PROGRAMMING BASICS

OVERVIEW

OVERVIEW

- **What is computer programming?**
  - The objective of programming is to give the computer detailed instructions to solve a desired problem
  - Computers have to read and process these instructions so they have to be written clearly and unambiguously
  - Hundreds of programming languages have been invented for this purpose over last 60 years

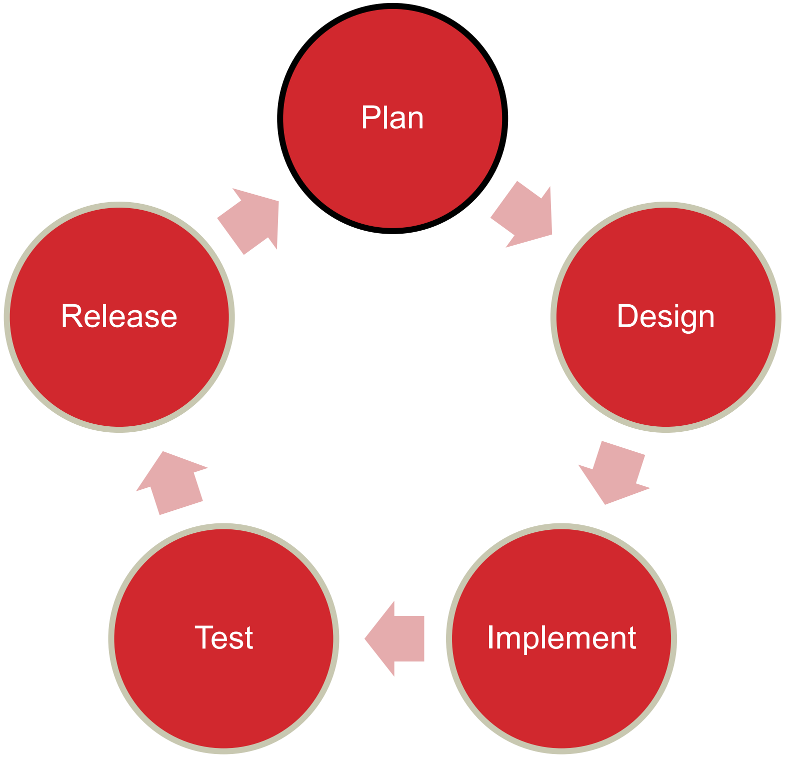
OVERVIEW

- **Why learn Java?**
    - This class will use the Java programming language because it is very powerful and widely used in industry
    - Java is an object oriented programming language (OOP) that evolved from C++ (simplifying and improving syntax)
    - Java provides over 4000 libraries of functions we can use in our program to solve a wide range of problems

OVERVIEW

- **Software development cycle**
  - Tools and techniques for writing programs have evolved over the last 50 years, and continue to evolve today
  - The goal is to convert abstract goals (what we want the program to do) into clear and unambiguous instructions for the computer (in our case Java code)
  - The classic software development cycle we will be using has five stages: plan, design, implement, test, and release

