true)
      System.out.println("hello");
```

Example 3:

```
//no loops
// statement is not even executed
while (false)
      System.out.println("hello");
```

6.3.2 do-while loop

The do-while loop is similar to the while-loop. The statements inside a do-while loop are executed several times as long as the condition is satisfied.

The main difference between a while and do-while loop is that, the statements inside a do-while loop are executed **at least once.**

The do-while statement has the form,

```
do{
      statement1;
      statement2;
      . . .
}while( boolean_expression );
```

The statements inside the do-while loop are first executed, and then the condition in the boolean_expression part is evaluated. If this evaluates to true, the statements inside the do-while loop are executed again.

Here are a few examples that uses the do-while loop:

Example 1:

```
int x = 0;
do
{
      System.out.println(x);
      x++;
}while (x<10);
```

This example will output `0123456789` on the screen.

Example 2:

```
//infinite loop
do{
       System.out.println("hello");
} while (true);
```

This example will result to an infinite loop, that prints `hello` on screen.

Example 3:

```
//one loop
// statement is executed once
do
  System.out.println("hello");
while (false);
```

This example will output `hello` on the screen.

Coding Guidelines:

1. *Common programming mistakes when using the do-while loop is forgetting to write the semi-colon after the while expression.*
   do{
   ...
   }while(boolean_expression) //WRONG->forgot semicolon ;
2. *Just like in while loops, make sure that your do-while loops will terminate at some point.*

6.3.3 for loop

The for loop, like the previous loops, allows execution of the same code a number of times.

The for loop has the form,

```
for (InitializationExpression; LoopCondition; StepExpression){
      statement1;
      statement2;
      . . .
}
```

where,

InitializationExpression -initializes the loop variable.
LoopCondition **-** compares the loop variable to some limit value.
StepExpression - updates the loop variable.

A simple example of the for loop is,

```
int i;
for( i = 0; i < 10; i++ ){
      System.out.print(i);
}
```

In this example, the statement i=0, first initializes our variable. After that, the condition expression i<10 is evaluated. If this evaluates to true, then the statement inside the for loop is executed. Next, the expression i++ is executed, and then the condition expression is again evaluated. This goes on and on, until the condition expression evaluates to false.

This example, is equivalent to the while loop shown below,

```
int i = 0;
while( i < 10 ){
      System.out.print(i);
      i++;
}
```

6.4 Branching Statements

Branching statements allows us to redirect the flow of program execution. Java offers three branching statements: break, continue and return.

6.4.1 break statement

The break statement has two forms: unlabeled (we saw its unlabeled form in the switch statement) and labeled.

6.4.1.1 Unlabeled break statement

The unlabeled break terminates the enclosing switch statement, and flow of control transfers to the statement immediately following the switch. You can also use the unlabeled form of the `break` statement to terminate a for, while, or do-while loop.

For example,

```
String names[] = {"Beah", "Bianca", "Lance", "Belle",
            "Nico", "Yza", "Gem", "Ethan"};

String      searchName = "Yza";
boolean     foundName = false;

for( int i=0; i< names.length; i++ ){
      if( names[i].equals( searchName )){
            foundName = true;
            break;
      }
}

if( foundName ){
      System.out.println( searchName + " found!" );
}
else{
      System.out.println( searchName + " not found." );
}
```

In this example, if the search string "Yza" is found, the for loop will stop and flow of control transfers to the statement following the for loop.

6.4.1.2 Labeled break statement

The labeled form of a break statement terminates an outer statement, which is identified by the label specified in the break statement. The following program searches for a value in a two-dimensional array. Two nested for loops traverse the array. When the value is found, a labeled break terminates the statement labeled search, which is the outer for loop.

```
int[][] numbers = {{1, 2, 3},                          {4, 5, 6},
            {7, 8, 9}};

int searchNum = 5;
boolean foundNum = false;

searchLabel:
for( int i=0; i<numbers.length; i++ ){
      for( int j=0; j<numbers[i].length; j++ ){
            if( searchNum == numbers[i][j] ){
                  foundNum = true;
                  break searchLabel;
            }
      }
}

if( foundNum ){
      System.out.println( searchNum + " found!" );
}
else{
      System.out.println( searchNum + " not found!" );
}
```

The break statement terminates the labeled statement; it does not transfer the flow of control to the label. The flow of control transfers to the statement immediately following the labeled (terminated) statement.

6.4.2 continue statement

The continue statement has two forms: unlabeled and labeled. You can use the continue statement to skip the current iteration of a for, while or do-while loop.

6.4.2.1 Unlabeled continue statement

The unlabeled form skips to the end of the innermost loop's body and evaluates the boolean expression that controls the loop, basically skipping the remainder of this iteration of the loop.

The following example counts the number of "Beah"s in the array.

```
String names[] = {"Beah", "Bianca", "Lance", "Beah"};
int   count = 0;

for( int i=0; i<names.length; i++ ){

      if( !names[i].equals("Beah") ){
            continue;   //skip next statement
      }

      count++;
}

System.out.println("There are " + count + " Beahs in the
list");
```

6.4.2.2 Labeled continue statement

The labeled form of the continue statement skips the current iteration of an outer loop marked with the given label.

```
outerLoop:
for( int i=0; i<5; i++ ){

    for( int j=0; j<5; j++ ){
       System.out.println("Inside for(j) loop"); //message1
       if( j == 2 )      continue outerLoop;
    }

    System.out.println("Inside for(i) loop"); //message2
}
```

In this example, message 2 never gets printed since we have the statement continue outerloop which skips the iteration.

6.4.3 return statement

The return statement is used to exit from the current method. The flow of control returns to the statement that follows the original method call. The return statement has two forms: one that returns a value and one that doesn't.

To return a value, simply put the value (or an expression that calculates the value) after the return keyword. For example,

```
return ++count;
```

or

```
return      "Hello";
```

The data type of the value returned by return must match the type of the method's declared return value. When a method is declared void, use the form of return that doesn't return a value. For example,

```
return;
```

We will cover more about return statements later when we discuss about methods.

6.5 Exercises

6.5.1 Grades

Get three exam grades from the user and compute the average of the grades. Output the average of the three exams. Together with the average, also include a smiley face in the output if the average is greater than or equal to 60, otherwise output :-(.
1. Use BufferedReader to get input from the user, and System.out to output the result.
2. Use JOptionPane to get input from the user and to output the result.

6.5.2 Number in words

Get a number as input from the user, and output the equivalent of the number in words. The number inputted should range from 1-10. If the user inputs a number that is not in the range, output, "Invalid number".
1. Use an if-else statement to solve this problem
2. Use a switch statement to solve this problem

6.5.3 Hundred Times

Create a program that prints your name a hundred times. Do three versions of this program using a while loop, a do-while loop and a for-loop.

6.5.4 Powers

Compute the power of a number given the base and exponent. Do three versions of this program using a while loop, a do-while loop and a for-loop.

7 Java Arrays

7.1 Objectives

In this section, we will be discussing about Java Arrays. First, we are going to define what arrays are, and then we are going to discuss on how to declare and use them.

At the end of the lesson, the student should be able to:

- Declare and create arrays
- Access array elements
- Determine the number of elements in an array
- Declare and create multidimensional arrays

7.2 Introduction to arrays

In the previous sections, we have discussed on how to declare different variables using the primitive data types. In declaring variables, we often use a unique identifier or name and a datatype. In order to use the variable, we call it by its identifier name.

For example, we have here three variables of type `int` with different identifiers for each variable.

```
int number1;
int number2;
int number3;

number1 = 1;
number2 = 2;
number3 = 3;
```

As you can see, it seems like a tedious task in order to just initialize and use the variables especially if they are used for the same purpose. In Java and other programming languages, there is one capability wherein we can use one variable to store a list of data and manipulate them more efficiently. This type of variable is called an **array**.

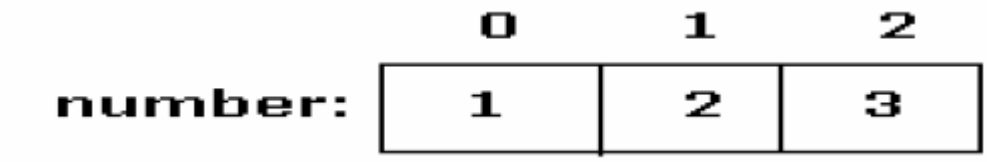


Figure 7.1: Example of an Integer Array

An **array** stores *multiple data items of the same datatype*, in a contiguous block of memory, divided into a number of slots. Think of an array as a stretched variable – a location that still has one identifier name, but can hold more than one value.

7.3 Declaring Arrays

Arrays must be declared like all variables. When declaring an array, you list the data type, followed by a set of square brackets[], followed by the identifier name. For example,

```
int []ages;
```

or you can place the brackets after the identifier. For example,

```
int ages[];
```

After declaring, we must create the array and specify its length with a **constructor** statement. This process in Java is called **instantiation** (the Java word for creates). In order to instantiate an object, we need to use a **constructor** for this. We will cover more about instantiating objects and constructors later. Take note, that the size of an array cannot be changed once you've initialized it. For example,

```
//declaration
int ages[];

//instantiate object
ages = new int[100];
```

or, can also be written as,

```
//declare and instantiate
object
int ages[] = new
int[100];
```

In the example, the declaration tells the Java Compiler that the identifier `ages` will be used as the name of an array containing integers, and to create or instantiate a new array containing 100 elements.

Instead of using the new keyword to instantiate an array, you can also automatically declare, construct and assign values at once.

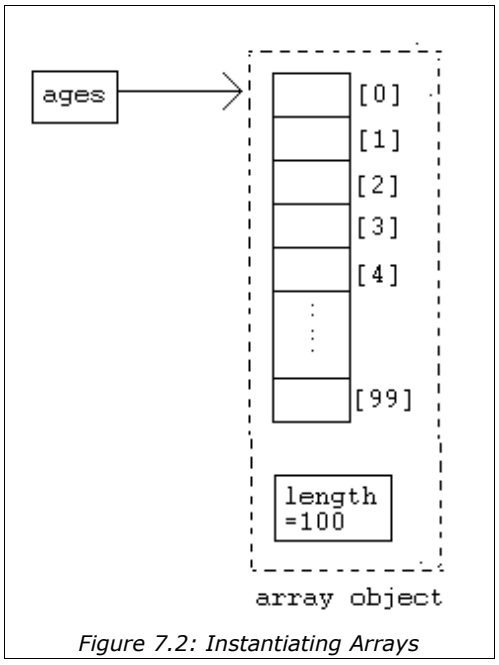


Figure 7.2: Instantiating Arrays

Examples are,

```
//creates an array of boolean variables with ientifier
//results. This array contains 4 elements that are
//initialized to values {true, false, true, false}
boolean results[] ={ true, false, true, false };

//creates an array of 4 double variables initialized
//to the values  {100, 90, 80, 75};
double []grades = {100, 90, 80, 75};

//creates an array of Strings with identifier days and
//initialized. This array contains 7 elements
String days[] = { "Mon", "Tue", "Wed", "Thu", "Fri", "Sat", "Sun"};
```

7.4 Accessing an array element

To access an array element, or a part of the array, you use a number called an **index** or a subscript.

An **index number or subscript** is assigned to each member of the array, allowing the program and the programmer to access individual values when necessary. Index numbers **are always integers**. They **begin with zero and progress sequentially by whole numbers to the end of the array**. Take note that the elements inside your array is from **0 to (sizeOfArray-1).**

For example, given the array we declared a while ago, we have

```
//assigns 10 to the first element in the array
ages[0] = 10;

//prints the last element in the array
System.out.print(ages[99]);
```

Take note that once an array is declared and constructed, the stored value of each member of the array will be initialized to zero for number data. However, reference data types such as Strings are not initialized to blanks or an empty string "". Therefore, you must populate the String arrays explicitly.

The following is a sample code on how to print all the elements in the array. This uses a for loop, so our code is shorter.

```
public class ArraySample{
      public static void main( String[] args ){

            int[] ages = new int[100];

            for( int i=0; i<100; i++ ){
                  System.out.print( ages[i] );
            }
      }
}
```

Coding Guidelines:

1. It is usually better to initialize or instantiate the array right away after you declare it. For example, the declaration,
int []arr = new int[100];
is preferred over,
int []arr;
arr = new int[100];
2. The elements of an n-element array have indexes from 0 to n-1. Note that there is no array element arr[n]! This will result in an array-index-out-of-bounds exception.
3. You cannot resize an array.

7.5 Array length

In order to get the number of elements in an array, you can use the **length** field of an array. The length field of an array returns the size of the array. It can be used by writing,

```
arrayName.length
```

For example, given the previous example, we can re-write it as,

```
public class ArraySample
{
      public static void main( String[] args ){

            int[] ages = new int[100];

            for( int i=0; i<ages.length; i++ ){
                  System.out.print( ages[i] );
            }
      }
}
```

Coding Guidelines:

1. *When creating for loops to process the elements of an array, use the array object's **length** field in the condition statement of the for loop. This will allow the loop to adjust automatically for different-sized arrays.*
2. *Declare the sizes of arrays in a Java program using named constants to make them easy to change. For example,*

```
final int ARRAY_SIZE = 1000;       //declare a constant
 . . .
int[] ages = new int[ARRAY_SIZE];
```

7.6 Multidimensional Arrays

Multidimensional arrays are implemented as arrays of arrays. Multidimensional arrays are declared by appending the appropriate number of bracket pairs after the array name. For example,

```
// integer array 512 x 128 elements
int[][] twoD = new int[512][128];

// character array 8 x 16 x 24
char[][][] threeD = new char[8][16][24];

// String array 4 rows x 2 columns
String[][] dogs = {{ "terry", "brown" },
            { "Kristin", "white" },
            { "toby", "gray"},
            { "fido", "black"}
            };
```

To access an element in a multidimensional array is just the same as accessing the elements in a one dimensional array. For example, to access the first element in the first row of the array dogs, we write,

```
System.out.print( dogs[0][0] );
```

This will print the String "terry" on the screen.

7.7 Exercises

7.7.1 Days of the Week

Create an array of Strings which are initialized to the 7 days of the week. For Example,

```
String days[] = {"Monday", "Tuesday"….};
```

Using a while-loop, print all the contents of the array. (do the same for do-while and for-loop)

7.7.2 Greatest number

Using BufferedReader or JOptionPane, ask for 10 numbers from the user. Use an array to store the values of these 10 numbers. Output on the screen the number with the greatest value.

7.7.3 Addressbook Entries

Given the following multidimensional array that contains addressbook entries:

```
String entry = {{"Florence", "735-1234", "Manila"},
                {"Joyce", "983-3333", "Quezon City"},
                {"Becca", "456-3322", "Manila"}};
```

Print the following entries on screen in the following format:

```
Name  : Florence
Tel. #      : 735-1234
Address     : Manila

Name  : Joyce
Tel. #      : 983-3333
Address     : Quezon City

Name  : Becca
Tel. #      : 456-3322
Address     : Manila
```

8 Command-line Arguments

8.1 Objectives

In this section, we will study on how to process input from the command-line by using arguments pass onto a Java program.

At the end of the lesson, the student should be able to:

- Know and explain what a command-line argument is
- Get input from the user using command-line arguments
- Learn how to pass arguments to your programs in NetBeans

8.2 Command-line arguments

A Java application can accept any number of arguments from the command-line. Command-line arguments allow the user to affect the operation of an application for one invocation. The user enters command-line arguments when invoking the application and specifies them after the name of the class to run.

For example, suppose you have a Java application, called Sort, that sorts five numbers, you run it like this:

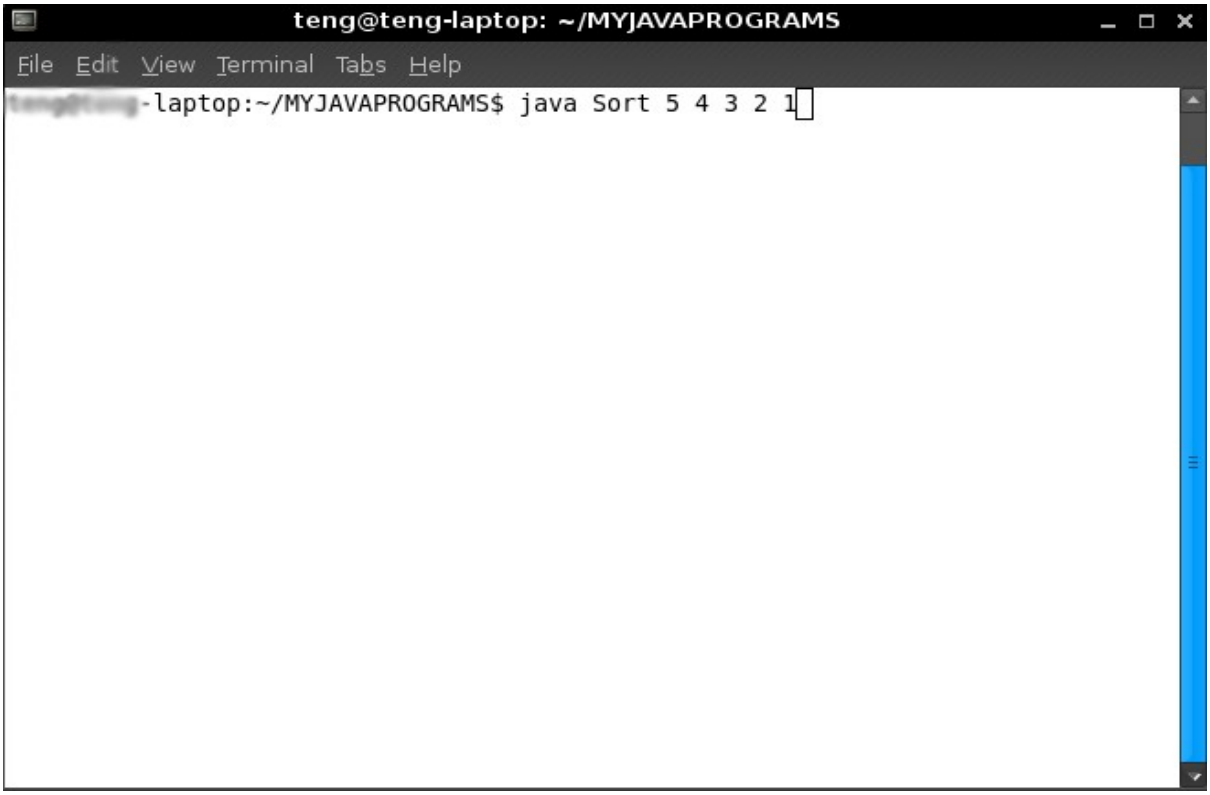


Figure 8.1: Running with Command-Line Arguments

Take note that the arguments are separated by spaces.

In the Java language, when you invoke an application, the runtime system passes the command-line arguments to the application's main method via an array of Strings. Each String in the array contains one of the command-line arguments. Remember the declaration for the main method,

```
public static void main( String[] args )
```

The arguments that are passed to your program are saved into an array of String with the args identifier.

In the previous example, the command-line arguments passed to the Sort application is an array that contains five strings which are: "5", "4", "3", "2" and "1". You can derive the number of command-line arguments with the array's length attribute.

For example,

```
int numberOfArgs = args.length;
```

If your program needs to support a numeric command-line argument, it must convert a String argument that represents a number, such as "34", to a number. Here's a code snippet that converts a command-line argument to an integer,

```
int firstArg = 0;
if (args.length > 0){
      firstArg = Integer.parseInt(args[0]);
}
```

parseInt throws a NumberFormatException (ERROR) if the format of args[0] isn't valid (not a number).

Coding Guidelines:
Before using command-line arguments, always check if the number of arguments before accessing the array elements so that there will be no exception generated.

8.3 Command-line arguments in NetBeans

To illustrate on how to pass some arguments to your programs in NetBeans, let us create a Java program that will print the number of arguments and the first argument passed to it.

```
public class CommandLineExample
{
    public static void main( String[] args ){

      System.out.println("Number of arguments=" +
                                 args.length);
      System.out.println("First Argument="+ args[0]);
    }
}
```

Now, run netbeans and create a new project and name this CommandLineExample. Copy the code shown above and compile the code. Now, follow these steps to pass arguments to your program using NetBeans.

Click on Projects (encircled below).

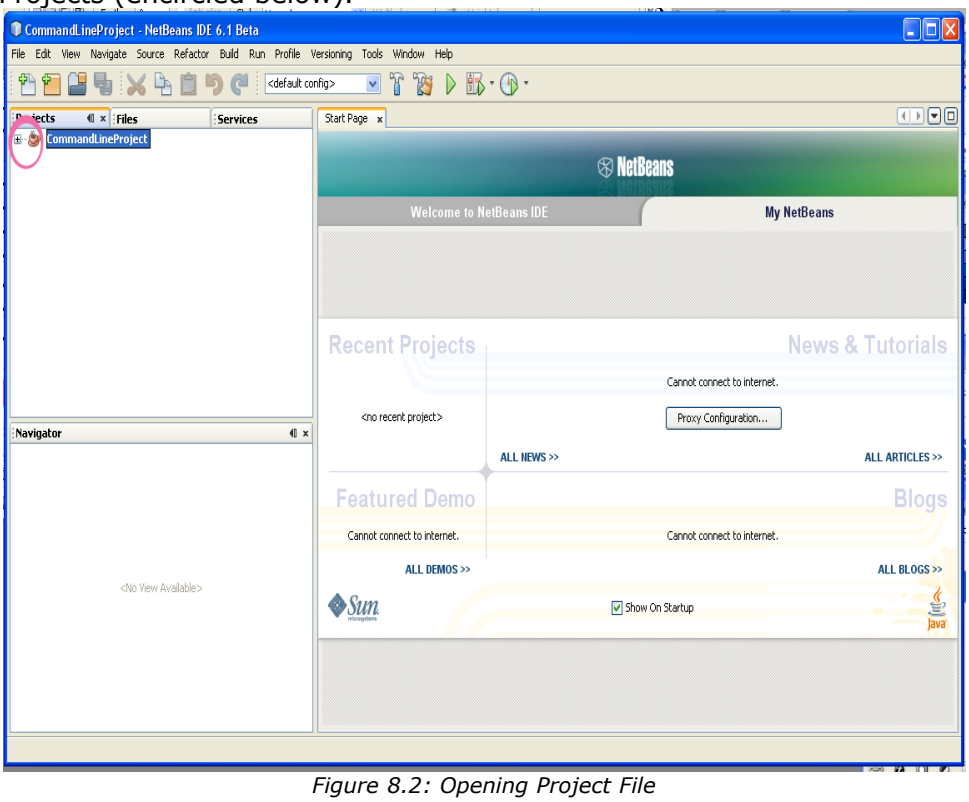


Figure 8.2: Opening Project File

Right-click on the CommandLineExample icon, and a popup menu will appear. Click on Properties.

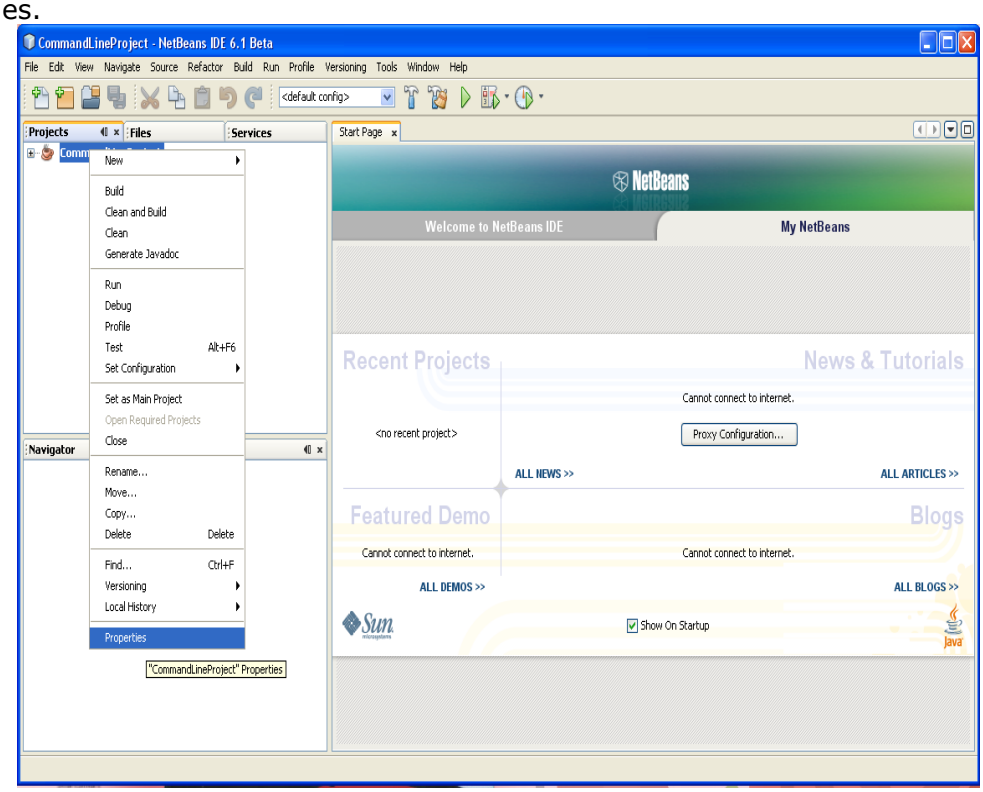


Figure 8.3: Opening Properties

The Project Properties dialog will then appear.

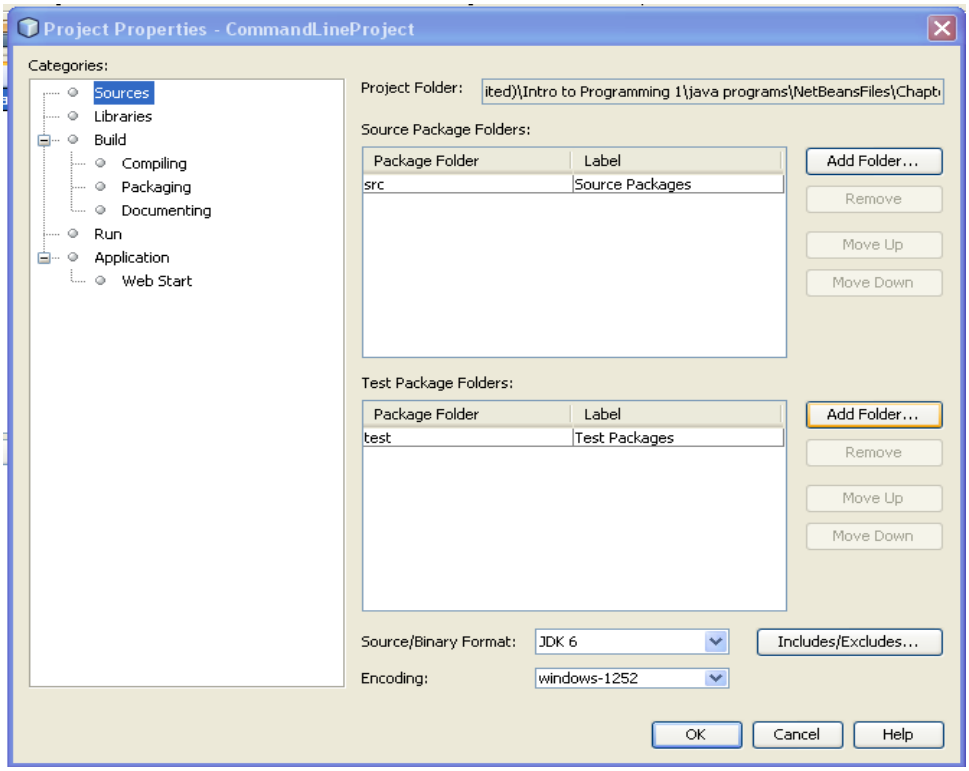


Figure 8.4: Properties Dialog

Now, click on Run

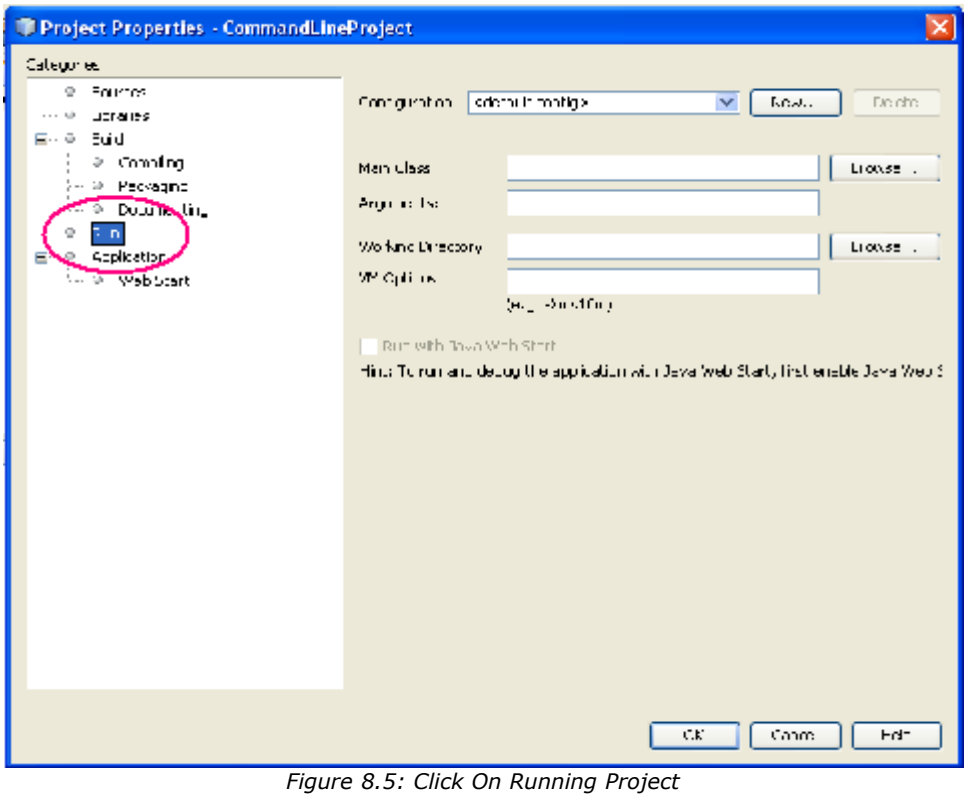


Figure 8.5: Click On Running Project

On the Arguments textbox, type the arguments you want to pass to your program. In this case we typed in the arguments 5 4 3 2 1. Then, click on the OK button.

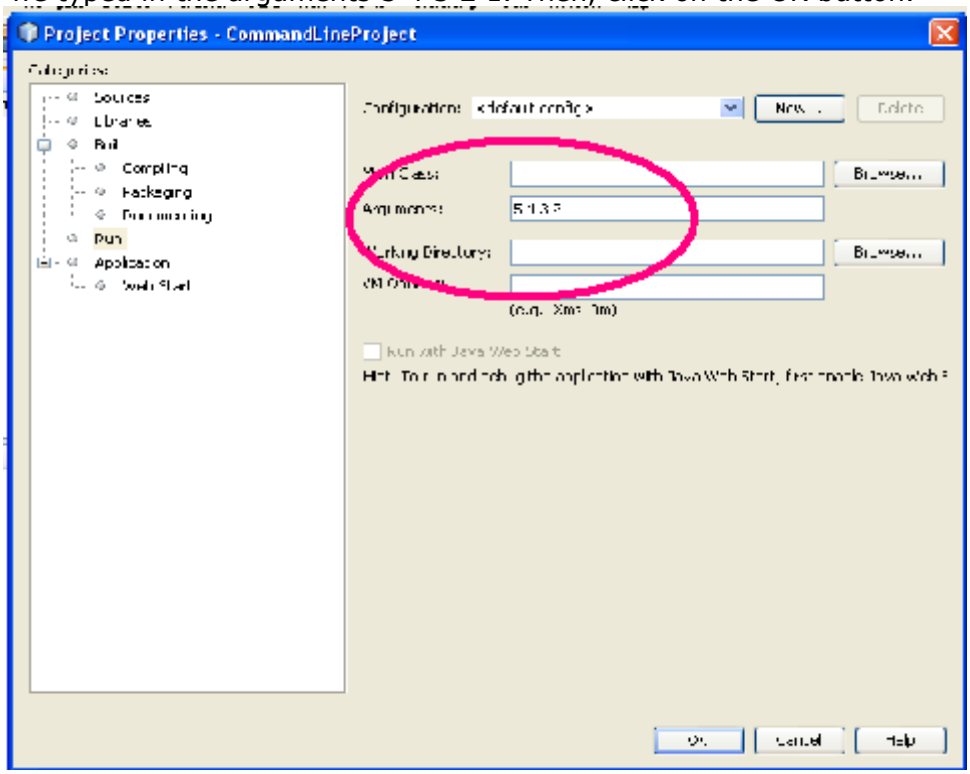


Figure 8.6: Set the Command-Line Arguments

Now try to RUN your program.

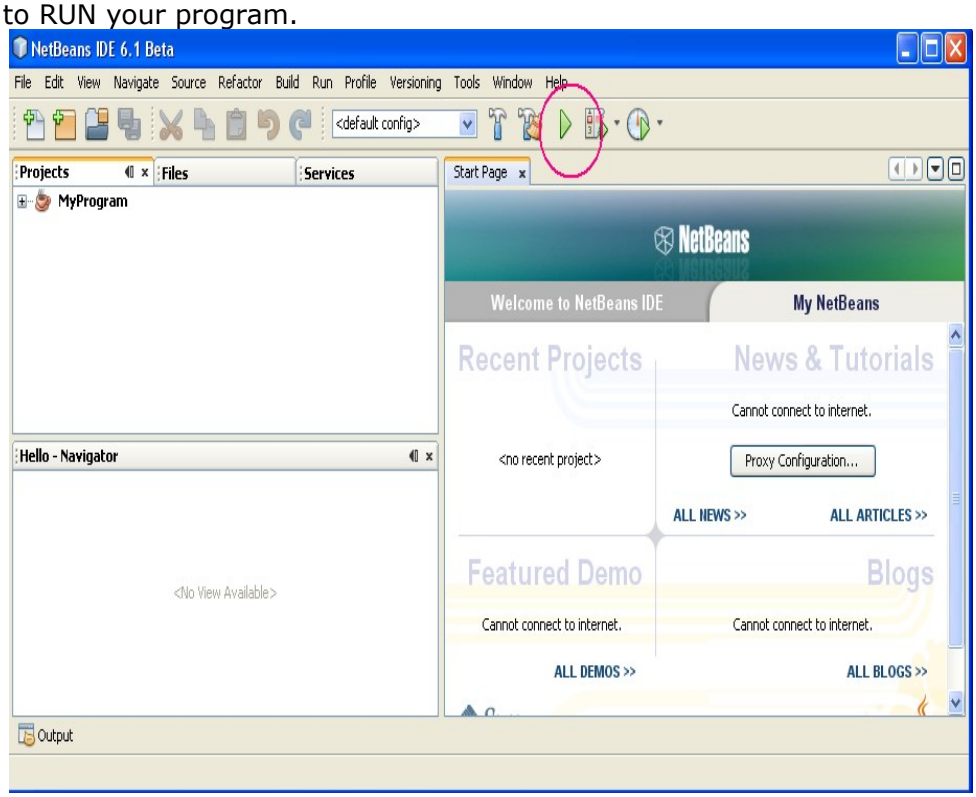


Figure 8.7: Running the Program in with the Shortcut Button

As you can see here, the output to your program is the number of arguments which is 5, and the first argument which is 5.

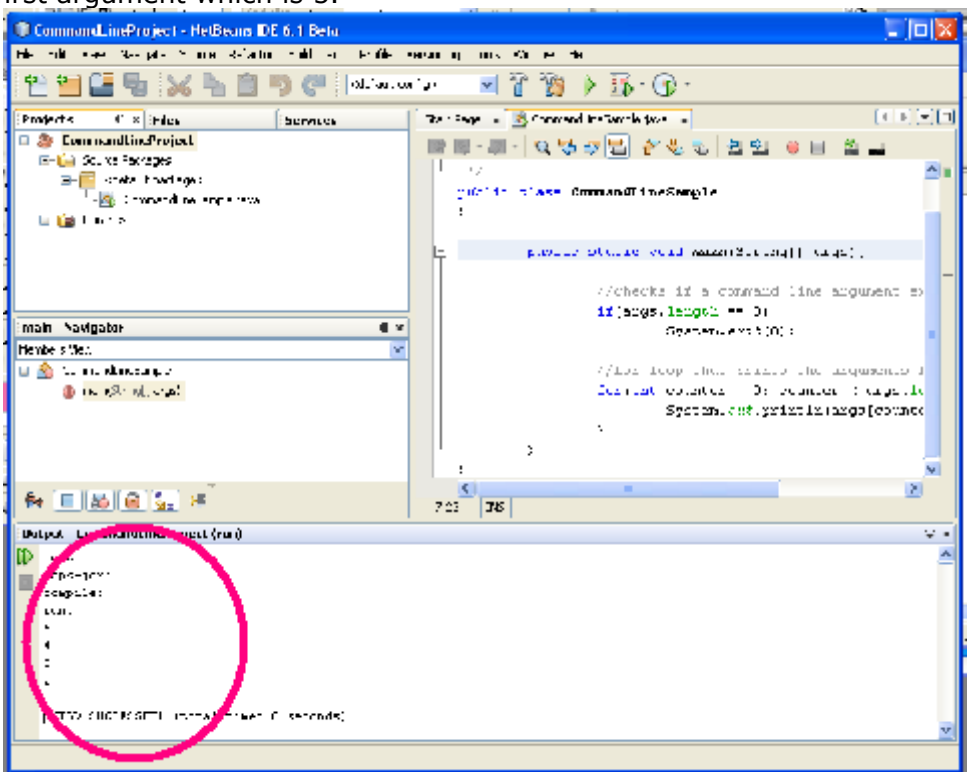


Figure 8.8: Program Output

8.4 Exercises

8.4.1 Print arguments

Get input from the user using command-line arguments and print all the arguments to the screen. For example, if the user entered,