OVERVIEW

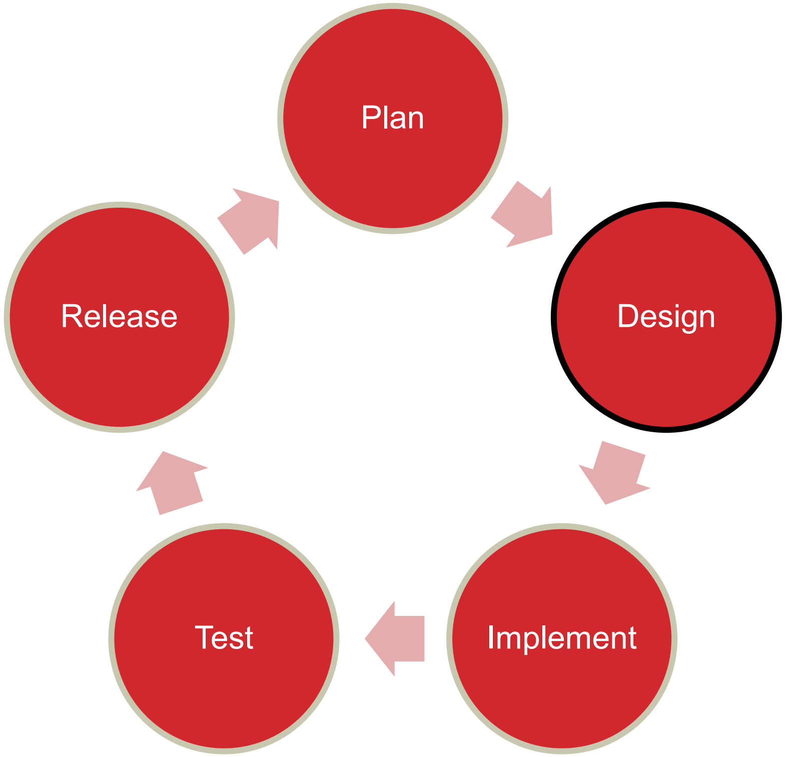


The classic software development cycle

Plan:

- Decide what problem we are trying to solve
- What are program inputs?
- What should the program output or do?

OVERVIEW



The classic software development cycle

Design:

- Break the problem into smaller steps we know how to solve
- Describe how these steps should be combined to solve the problem

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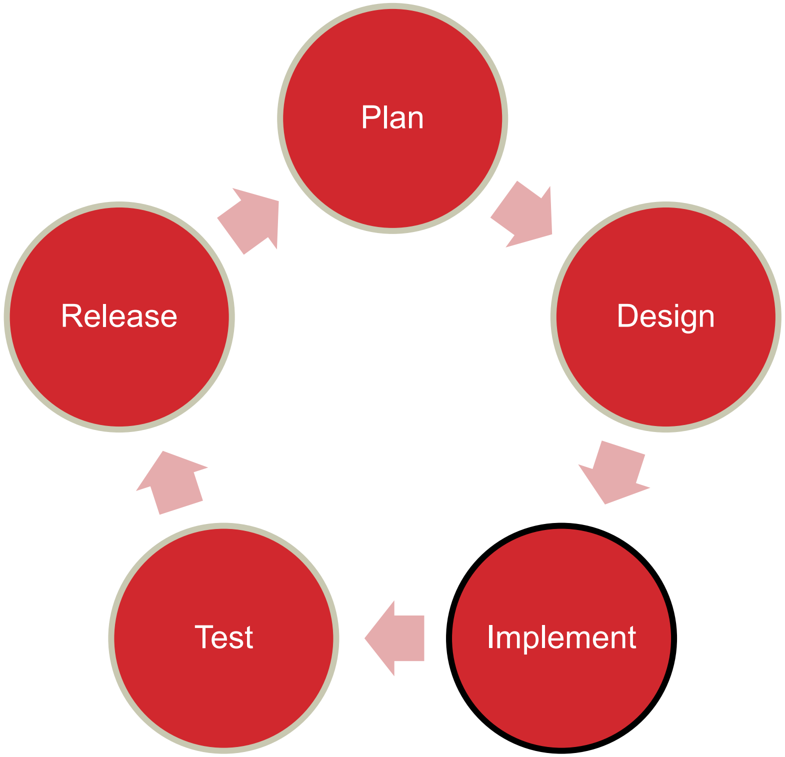
OVERVIEW