```
java  Hello  world  that  is  all
```

your program should print

```
Hello
world
that
is
all
```

8.4.2 Arithmetic Operations

Get two numbers from the user using command-line arguments and print sum, difference, product and quotient of the two numbers. For example, if the user entered,

```
java  ArithmeticOperation  20  4
```

your program should print

```
sum = 24
difference = 16
product = 80
quotient = 5
```

9 Working with the Java Class Library

9.1 Objectives

In this section, we will introduce some basic concepts of object-oriented programming. Later on, we will discuss the concept of classes and objects, and how to use these classes and their members. Comparison, conversion and casting of objects will also be covered. For now, we will focus on using classes that are already defined in the Java class library, we will discuss later on how to create your own classes.

At the end of the lesson, the student should be able to:

- Explain object-oriented programming and some of its concepts
- Differentiate between classes and objects
- Differentiate between instance variables/methods and class(static) variables/methods
- Explain what methods are and how to call and pass parameters to methods
- Identify the scope of a variable
- Cast primitive data types and objects
- Compare objects and determine the class of an objects

9.2 Introduction to Object-Oriented Programming

Object-Oriented programming or OOP revolves around the concept of **objects** as the basic elements of your programs. When we compare this to the physical world, we can find many objects around us, such as cars, lion, people and so on. These objects are characterized by their **properties (or attributes)** and **behaviors**.

For example, a car object has the properties, *type of transmission*, *manufacturer* and *color*. Its behaviors are *turning, braking and accelerating*. Similarly, we can define different properties and behavior of a lion. Please refer to the table below for the examples.

Object	***Properties***	***Behavior***
Car	type of transmission manufacturer color	turning braking accelerating
Lion	Weight Color hungry or not hungry tamed or wild	roaring sleeping hunting

Table 17: Example of Real-life Objects

With these descriptions, the objects in the physical world can easily be modeled as software objects using the **properties as data** and the **behaviors as methods**. These data and methods could even be used in programming games or interactive software to simulate the real-world objects! An example would be a car software object in a racing game or a lion software object in an educational interactive software zoo for kids.

9.3 Classes and Objects

9.3.1 Difference Between Classes and Objects

In the software world, an **object** is a software component whose structure is similar to objects in the real world. Each object is composed of a set of **data** (properties/attributes) which are variables describing the essential characteristics of the object, and it also consists of a set of **methods** (behavior) that describes how an object behaves. Thus, an object is a software bundle of variables and related methods. The variables and methods in a Java object are formally known as **instance variables** and **instance methods** to distinguish them from class variables and class methods, which will be discussed later.

The **class** is the fundamental structure in object-oriented programming. It can be thought of as a template, a prototype or a blueprint of an object. It consists of two types of members which are called **fields (properties or attributes)** and methods. Fields specifiy the data types defined by the class, while methods specify the operations. An object is an ***instance*** of the class.

To differentiate between classes and objects, let us discuss an example. What we have here is a Car Class which can be used to define several Car Objects. In the table shown below, Car A and Car B are objects of the Car class. The class has *fields* plate number, color, manufacturer, and current speed which are filled-up with corresponding values in objects Car A and Car B. The Car has also some methods Accelerate, Turn and Brake.

Car Class		Object Car A	Object Car B
Instance Variables	Plate Number	ABC 111	XYZ 123
	Color	Blue	Red
	Manufacturer	Mitsubishi	Toyota
	Current Speed	50 km/h	100 km/h
Instance Methods	Accelerate Method		
	Turn Method		
	Brake Method		

Table 18: Example of Car class and its objects

When instantiated, each object gets a fresh set of state variables. However, the method implementations are shared among objects of the same class.

Classes provide the benefit of **reusability**. Software programmers can use a class over and over again to create many objects.

9.3.2 Encapsulation

Encapsulation is the method of hiding certain elements of the implementation of a certain class. By placing a boundary around the properties and methods of our objects, we can prevent our programs from having side effects wherein programs have their variables changed in unexpected ways.

We can prevent access to our object's data by declaring them declaring them in a certain way such that we can control access to them. We will learn more about how Java implements encapsulation as we discuss more about classes.

9.3.3 Class Variables and Methods

In addition to the instance variables, it is also possible to define **class variables,** which are variables that belong to the whole class. This means that it has the same value for all the objects in the same class. They are also called **static member variables**.

To clearly describe class variables, let's go back to our Car class example. Suppose that our Car class has one class variable called Count. If we change the value of Count to 2, all of the objects of the Car class will have the value 2 for their Count variable.

Car Class		Object Car A	Object Car B
Instance Variables	Plate Number	ABC 111	XYZ 123
	Color	Blue	Red
	Manufacturer	Mitsubishi	Toyota
	Current Speed	50 km/h	100 km/h
Class Variable	Count = 2		
Instance Methods	Accelerate Method		
	Turn Method		
	Brake Method		

Table 19: Car class' methods and variables

9.3.4 Class Instantiation

To create an object or an instance of a class, we use the **new** operator. For example, if you want to create an instance of the class String, we write the following code,

```
String  str2 = new String("Hello world!");
```

or also equivalent to,

```
String str2 = "Hello";
```

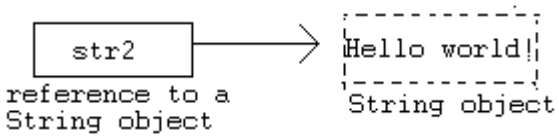


Figure 9.1: Classs Instantiation

The new operator allocates a memory for that object and returns a **reference** of that memory location to you. When you create an object, you actually invoke the class' **constructor.** The **constructor** is a method where you place all the initializations, it has the same name as the class.

9.4 Methods

9.4.1 What are Methods and Why Use Methods?

In the examples we discussed before, we only have one method, and that is the main() method. In Java, we can define many methods which we can call from different methods.

A **method** is a separate piece of code that can be called by a main program or any other method to perform some specific function.

The following are characteristics of methods:
- It can return one or no values
- It may accept as many parameters it needs or no parameter at all. Parameters are also called function arguments.
- After the method has finished execution, it goes back to the method that called it.

Now, why do we need to create methods? Why don't we just place all the code inside one big method? The heart of effective problem solving is in problem decomposition. We can do this in Java by creating methods to solve a specific part of the problem. Taking a problem and breaking it into small, manageable pieces is critical to writing large programs.

9.4.2 Calling Instance Methods and Passing Variables

Now, to illustrate how to call methods, let's use the String class as an example. You can use the Java API documentation to see all the available methods in the String class. Later on, we will create our own methods, but for now, let us use what is available.

To call an **instance method**, we write the following,

```
nameOfObject.nameOfMethod( parameters );
```

Let's take two sample methods found in the class String,

Method declaration	Definition
public char charAt(int index)	Returns the character at the specified index. An index ranges from 0 to length() - 1. The first character of the sequence is at index 0, the next at index 1, and so on, as for array indexing.
public boolean equalsIgnoreCase (String anotherString)	Compares this String to another String, ignoring case considerations. Two strings are considered equal ignoring case if they are of the same length, and corresponding characters in the two strings are equal ignoring case.

Table 20: Sample Methods of class String

Using the methods,

```
String      str1 = "Hello";
char        x = str2.charAt(0); //will return the character H
                  //and store it to variable x

String      str2 = "hello";

//this will return a boolean value true
boolean  result = str1.equalsIgnoreCase( str1 );
```

9.4.3 Passing Variables in Methods

In our examples, we already tried passing variables to methods. However, we haven't differentiated between the different types of variable passing in Java. There are two types of passing data to methods, the first one is pass-by-value and then, pass-by-reference.

9.4.3.1 Pass-by-value

When a pass-by-value occurs, the method makes a copy of the value of the variable passed to the method. The method cannot accidentally modify the original argument even if it modifies the parameters during calculations.

For example,

```
public class TestPassByValue
{
     public static void main( String[] args ){
      int i = 10;
      //print the value of i
      System.out.println( i );

      //call method test
      //and pass i to method test
      test( i );

      //print the value of i. i not changed
      System.out.println( i );
     }

     public static void test( int j ){
      //change value of parameter j
      j = 33;
     }
}
```

Pass i as parameter which is copied to j

In the given example, we called the method test and passed the value of i as parameter. The value of i is copied to the variable of the method j. Since j is the variable changed in the test method, it will not affect the variable value if i in main since it is a different copy of the variable.

By default, all primitive data types when passed to a method are pass-by-value.

9.4.3.2 Pass-by-reference

When a pass-by-reference occurs, the reference to an object is passed to the calling method. This means that, the method makes a copy of the reference of the variable passed to the method. However, unlike in pass-by-value, the method can modify the actual object that the reference is pointing to, since, although different references are used in the methods, the location of the data they are pointing to is the same.

For example,

```
class TestPassByReference
{
      public static void main( String[] args ){
            //create an array of integers
            int []ages  = {10, 11, 12};

            //print array values
            for( int i=0; i<ages.length; i++ ){
                  System.out.println( ages[i] );
            }

            //call test and pass reference to array
            test( ages );

            //print array values again
            for( int i=0; i<ages.length; i++ ){
                  System.out.println( ages[i] );
            }
      }

      public static void test( int[] arr ){
            //change values of array
            for( int i=0; i<arr.length; i++ ){
                  arr[i] = i + 50;
            }
      }
}
```

Pass ages as parameter which is copied to variable arr

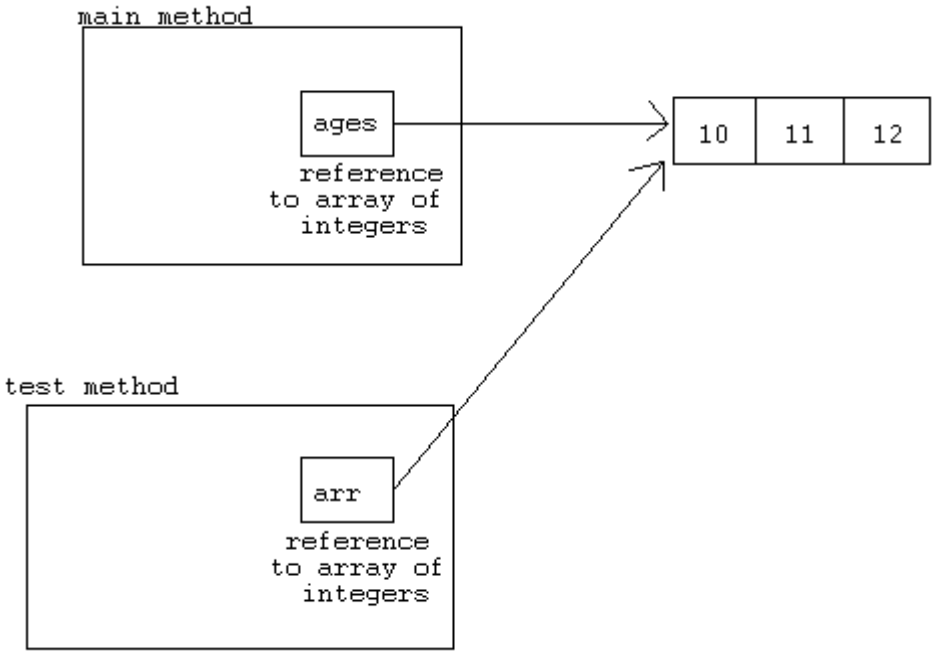


Figure 9.2: Pass-by-reference example

Coding Guidelines:

A common misconception about pass-by-reference in Java is when creating a swap method using Java references. Take note that Java manipulates objects 'by reference,' but it passes object references to methods 'by value.'" As a result, you cannot write a standard swap method to swap objects.

9.4.4 Calling Static Methods

Static methods are methods that can be invoked without instantiating a class (means without invoking the new keyword). Static methods belongs to the class as a whole and not to a certain instance (or object) of a class. Static methods are distinguished from instance methods in a class definition by the keyword static.

To call a static method, just type,

```
Classname.staticMethodName(params);
```

Examples of static methods, we've used so far in our examples are,

```
//prints data to screen
System.out.println(“Hello world”);

//converts the String 10, to an integer
int i = Integer.parseInt(“10”);

//Returns a String representation of the integer argument as an
//unsigned integer base 16
String hexEquivalent = Integer.toHexString( 10 );
```

9.4.5 Scope of a variable

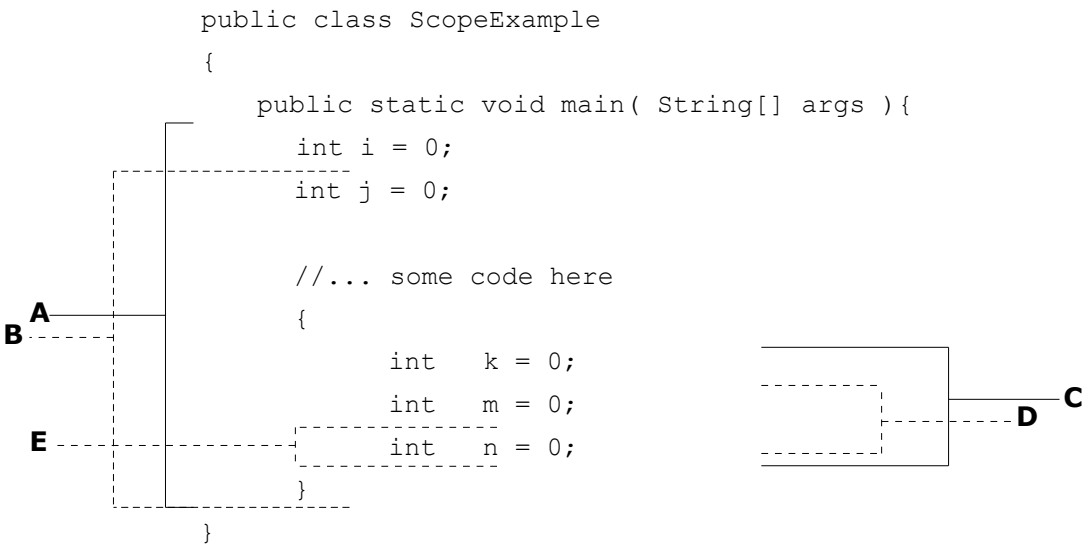
In addition to a variable's data type and name, a variable has scope. The **scope** determines where in the program the variable is accessible. The scope also determines the lifetime of a variable or how long the variable can exist in memory. The scope is determined by where the variable declaration is placed in the program.

To simplify things, just think of the scope as anything between the curly braces {...}. The outer curly braces is called the **outer** blocks, and the inner curly braces is called **inner** blocks.

If you declare variables in the outer block, they are visible (i.e. usable) by the program lines inside the inner blocks. However, if you declare variables in the inner block, you cannot expect the outer block to see it.

A variable's scope is inside the block where it is declared, starting from the point where it is declared, and in the inner blocks.

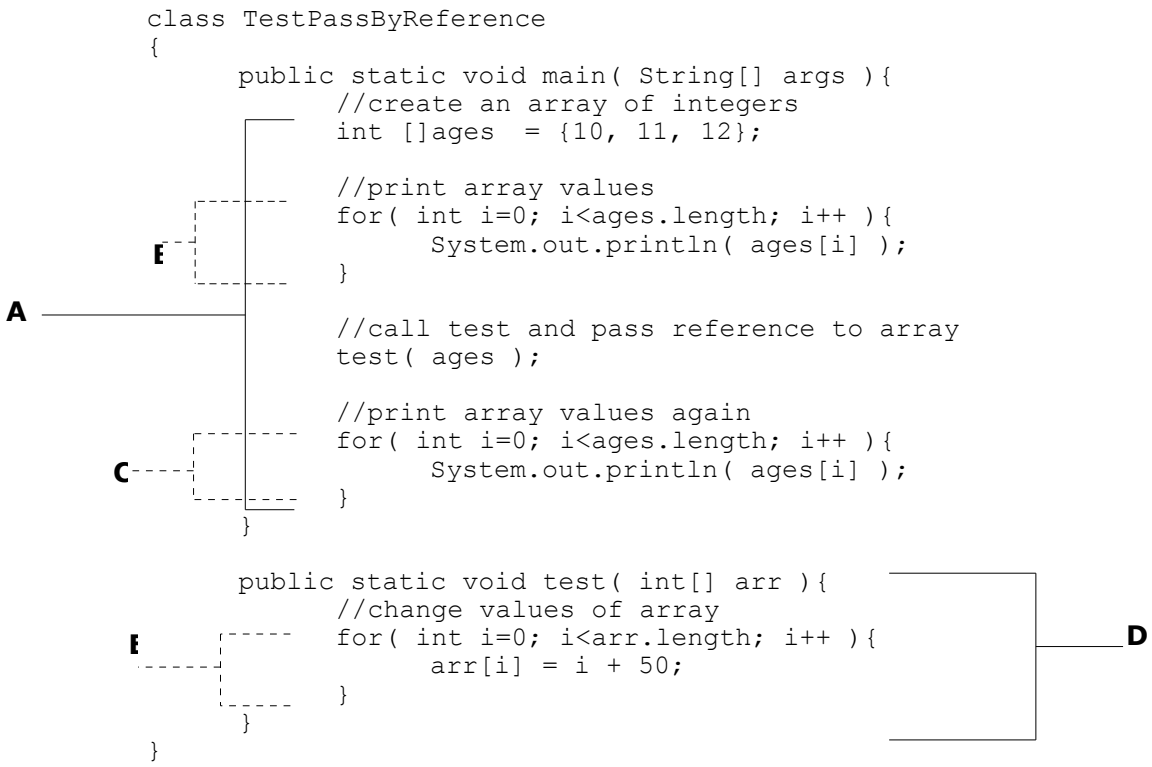
For example, given the following code snippet,



The code we have here represents five scopes indicated by the lines and the letters representing the scope. Given the variables i,j,k,m and n, and the five scopes A,B,C,D and E, we have the following scopes for each variable:

The scope of variable i is A.
The scope of variable j is B.
The scope of variable k is C.
The scope of variable m is D.
The scope of variable n is E.

Now, given the two methods main and test in our previous examples,



In the main method, the scope of the variables are,

ages[] - scope A
i in B - scope B
i in C – scope C

In the test method, the scope ofthe variables are,

arr[] - scope D
i in E - scope E

When declaring variables, only one variable with a given identifier or name can be declared in a scope. That means that if you have the following declaration,

```
{
      int test = 10;
      int test = 20;
}
```

your compiler will generate an error since you should have unique names for your variables in one block. However, you can have two variables of the same name, if they are not declared in the same block. For example,

```
int test = 0;
System.out.print( test );
//..some code here
{
      int test = 20;
      System.out.print( test );
}
```

When the first System.out.print is invoke, it prints the value of the first test variable since it is the variable seen at that scope. For the second System.out.print, the value 20 is printed since it is the closest test variable seen at that scope.

Coding Guidelines:

Avoid having variables of the same name declared inside one method to avoid confusion.

9.5 Casting, Converting and Comparing Objects

In this section, we are going to learn how to do **typecasting**. Typecasting or casting is the process of converting a data of a certain data type to another data type. We will also learn how to convert primitive data types to objects and vice versa. And finally, we are going to learn how to compare objects.

9.5.1 Casting Primitive Types

Casting between primitive types enables you to convert the value of one data from one type to another primitive type. This commonly occurs between numeric types.

There is one primitive data type that we cannot do casting though, and that is the **boolean** data type.

An example of typecasting is when you want to store an integer data to a variable of data type double. For example,

```
int    numInt = 10;
double  numDouble = numInt; //implicit cast
```

In this example, since the destination variable (double) holds a larger value than what we will place inside it, the data is implicitly casted to data type double.

Another example is when we want to typecast an int to a char value or vice versa. A character can be used as an int because each character has a corresponding numeric code that represents its position in the character set. If the variable i has the value 65, the cast (char)i produces the character value 'A'. The numeric code associated with a capital A is 65, according to the ASCII character set, and Java adopted this as part of its character support. For example,

```
char valChar = 'A';
int  valInt = valChar;
System.out.print( valInt ); //explicit cast: output 65
```

When we convert a data that has a large type to a smaller type, we must use an **explicit cast**. Explicit casts take the following form:

```
(dataType)value
```

where,

dataType, is the name of the data type you're converting to
value, is an expression that results in the value of the source type.

For example,

```
double      valDouble = 10.12;
int   valInt = (int)valDouble; //convert valDouble to int type

double      x = 10.2;
int   y = 2;

int   result = (int)(x/y); //typecast result of operation to
int
```

9.5.2 Casting Objects

Instances of classes also can be cast into instances of other classes, with **one restriction**: **The source and destination classes must be related by inheritance; one class must be a subclass of the other.** We'll cover more about inheritance later.

Analogous to converting a primitive value to a larger type, some objects might not need to be cast explicitly. In particular, because a subclass contains all the same information as its superclass, you can use an instance of a subclass anywhere a superclass is expected.

For example, consider a method that takes two arguments, one of type Object and another of type Window. You can pass an instance of any class for the Object argument because all Java classes are subclasses of Object. For the Window argument, you can pass in its subclasses, such as Dialog, FileDialog, and Frame. This is true anywhere in a program, not just inside method calls. If you had a variable defined as class Window, you could assign objects of that class or any of its subclasses to that variable without casting.

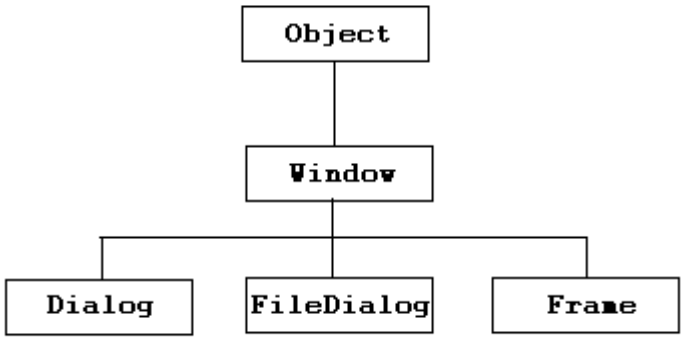


Figure 9.3: Sample Class Hierarchy

This is true in the reverse, and you can use a superclass when a subclass is expected. There is a catch, however: **Because subclasses contain more behavior than their superclasses, there's a loss in precision involved.** Those superclass objects might not have all the behavior needed to act in place of a subclass object. For example, if you have an operation that calls methods in objects of the class Integer, using an object of class Number won't include many methods specified in Integer. Errors occur if you try to call methods that the destination object doesn't have.

To use superclass objects where subclass objects are expected, you must cast them explicitly. You won't lose any information in the cast, but you gain all the methods and variables that the subclass defines. To cast an object to another class, you use the same operation as for primitive types:

To cast,

```
(classname)object
```

where,

classname, is the name of the destination class
object, is a reference to the source object.

- **Note:** that casting creates a reference to the old object of the type classname; the old object continues to exist as it did before.

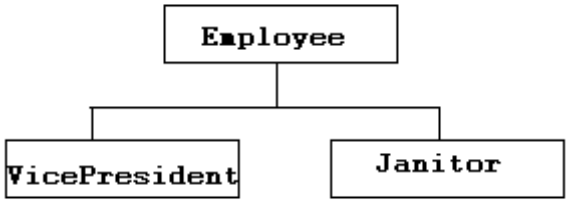


Figure 9.4: Class Hierarchy for superclass Employee

The following example casts an instance of the class VicePresident to an instance of the class Employee; VicePresident is a subclass of Employee with more information, which here defines that the VicePresident has executive washroom privileges,

```
Employee emp = new Employee();
VicePresident veep = new VicePresident();
emp = veep; // no cast needed for upward use
veep = (VicePresident)emp; // must cast explicitlyCasting
```

9.5.3 Converting Primitive Types to Objects and Vice Versa

One thing you can't do under any circumstance is cast from an object to a primitive data type, or vice versa. Primitive types and objects are very different things in Java, and you can't automatically cast between the two or use them interchangeably.

As an alternative, the **java.lang** package includes classes that correspond to each primitive data type: Float, Boolean, Byte, and so on. Most of these classes have the same names as the data types, except that the class names begin with a capital letter (Short instead of short, Double instead of double, and the like). Also, two classes have names that differ from the corresponding data type: Character is used for char variables and Integer for int variables. **(Called Wrapper Classes)**

Java treats the data types and their class versions very differently, and a program won't compile successfully if you use one when the other is expected.

Using the classes that correspond to each primitive type, you can create an object that holds the same value.

Examples:

```
//The following statement creates an instance of the Integer
// class with the integer value 7801 (primitive -> Object)
Integer dataCount = new Integer(7801);

//The following statement converts an Integer object to
// its primitive data type int. The result is an int with
//value 7801
int newCount = dataCount.intValue();

// A common translation you need in programs
// is converting a String to a numeric type, such as an int
// Object->primitive
String pennsylvania = "65000";
int penn = Integer.parseInt(pennsylvania);
```

- **CAUTION:** The Void class represents nothing in Java, so there's no reason it would be used when translating between primitive values and objects. It's a placeholder for the void keyword, which is used in method definitions to indicate that the method does not return a value.

9.5.4 Comparing Objects

In our previous discussions, we learned about operators for comparing values—equal, not equal, less than, and so on. Most of these operators work only on primitive types, not on objects. If you try to use other values as operands, the Java compiler produces errors.

The exceptions to this rule are the operators for equality: == (equal) and != (not equal). When applied to objects, these operators don't do what you might first expect. Instead of checking whether one object has the same value as the other object, they determine whether both sides of the operator refer to the same object.

To compare instances of a class and have meaningful results, you must implement special methods in your class and call those methods. A good example of this is the String class.

It is possible to have two different String objects that contain the same values. If you were to employ the == operator to compare these objects, however, they would be considered unequal. Although their contents match, they are not the same object.

To see whether two String objects have matching values, a method of the class called equals() is used. The method tests each character in the string and returns true if the two strings have the same values.

The following code illustrates this,

```
class EqualsTest {
   public static void main(String[] arguments) {
     String str1, str2;
     str1 = "Free the bound periodicals.";
     str2 = str1;

     System.out.println("String1: " + str1);
     System.out.println("String2: " + str2);
     System.out.println("Same object? " + (str1 == str2));

     str2 = new String(str1);

     System.out.println("String1: " + str1);
     System.out.println("String2: " + str2);
     System.out.println("Same object? " + (str1 == str2));
     System.out.println("Same value? " + str1.equals(str2));
   }
 }
```

This program's output is as follows,

OUTPUT:

```
String1: Free the bound periodicals.
String2: Free the bound periodicals.
Same object? true
String1: Free the bound periodicals.
String2: Free the bound periodicals.
Same object? false
Same value? True
```

Now let's discuss the code.

```
String str1, str2;
str1 = "Free the bound periodicals.";
```

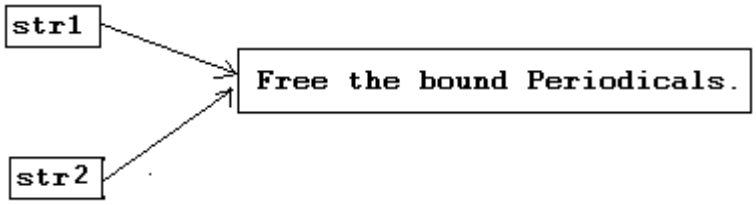


Figure 9.5: Both references point to the same object

The first part of this program declares two variables (str1 and str2), assigns the literal "Free the bound periodicals." to str1, and then assigns that value to str2. As you learned earlier, str1 and str2 now point to the same object, and the equality test proves that.

```
str2 = new String(str1);
```

In the second part of this program, you create a new String object with the same value as str1 and assign str2 to that new String object. Now you have two different string objects in str1 and str2, both with the same value. Testing them to see whether they're the same object by using the == operator returns the expected answer: false—they are not the same object in memory. Testing them using the equals() method also returns the expected answer: true—they have the same values.

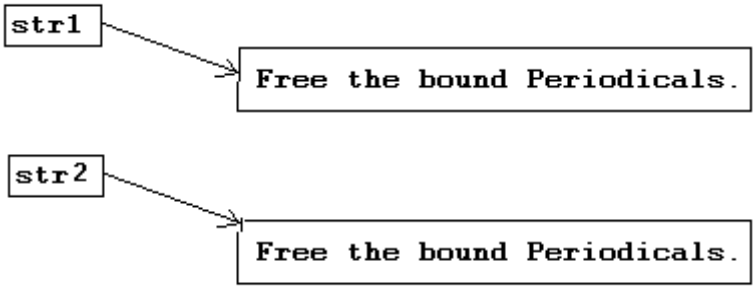


Figure 9.6: References now point to different objects

- **NOTE:** Why can't you just use another literal when you change str2, rather than using new? String literals are optimized in Java; if you create a string using a literal and then use another literal with the same characters, Java knows enough to give you the first String object back. Both strings are the same objects; you have to go out of your way to create two separate objects.

9.5.5 Determining the Class of an Object

Want to find out what an object's class is? Here's the way to do it for an object assigned to the variable key:

1. The **getClass() method** returns a Class object (where Class is itself a class) that has a method called getName(). In turn, getName() returns a string representing the name of the class.

   For Example,

   ```
   String name = key.getClass().getName();
   ```

2. The instanceOf operator

The instanceOf has two operands: a reference to an object on the left and a class name on the right. The expression returns true or false based on whether the object is an instance of the named class or any of that class's subclasses.

For Example,

```
boolean ex1 = "Texas" instanceof String; // true
Object pt = new Point(10, 10);
boolean ex2 = pt instanceof String; // false
```

9.6 Exercises

9.6.1 Defining terms

In your own words, define the following terms:
1. Class
2. Object
3. Instantiate
4. Instance Variable
5. Instance Method
6. Class Variables or static member variables
7. Constructor

9.6.2 Java Scavenger Hunt

Pipoy is a newbie in the Java programming language. He just heard that there are already ready-to-use APIs in Java that one could use in their programs, and he's eager to try them out. The problem is, Pipoy does not have a copy of the Java Documentation, and he also doesn't have an internet access, so there's no way for him to view the Java APIs.

Your task is to help Pipoy look for the APIs (Application Programming Interface). You should state the class where the method belongs, the method declaration and a sample usage of the said method.

For example, if Pipoy wants to know the method that converts a String to integer, your answer should be:

Class: Integer
Method Declaration: public static int parseInt(String value)
Sample Usage:

```
String          strValue = "100";
int      value = Integer.parseInt( strValue );
```

Make sure that the snippet of code you write in your sample usage compiles and outputs the correct answer, so as not to confuse Pipoy. **(Hint: All methods are in the java.lang package).** In cases where you can find more methods that can accomplish the task, give only one.

Now let's start the search!
1. Look for a method that checks if a certain String ends with a certain suffix. For example, if the given string is "Hello", the method should return true the suffix given is "lo", and false if the given suffix is "alp".
2. Look for the method that determines the character representation for a specific digit in the specified radix. For example, if the input digit is 15, and the radix is 16, the method would return the character F, since F is the hexadecimal representation for the number 15 (base 10).
3. Look for the method that terminates the currently running Java Virtual Machine
4. Look for the method that gets the floor of a double value. For example, if I input a 3.13, the method should return the value 3.
5. Look for the method that determines if a certain character is a digit. For example, if I input '3', it returns the value true.

10 Creating your own Classes

10.1 Objectives

Now that we've studied on how to use existing classes from the Java class library, we will now be studying on how to write our own classes. For this section, in order to easily understand how to create classes, we will make a sample class wherein we will add more data and functionality as we go along the way.

We will create a class that contains information of a Student and operations needed for a certain student record.

Things to take note of for the syntax defined in this section and for the other sections:

*	- means that there may be 0 or more occurrences of the line whereit was applied to.
<description>	- indicates that you have to substitute an actual value for this part instead of typing it as it is.
[]	- indicates that this part is optional

At the end of the lesson, the student should be able to:

- Create their own classes
- Declare attributes and methods for their classes
- Use the this reference to access instance data
- Create and call overloaded methods
- Import and create packages
- Use access modifiers to control access to class members

10.2 Defining your own classes

Before writing your class, think first on where you will be using your class and how your class will be used. Think of an appropriate name for the class, and list all the information or properties that you want your class to contain. Also list down the methods that you will be using for your class.

To define a class, we write,

```
<modifier> class <name> {
      <attributeDeclaration>*
      <constructorDeclaration>*
      <methodDeclaration>*
   }
```

where
<*modifier*> is an access modifier, which may be combined with other types of modifier.

Coding Guidelines:

Remember that for a top-level class, the only valid access modifiers are public and package (i.e., if no access modifier prefixes the class keyword).

In this section, we will be creating a class that will contain a student record. Since we've already identified the purpose of our class, we can now name it. An appropriate name for our class would be `StudentRecord`.

Now, to define our class we write,

```
public class StudentRecord
{
      //we'll add more code here later
}
```

where,

public	- means that our class is accessible to other classes outside the package
class	- this is the keyword used to create a class in Java
StudentRecord	- a unique identifier that describes our class

Coding Guidelines:

1. *Think of an appropriate name for your class. Don't just call your class XYZ or any random names you can think of.*
2. *Class names should start with a CAPITAL letter.*
3. *The filename of your class should have the SAME NAME as your public class name.*

10.3 Declaring Attributes

To declare a certain attribute for our class, we write,

```
<modifier> <type> <name> [= <default_value>];
```

Now, let us write down the list of attributes that a student record can contain. For each information, also list what data types would be appropriate to use. For example, you don't want to have a data type int for a student's name, or a String for a student's grade.

The following are some sample information we want to add to the student record.

name	- String
address	- String
age	- int
math grade	- double
english grade	- double
science grade	- double
average grade	- double

You can add more information if you want to, it's all really up to you. But for this example, we will be using these information.

10.3.1 Instance Variables

Now that we have a list of all the attributes we want to add to our class, let us now add them to our code. Since we want these attributes to be unique for each object (or for each student), we should declare them as instance variables.

For example,

```
public class StudentRecord
{
      private String    name;
      private String    address;
      private int       age;
      private double    mathGrade;
      private double    englishGrade;
      private double    scienceGrade;
      private double    average;
      //we'll add more code here later
}
```

where,
private here means that the variables are only accessible within the class. Other objects cannot access these variables directly. We will cover more about accessibility later.

Coding Guidelines:

1. *Declare all your instance variables on the top of the class declaration.*
2. *Declare one variable for each line.*
3. *Instance variables, like any other variables should start with a SMALL letter.*
4. *Use an appropriate data type for each variable you declare.*
5. *Declare instance variables as private so that only class methods can access them directly.*

10.3.2 Class Variables or Static Variables

Aside from instance variables, we can also declare class variables or variables that belong to the class as a whole. The value of these variables are the same for all the objects of the same class. Now suppose, we want to know the total number of student records we have for the whole class, we can declare one static variable that will hold this value. Let us call this as studentCount.

To declare a static variable,

```
public class StudentRecord
{
      //instance variables we have declared

      private static int studentCount;

      //we'll add more code here later
}
```

we use the keyword static to indicate that a variable is a static variable.

So far, our whole code now looks like this.

```
public class StudentRecord
{
      private String    name;
      private String    address;
      private int       age;
      private double    mathGrade;
      private double    englishGrade;
      private double    scienceGrade;
      private double    average;

      private static int studentCount;

      //we'll add more code here later
}
```

10.4 Declaring Methods

Before we discuss what methods we want our class to have, let us first take a look at the general syntax for declaring methods.

To declare methods we write,

```
<modifier> <returnType> <name>(<parameter>*) {
      <statement>*
}
```

where,
<modifier> can carry a number of different modifiers
<returnType> can be any data type (including void)
<name> can be any valid identifier
<parameter> ::= <parameter_type> <parameter_name>[,]

10.4.1 Accessor methods

In order to implement encapsulation, that is, we don't want any objects to just access our data anytime, we declare the fields or attributes of our classes as private. However, there are times wherein we want other objects to access private data. In order to do this, we create accessor methods.

Accessor methods are used to read values from class variables (instance/static). An accessor method usually starts with a **get<NameOfInstanceVariable>.** It also returns a value.

For our example, we want an accessor method that can read the name, address, english grade, math grade and science grade of the student.

Now let's take a look at one implementation of an accessor method,

```
public class StudentRecord
{
      private String    name;
            :
            :
      public String getName(){
            return name;
      }
}
```

where,

public - means that the method can be called from objects outside the class
String - is the return type of the method. This means that the method should return a value of type String
getName - the name of the method
() - this means that our method does not have any parameters

The statement,

```
return name;
```

in our program signifies that it will return the value of the instance variable name to the calling method. Take note that the return type of the method should have the same data type as the data in the return statement. You usually encounter the following error if the two does not have the same data type,

```
StudentRecord.java:14: incompatible types
found   : int
required: java.lang.String
                return age;
                       ^
1 error
```

Another example of an accessor method is the getAverage method,

```
public class StudentRecord
{
   private String       name;
      :
      :
   public double getAverage(){

      double result = 0;
      result = ( mathGrade+englishGrade+scienceGrade )/3;

      return result;
   }
}
```

The getAverage method computes the average of the 3 grades and returns the result.

10.4.2 Mutator Methods

Now, what if we want other objects to alter our data? What we do is we provide methods that can write or change values of our class variables (instance/static). We call these methods, **mutator methods.** A mutator method is usuallyu written as **set<NameOfInstanceVariable>.**

Now let's take a look at one implementation of a mutator method,

```
public class StudentRecord
{
      private String    name;
            :
            :
      public void setName( String temp ){
            name = temp;
      }
}
```

where,

public	-	means that the method can be called from objects outside the class
void	-	imeans that the method does not return any value
setName	-	the name of the method
(String temp)	-	parameter that will be used inside our method

The statement,

```
name = temp;
```

assigns the value of temp to name and thus changes the data inside the instance variable name.

Take note that mutator methods don't return values. However, it contains some program argument or arguments that will be used inside the method.

10.4.3 Multiple Return statements

You can have multiple return statements for a method as long as they are not on the same block. You can also use constants to return values instead of variables.

For example, consider the method,

```
public String getNumberInWords( int num ){

      String defaultNum = "zero";

      if( num == 1 ){
            return "one"; //return a constant
      }
      else if( num == 2){
            return "two"; //return a constant
      }

      //return a variable
      return defaultNum;
}
```

10.4.4 Static methods

For the static variable studentCount, we can create a static method to access its value.

```
public class StudentRecord
{
   private static int studentCount;

   public static int getStudentCount(){
      return studentCount;
   }
}
```

where,

public	- means that the method can be called from objects outside the class
static	- means that the method is static and should be called by typing,[ClassName].[methodName]. For example, in this case, we call the method `StudentRecord.getStudentCount()`
int	- is the return type of the method. This means that the method should return a value of type int
getStudentCount	- the name of the method
()	- this means that our method does not have any parameters

For now, getStudentCount will always return the value zero since we haven't done anything yet in our program in order to set its value. We will try to change the value of studentCount later on when we discuss constructors.

Coding Guidelines:

1. Method names should start with a SMALL letter.
2. Method names should be verbs
3. Always provide documentation before the declaration of the method. You can use javadocs style for this. Please see example.

10.4.5 Sample Source Code for StudentRecord class

Here is the code for our StudentRecord class,

```
public class StudentRecord
{
     private String     name;
     private String     address;
     private int        age;
     private double     mathGrade;
     private double     englishGrade;
     private double     scienceGrade;
     private double     average;

     private static int studentCount;

     /**
      * Returns the name of the student
      */
     public String getName(){
      return name;
     }

     /**
      * Changes the name of the student
      */
     public void setName( String temp ){
      name = temp;
     }

     // other code here ....

     /**
      * Computes the average of the english, math and science
      * grades
      */
     public double getAverage(){

      double result = 0;
      result = ( mathGrade+englishGrade+scienceGrade )/3;

      return result;
     }

     /**
      * returns the number of instances of StudentRecords
      */
     public static int getStudentCount(){
      return studentCount;
     }
}
```

Now, here's a sample code of a class that uses our StudentRecord class.

```
public class StudentRecordExample
{
     public static void main( String[] args ){

       //create three objects for Student record
       StudentRecord     annaRecord = new StudentRecord();
       StudentRecord     beahRecord = new StudentRecord();
       StudentRecord     crisRecord = new StudentRecord();

       //set the name of the students
       annaRecord.setName("Anna");
       beahRecord.setName("Beah");
       crisRecord.setName("Cris");

       //print anna's name
       System.out.println( annaRecord.getName() );

       //print number of students

System.out.println("Count="+StudentRecord.getStudentCount());
     }
}
```

The output of this program is,

```
Anna
Student Count = 0
```

10.5 The this reference

The **this** reference is used to access the instance variables shadowed by the parameters. To understand this better, let's take for example the setAge method. Suppose we have the following declaration for setAge.

```
public void setAge( int age ){
     age = age; //WRONG!!!
}
```

The parameter name in this declaration is age, which has the same name as the instance variable age. Since the parameter age is the closest declaration to the method, the value of the parameter age will be used. So in the statement,

```
age = age;
```

we are just assigning the value of the parameter age to itself! This is not what we want to happen in our code. In order to correct this mistake, we use the **this** reference. To use the this reference, we type,

```
this.<nameOfTheInstanceVariable>
```

So for example, we can now rewrite our code to,

```
public void setAge( int age ){
 this.age = age;
}
```

This method will then assign the value of the parameter age to the instance variable of the object StudentRecord.

NOTE: You can only use the this reference for instance variables and NOT static or class variables.

10.6 Overloading Methods

In our classes, we want to sometimes create methods that has the same names but function differently depending on the parameters that are passed to them. This capability is possible in Java, and it is called **Method Overloading**.

Method overloading allows a method with the same name but different parameters, to have different implementations and return values of different types. Rather than invent new names all the time, method overloading can be used when the same operation has different implementations.

For example, in our StudentRecord class we want to have a method that prints information about the student. However, we want the print method to print things differently depending on the parameters we pass to it. For example, when we pass a String, we want the print method to print out the name, address and age of the student. When we pass 3 double values, we want the method to print the student's name and grades.

We have the following overloaded methods inside our StudentRecord class,

```
public void print( String temp ){
      System.out.println("Name:" + name);
      System.out.println("Address:" + address);
      System.out.println("Age:" + age);
}

public void print(double eGrade, double mGrade, double sGrade)
      System.out.println("Name:" + name);
      System.out.println("Math Grade:" + mGrade);
      System.out.println("English Grade:" + eGrade);
      System.out.println("Science Grade:" + sGrade);
}
```

When we try to call this in the following main method,

```
public static void main( String[] args )
{
      StudentRecord     annaRecord = new StudentRecord();

      annaRecord.setName("Anna");
      annaRecord.setAddress("Philippines");
      annaRecord.setAge(15);
      annaRecord.setMathGrade(80);
      annaRecord.setEnglishGrade(95.5);
      annaRecord.setScienceGrade(100);

      //overloaded methods
      annaRecord.print( annaRecord.getName() );
      annaRecord.print( annaRecord.getEnglishGrade(),
                  annaRecord.getMathGrade(),
                  annaRecord.getScienceGrade());
}
```

we will have the output for the first call to print,

```
Name:Anna
Address:Philippines
Age:15
```

we will have the output for the second call to print,

```
Name:Anna
Math Grade:80.0
English Grade:95.5
Science Grade:100.0
```

Always remember that overloaded methods have the following properties,
- the same name
- **different parameters**
- return types can be different or the same

10.7 Declaring Constructors

We have discussed before the concept of constructors. Constructors are important in instantiating an object. It is a method where all the initializations are placed.

The following are the properties of a constructor:
1. Constructors have the **same name as the class**
2. A constructor is just like an ordinary method, however only the following information can be placed in the header of the constructor,
   scope or accessibility identifier (like public...), constructor's name and parameters if it has any.
3. Constructors **does not have any return value**
4. **You cannot call a constructor directly**, it can only be called by using the **new** operator during class instantiation.

To declare a constructor, we write,

```
<modifier> <className> (<parameter>*) {
      <statement>*
  }
```

10.7.1 Default Constructor

Every class has a default constructor. The **default constructor** is the constructor without any parameters. If the class does not specify any constructors, then an implicit default constructor is created.

For example, in our StudentRecord class, the default constructor would look like this,

```
public StudentRecord()
{
      //some code here
}
```

10.7.2 Overloading Constructors

As we have mentioned, constructors can also be overloaded, for example, we have here four overloaded constructors,

```
public StudentRecord(){
      //some initialization code here
}

public StudentRecord(String temp){
      this.name = temp;
}

public StudentRecord(String name, String address){
      this.name = name;
      this.address = address;
}

public StudentRecord(double mGrade, double eGrade,
                                 double sGrade){
      mathGrade = mGrade;
      englishGrade = eGrade;
      scienceGrade = sGrade;
}
```

10.7.3 Using Constructors

To use these constructors, we have the following code,

```
public static void main( String[] args )
{

     //create three objects for Student record
     StudentRecord      annaRecord=new StudentRecord("Anna");

     StudentRecord      beahRecord=new StudentRecord("Beah",
                              "Philippines");
     StudentRecord      crisRecord=new
StudentRecord(80,90,100);
     //some code here
}
```

Now, before we move on, let us go back to the static variable studentCount we have declared a while ago. The purpose of the studentCount is to count the number of objects that are instantiated with the class StudentRecord. So, what we want to do here is, everytime an object of class StudentRecord is instantiated, we increment the value of studentCount. A good location to modify and increment the value of studentCount is in the constructors, because it is always called everytime an object is instantiated. For example,

```
public StudentRecord(){
      //some initialization code here
      studentCount++; //add a student
}

public StudentRecord(String temp){
      this.name = temp;
      studentCount++; //add a student
}

public StudentRecord(String name, String address){
      this.name = name;
      this.address = address;
      studentCount++; //add a student
}

public StudentRecord(double mGrade, double eGrade,
                              double sGrade){
      mathGrade = mGrade;
      englishGrade = eGrade;
      scienceGrade = sGrade;
      studentCount++; //add a student
}
```

10.7.4 The this() Constructor Call

Constructor calls can be chained, meaning, you can call another constructor from inside another constructor. We use the **this()** call for this. For example, given the following code,

```
1: public StudentRecord(){
2:    this("some string");
3:
4: }
5:
6: public StudentRecord(String temp){
7:    this.name = temp;
8: }
9:
10: public static void main( String[] args )
11: {
12:
13:   StudentRecord     annaRecord = new StudentRecord();
14: }
```

Given the code above, when the statement at line 13 is called, it will call the default constructor line 1. When statement in line 2 is executed, it will then call the constructor that has a String parameter (in line 6).

There are a few things to remember when using the **this** constructor call:

1. When using the this constructor call, **IT MUST OCCUR AS THE FIRST STATEMENT in a constructor**
2. It can **ONLY BE USED IN A CONSTRUCTOR DEFINITION**. The this call can then be followed by any other relevant statements.

10.8 Packages

Packages are Java's means of grouping related classes and interfaces together in a single unit (interfaces will be discussed later). This powerful feature provides for a convenient mechanism for managing a large group of classes and interfaces while avoiding potential naming conflicts.

10.8.1 Importing Packages

To be able to use classes outside of the package you are currently working in, you need to import the package of those classes. By default, all your Java programs import the java.lang.* package, that is why you can use classes like String and Integers inside the program eventhough you haven't imported any packages.

The syntax for importing packages is as follows,

```
import <nameOfPackage>;
```

For example, if you want to use the class Color inside package awt, you have to type the following,

```
import java.awt.Color;
import java.awt.*;
```

The first statement imports the specific class Color while the other imports all of the classes in the java.awt package.

Another way to import classes from other packages is through explicit package referencing. This is done by using the package name to declare an object of a class.

```
java.awt.Color color;
```

10.8.2 Creating your own packages

To create our own package, we write,

```
package <packageName>;
```

Suppose we want to create a package where we will place our StudentRecord class, together with other related classes. We will call our package, schoolClasses.

The first thing you have to do is create a folder named schoolClasses. Copy all the classes that you want to belong to this package inside this folder. After copying, add the following code at the top of the class file. For example,

```
package schoolClasses;

public class StudentRecord
{
      private String    name;
      private String    address;
      private int       age;
      :
```

Packages can also be nested. In this case, the Java interpreter expects the directory structure containing the executable classes to match the package hierarchy.

10.8.3 Setting the CLASSPATH

Now, suppose we place the package schoolClasses under the C:\ directory. We need to set the classpath to point to that directory so that when we try to run it, the JVM will be able to see where our classes are stored.

Before we discuss how to set the classpath, let us take a look at an example on what will happen if we don't set the classpath.

Suppose we compile and then run the StudentRecord class we wrote in the last section,

```
C:\schoolClasses>javac StudentRecord.java

C:\schoolClasses>java StudentRecord
Exception in thread "main" java.lang.NoClassDefFoundError:
StudentRecord (wrong name: schoolClasses/StudentRecord)
        at java.lang.ClassLoader.defineClass1(Native Method)
        at java.lang.ClassLoader.defineClass(Unknown Source)
        at java.security.SecureClassLoader.defineClass(Unknown
Source)
        at java.net.URLClassLoader.defineClass(Unknown Source)
        at java.net.URLClassLoader.access$100(Unknown Source)
        at java.net.URLClassLoader$1.run(Unknown Source)
        at java.security.AccessController.doPrivileged(Native
Method)
        at java.net.URLClassLoader.findClass(Unknown Source)
        at java.lang.ClassLoader.loadClass(Unknown Source)
        at sun.misc.Launcher$AppClassLoader.loadClass(Unknown
Source)
        at java.lang.ClassLoader.loadClass(Unknown Source)
        at java.lang.ClassLoader.loadClassInternal(Unknown
Source)
```

We encounter a **NoClassDefFoundError** which means that Java did not know where to look for your class. The reason for this is that your class StudentRecord now belongs to a package named studentClasses. If we want to run our class, we jave to tell Java about its full class name which is **schoolClasses.StudentRecord**. We also have to tell JVM where to look for our packages, which in this case is in location C:\. To do this, we must set the classpath.

To set the classpath in Windows, we type this at the command prompt,

```
C:\schoolClasses> set classpath=C:\
```

where C:\ is the directory in which we have placed the packages. After setting the classpath, we can now run our program anywhere by typing,

```
C:\schoolClasses> java schoolClasses.StudentRecord
```

For Unix base systems, suppose we have our classes in the directory /usr/local/myClasses, we write,

```
export classpath=/usr/local/myClasses
```

Take note that you can set the classpath anywhere. You can also set more than one classpath, we just have to separate them by ;(for windows) and : (for Unix based systems). For example,

```
set classpath=C:\myClasses;D:\;E:\MyPrograms\Java
```

and for Unix based systems,

```
export classpath=/usr/local/java:/usr/myClasses
```

10.9 Access Modifiers

When creating our classes and defining the properties and methods in our class, we want to implement some kind of restriction to access these data. For example, if you want a certain attribute to be changed only by the methods inside the class, you may want to hide this from other objects using your class. In Java, we have what we call **access modifiers** in order to implement this.

There are four different types of member access modifiers in Java: public, private, protected and default. The first three access modifiers are explicitly written in the code to indicate the access type, for the fourth one which is default, no keyword is used.

10.9.1 default access (also called package accessibility)

This specifies that only classes in the same package can have access to the class' variables and methods. There are no actual keyword for the default modifier; it is applied in the absence of an access modifier. For example,

```
public class StudentRecord
{
      //default access to instance variable
      int   name;

      //default access to method
      String getName(){
            return name;
      }
}
```

In this example, the instance variable name and the method getName() can be accessed from other objects, as long as the object belongs to the same package where the class StudentRecord belongs to.

10.9.2 public access

This specifies that class members are accessible to anyone, both inside and outside the class. Any object that interacts with the class can have access to the public members of the class. For example,

```
public class StudentRecord
{
      //default access to instance variable
      public int  name;

      //default access to method
      public String getName(){
            return name;
      }
}
```

In this example, the instance variable name and the method getName() can be accessed from other objects.

10.9.3 protected access

This specifies that the class members are accessible only to methods in that class and the subclasses of the class. For example,

```
public class StudentRecord
{
      //default access to instance variable
      protected int     name;

      //default access to method
      protected String getName(){
            return name;
      }
}
```

In this example, the instance variable name and the method getName() can be accessed only from methods inside the class and from subclasses of StudentRecord. We will discuss about subclasses on the next chapter.

10.9.4 private access

This specifies that the class members are only accessible by the class they are defined in. For example,

```
public class StudentRecord
{
      //default access to instance variable
      private int name;

      //default access to method
      private String getName(){
            return name;
      }
}
```

In this example, the instance variable name and the method getName() can be accessed only from methods inside the class.

Coding Guidelines:
The instance variables of a class should normally be declared private, and the class will just provide accessor and mutator methods to these variables.

10.10 Exercises

10.10.1 Address Book Entry

Your task is to create a class that contains an address book entry. The following table describes the information that an adressbook entry has.

Attributes/Properties	Description
Name	Name of the person in the addressbook
Address	Address of the person
Telephone Number	Telephone number of the person
Email Address	Person's Email address

Table 21: Attributes and Attributes Descriptions

For the methods, create the following:
1. Provide the necessary accessor and mutator methods for all the attributes.
2. Constructors

10.10.2 AddressBook

Create a class address book that can contain 100 entries of AddressBookEntry objects (use the class you created in the first exercise). You should provide the following methods for the address book.

1. Add entry
2. Delete entry
3. View all entries
4. Update an entry

11 Inheritance, Polymorphism and Interfaces

11.1 Objectives

In this section, we will be discussing on how a class can inherit the properties of an existing class. A class that does this is called a subclass and its parent class is called the superclass. We will also be discussing a special property of Java wherein it can automatically apply the proper methods to each object regardless of what subclass the object came from. This property is known as polymorphism. Finally, we are going to discusss about interfaces that helps reduce programming effort.

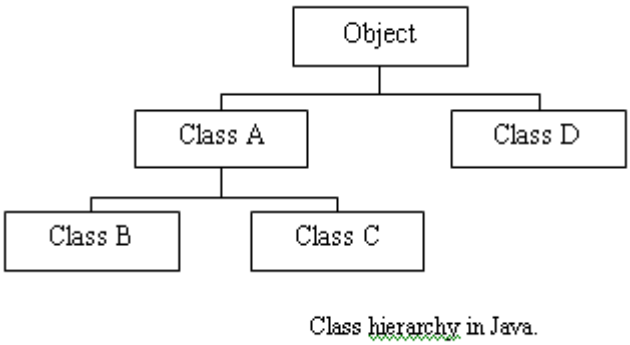
At the end of the lesson, the student should be able to:

- Define super classes and subclasses
- Override methods of superclasses
- Create final methods and final classes

11.2 Inheritance

In Java, all classes, including the classes that make up the Java API, are subclassed from the **Object** superclass. A sample class hierarchy is shown below.

Any class above a specific class in the class hierarchy is known as a **superclass**. While any class below a specific class in the class hierarchy is known as a subclass of that class.



Class hierarchy in Java.

Figure 11.1: Class Hierarchy

Inheritance is a major advantage in object-oriented programming since once a behavior (method) is defined in a superclass, that behavior is automatically inherited by all subclasses. Thus, you can encode a method only once and they can be used by all subclasses. A subclass only need to implement the differences between itself and the parent.

11.2.1 Defining Superclasses and Subclasses

To derive a class, we use the **extends** keyword. In order to illustrate this, let's create a sample parent class. Suppose we have a parent class called Person.

```
public class Person
{
      protected String  name;
      protected String  address;

      /**
       * Default constructor
       */
      public Person(){
            System.out.println("Inside Person:Constructor");
            name = "";
            address = "";
      }

      /**
       * Constructor with 2 parameters
       */
      public Person( String name, String address ){
            this.name = name;
            this.address = address;
      }

      /**
       * Accessor methods
       */
      public String getName(){
            return name;
      }

      public String getAddress(){
            return address;
      }

      public void setName( String name ){
            this.name = name;
      }

      public void setAddress( String add ){
            this.address = add;
      }

}
```

Notice that, the attributes name and address are declared as **protected**. The reason we did this is that, we want these attributes to be accessible by the subclasses of the superclass. If we declare this as private, the subclasses won't be able to use them. Take note that all the properties of a superclass that are declared as **public, protected and default** can be accessed by its subclasses.

Now, we want to create another class named Student. Since a student is also a person, we decide to just extend the class Person, so that we can inherit all the properties and methods of the existing class Person. To do this, we write,

```
public class Student extends Person
{
      public Student(){
            System.out.println("Inside Student:Constructor");
            //some code here
      }

      // some code here
}
```

When a Student object is instantiated, the default constructor of its superclass is invoked implicitly to do the necessary initializations. After that, the statements inside the subclass are executed. To illustrate this, consider the following code,

```
public static void main( String[] args ){
      Student anna = new Student();
}
```

In the code, we create an object of class Student. The output of the program is,

```
Inside Person:Constructor
Inside Student:Constructor
```

The program flow is shown below.

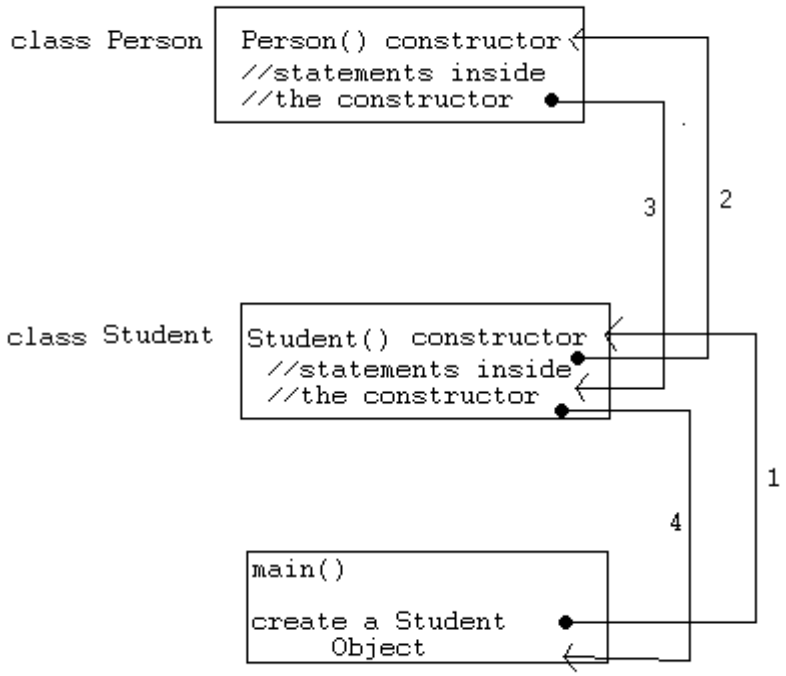


Figure 11.2: Program Flow

11.2.2 The super keyword

A subclass can also **explicitly** call a constructor of its immediate superclass. This is done by using the **super** constructor call. A super constructor call in the constructor of a subclass will result in the execution of relevant constructor from the superclass, based on the arguments passed.

For example, given our previous example classes Person and Student, we show an example of a super constructor call. Given the following code for Student,

```
public Student(){
      super( "SomeName", "SomeAddress" );
      System.out.println("Inside Student:Constructor");
}
```

This code calls the second constructor of its immediate superclass (which is Person) and executes it. Another sample code shown below,

```
public Student(){
      super();
      System.out.println("Inside Student:Constructor");
}
```

This code calls the default constructor of its immediate superclass (which is Person) and executes it.

There are a few things to remember when using the super constructor call:

1. The super() call MUST OCCUR THE FIRST STATEMENT IN A CONSTRUCTOR.
2. The super() call can only be used in a constructor definition.
3. This implies that the this() construct and the super() calls CANNOT BOTH OCCUR IN THE SAME CONSTRUCTOR.

Another use of super is to refer to members of the superclass (just like the **this** reference). For example,

```
public Student()
{
      super.name = "somename";
      super.address = "some address";
}
```

11.2.3 Overriding Methods

If for some reason a derived class needs to have a different implementation of a certain method from that of the superclass, ***overriding*** methods could prove to be very useful. A subclass can override a method defined in its superclass by providing a new implementation for that method.

Suppose we have the following implementation for the getName method in the Person superclass,

```
public class Person
{
      :
      :
      public String getName(){
            System.out.println("Parent: getName");
            return name;
      }
      :
}
```

To override, the getName method in the subclass Student, we write,

```
public class Student extends Person
{
      :
      :
      public String getName(){
            System.out.println("Student: getName");
            return name;
      }
      :
}
```

So, when we invoke the getName method of an object of class Student, the overridden method would be called, and the output would be,

```
Student: getName
```

11.2.4 Final Methods and Final Classes

In Java, it is also possible to declare classes that can no longer be subclassed. These classes are called **final classes**. To declare a class to be final, we just add the final keyword in the class declaration. For example, if we want the class Person to be declared final, we write,

```
public final class Person
{
      //some code here
}
```

Many of the classes in the Java API are declared final to ensure that their behavior cannot be overridden. Examples of these classes are Integer, Double and String.

It is also possible in Java to create methods that cannot be overridden. These methods are what we call **final methods**. To declare a method to be final, we just add the final keyword in the method declaration. For example, if we want the getName method in class Person to be declared final, we write,

```
public final String getName(){
      return name;
}
```

Static methods are automatically final. This means that you cannot override them.

11.3 Polymorphism

Now, given the parent class Person and the subclass Student of our previous example, we add another subclass of Person which is Employee. Below is the class hierarchy for that,

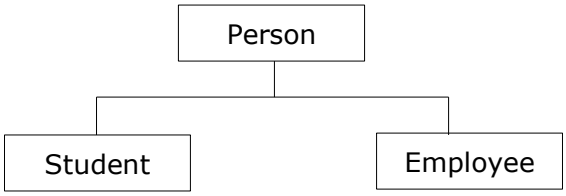


Figure 11.3: Hierarchy for Person class and it's classes

In Java, we can create a reference that is of type superclass to an object of its subclass. For example,

```
public static main( String[] args )
{
      Person      ref;

      Student     studentObject = new Student();
      Employee    employeeObject = new Employee();

      ref = studentObject; //Person ref points to a
                                  // Student object

      //some code here
}
```

Now suppose we have a getName method in our superclass Person, and we override this method in both the subclasses Student and Employee,

```
public class Person
{
      public String getName(){
            System.out.println("Person Name:" + name);
            return name;
      }
}

public class Student extends Person
{
      public String getName(){
            System.out.println("Student Name:" + name);
            return name;
      }
}

public class Employee extends Person
{
      public String getName(){
            System.out.println("Employee Name:" + name);
            return name;
      }
}
```

Going back to our main method, when we try to call the getName method of the reference Person ref, the getName method of the Student object will be called. Now, if we assign ref to an Employee object, the getName method of Employee will be called.

```
public static main( String[] args )
{
      Person      ref;

      Student     studentObject = new Student();
      Employee    employeeObject = new Employee();

      ref = studentObject; //Person reference points to a
                           // Student object
      String temp = ref.getName(); //getName of Student
                                   //class is called
      System.out.println( temp );

      ref = employeeObject; //Person reference points to an
                            // Employee object

      String temp = ref.getName(); //getName of Employee
                                   //class is called
      System.out.println( temp );
}
```

This ability of our reference to change behavior according to what object it is holding is called **polymorphism**. Polymorphism allows multiple objects of different subclasses to be treated as objects of a single superclass, while automatically selecting the proper methods to apply to a particular object based on the subclass it belongs to.

Another example that exhibits the property of polymorphism is when we try to pass a reference to methods. Suppose we have a static method **printInformation** that takes in a Person object as reference, we can actually pass a reference of type Employee and type Student to this method as long as it is a subclass of the class Person.