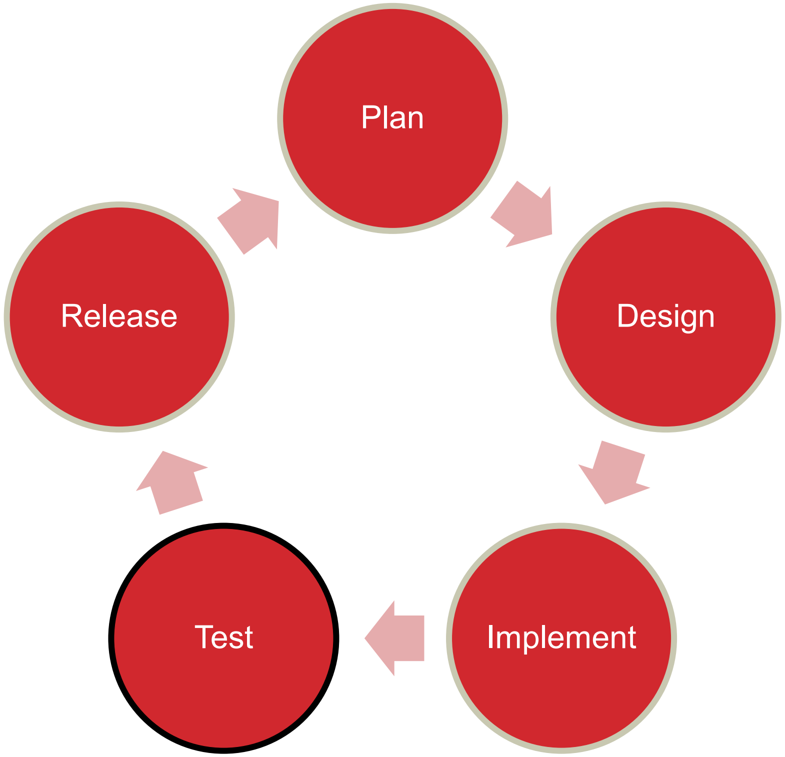


The classic software development cycle

Implement:

- Write code that performs the steps needed to solve the problem
- Use existing code and software libraries whenever possible

OVERVIEW

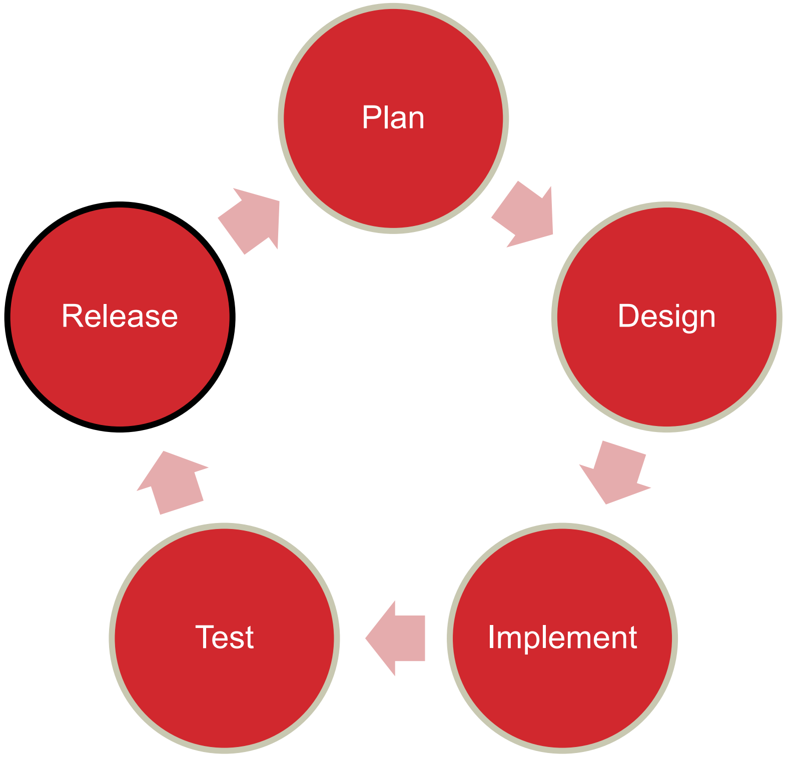


The classic software development cycle

Test:

- Run the program with normal inputs to see if it produces correct outputs
- Run the program with incorrect inputs to check the error handling