```
public static main( String[] args )
{
      Student     studentObject = new Student();
      Employee    employeeObject = new Employee();

      printInformation( studentObject );

      printInformation( employeeObject );
}

public static printInformation( Person p ){
      . . . .
}
```

11.4 Abstract Classes

Now suppose we want to create a superclass wherein it has certain methods in it that contains some implementation, and some methods wherein we just want to be overridden by its subclasses.

For example, we want to create a superclass named LivingThing. This class has certain methods like breath, eat, sleep and walk. However, there are some methods in this superclass wherein we cannot generalize the behavior. Take for example, the walk method. Not all living things walk the same way. Take the humans for instance, we humans walk on two legs, while other living things like dogs walk on four legs. However, there are many characteristics that living things have in common, that is why we want to create a general superclass for this.

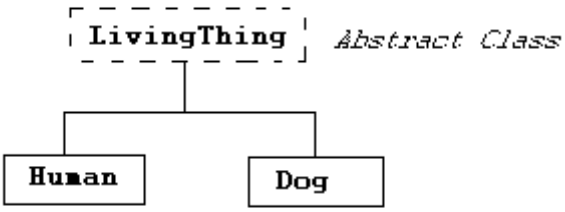


Figure 11.4: Abstract class

In order to do this, we can create a superclass that has some methods with implementations and others which do not. This kind of class is called an abstract class.

An **abstract class** is a class that cannot be instantiated. It often appears at the top of an object-oriented programming class hierarchy, defining the broad types of actions possible with objects of all subclasses of the class.

Those methods in the abstract classes that do not have implementation are called **abstract methods**. To create an abstract method, just write the method declaration without the body and use the abstract keyword. For example,

```
public abstract void someMethod();
```

Now, let's create an example abstract class.

```
public abstract class LivingThing
{
      public void breath(){
            System.out.println("Living Thing breathing...");

      }

      public void eat(){
            System.out.println("Living Thing eating...");
      }

      /**
       * abstract method walk
       * We want this method to be overridden by subclasses of
       * LivingThing
       */
      public abstract void walk();
}
```

When a class extends the LivingThing abstract class, it is required to override the abstract method walk(), or else, that subclass will also become an abstract class, and therefore cannot be instantiated. For example,

```
public class Human extends LivingThing
{
      public void walk(){
            System.out.println("Human walks...");
      }
}
```

If the class Human does not override the walk method, we would encounter the following error message,

```
Human.java:1: Human is not abstract and does not override
abstract method walk() in LivingThing
public class Human extends LivingThing
       ^
1 error
```

Coding Guidelines:

Use abstract classes to define broad types of behaviors at the top of an object-oriented programming class hierarchy, and use its subclasses to provide implementation details of the abstract class.

11.5 Interfaces

An **interface** is a special kind of block containing method signatures (and possibly constants) only. Interfaces define the signatures of a set of methods without the body.

Interfaces define a standard and public way of specifying the behavior of classes. They allow classes, regardless of their location in the class hierarchy, to implement common behaviors. Note that interfaces exhibit polymorphism as well, since program may call an interface method and the proper version of that method will be executed depending on the type of object passed to the interface method call.

11.5.1 Why do we use Interfaces?

We need to use interfaces if *we want unrelated classes to implement similar methods.* Thru interfaces, we can actually capture similarities among unrelated classes without artificially forcing a class relationship.

Let's take as an example a class **Line** which contains methods that computes the length of the line and compares a **Line** object to objects of the same class. Now, suppose we have another class **MyInteger** which contains methods that compares a **MyInteger** object to objects of the same class. As we can see here, both of the classes have some similar methods which compares them from other objects of the same type, but they are not related whatsoever. In order to enforce a way to make sure that these two classes implement some methods with similar signatures, we can use an interface for this. We can create an interface class, let's say interface **Relation** which has some comparison method declarations. Our interface Relation can be declared as,

```
public interface Relation
{
      public boolean isGreater( Object a, Object b);
      public boolean isLess( Object a, Object b);
      public boolean isEqual( Object a, Object b);
}
```

Another reason for using an object's programming interface is to *reveal an object's programming interface without revealing its class*. As we can see later on the section *Interface vs. Classes*, we can actually use an interface as data type.

Finally, we need to use interfaces to *model multiple inheritance* which allows a class to have more than one superclass. Multiple inheritance is not present in Java, but present in other object-oriented languages like C++.

11.5.2 Interface vs. Abstract Class

The following are the main differences between an interface and an abstract class: interface methods have no body, an interface can only define constants and an interface have no direct inherited relationship with any particular class, they are defined independently.

11.5.3 Interface vs. Class

One common characteristic of an interface and class is that they are both types. This means that an interface can be used in places where a class can be used. For example, given a class Person and an interface PersonInterface, the following declarations are valid:

```
PersonInterface   pi = new Person();
Person            pc = new Person();
```

However, you cannot create an instance from an interface. An example of this is:

```
PersonInterface   pi = new PersonInterface(); //COMPILE
                                                //ERROR!!!
```

Another common characteristic is that both interface and class can define methods. However, an interface does not have an implementation code while the class have one.

11.5.4 Creating Interfaces

To create an interface, we write,

```
public interface [InterfaceName]
{
      //some methods without the body
}
```

As an example, let's create an interface that defines relationships between two objects according to the "natural order" of the objects.

```
public interface Relation
{
      public boolean isGreater( Object a, Object b);
      public boolean isLess( Object a, Object b);
      public boolean isEqual( Object a, Object b);
}
```

Now, to use the interface, we use the **implements** keyword. For example,

```
/**
 * This class defines a line segment
 */
public class Line implements Relation
{
      private double x1;
      private double x2;
      private double y1;
      private double y2;

      public Line(double x1, double x2, double y1, double y2){
            this.x1 = x1;
            this.x2 = x2;
            this.y1 = y1;
            this.y2 = y2;
      }

      public double getLength(){
```

```
                double length = Math.sqrt((x2-x1)*(x2-x1) +
                                          (y2-y1)* (y2-y1));
                return length;
        }

        public boolean isGreater( Object a, Object b){
                double aLen = ((Line)a).getLength();
                double bLen = ((Line)b).getLength();
                return (aLen > bLen);
        }

        public boolean isLess( Object a, Object b){
                double aLen = ((Line)a).getLength();
                double bLen = ((Line)b).getLength();
                return (aLen < bLen);

        }

        public boolean isEqual( Object a, Object b){
                double aLen = ((Line)a).getLength();
                double bLen = ((Line)b).getLength();
                return (aLen == bLen);
        }
}
```

When your class tries to implement an interface, always make sure that you implement all the methods of that interface, or else, you would encounter this error,

```
Line.java:4: Line is not abstract and does not override
abstract method isGreater(java.lang.Object,java.lang.Object) in
Relation
public class Line implements Relation
       ^
1 error
```

Coding Guidelines:

Use interfaces to create the same standard method definitions in may different classes. Once a set of standard method definition is created, you can write a single method to manipulate all of the classes that implement the interface.

11.5.5 Relationship of an Interface to a Class

As we have seen in the previous section, a class can implement an interface as long as it provides the implementation code for all the methods defined in the interface.

Another thing to note about the relationship of interfaces to classes is that, a class can only EXTEND ONE super class, but it can IMPLEMENT MANY interfaces. An example of a class that implements many interfaces is,

```
public class Person implements PersonInterface,
                               LivingThing,
                               WhateverInterface {

      //some code here
}
```

Another example of a class that extends one super class and implements an interface is,

```
public class ComputerScienceStudent extends Student
                               implements PersonInterface,
                                          LivingThing {

      //some code here
}
```

Take note that an interface is not part of the class inheritance hierarchy. Unrelated classes can implement the same interface.

11.5.6 Inheritance among Interfaces

Interfaces are not part of the class hierarchy. However, interfaces can have inheritance relationship *among themselves*. For example, suppose we have two interfaces **StudentInterface** and **PersonInterface**. If StudentInterface extends PersonInterface, it will inherit all of the method declarations in PersonInterface.

```
public interface PersonInterface {
      . . .
}

public interface StudentInterface extends PersonInterface {
      . . .
}
```

11.6 Exercises

11.6.1 Extending StudentRecord

In this exercise, we want to create a more specialized student record that contains additional information about a Computer Science student. Your task is to extend the StudentRecord class that was implemented in the previous lessons. Add some attributes and methods that you think are needed for a Computer Science student record. Try to override some existing methods in the superclass StudentRecord, if you really need to.

11.6.2 The Shape abstract class

Try to create an abstract class called Shape with abstract methods getArea() and getName(). Write two of its subclasses Circle and Square. You can add additional methods to its subclasses if you want to.

12 Basic Exception Handling

12.1 Objectives

In this section, we are going to study a technique used in Java to handle unusual conditions that interrupt the normal operation of the program. This technique is called e**xception handling**.

At the end of the lesson, the student should be able to:

- Define exceptions
- Handle exceptions using a simple try-catch-finally block

12.2 What are Exceptions?

An exception is an event that interrupts the normal processing flow of a program. This event is usually some error of some sort. This causes our program to terminate abnormally.

Some examples of exceptions that you might have encountered in our previous exercises are: ArrayIndexOutOfBounds exceptions, which occurs if we try to access a non-existent array element, or maybe a NumberFormatException, which occurs when we try to pass as a parameter a non-number in the Integer.parseInt method.

12.3 Handling Exceptions

To handle exceptions in Java, we use a try-catch-finally block. What we do in our programs is that we place the statements that can possibly generate an exception inside this block.

The general form of a try-catch-finally block is,

```
try{
      //write the statements that can generate an exception
      //in this block
}
catch( <exceptionType1> <varName1> ){

      //write the action your program will do if an exception
      //of a certain type occurs
}
. . .
catch( <exceptionTypen> <varNamen> ){
      //write the action your program will do if an
      //exception of a certain type occurs
}
finally{
      //add more cleanup code here
}
```

Exceptions thrown during execution of the try block can be caught and handled in a catch block. The code in the finally block is always executed.

The following are the key aspects about the syntax of the try-catch-finally construct:
- The block notation is mandatory.
- For each try block, there can be one or more catch blocks, but only one finally block.
- The catch blocks and finally blocks must always appear in conjunction with the try block, and in the above order.
- A try block must be followed by **at least** one catch block OR one finally block, or both.
- Each catch block defines an exception handle. The header of the catch block takes exactly one argument, which is the exception its block is willing to handle. The exception must be of the Throwable class or one of its subclasses.

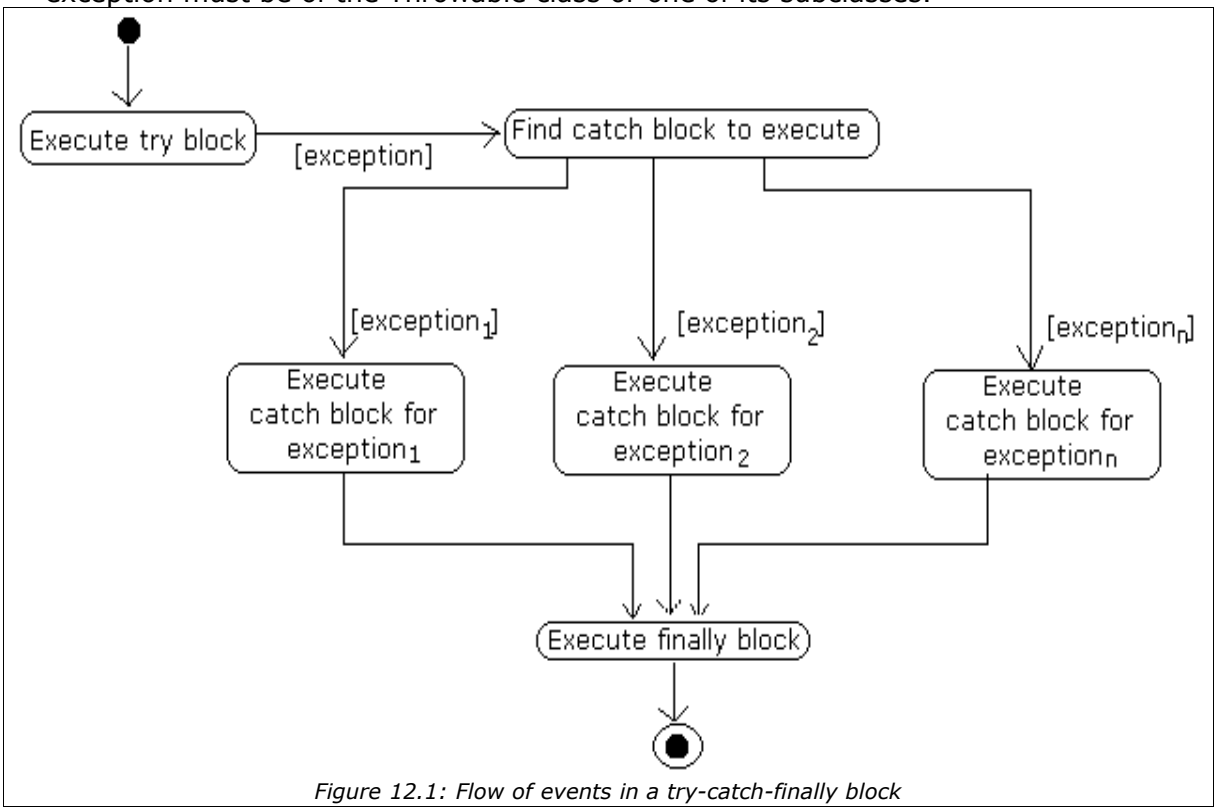


Figure 12.1: Flow of events in a try-catch-finally block

Let's take for example a code that prints the second argument when we try to run the code using command-line arguments. Suppose, there is no checking inside your code for the number of arguments and we just access the second argument args[1] right away, we'll get the following exception.

```
Exception in thread "main"
java.lang.ArrayIndexOutOfBoundsException: 1
        at ExceptionExample.main(ExceptionExample.java:5)
```

To prevent this from happening, we can place the code inside a try-catch block. The finally block is just optional. For this example, we won't use the finally block.

```
public class ExceptionExample
{
     public static void main( String[] args ){

      try{
            System.out.println( args[1] );
      }catch( ArrayIndexOutOfBoundsException exp ){
            System.out.println("Exception caught!");
      }
     }
}
```

So when we try to run the program again without arguments, the output would be,

```
Exception caught!
```

12.4 Exercises

12.4.1 Catching Exceptions1

Given the following code:

```
public class TestExceptions{
      public static void main( String[] args ){
            for( int i=0; true; i++ ){
                  System.out.println("args["+i+"]="+
                              args[i]);
            }
      }
}
```

Compile and run the TestExceptions program. The output should look like this:

```
javac TestExceptions  one  two  three
args[0]=one
args[1]=two
args[2]=three
Exception in thread "main"
      java.lang.ArrayIndexOutOfBoundsException: 3
            at TestExceptions.main(1.java:4)
```

Modify the TestExceptions program to handle the exception. The output of the program after catching the exception should look like this:

```
javac TestExceptions  one  two  three
args[0]=one
args[1]=two
args[2]=three
Exception caught:
      java.lang.ArrayIndexOutOfBoundsException: 3
Quiting...
```

12.4.2 Catching Exceptions 2

Chances are very good that some programs you've written before have encountered exceptions. Since you didn't catch the exceptions, they simply halted the execution of your code. Go back to those programs and implement exception handling.

Appendix A : Java and NetBeans Installation

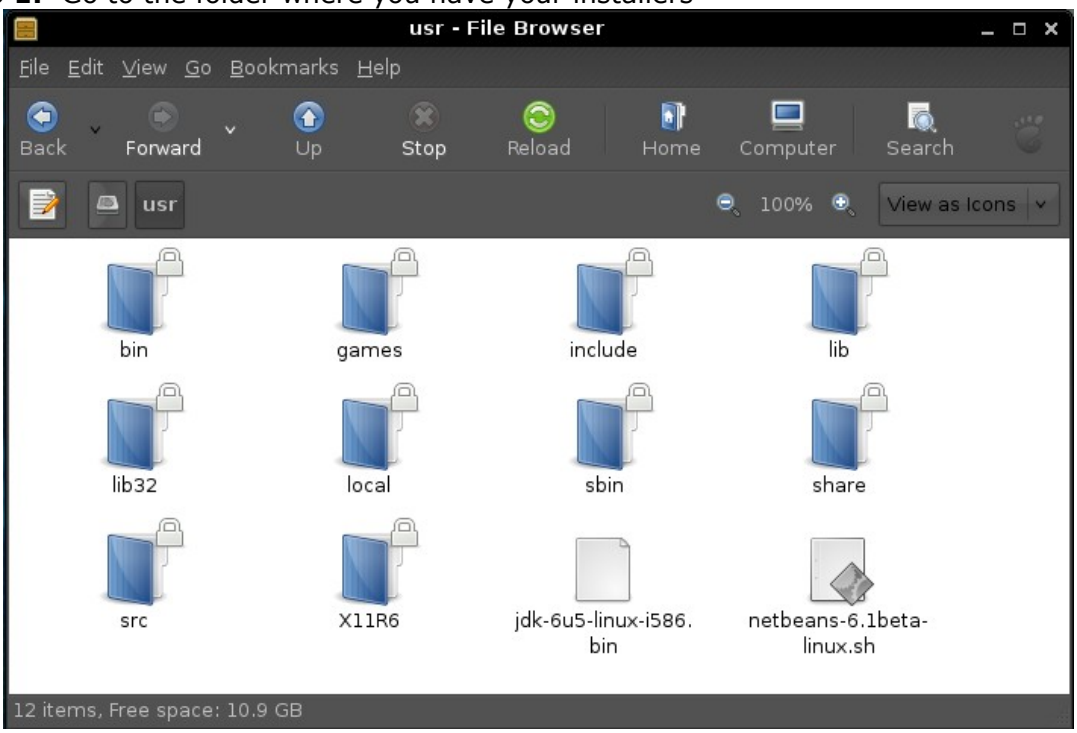
In this section, we will discuss on how to install Java and NetBeans in your system (Ubuntu Dapper/Windows XP). If you are not provided with the Java 6.0.05 and NetBeans 6.1 installers by your instructor, you can download a copy of the installers from the Sun Microsystems website (http://java.sun.com/) for Java and http://www.NetBeans.org/downloads/ for NetBeans). Before starting with the installation, copy the installers in your hard disk first.

For Ubuntu Gutsy:
Copy all the installers inside the /usr folder.

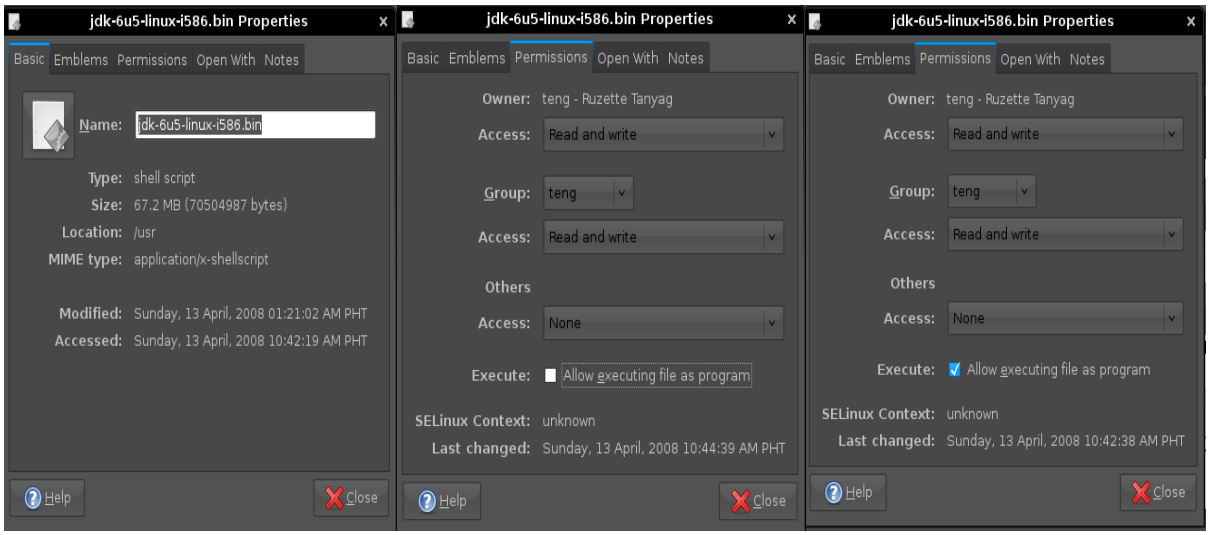
For Windows:
Just copy the installers in any temporary directory.

Installing Java in Ubuntu Gutsy

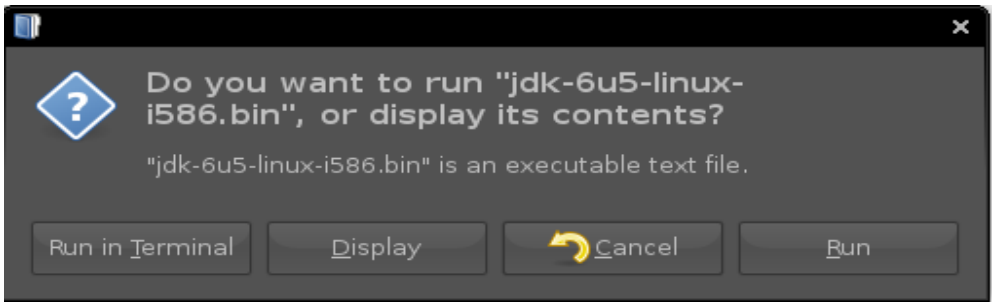
Step 1: Go to the folder where you have your installers



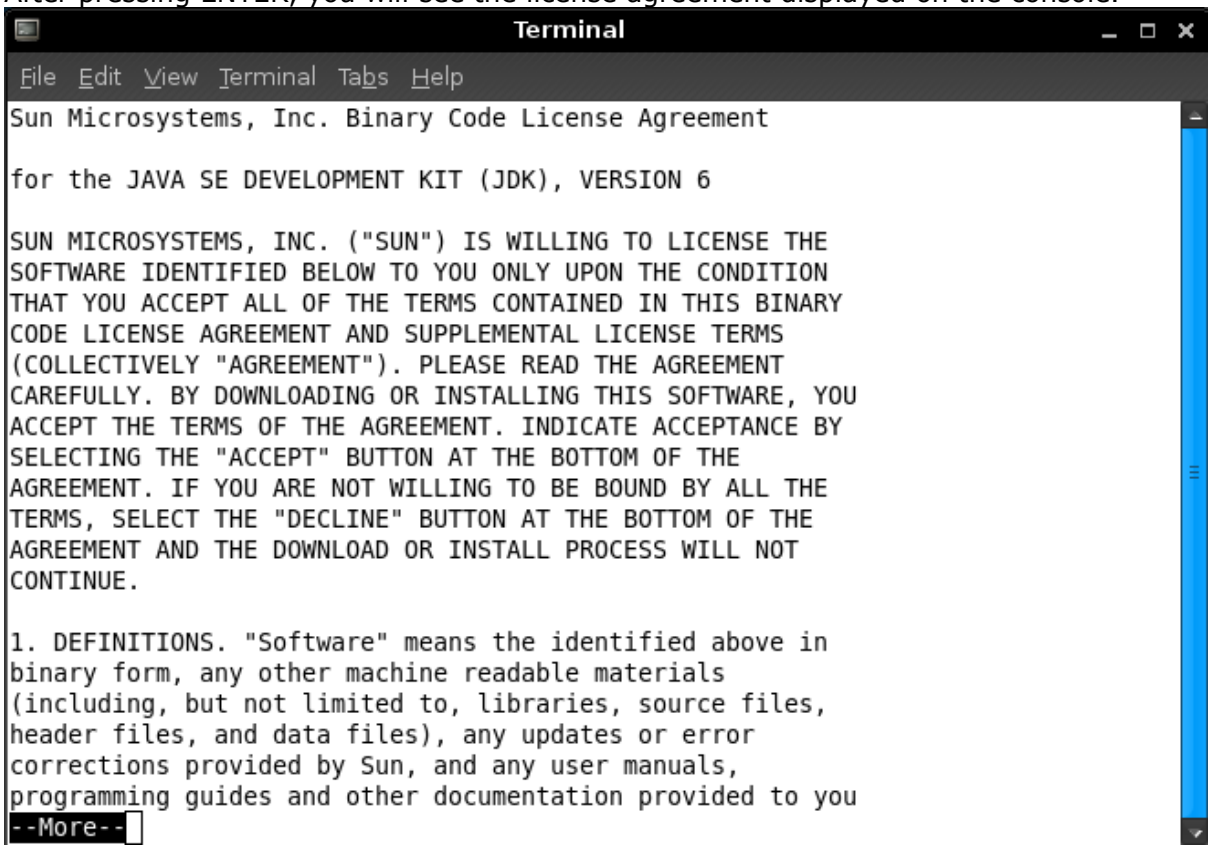
Step 2: Before running your installer, make sure it is executable. To do this, right click on the installer,click on Properties. Next, Click on the Permissions tab, and then Click on the Check Box "Allow executing files as program." Close the window.



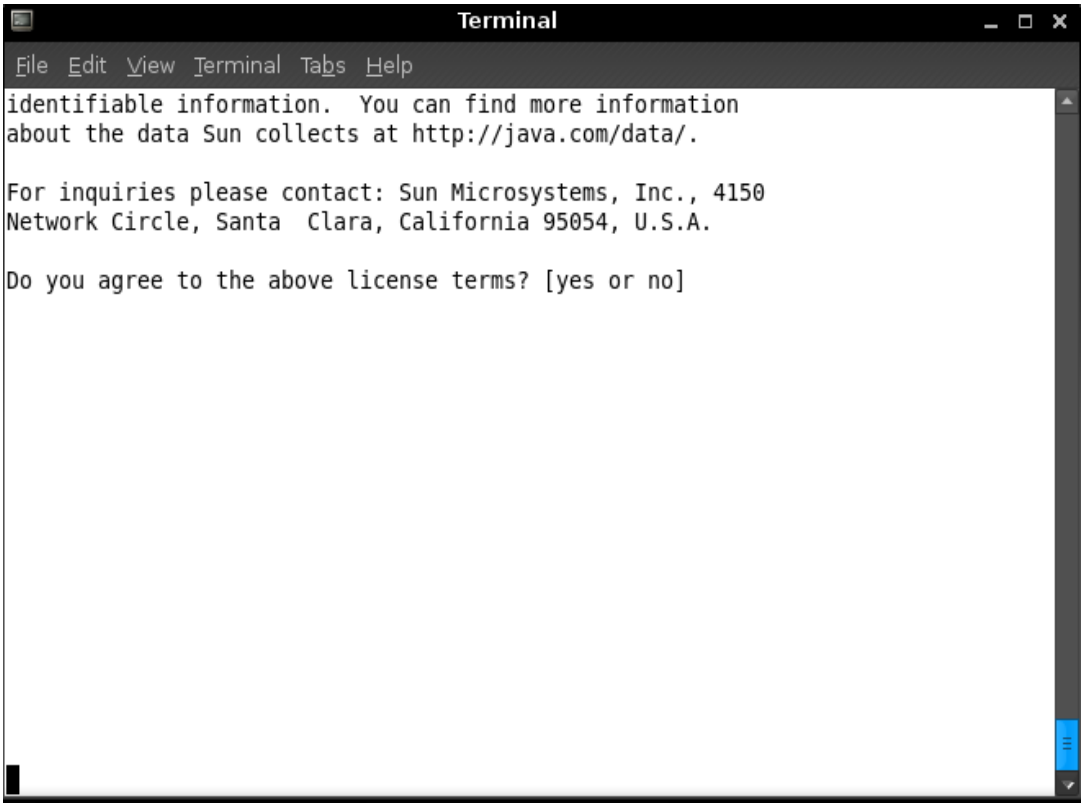
Step 3: Double click on the file jdk-6u5-linux-i586.bin. A dialog box will display, click on the button 'Run In Terminal'.



After pressing ENTER, you will see the license agreement displayed on the console.

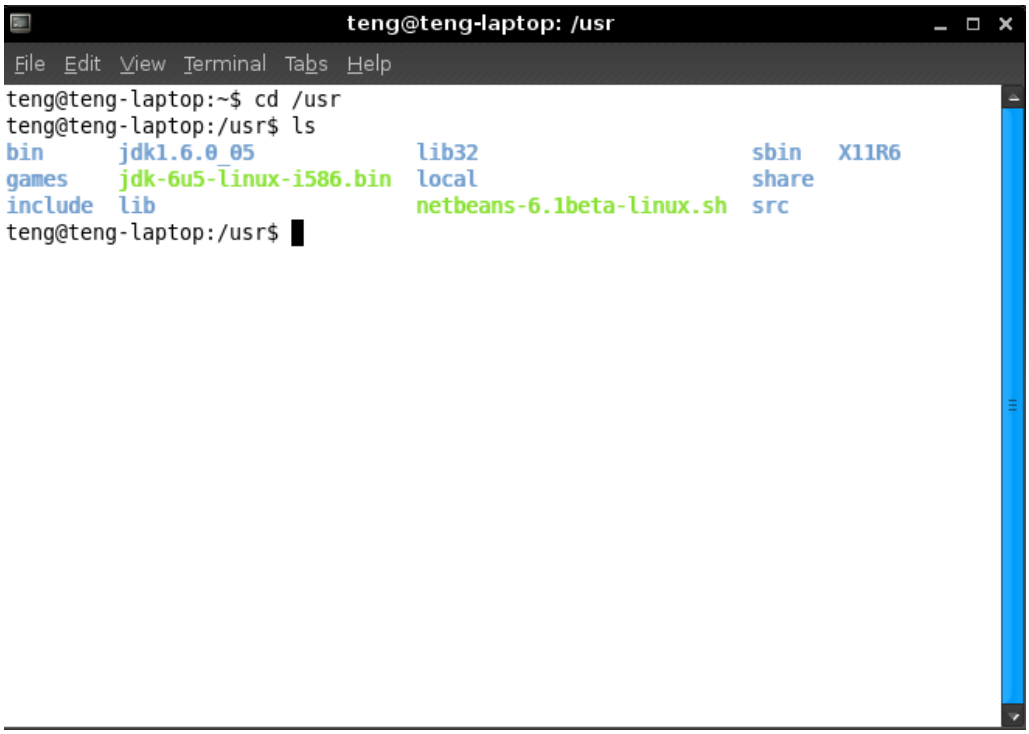


Just press enter, until you see the question: Do you agree to the above license terms? [yes or no]. Just type: yes and press ENTER. Just wait for the installer to finish unpacking all its contents and installing Java.



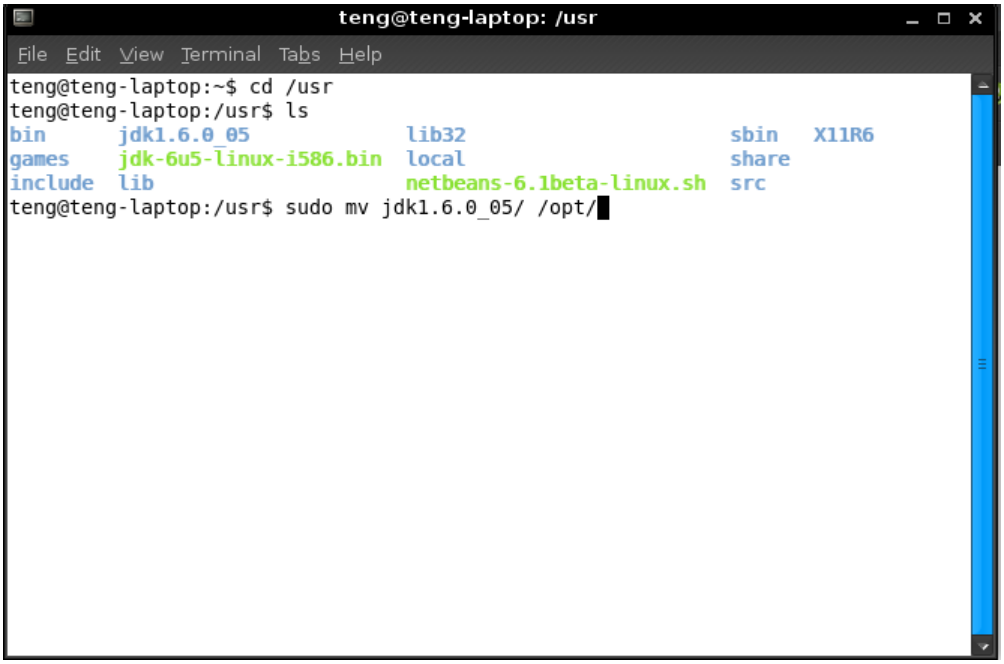
Step 4: Creating symbolic links

In order to run java commands anywhere, we need to create symbolic links for all the commands in JDK inside the /usr/local/bin directory. To do this, Open the terminal and go to the *usr* folder by typing cd usr/.



Next, Move the installed directory to /opt/ folder, type:

```
sudo mv jdk1.6.0_05/ /opt/
```



To make the symbolic links to the commands, type:

```
sudo ln -s /opt/jdk1.6.0_05/bin/* /usr/bin/
```

Installing Java in Windows

Step 1: Using Windows Explorer, go to the folder where your Java installer is located

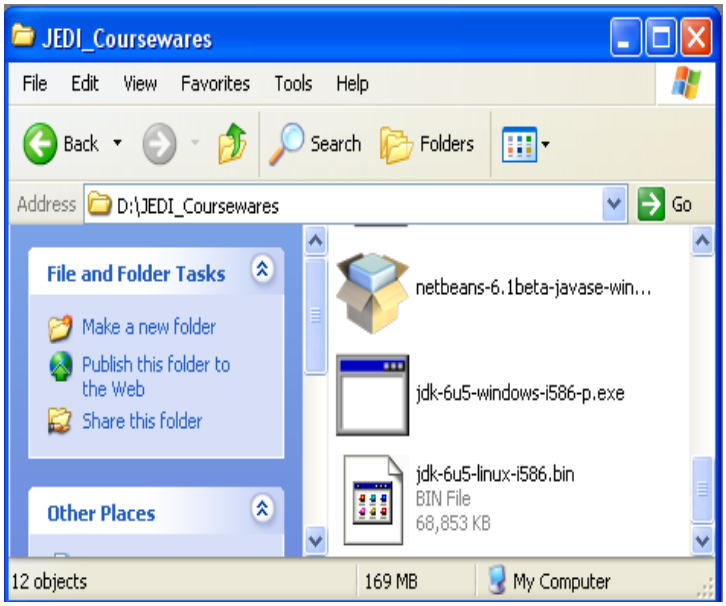


Figure 12.2: Folder containing installers

Step 2: Run the installer

To run the installer, just double-click on the installer icon. Press ACCEPT.

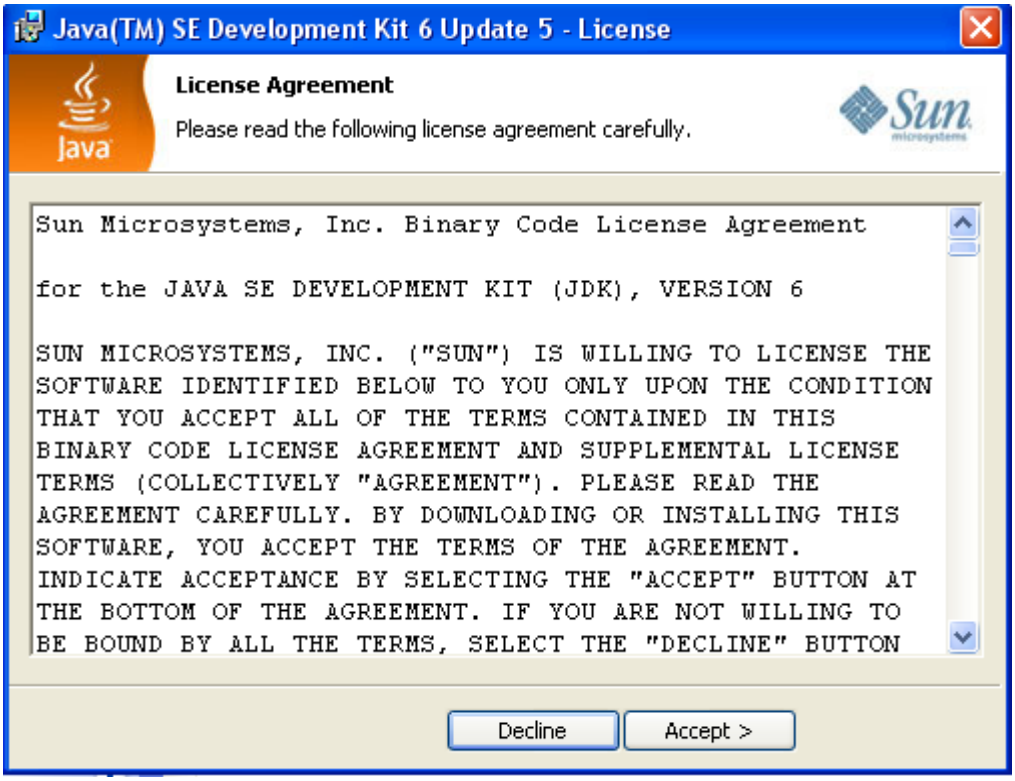


Figure 12.3: License agreement

Click on NEXT to continue installation.

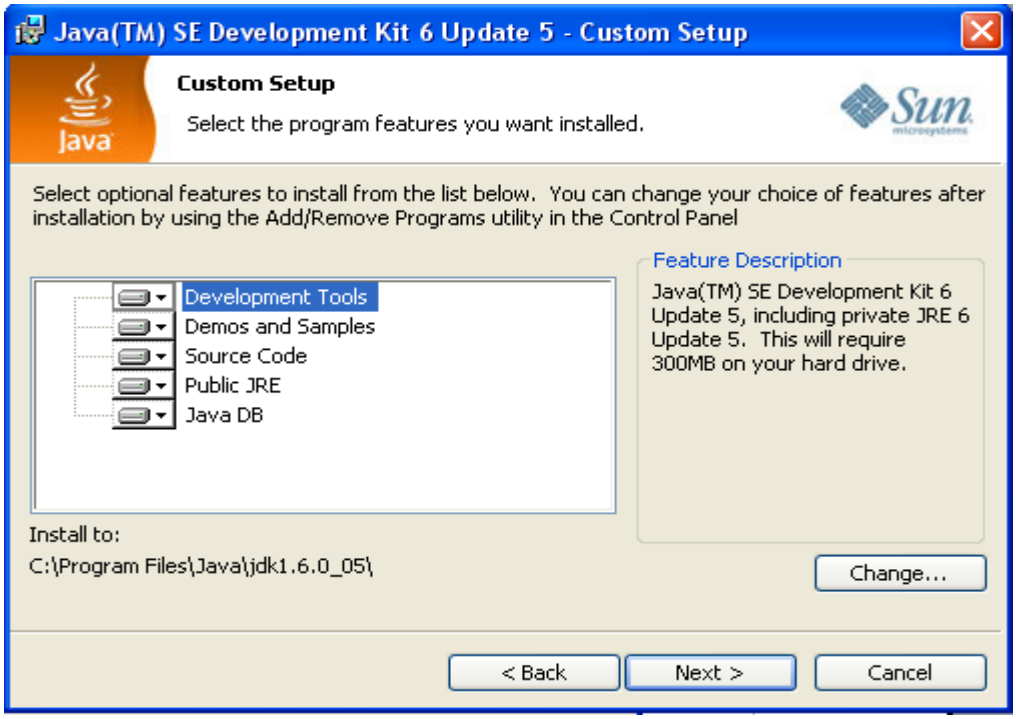


Figure 12.4: Custom setup

Click on NEXT to continue installation.

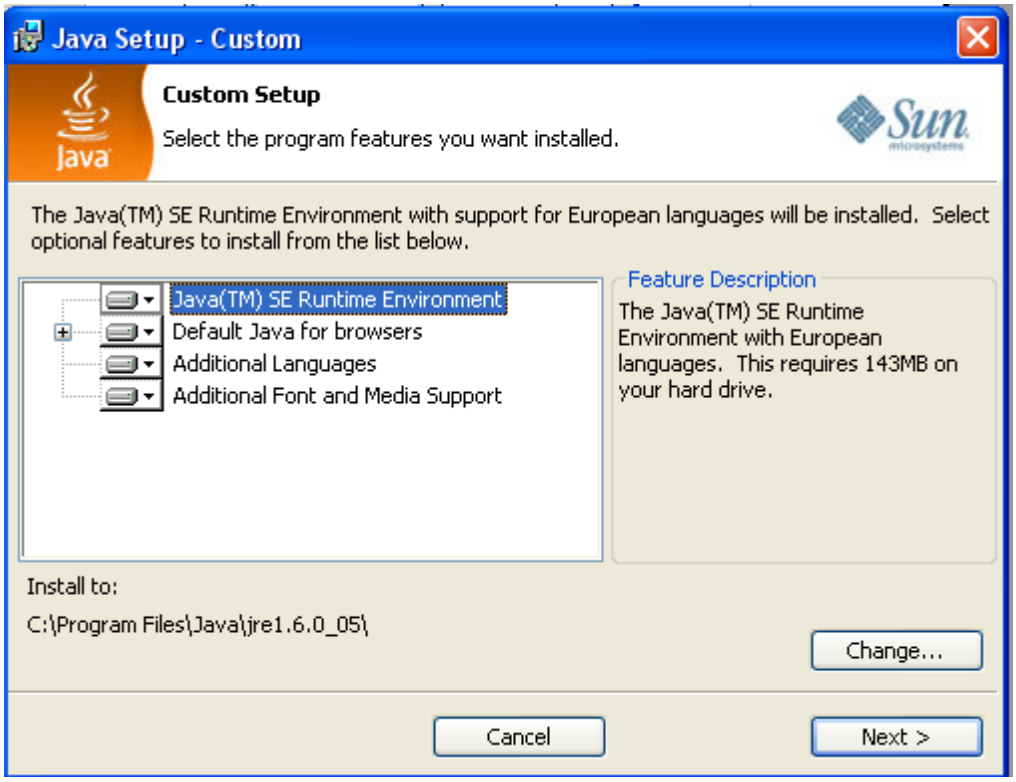


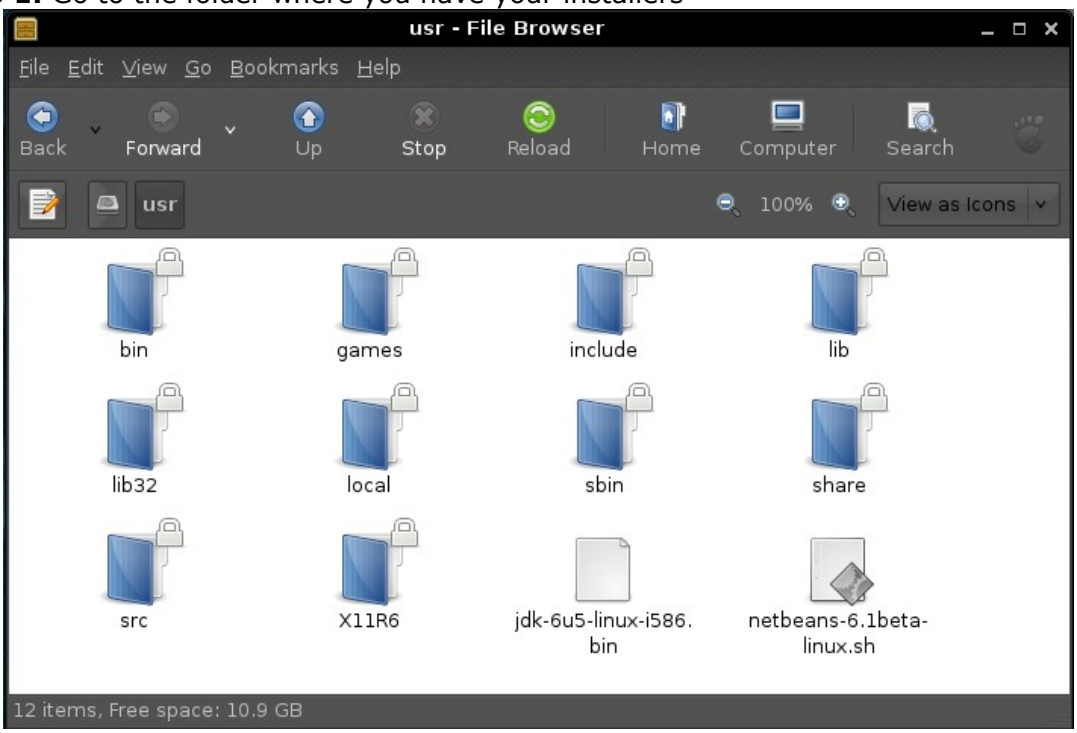
Figure 12.5: Custom setup

Click on FINISH to complete installation.

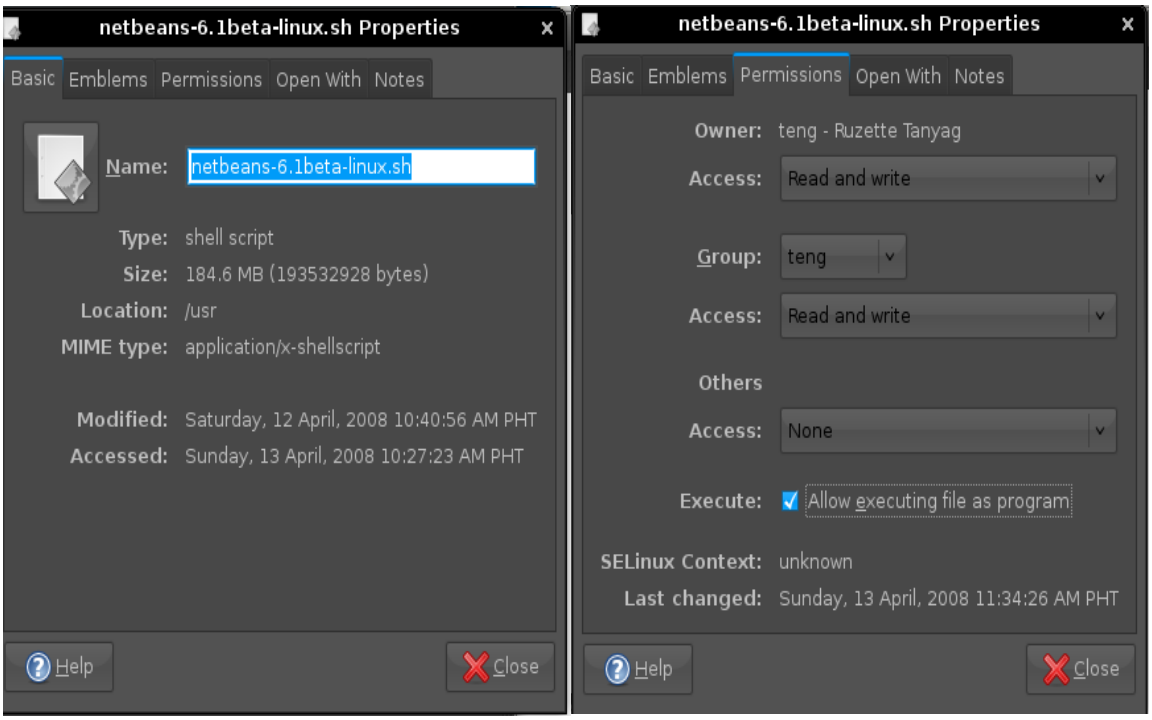
Figure 12.6: Finish installation

Installing NetBeans in Ubuntu Gutsy

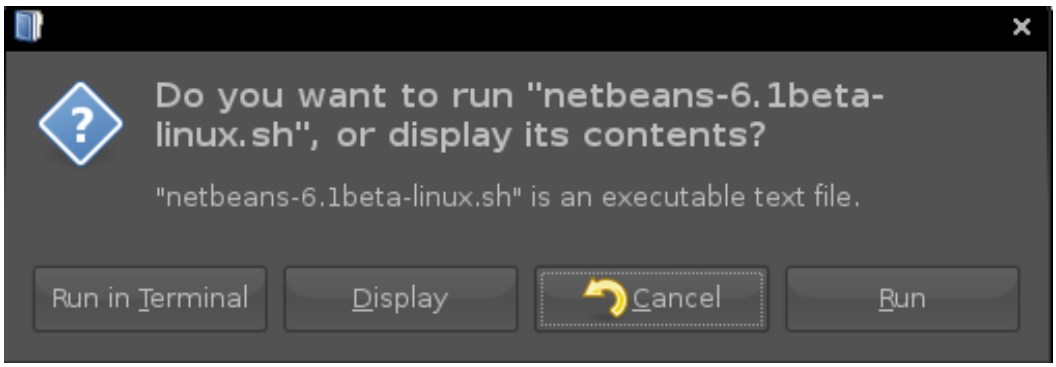
Step 1: Go to the folder where you have your installers

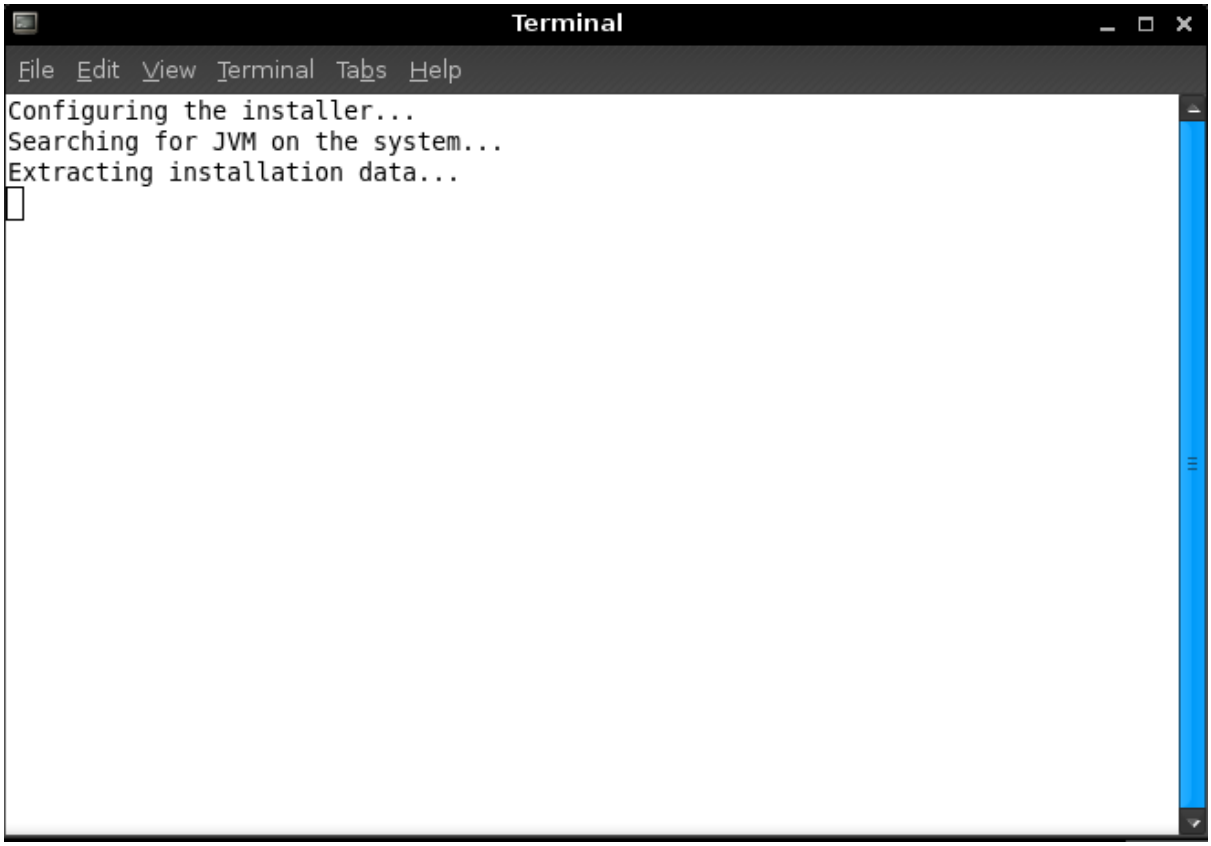


Step 2: Before running your installer, make sure it is executable.
To do this, right click on the installer, click on Properties. Click on the Permissions tab, and then Click on the execute box. Close the window.

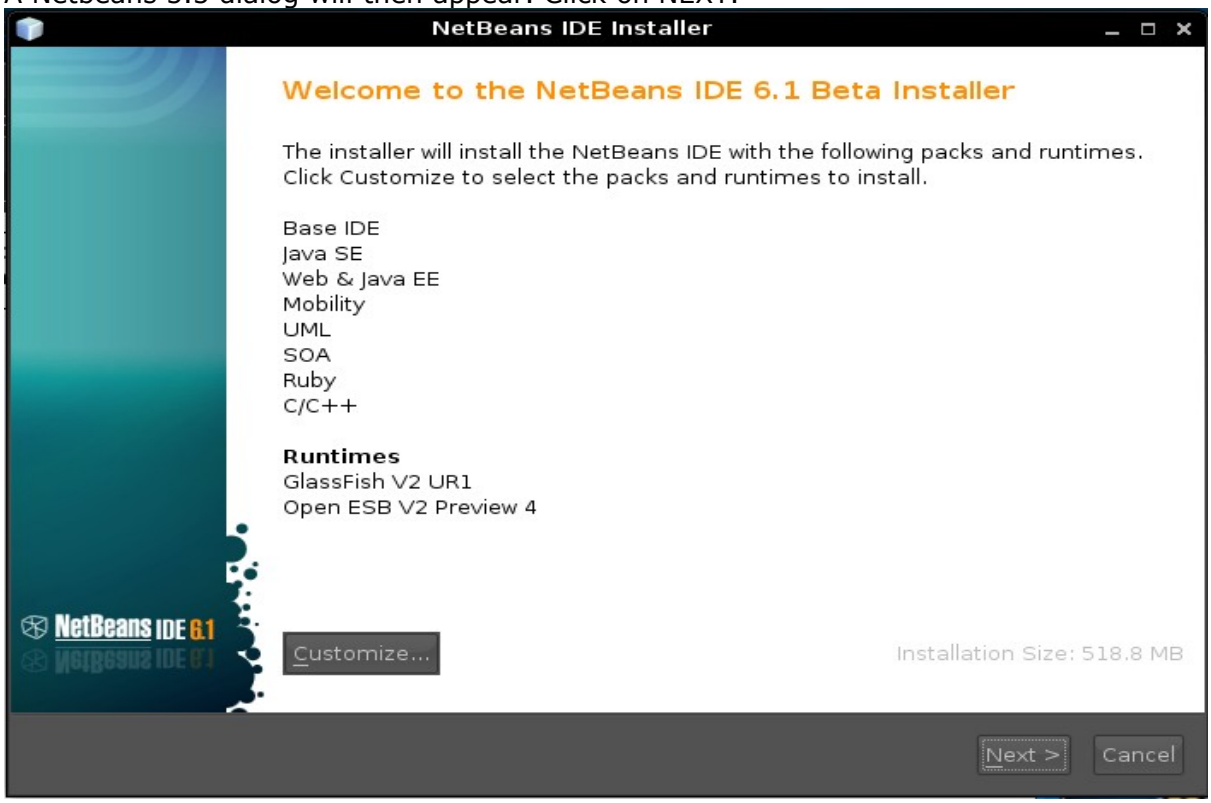


Step 3: Double click on the file netbeans-5_5-beta-linux.bin. Click on Run in Terminal.



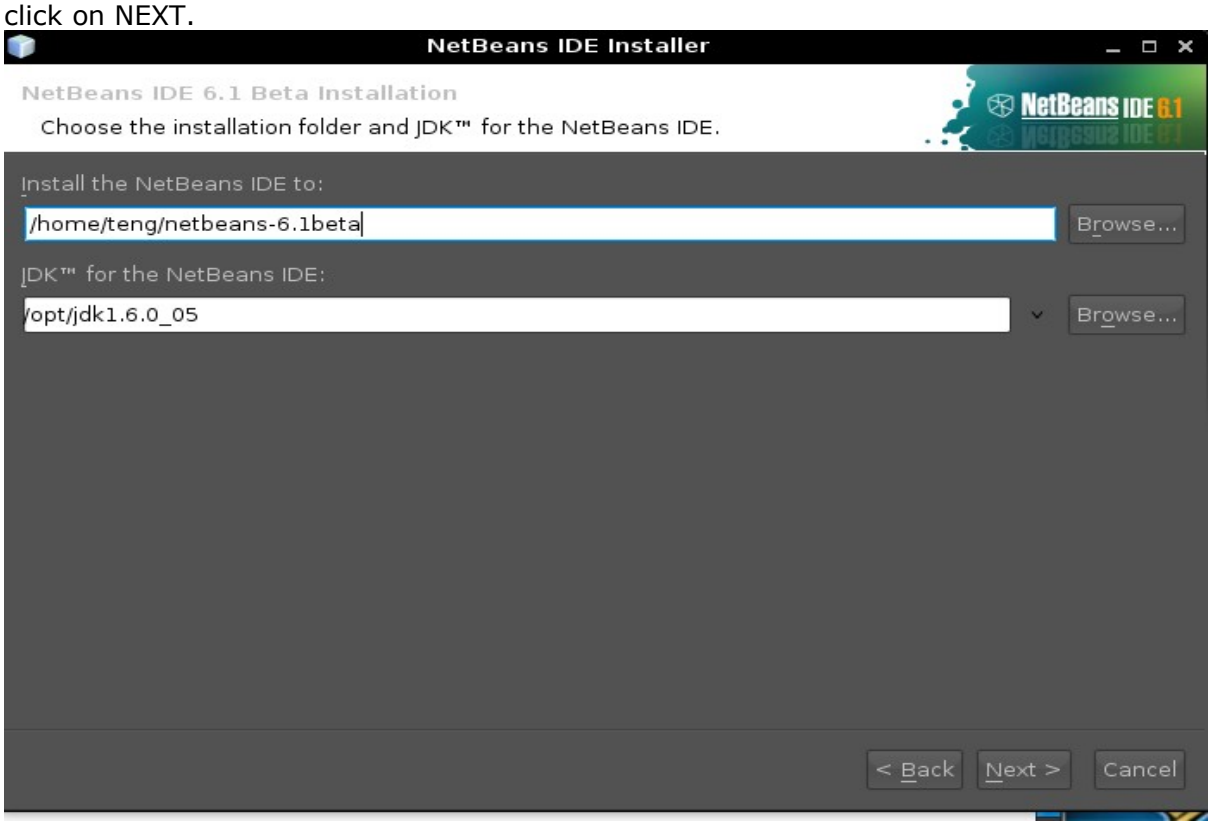


A Netbeans 5.5 dialog will then appear. Click on NEXT.

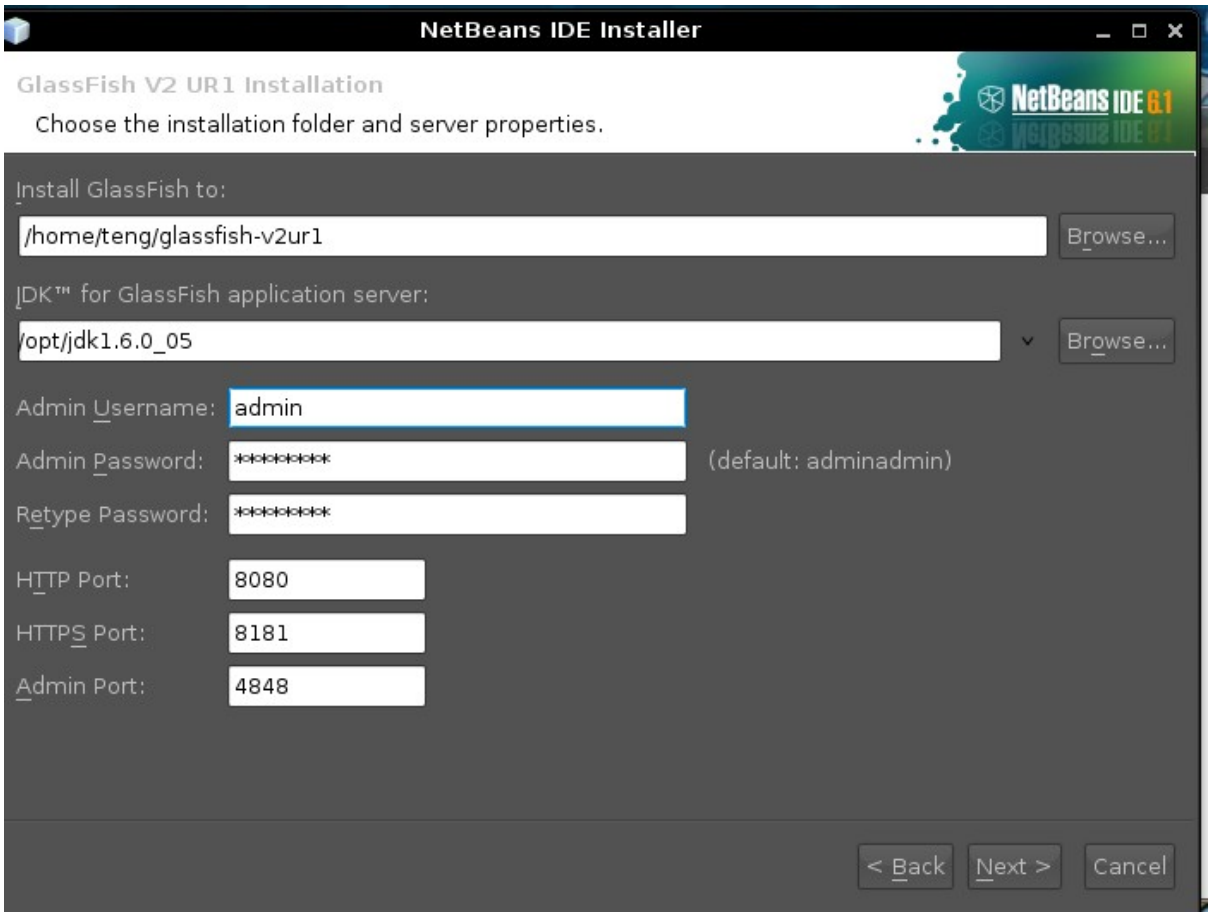


Click on the radio button that says "I accept the terms in the license agreement". And then click on NEXT.

click on NEXT.

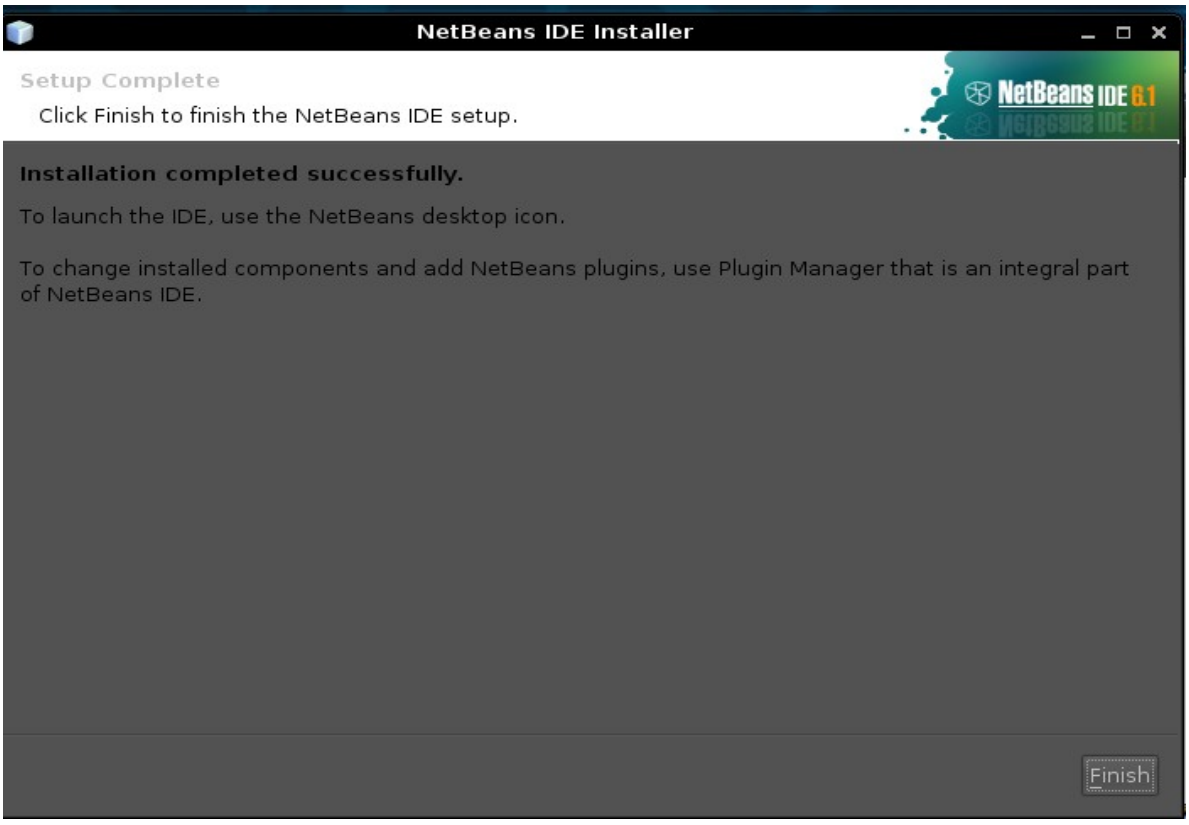


Click on NEXT.

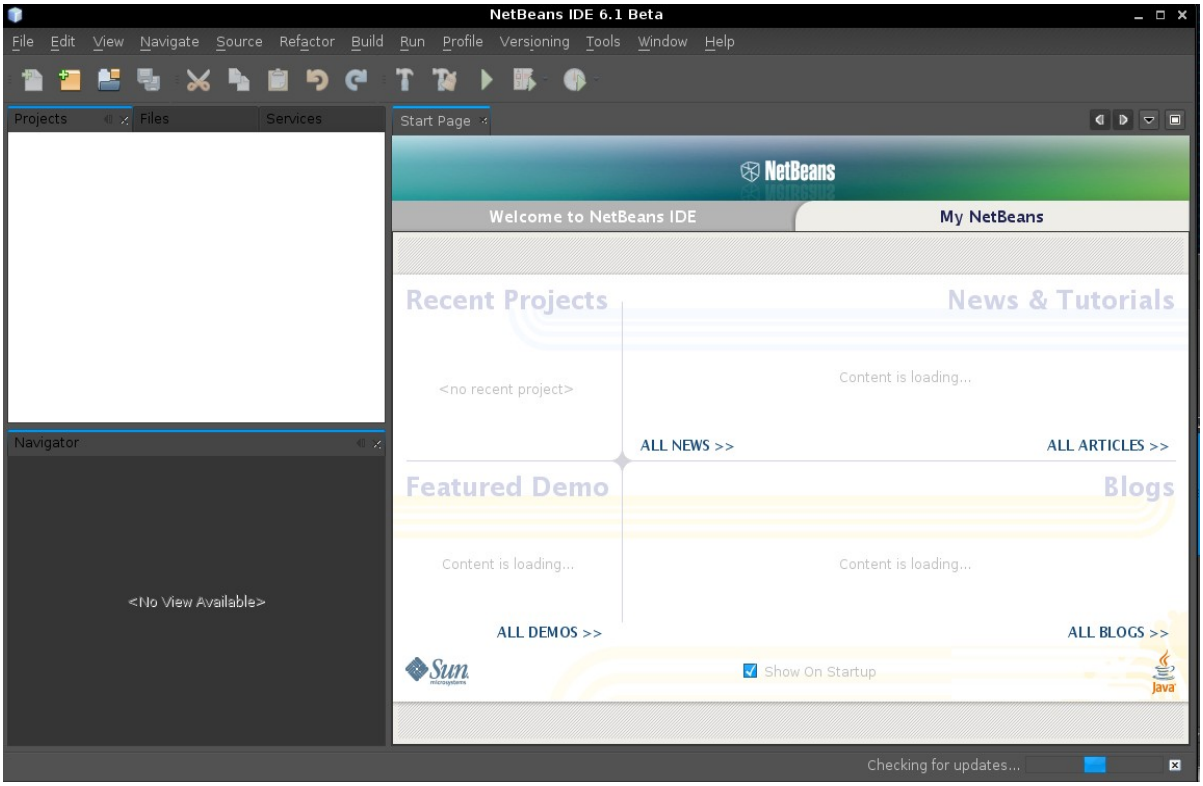


The next dialog just shows information about NetBeans thatyou will install. Just click again on NEXT.

Now, just wait for NetBeans to finish its installation. Click on FINISH to complete the installation.



Now, you can run NetBeans by double clicking the Netbeans icon on your desktop.



Installing NetBeans in Windows

Step 1: Using Windows Explorer, go to the folder where your NetBeans installer is located

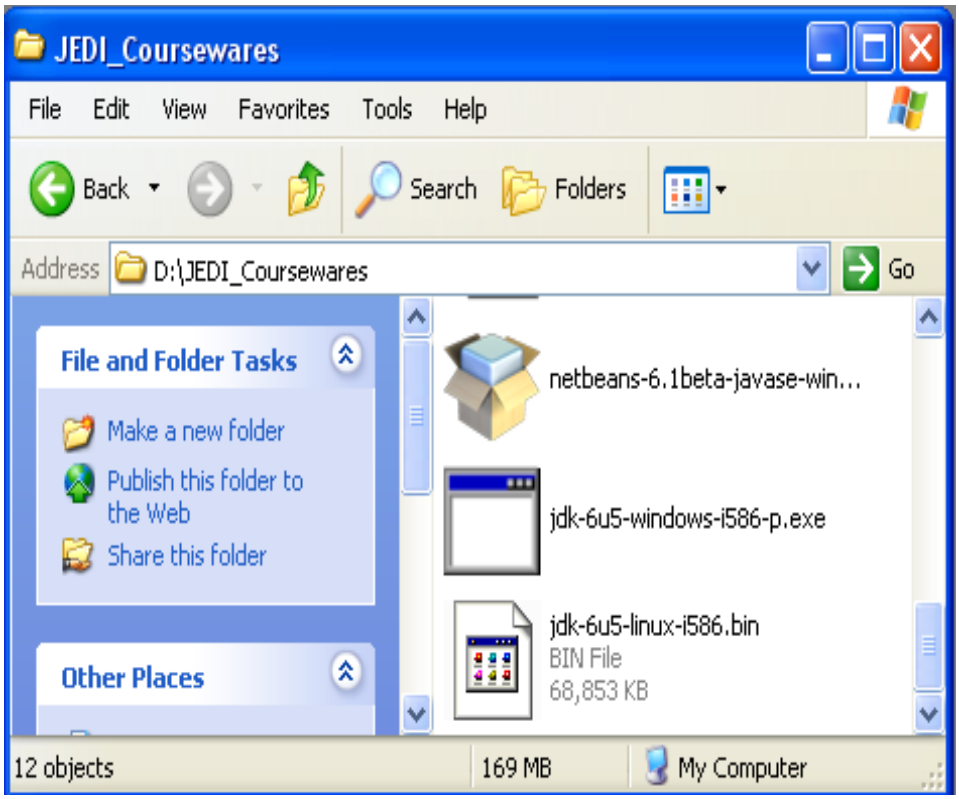


Figure 12.7: NetBeans installer file

Step 2: Run the installer

To run the installer, just double-click on the installer icon. After clicking on the netbeans-6.1beta-javase-windows icon, the NetBeans installation wizard will appear. Click on NEXT to enter installation process.

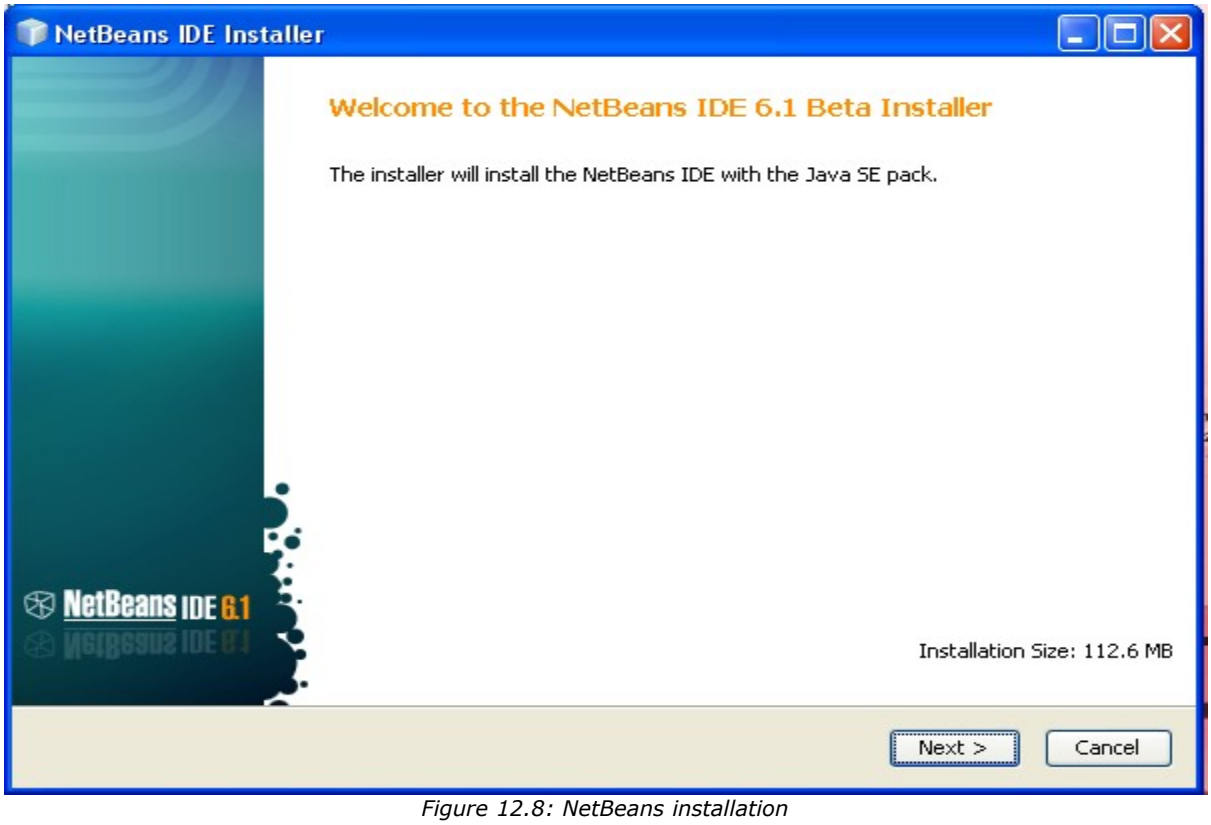


Figure 12.8: NetBeans installation

The agreement page will the appear. Choose to ACCEPT and click NEXT to continue.

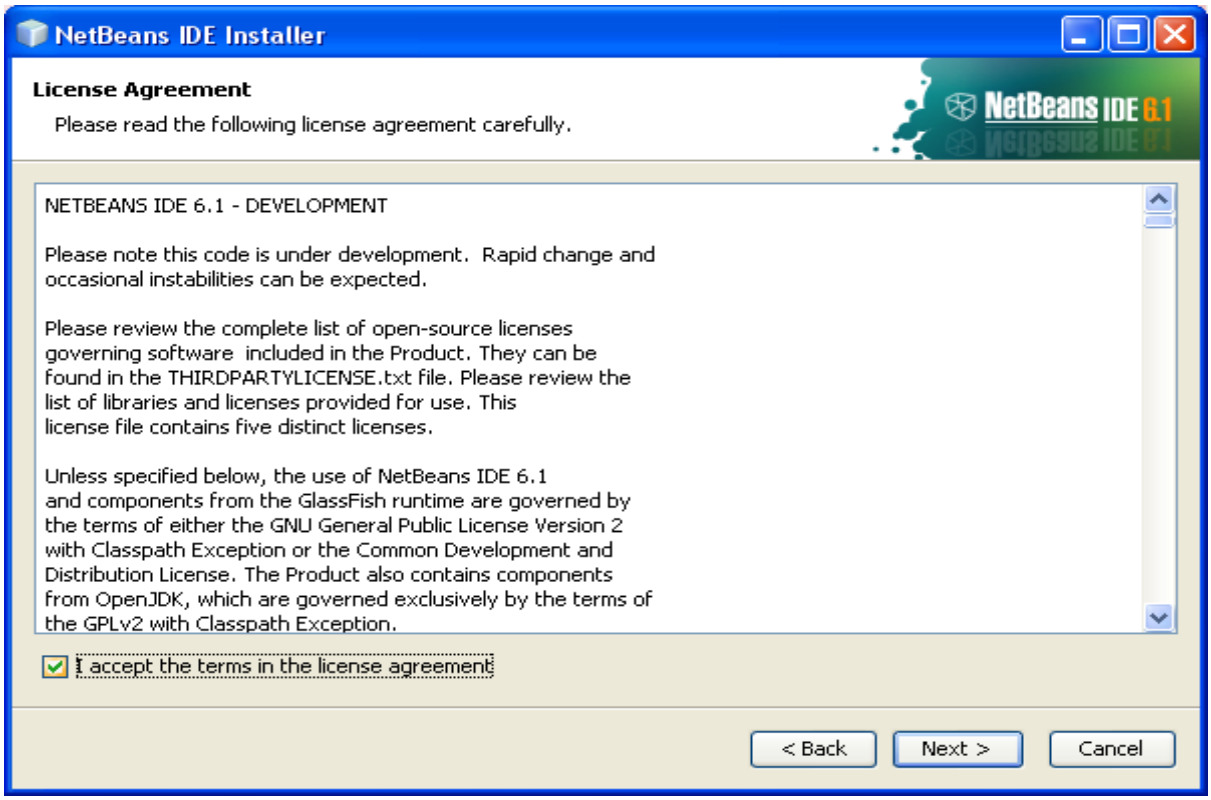


Figure 12.9: License Agreement

Then you will be given the choice on which directory to place the NetBeans. You can click on BROWSE to choose a different directory. Next is choosing the Standard Edition JDKs from your machine. If you have finished installing Java, the jdk1.6.0_03 should appear from your choices. Click on NEXT to continue.

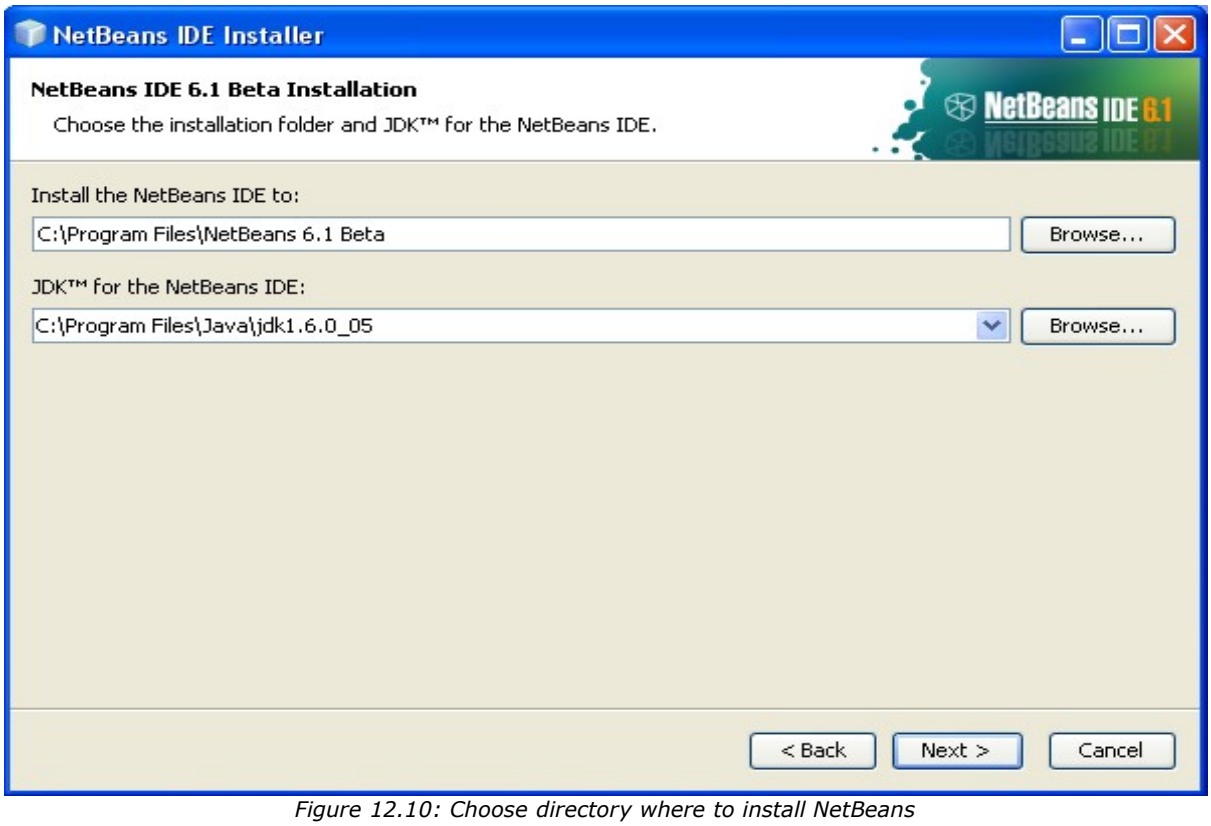


Figure 12.10: Choose directory where to install NetBeans

It will then inform you the location and size of NetBeans which will be installed to your machine. Click on NEXT to finish installation.

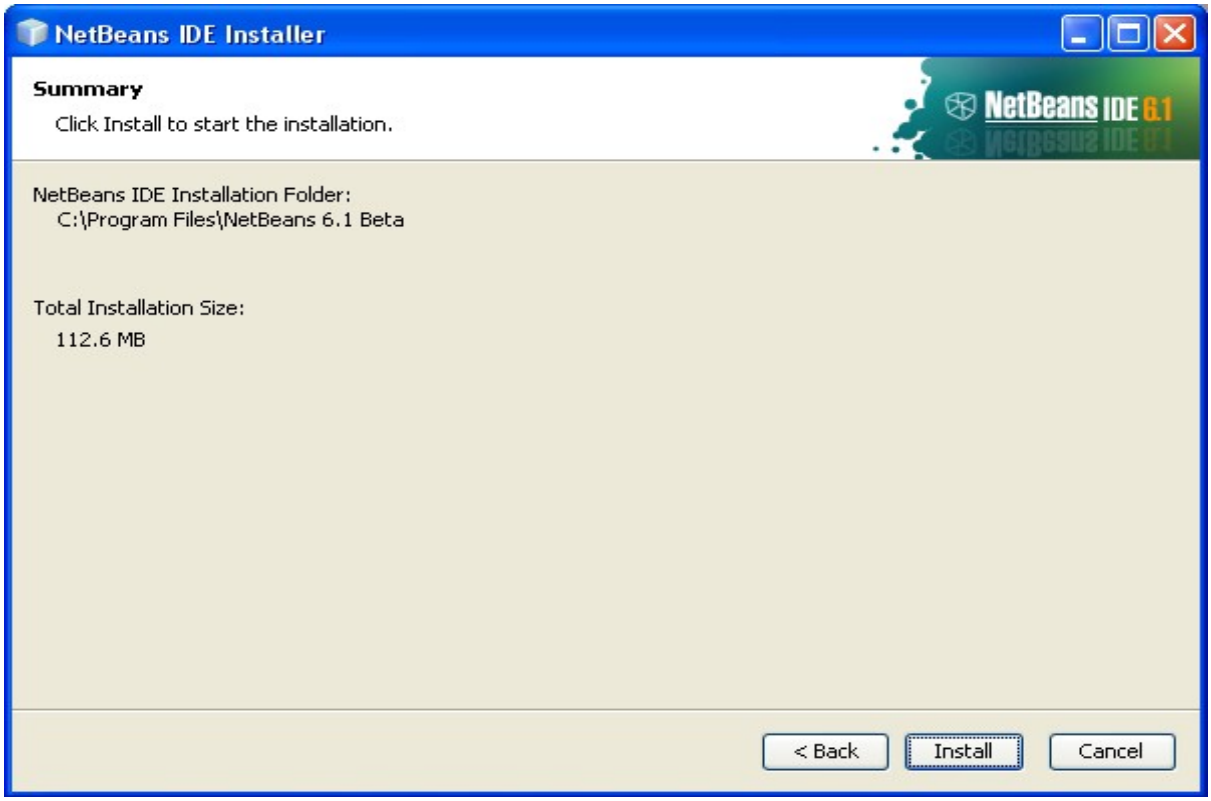


Figure 12.11: Installation Summary

You have installed NetBeans on your computer. Click on FINISH to complete installation.

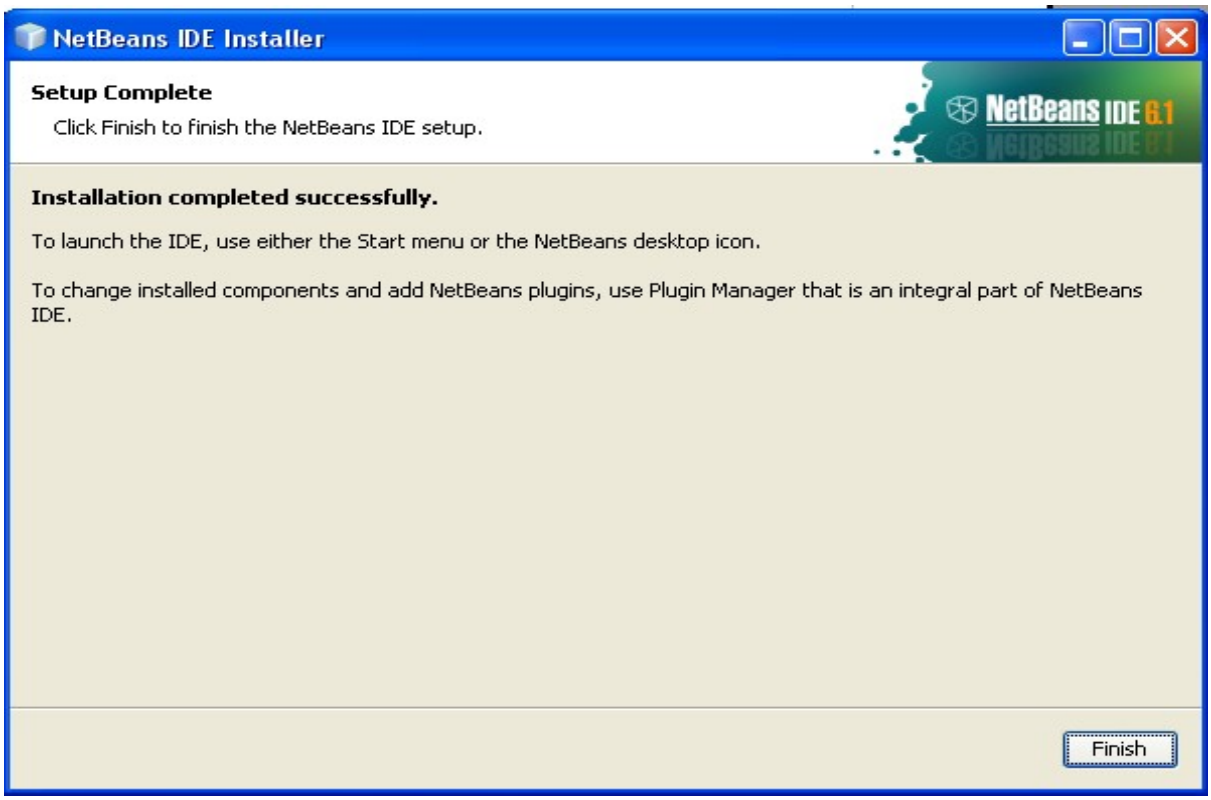


Figure 12.12: Successful installation

Appendix B: Getting to know your Programming Environment (Windows XP version)

In this section, we will be discussing on how to write, compile and run Java programs. There are two ways of doing this, the first one is by using a console and a text editor. The second one is by using NetBeans which is an **Integrated Development Environment or IDE**.

An IDE is a programming environment integrated into a software application that provides a GUI builder, a text or code editor, a compiler and/or interpreter and a debugger.

Before going into details, let us first take a look at the first Java program you will be writing.

My First Java Program