OVERVIEW

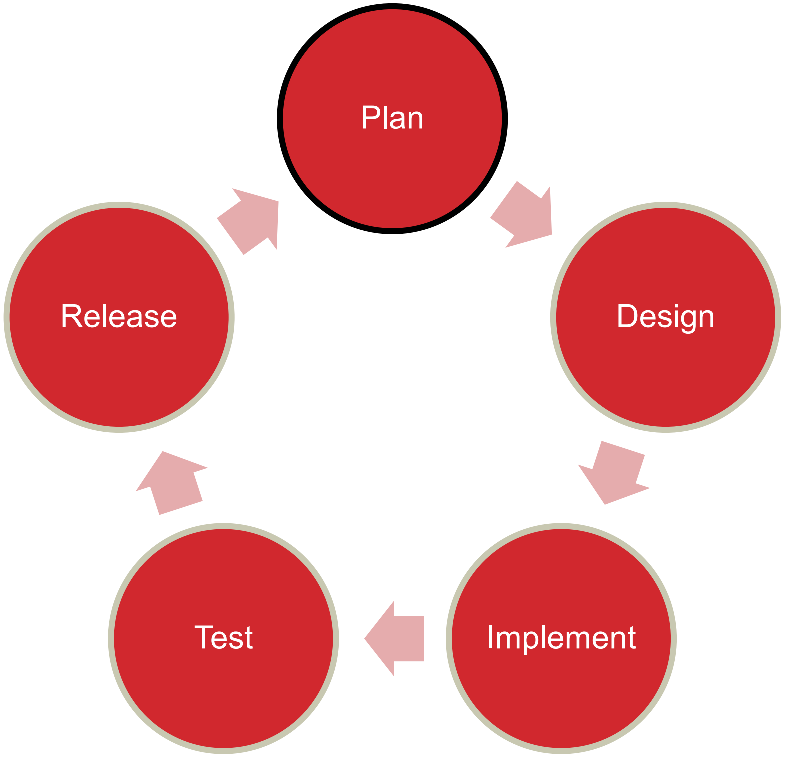


The classic software development cycle

Release:

- Distribute the working program to users
- Collect user feedback to identify problems to fix and new features to add

OVERVIEW



The classic software development cycle

Plan:

- Decide what to do next with the program
- What new features to add
- What problems/bugs to fix

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OVERVIEW

- **There are many ways to create programs**
  - Manager: Buy all or part of solution from someone else
  - Mimic: Extend or improve solution to similar problem
  - Inventor: Create new solution from scratch
  - We must be part manager, part mimic, part inventor

- **How can we become great programmers?**
  - Learn programming tools by looking at libraries
  - Learn programming patterns by looking at examples
  - Learn programming skills by writing a lot of code

OVERVIEW

- **How will we learn to program?**
  - We will learn the syntax of the language
    - How to write instructions
  - We will learn semantics of the language
    - What the computer does with instructions
  - We will learn problem solving techniques
    - How to break problems into smaller pieces to solve
  - We will learn how to test and evaluate programs
    - How to find and fix bugs

OVERVIEW

- **Lesson objectives:**
  - Learn the structure of Java programs
  - Learn how program input / output works
  - Learn about Java variables and data types
  - Study example program using programming basics
  - Complete programming project on programming basics

PROGRAMMING BASICS

PART 1

WHAT MAKES A PROGRAM?

WHAT MAKES A PROGRAM?

- **A program is a sequence of instructions to a computer**
  - Every programming language has its own “rules” describing how these instructions should be written
  - These rules define the “syntax” of the language
  - When the program runs, it will execute your written instructions one line at a time
  - For us to understand what a program will do, we need to know the meaning or “semantics” of each instruction

- **In this section, we will focus on the basic layout of a Java program and fundamental Java instructions**

WHAT MAKES A PROGRAM?

- **All Java programs have the following structure:**
  - Comments – explain the purpose of program
  - Import commands – give access to existing function libraries
  - Classes and methods – used to decompose problem (later)
  - Main method – variables and statements for program

- **The following example Java program prints the message "Hello Mom" to the screen**

WHAT MAKES A PROGRAM?

```
// This program prints a message
import java.util.Scanner;
public class Main
{
   public static void main(String[] args)
   {
      System.out.println("Hello Mom");
   }
}
```

This Java comment starts with a // and describes the purpose of the program

WHAT MAKES A PROGRAM?

```
// This program prints a message
import java.util.Scanner;
public class Main
{
  public static void main(String[] args)
  {
    System.out.println("Hello Mom");
  }
}
```