```
public class Hello
{
    /**
     * My first java program
     */
    public static void main(String[] args) {

      //prints the string "Hello world" on screen
         System.out.println("Hello world!");

    }
}
```

Before we try to explain what the program means, let's first try to write this program in a file and try to run it.

Using a Text Editor and Console

For this example, we will be using the text editor "Notepad"(for Windows) to edit the Java source code. You can use other text editors if you want to. You will also need to open the MS-DOS prompt window to compile and execute your Java programs.

Step 1: Start Notepad

To start Notepad in Windows, click on start-> All Programs-> Accessories-> Notepad.

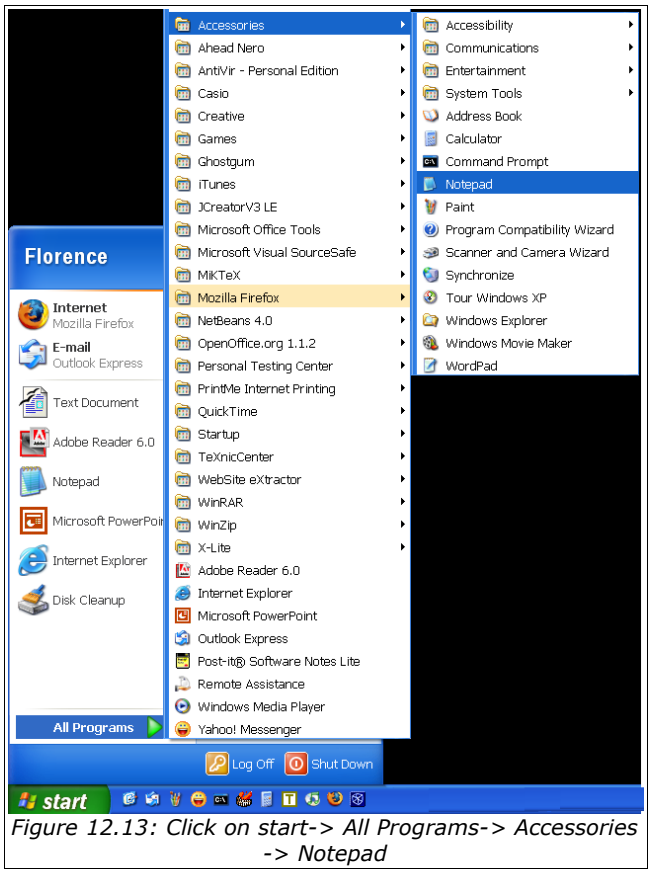


Figure 12.13: Click on start-> All Programs-> Accessories -> Notepad

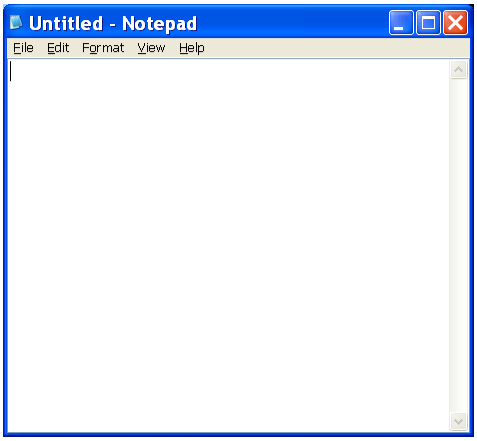


Figure 12.14: Notepad Application

Step 2: Open the Command Prompt window

To open the MSDOS command prompt in Windows, click on start-> All programs-> Accessories-> Command Prompt.

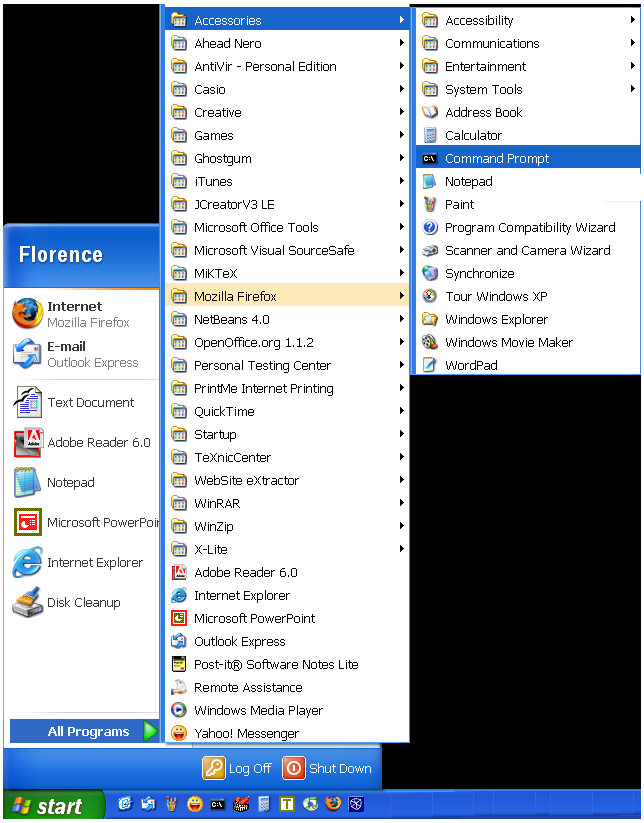


Figure 12.15: start-> All programs-> Accessories -> Command Prompt

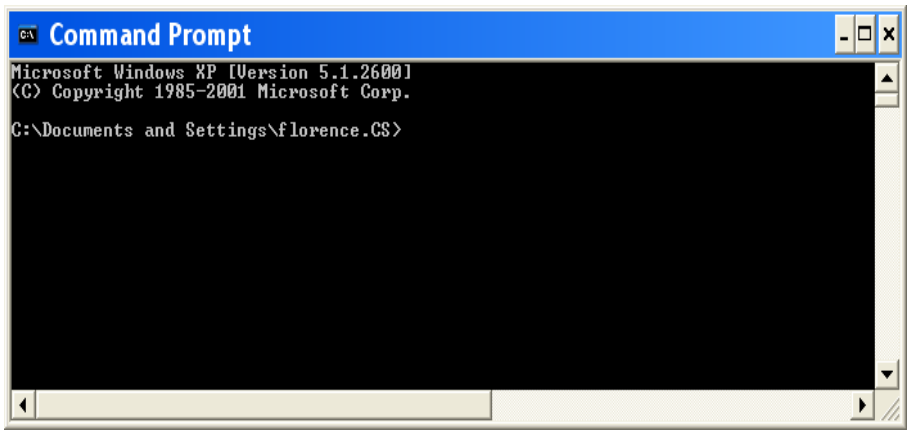
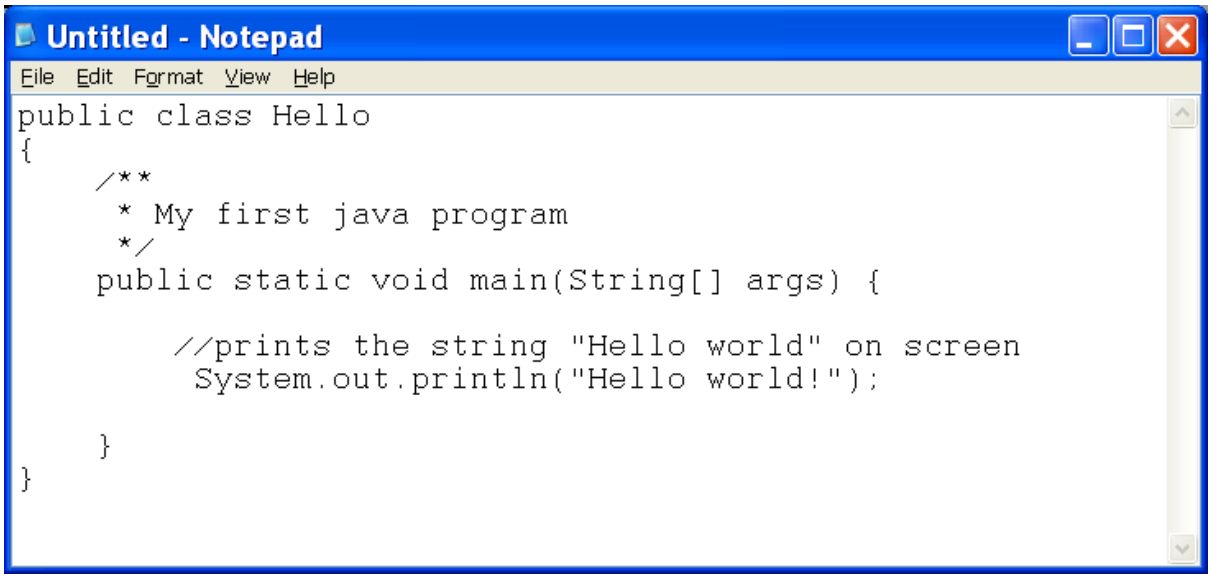


Figure 12.16: MSDOS Command Prompt

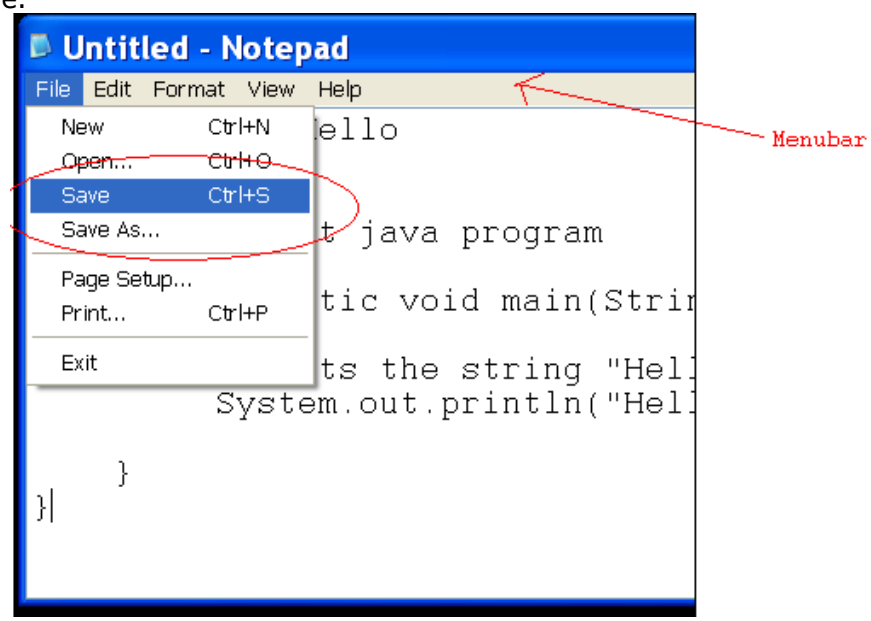
Step 3: Write your the source code of your Java program in Notepad



Step 4: Save your Java Program

We will save our program on a file named "Hello.java", and we will be saving it inside a folder named MYJAVAPROGRAMS.

To open the **Save** dialog box, click on the File menu found on the menubar and then click on Save.



After doing the procedure described above, a dialog box will appear as shown in Figure below.

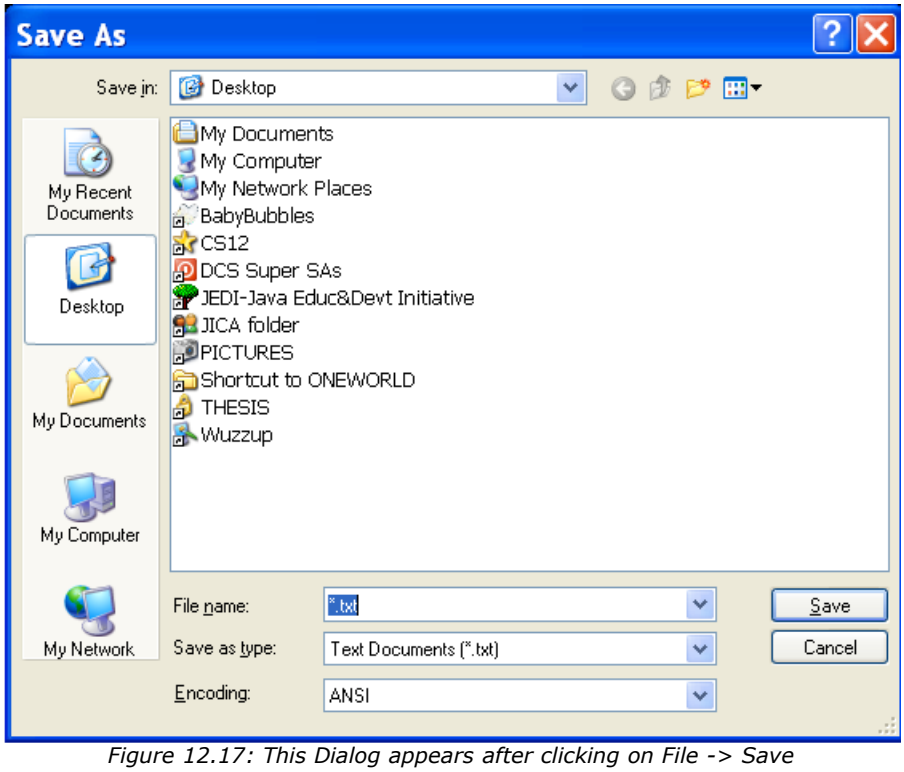


Figure 12.17: This Dialog appears after clicking on File -> Save

Click on the **MY DOCUMENTS** button to open the My Documents folder where we will be saving all your Java programs.

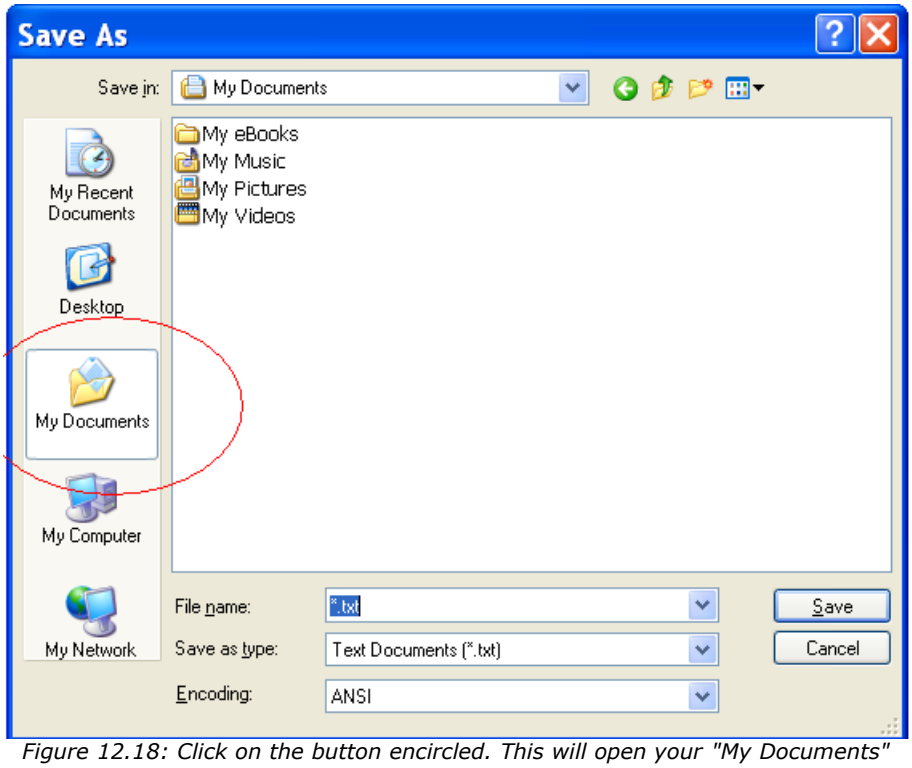


Figure 12.18: Click on the button encircled. This will open your "My Documents" folder

Now, we'll create a new folder inside the My Documents folder where we will save your programs. We shall name this folder MYJAVAPROGRAMS. Click on the button encircled in the figure below to create the folder.

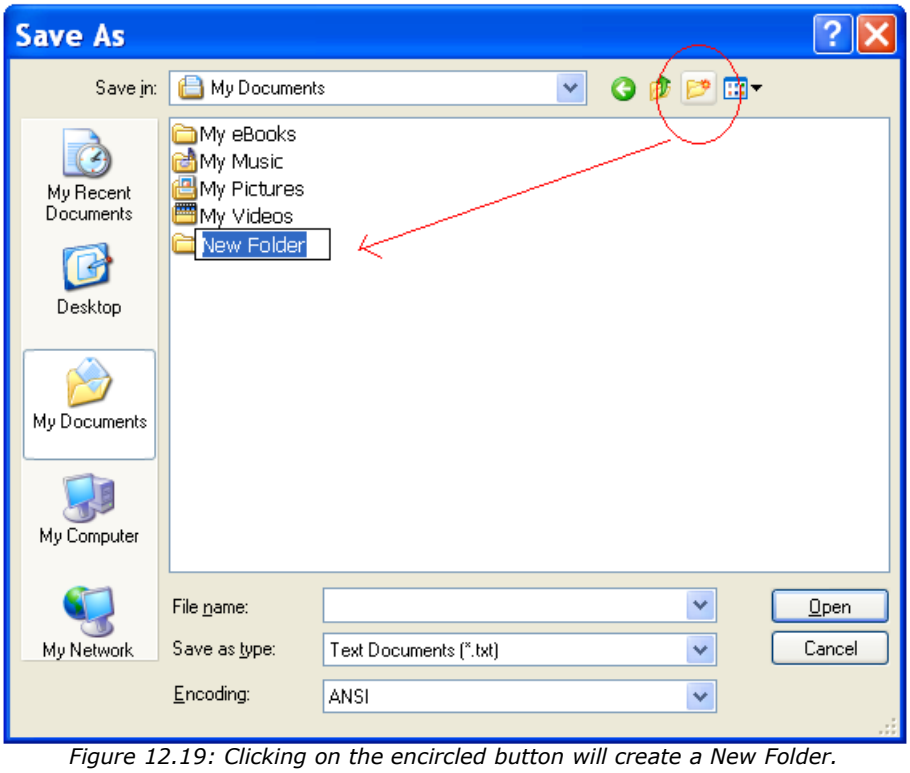
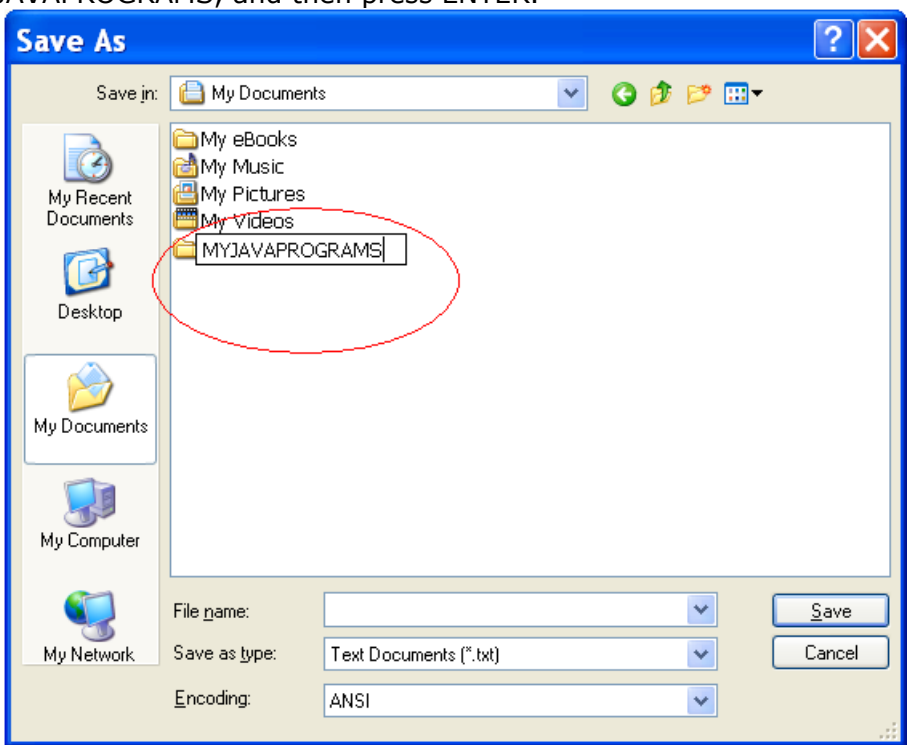
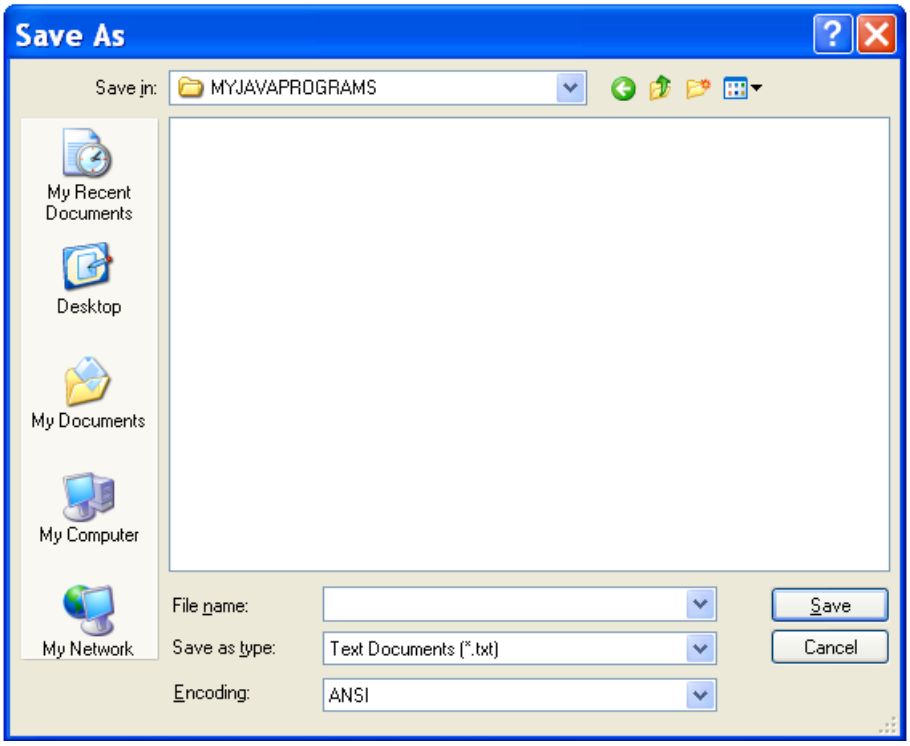


Figure 12.19: Clicking on the encircled button will create a New Folder.

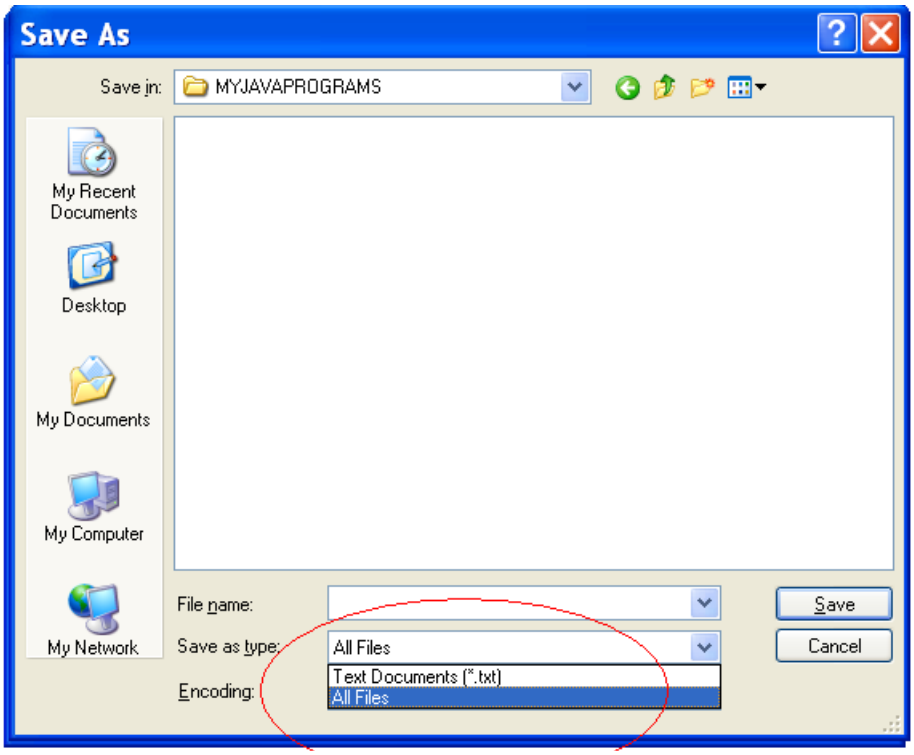
After the folder is created, you can type in the desired name for this folder. In this case, type in MYJAVAPROGRAMS, and then press ENTER.



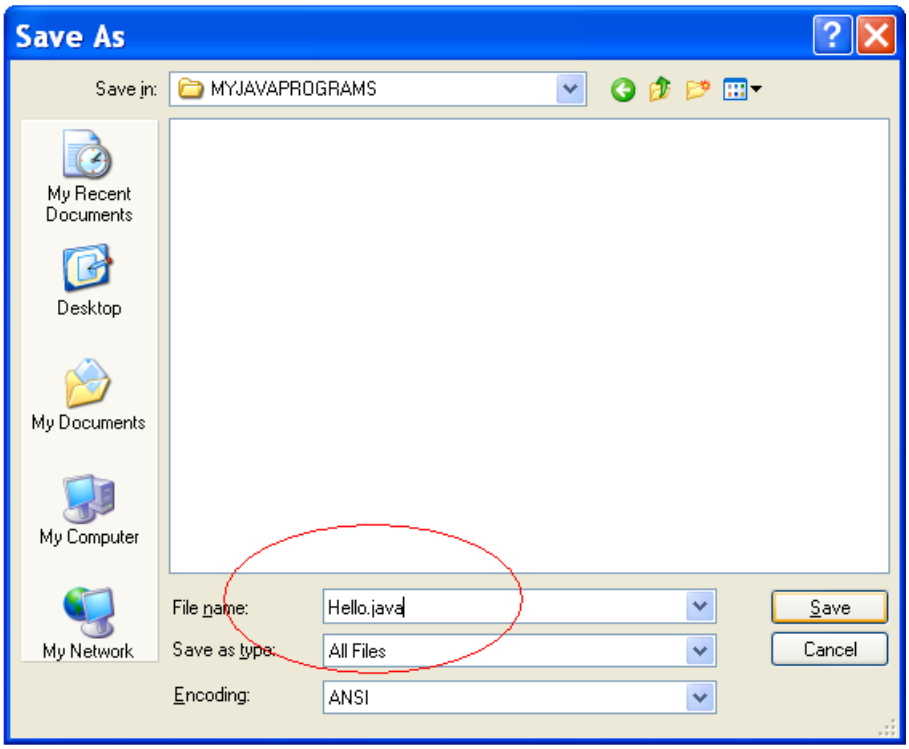
Now that we've created the folder where we will save all the files, double click on that folder to open it. You will see a similar figure as shown below. The folder should be empty for now since it's a newly created folder and we haven't saved anything in it yet.



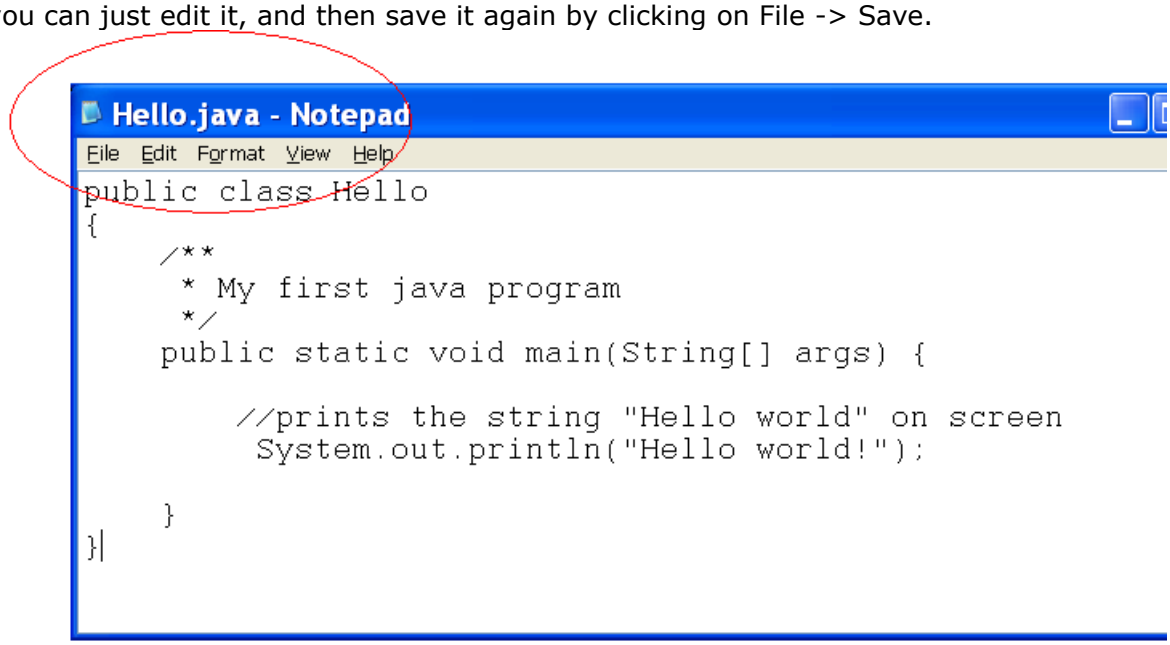
Now click on the drop down list box "Save as type", so that we can choose what kind of file we want to save. Click on the "All Files" option.



Now, in the Filename textbox, type in the filename of your program, which is "Hello.java", and then click on the SAVE button.



Now that you've saved your file, notice how the title of the frame changes from Untitled-Notepad to Hello.java-Notepad. Take note that if you want to make changes in your file, you can just edit it, and then save it again by clicking on File -> Save.



Step 5: Compiling your program

Now, the next step is to compile your program. Go to the MSDOS command prompt window we just opened a while ago.

Typically, when you open the command prompt window, it opens up and takes you directly to what is called your **home folder**. To see what is inside that home folder, type **DIR or dir** and then press ENTER. What you will see is a list of files and folders inside your home folder.

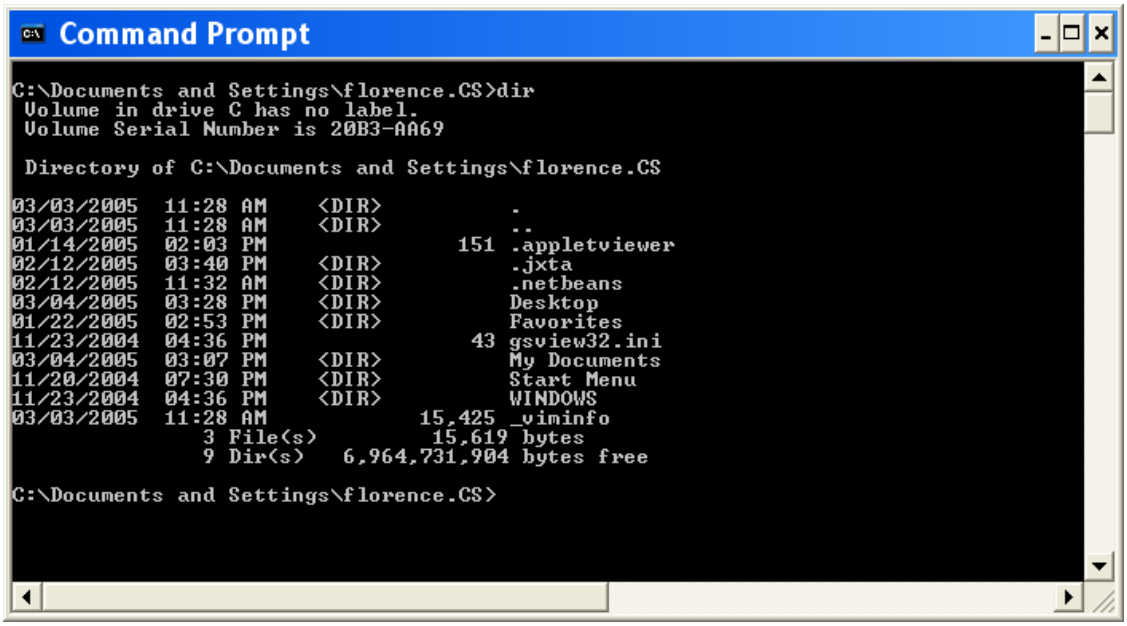


Figure 12.20: List of files and folders shown after executing the command DIR.

Now, you can see here that there is a folder named "My Documents" where we created your MYJAVAPROGRAMS folder. Now let's go inside that directory.

To go inside a directory, you type in the command: **cd [directory name].** The "cd" command stands for, change directory. In this case, since the name of our directory is My Documents, you type in: **cd My Documents.**

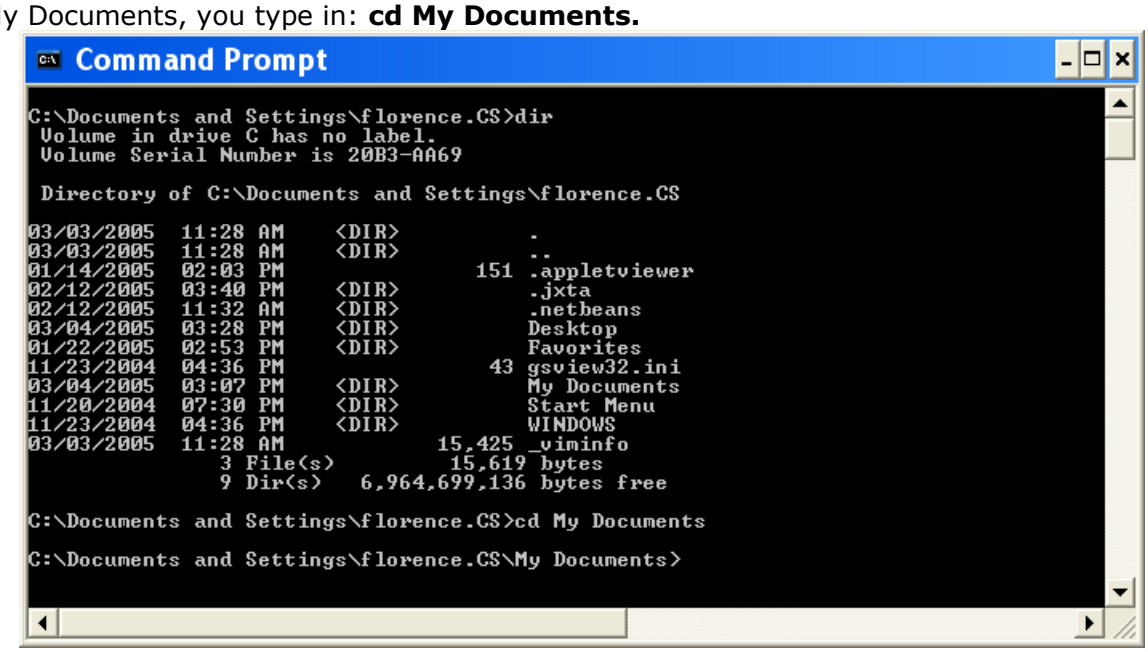


Figure 12.21: Inside the My Documents folder

Now that you are inside the "My Documents" folder, try typing in the "dir" command again, and tell me what you see.

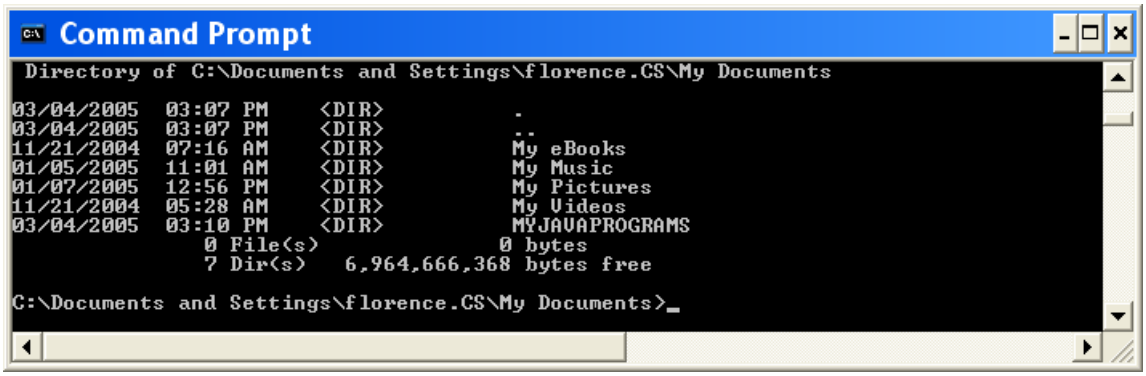


Figure 12.22: The contents of My Documents

Now perform the same steps described before to go inside the MYJAVAPROGRAMS folder.

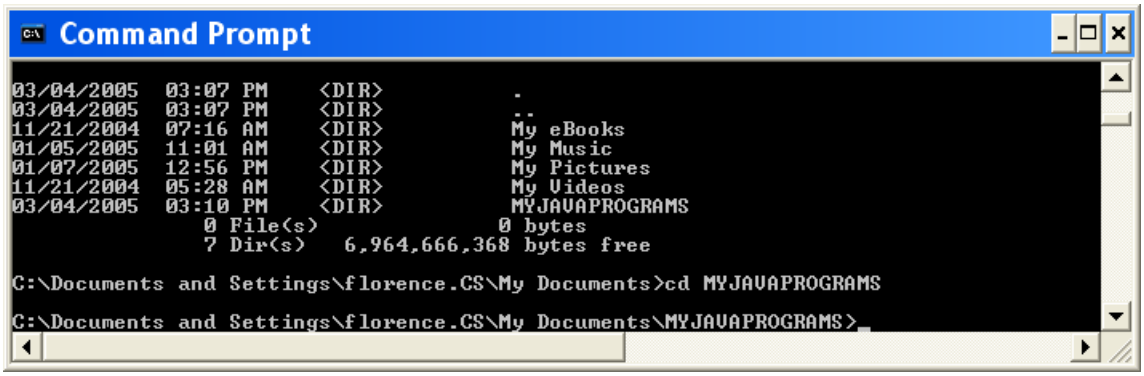


Figure 12.23: Inside the MYJAVAPROGRAMS folder

Once inside the folder where your Java programs are, let us now start compiling your Java program. Take note that, you should make sure that the file is inside the folder where you are in. In order to do that, execute the **dir** command again to see if your file is inside that folder.

To compile a Java program, we type in the command: **javac [filename]**. So in this case, type in: **javac Hello.java.**

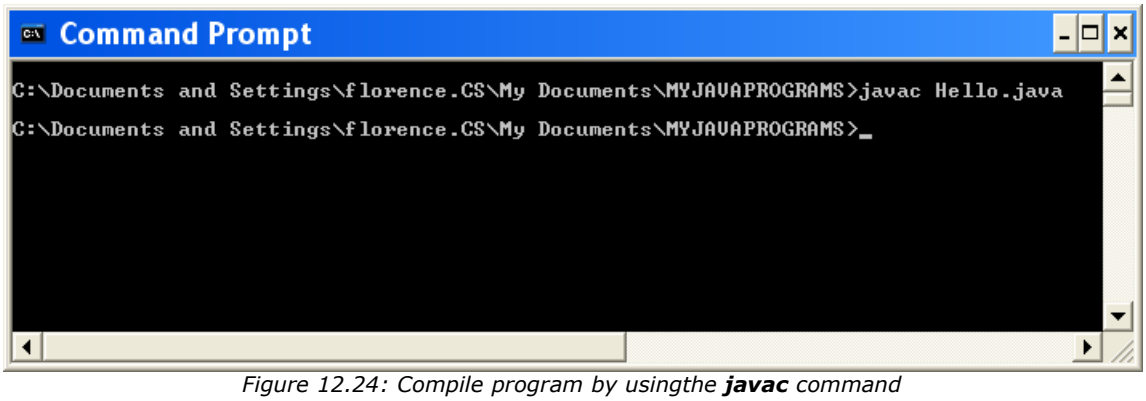


*Figure 12.24: Compile program by usingthe **javac** command*

During compilation, javac adds a file to the disk called **[filename].class,** or in this case, **Hello.class**, which is the actual bytecode.

Step 6: Running the Program

Now, assuming that there are no problems during compilation (we'll explore more of the problems encountered during compilation in the next section), we are now ready to run your program.

To run your Java program, type in the command: **java [filename without the extension]**, so in the case of our example, type in: **java Hello**

You can see on the screen that you have just run your first Java program that prints the message, "Hello world!".

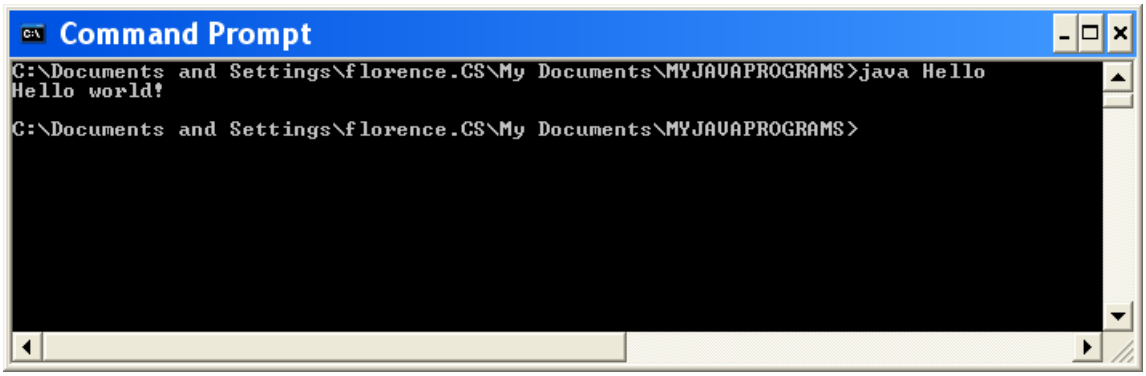


Figure 12.25: Output of the program

Setting the Path