This command tells the Java compiler that we want to use Scanner library for user input

WHAT MAKES A PROGRAM?

```
// This program prints a message
import java.util.Scanner;
public class Main
{
  public static void main(String[] args)
  {
    System.out.println("Hello Dad");
  }
}
```

The main method is where the Java program begins executing instructions

This is the line of code that prints the “Hello Mom” message on the screen

SUMMARY

- **In this section we have studied what a program is and what the basic parts of a Java program are:**
  - Comments describing the goals of the program
  - Import commands that let us use the input/output libraries
  - The main method containing the code we want to run

- **In the next section we will talk about variables, numerical calculations and program input/output**

PROGRAMMING BASICS

PART 2

STORING DATA

VARIABLES AND DATA TYPES

- **The most common Java data types are:**
  - byte – stores 8-bit integer values
  - short – stores 16-bit integer values
  - int – stores 32-bit integer values
  - long – stores 64-bit integer values
  - float – stores 32-bit floating point numbers
  - double – stores 64-bit floating point numbers
  - bool – stores Boolean values (true/false)
  - char – stores a single character like 'A' .. 'Z’
  - String – stores sequences of characters like “hello mom”

VARIABLES AND DATA TYPES

- **Variables are used to store and manipulate data in a program**
  - The amount of memory used depends on the data type

- **The syntax for variable declaration is: “data_type name;”**
  - data_type: This specifies what kind of data can be stored
  - name: We refer to variables by name to perform operations

- **Example:**

```
int Age;                // Can store age in years
float Height;           // Can store height in meters
char Gender;            // Can store 'M' or 'F' for gender
String Name;            // Can store “John” or “Susan” for name
```

VARIABLES AND DATA TYPES

- **Syntax rules for variable names:**
  - Names may contain upper or lower case characters
  - Names may also contain the digits 0..9 and the underscore character, but NO other characters are allowed
  - Names must start with an upper or lower case character

- **Incorrect variable declarations**

```
int float;      // Can not use reserved word ‘float’ as a name
float 2pi;      // Can not start the name of a variable with digit
int num         // Semi-colon at end of line is missing
```

VARIABLES AND DATA TYPES

- **Make your variable names meaningful**
  - “the_persons_middle_name” is a bit much to type
  - “n” is just to short to have any meaning
  - “per_mid_nme” is too cryptic
  - “middle_name” is about right

- **There are several programming conventions for variables with multi-part names**
  - Use underscore characters: “person_age”
  - Use capital letters for each part: “PersonAge”
  - Use capital letters for all but first part: “personAge”

VARIABLES AND DATA TYPES

- **It is possible to save space in your program by declaring several variables of the same data type on one line**
  - Generally these variables logically belong together

- **The syntax for this is: “type name1, name2, name3;”**

```
float x, y, z;                  // Coordinates of 3D point
int height, length, width;      // Dimensions of a box
String first_name, last_name;   // Student’s full name
```

VARIABLES AND DATA TYPES

- **It is a good programming practice to initialize all variables when they are declared**
  - This way we know for sure what the variables contain

- **The syntax for this is: “data_type name = value;”**

```
int Answer = 42;              // Answer to ultimate question
float Height = 0.0;           // Height in meters
char Gender = ‘F’;            // Gender of person
string Name = “Susan”;        // Name of person
```

CONSTANTS

- **Constants are like variables but they never change value**
  - For example, the quantity PI = 3.14159265 should remain unchanged throughout the program
  - We define constants in Java by adding the reserved word “public static” before the variable declaration
  - We must provide the value of constant at declaration time
  - Constants can be of any variable data type

CONSTANTS

- **Example:**

```
public static int SILLY = 42;         // My favorite number
public static float PI = 3.14159;     // My second favorite number
public static char YES = 'Y';         // A character constant
```

- **Conventions when using constants:**
  - Constant names are normally written in upper case
  - Constants are typically added just before the main method so they can be used by the whole program

ASSIGNMENT STATEMENTS

- **The operator “=” is used to assign data into a variable**

- **The Java syntax for assignment is: “name = value;”**
  - name: the variable we wish to copy data into
  - value: the data we want to store in the variable
  - Be sure to put a semicolon at end of the statement

ASSIGNMENT STATEMENTS

- **Java will automatically convert data types if possible**
  - If variable and value are same type – no conversion
  - If variable is more accurate – no data loss will occur
  - If variable is less accurate – conversion will lose data (most compilers will give you a warning message)

- **Example:**

```
int data1 = 42;         // int value 42 is stored
float data2 = 42;       // float value 42.0 is stored
int data3 = 4.2;        // int value 4 is stored (0.2 is discarded)
float data4 = 4.2;      // float value 4.2 is stored
int data5 = “hello”;    // will not compile
```

ASSIGNMENT STATEMENTS

- **Example:**

```
int Value, Number;
float Data;

Data = 2.158;         // Data variable now equals 2.158
Value = 17;           // Value variable now equals 17
Number = Value;       // Number variable now equals 17
Data = 42;            // Data variable now equals 42.0
Number = 3.14159;     // Number variable now equals 3
```

The floating point value will be truncated and the 0.14159 will be discarded

SUMMARY

- **In this section, we have studied how Java variables are declared and to store information**
  - Basic data types of the language
  - Rules for choosing variable names
  - How to initialize variables
- **Then, we showed how Java constants can be created**
- **Finally, we described the Java assignment statement**
  - What happens if we store integer values in float variables
  - What happens if we store float values in integer variables

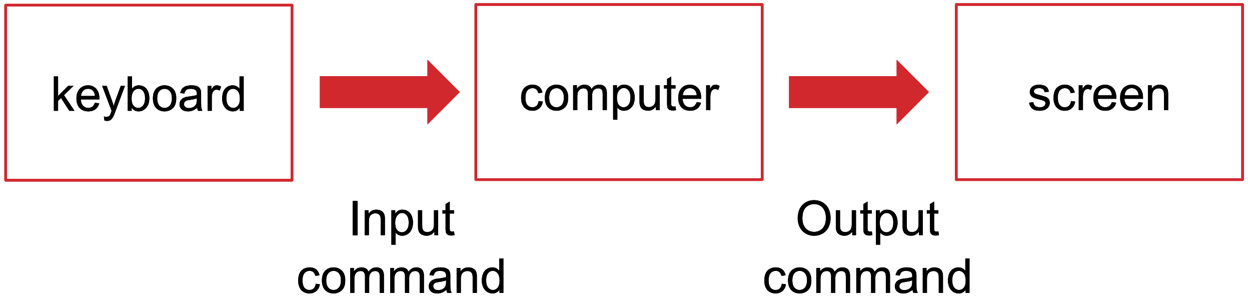
PROGRAMMING BASICS

PART 3

PROGRAM INPUT / OUTPUT

OVERVIEW

- **We need some way to get data in and out of program**
  - Input commands read values entered on the keyboard
  - Output commands write values onto the screen



OVERVIEW

- **Many programs have the following pattern:**
  - Print a message to the user with input instructions
  - Read the input typed by the user
  - Do some calculations based on user input
  - Print the results of the calculations

- **Next we will go over Java commands for input / output**
  - System.in and Scanner commands for input
  - System.out commands for output
  - Formatted output with Java

PROGRAM INPUT

- **Java input is done using the following commands**
  - **System.in** gives us access to a stream of characters that are typed in by the user
  - **Scanner** commands let us convert characters into Java data types (int, float, string, etc.)