Sometimes, when you try to invoke the javac or java command, you encounter the message: **'javac' is not recognized as an internal or external command, operable program or batch file**. This means that either you haven't installed Java in your system yet, or you have to configure the path on where the Java commands are installed so that your system will know where to find them.

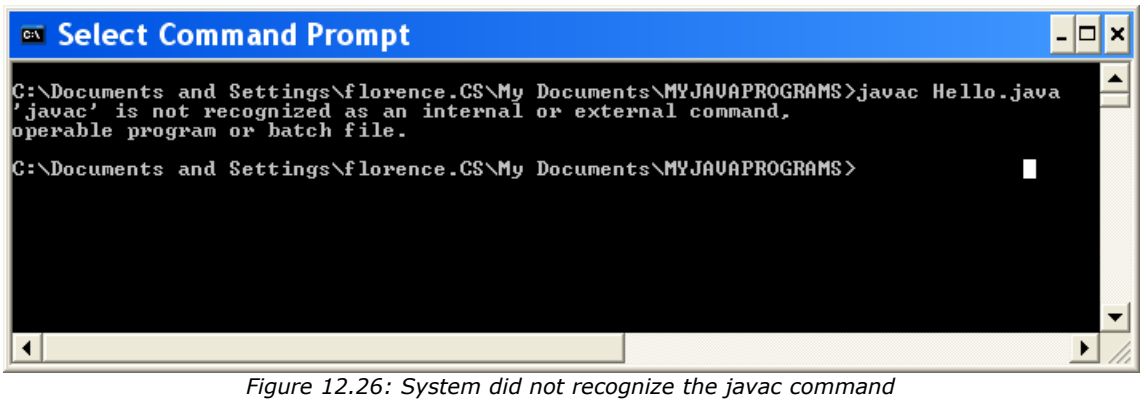


Figure 12.26: System did not recognize the javac command

If you are sure that you've already installed Java in your system, try setting the PATH variable to point to where the Java commands are installed. To do this, type in the command: **set PATH=C:\j2sdk1.4.2_04\bin.** This will tell your system to look for the commands in the **C:\j2sdk1.4.2_04\bin** folder, which is usually the default location wherein your Java files are placed during installation. After doing this, you can now use the Java commands.

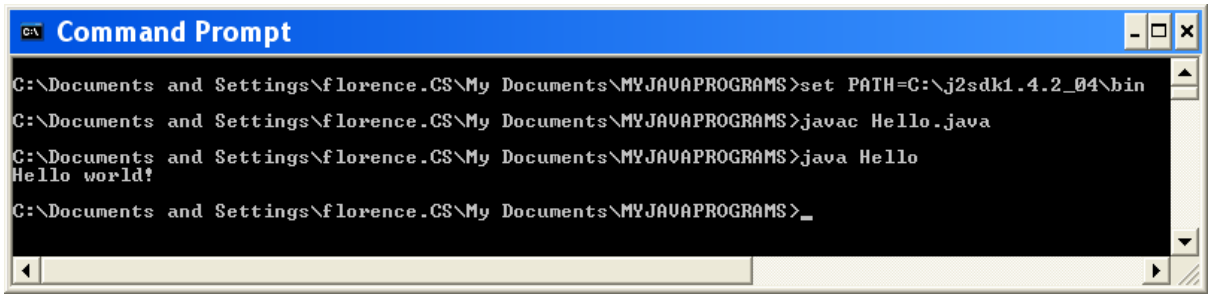


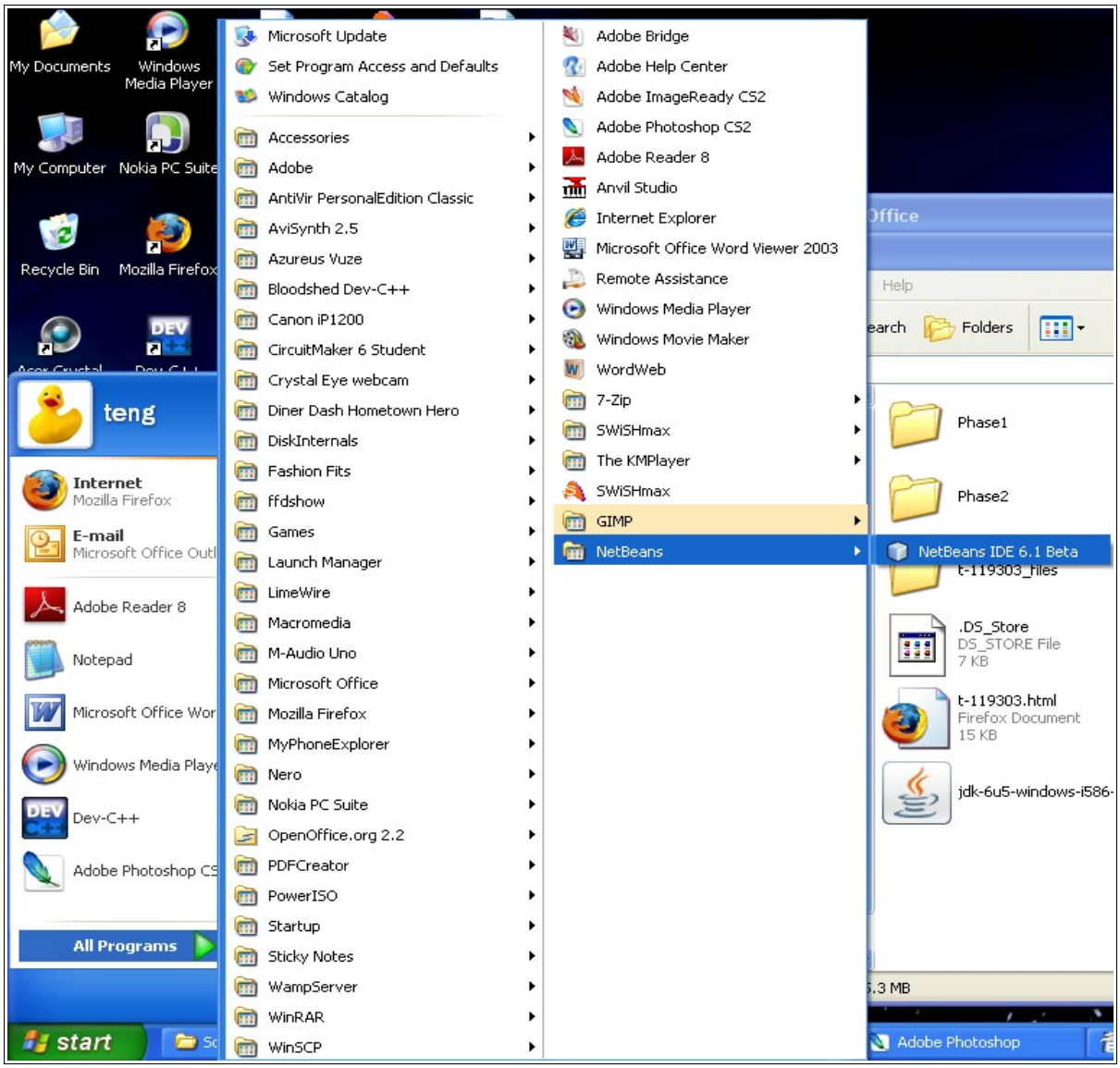
Figure 12.27: Setting the path and running java

Using NetBeans

Now that we've tried doing our programs the complicated way, let's now see how to do all the processes we've described in the previous sections by using just one application.

In this part of the lesson, we will be using **NetBeans**, which is an **Integrated Development Environment or IDE**. An IDE is a programming environment integrated into a software application that provides a GUI builder, a text or code editor, a compiler and/or interpreter and a debugger.

Step 1: Run NetBeans
To run NetBeans, click on start-> All Programs-> NetBeans 5.5 Beta -> NetBeans IDE



After you've open NetBeans IDE, you will see a graphical user interface (GUI) similar to what is shown below.

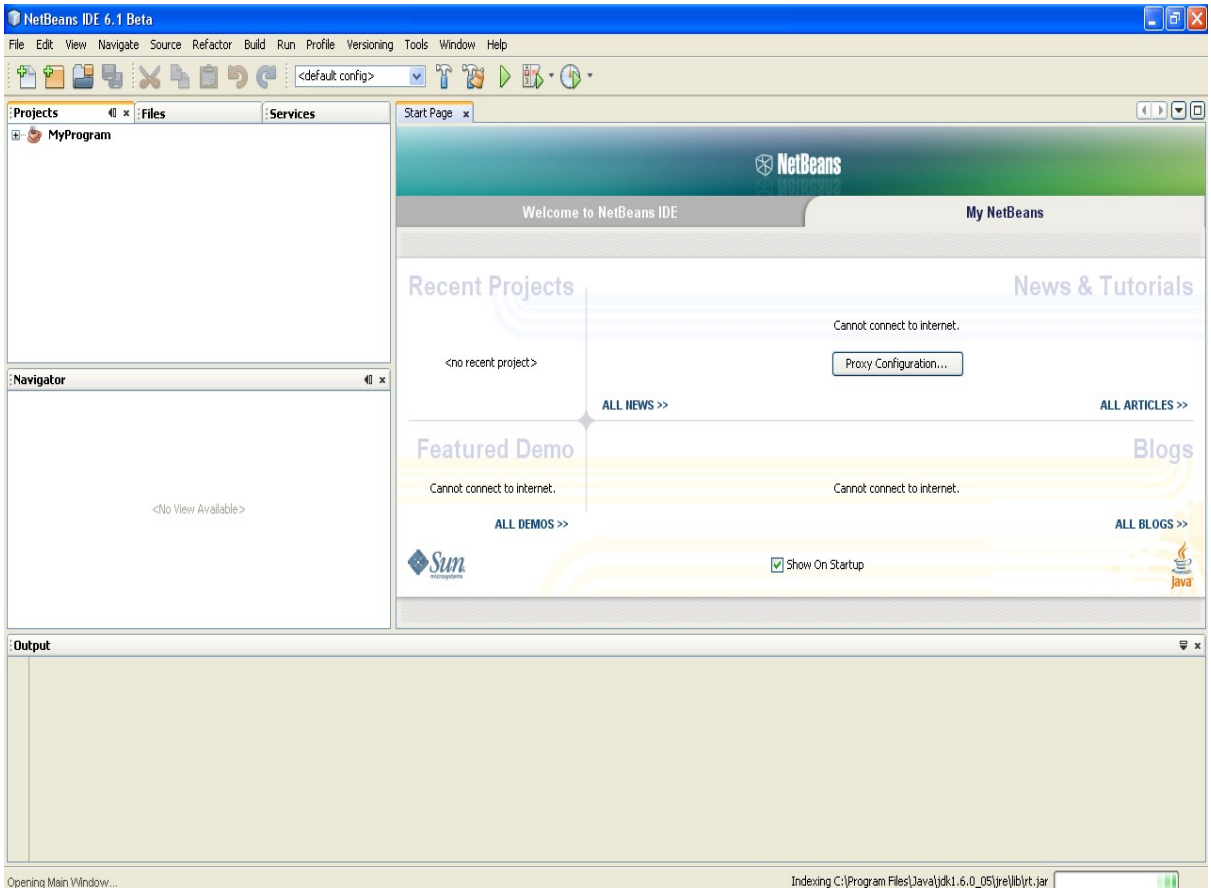
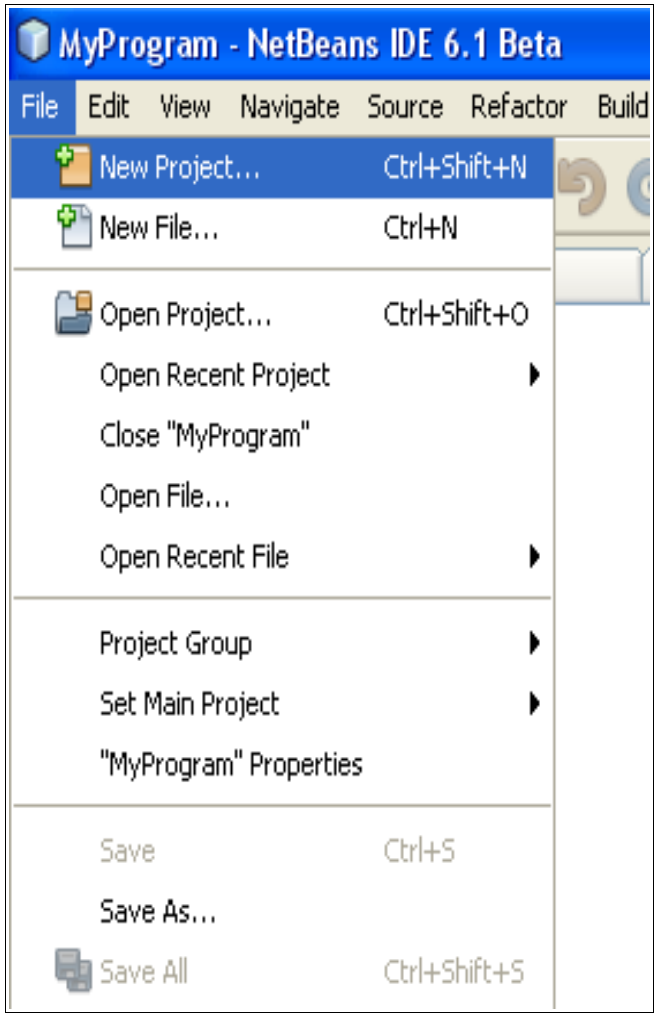


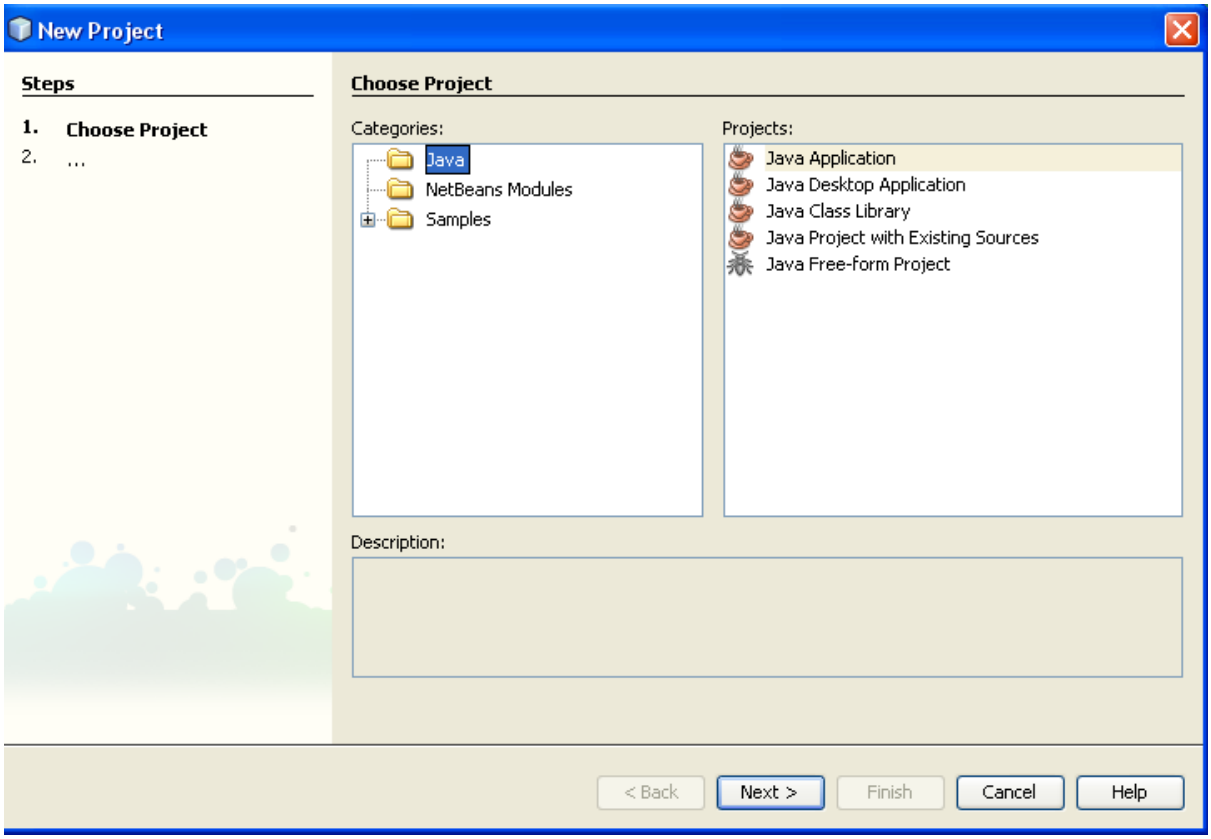
Figure 12.28: NetBeans IDE

Step 2: Make a project

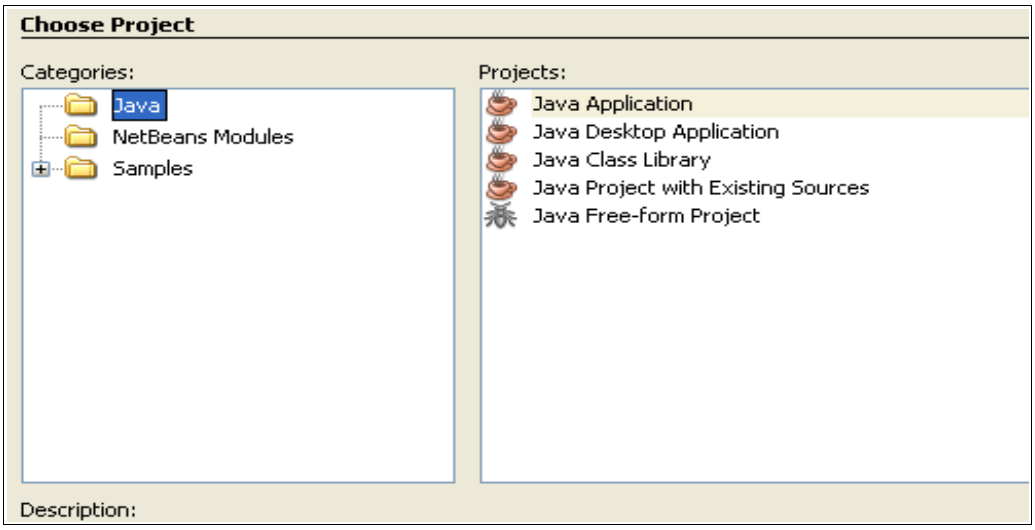
Now, let's first make a project. Click on File-> New Project.



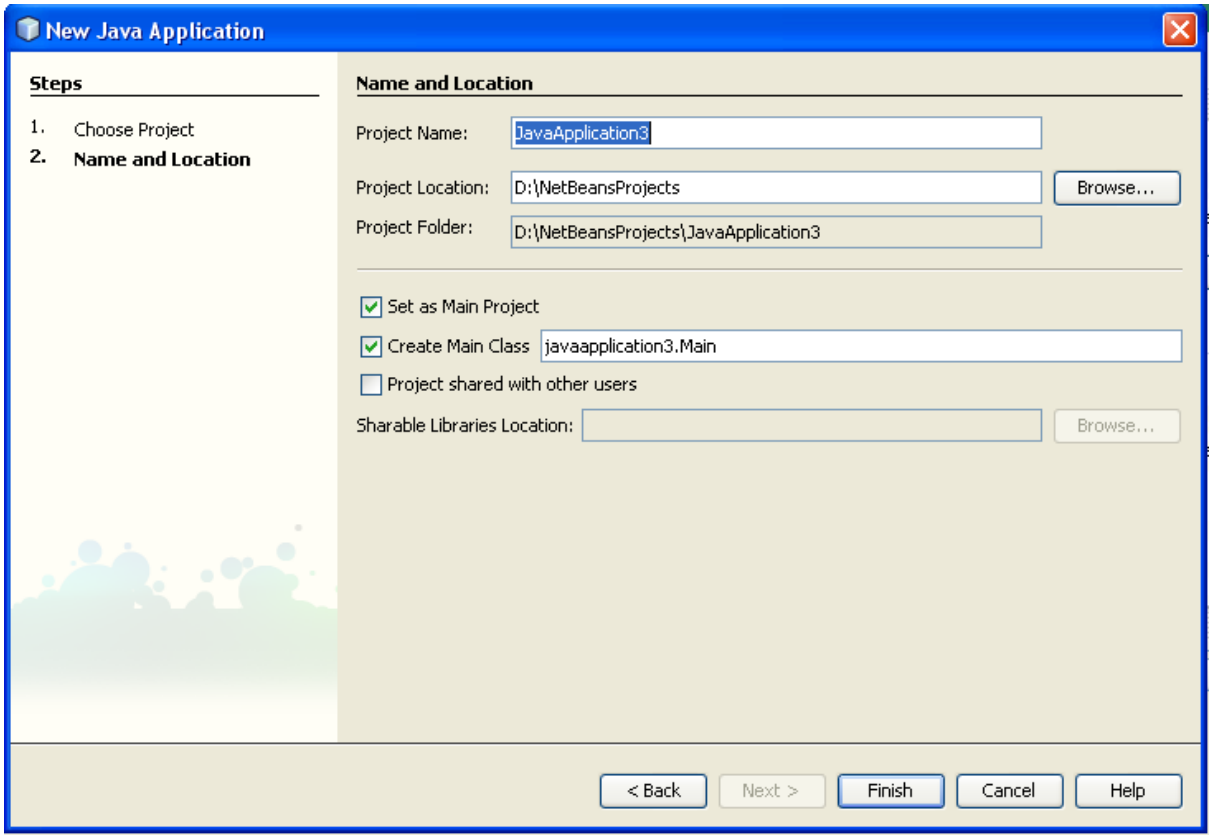
After doing this, a New Project dialog will appear.



Now click on Java Application and click on the NEXT button.



Now, a New Application dialog will appear. Edit the Project Name part and type in "HelloApplication".



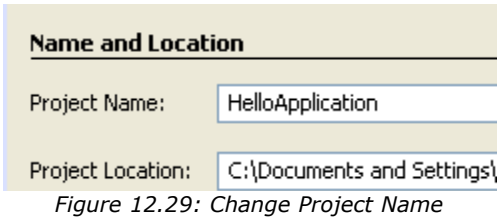
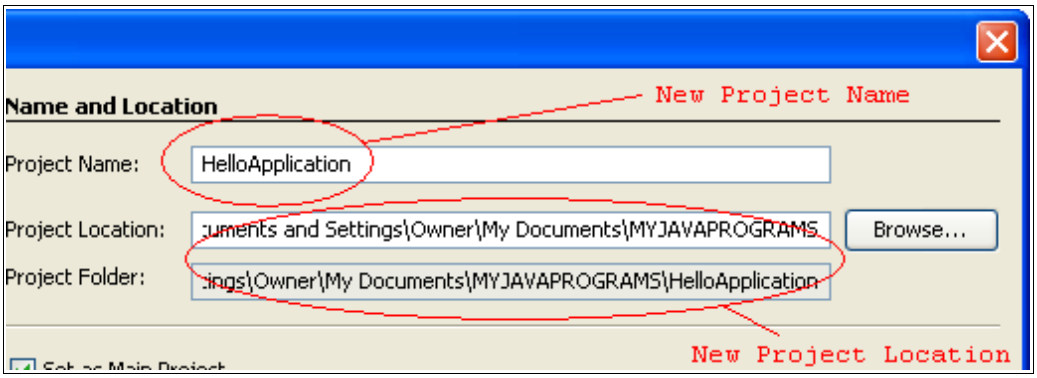
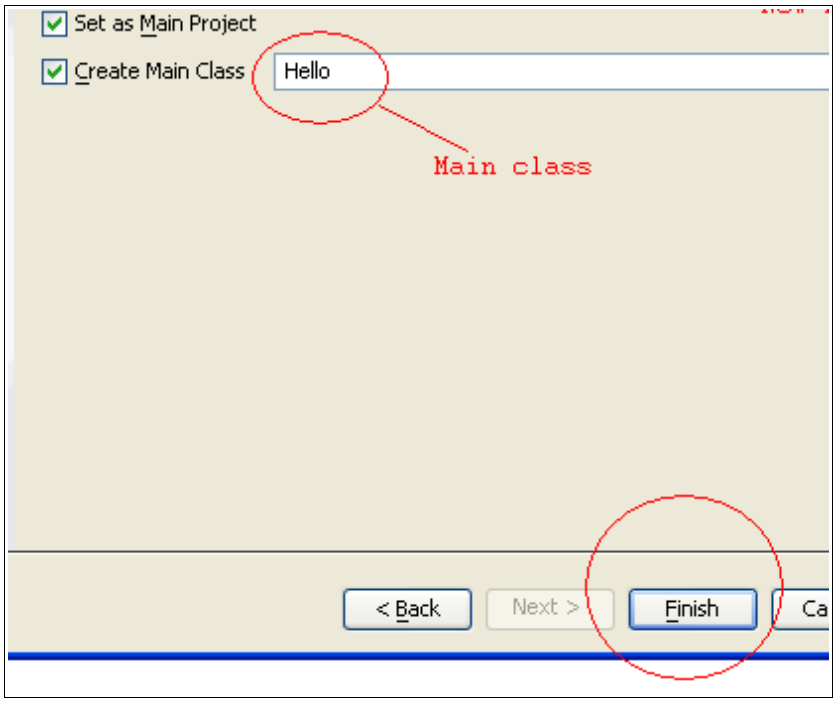


Figure 12.29: Change Project Name

Now try to change the Application Location, by clicking on the BROWSE button. Follow the steps described in the previous section to go to your MYJAVAPROGRAMS folder.



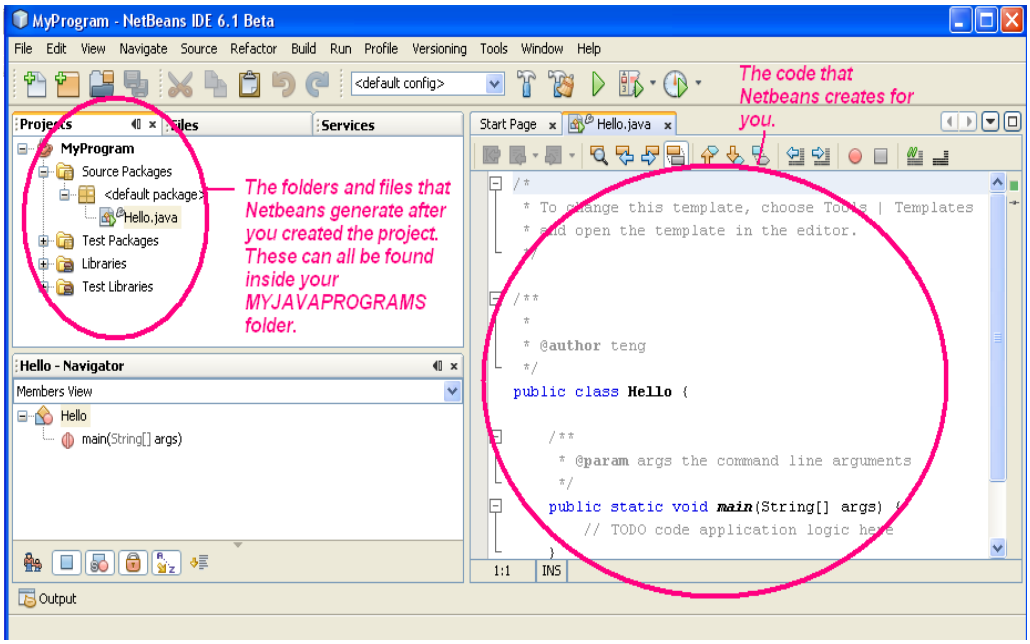
Finally, on the Create Main Class textfield, type in Hello as the main class' name, and then click on the FINISH button.



Step 3: Type in your program

Before typing in your program, let us first describe the main window after creating the project.

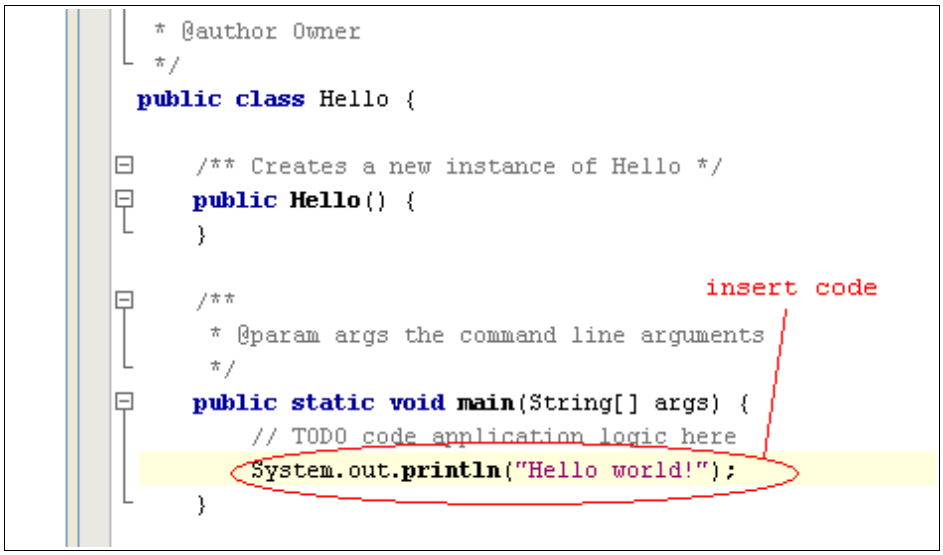
As shown below, NetBeans automatically creates the basic code for your Java program. You can just add your own statements to the generated code. On the left side of the window, you can see a list of folders and files that NetBeans generated after creating the project. This can all be found in your MYJAVAPROGRAMS folder, where you set the Project location.



Now, try to modify the code generated by NetBeans. Ignore the other parts of the program for now, as we will explain the details of the code later. Insert the code:

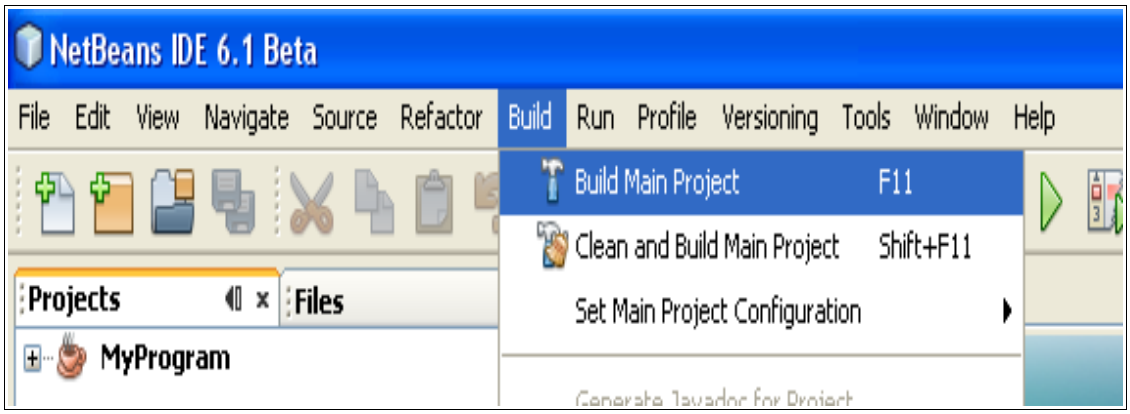
```
System.out.println("Hello world!");
```

after the statement, //TODO code application logic here.



Step 4: Compile your program

Now, to compile your program, just click on Build -> Build Main Project. Or, you could also use the shortcut button to compile your code.



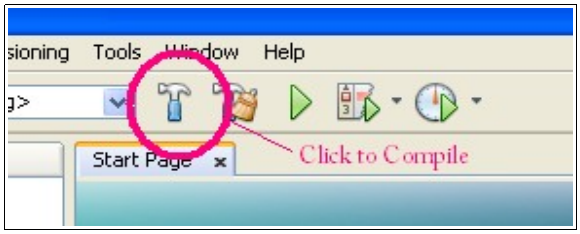


Figure 12.30: Shortcut button to compile code

If there are no errors in your program, you will see a build successful message on the output window.

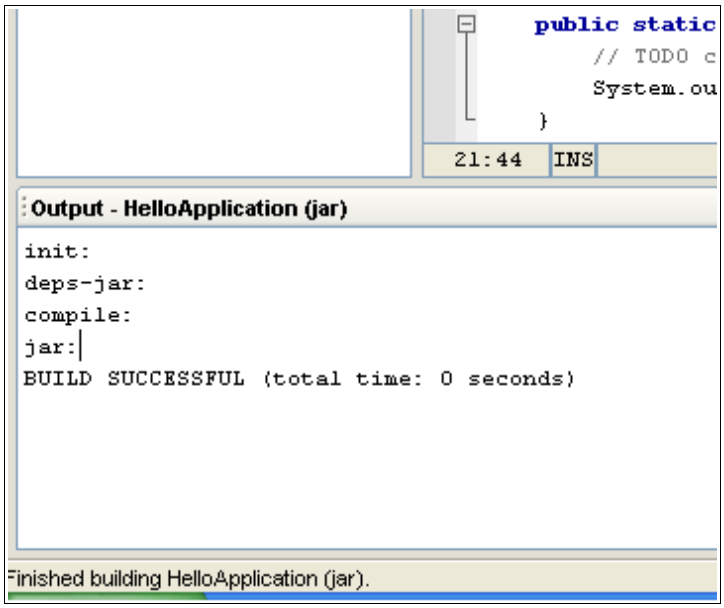


Figure 12.31: Output window just below the window where you type your source code

Step 5: Run your program

To run your program, click on Run-> Run Main Project. Or you could also use the shortcut button to run your program.

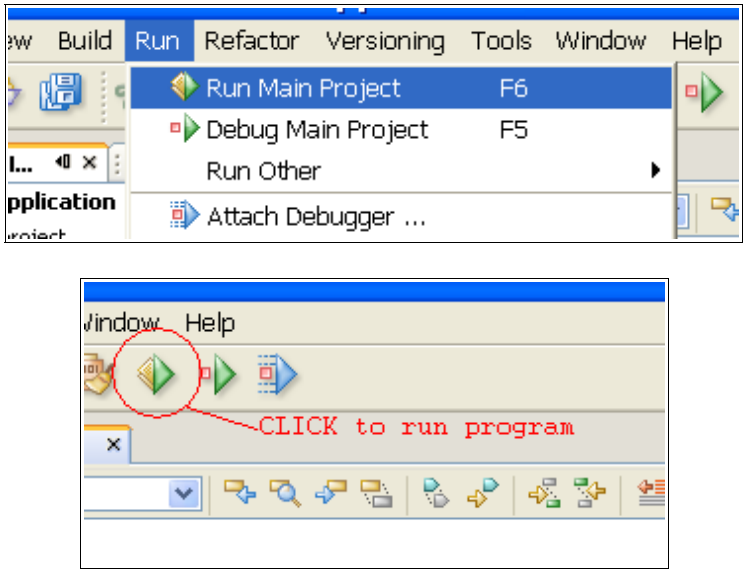


Figure 12.32: Shortcut button to run program

The output of your program is displayed in the output window.

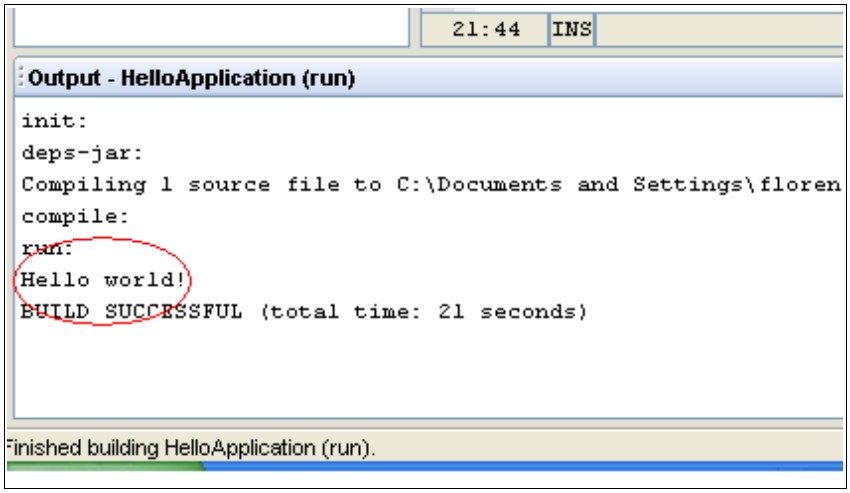


Figure 12.33: Output of Hello.java

Appendix D : Machine Problems

Machine Problem 1: Phone Book

Write a program that will create an phonebook, wherein you can **add** entries in the phonebook, **delete** entries, **view all** entries and **search** for entries. In viewing all entries, the user should have a choice, whether to view the entries in **alphabetical** order or in **increasing** order of telephone numbers. In searching for entries, the user should also have an option to search entries **by name** or **by telephone** numbers. In searching by name, the user should also have an option if he/she wants to search by first name or last name.

MAIN MENU
- 1 - Add phonebook entry
- 2 - Delete phonebook entry
- 3 - View all entries
  - a - alphabetical order
  - b - increasing order of telephone numbers
- 4 - Search entries
  - a - by name
  - b - by telephone number
- 5 – Quit

The following will appear when one of the choices in the main menu is chosen.

Add phonebook entry
- Enter Name:
- Enter Telephone number:
- (* if entry already exists, warn user about this)

View all entries
- Displays all entries in alphabetical order
- Displays all entries in increasing order of telephone #s

Search entries
- Search phonebook entry by name
- Search phonebook entry by telephone number

Quit
- close phonebook

Machine Problem 2: Minesweeper

This is a one player game of a simplified version of the popular computer game minesweeper. First, the user is asked if he or she wants to play on a 5x5 grid or 10x10 grid. You have two 2-dimensional arrays that contains information about your grid. An entry in the array should either contain a 0 or 1. A 1 signifies that there is a bomb in that location, and a 0 if none.

For example, given the array:

```
int  bombList5by5[][]={{0, 0, 1, 0, 0},
                       {0, 0, 0, 0, 0},
                       {0, 1, 0, 0, 0},
                       {0, 0, 0, 1, 1},
                       {0, 1, 1, 0, 0}};
```

Given the bomb list, we have 6 bombs on our list. The bombs are located in (row,col) cells, (0,2), (2,1), (3,3), (3,4), (4,1) and (4,2).

If the user chooses a cell that contains a bomb, the game ends and all the bombs are displayed. If the user chooses a cell that does not contain a bomb, a number appears at that location indicating the number of neighbors that contain bombs. The game should end when all the cells that do not contain bombs have been marked (player wins) or when the user steps on a bomb(player loses).

Here's a sample output of the game, given the bombList5by5.

```
Welcome to Minesweeper!
Choose size of grid (Press 1 for 5x5, Press 2 for 10x10): 1
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
Enter row and column of the cell you want to open[row  col]: 1  1
[ ] [ ] [ ] [ ] [ ]
[ ] [2] [ ] [ ] [ ]
[ ] [ ] [] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
Enter row and column of the cell you want to open[row  col]: 3  2
[ ] [ ] [ ] [ ] [ ]
[ ] [2 ] [ ] [] [ ]
[ ] [ ] [ ] [ ] [ ]
[ ] [ ] [4 ] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
Enter row and column of the cell you want to open[row  col]: 0 2
[] [ ] [ ] [ ] [ ]
[ ] [2] [ ] [] [ ]
[ ] [X ] [ ] [ ] [ ]
[ ] [ ] [4] [ ] [ ]
[ ] [ ] [ ] [ ] [ ]
Ooppps! You stepped on a bomb. Sorry, game over!
```

Machine Problem 3: Number Conversion

Create your own scientific calculator that will convert the inputted numbers to the four number representations (Decimal, Binary, Octal, Hexadecimal). Your program should output the following menu on screen.

MAIN MENU:
Please type the number of your choice:
1 – Binary to Decimal
2 – Decimal to Octal
3 – Octal to Hexadecimal
4 – Hexadecimal to Binary
5 – Quit

The following will appear when one of the choices in the main menu is chosen.

Choice 1:
  Enter a binary number: 11000
  11000 base 2 = 24 base 10
  (goes back to main menu)

Choice 2:
  Enter a Decimal number: 24
  24 base 10 = 30 base 8
  (goes back to main menu)

Choice 3:
  Enter an Octal number: 30
  30 base 8 = 18 base 16
  (goes back to main menu)

Choice 4:
  Enter a Hexadecimal number: 18
  18 base 16 = 11000 base 2

Choice 1:
  Enter a binary number: 110A
  Invalid binary number!
  Enter a binary number: 1
  1 base 2 = 1 base 10
  (goes back to main menu)

(user chooses 5)
  Goodbye!

You can be more creative with your user interface if you want to, as long as the program outputs the correct conversion of numbers.

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