- **How is this done?**
  - Scanner will skip over spaces or return characters
  - Scanner will read characters from the keyboard
  - Scanner will convert characters to desired data type
  - Scanner will store this value in a variable
  - Read and convert steps will **vary** for different data types

PROGRAM INPUT

- **Java input is done using Scanner commands**
  - First, we have to create a Scanner object called “scanner”

```
Scanner scanner = new Scanner(System.in);
```

  - Then, we use the Scanner object scanner to read the sequence of characters that are typed by the user

```
String input = scanner.next();
```

  - There are also ways to read into other data types

PROGRAM INPUT

- **Integer input example:**

```
Scanner scanner = new Scanner(System.in);
int number1 = scanner.nextInt();
```

  - The user types in a sequence of characters “123”
  - The Scanner skips over leading spaces or carriage returns
  - The Scanner reads all characters that are digits
  - The Scanner converts “123” into an integer 123 and stores this value in the variable number1

PROGRAM INPUT

- **Float input example:**

```
Scanner scanner = new Scanner(System.in);
float number2 = scanner.nextFloat();
```

  - The user types in a sequence of characters “3.14159”
  - The system skips over leading spaces or carriage returns
  - Then the system reads all characters that are digits then it reads the “.” then it reads more digit characters
  - Then the system converts “3.14159” into a float value 3.14159 and stores this value in the variable number2

PROGRAM INPUT

- **More on reading float variables…**

- **The user can omit the digits after the decimal point and the Scanner command will assume they are 0**
  - User input “42.” will be treated like “42.0”

- **The user can omit the digits before the decimal point and the Scanner command will assume they are 0**
  - User input “.125” will be treated like “0.125”

PROGRAM INPUT

- **String input example:**

```
Scanner scanner = new Scanner(System.in);
String message = scanner.next();
```

  - The user types in a sequence of characters “hello”
  - The system skips over leading spaces or carriage returns
  - Then the system reads sequence of characters “hello”
  - Then the system stores this string in the variable message

PROGRAM INPUT

- **Longer string input example:**

```
Scanner scanner = new Scanner(System.in);
String str = scanner.nextLine();
```

  - The user types in “hello mom please send money”
  - The system skips over leading spaces or carriage returns
  - Then the system reads “hello mom please send money”
  - Then the system stores this string in the variable str

PROGRAM INPUT

- **Example reading sequence input values:**

  ```
  Scanner scanner = new Scanner(System.in);
  int number1 = scanner.nextInt();
  float number2 = scanner.nextFloat();
  String message = scanner.next();
  ```

- **When user types in “42 3.14 hello” these three values will be stored in variables number1, number2 and message**
- **User inputs can have any number of spaces, tabs or new line characters between them**

PROGRAM OUTPUT

- **To output data in Java we use the following command System.out.println(output);**
  - “System.out” is a built in Java library
  - “println” is the name of the output command
  - “output” is the variable (or message) to print

- **How is this done?**
  - First, println will look at variable to get its value
  - Then, it will convert value to sequence of characters
  - Then, it will output these characters on the monitor
  - The conversion step will **vary** for different data types

PROGRAM OUTPUT

- **Integer output example:**

```
int number1 = 123;
System.out.println(number1);
```

  - The system converts the integer value of the variable 123 to a sequence of ascii characters “123”
  - The system displays the characters “123” on the screen at the current cursor position

PROGRAM OUTPUT

- **Float output example:**

```
float number2 = 3.14;
System.out.println(number2);
```

  - The system converts the float value of the variable 3.14 to a sequence of ascii characters “3.14”
  - The system displays the characters “3.14” on the screen at the current cursor position

PROGRAM OUTPUT

- **String output example:**

```
String message = “hello mom”;
System.out.println(message);
```

  - No conversion to ascii character is needed since the variable is already a sequence of ascii characters

  - The system displays the character “hello mom” on the screen at the current cursor position

PROGRAM OUTPUT

- **Java has two output commands: println and print.**
  - System.out.println(output) will print the value of output and then go to the **next line**. The next print will start there.
  - System.out.print(output) will print the value of output and **stop** at that point. The next print will start there.

PROGRAM OUTPUT

- **Example of println:**

```
int num1 = 17;
int num2 = 42;
System.out.println(num1);
System.out.println(num2);
```

  - This will print “17” on first line and “42” on next line

PROGRAM OUTPUT

- **Example of print:**

```
int num1 = 17;
int num2 = 42;
System.out.print(num1);
System.out.print(num2);
```

- This will print “1742” on one line.

PROGRAM OUTPUT

- **We can use the Java string concatenation operator "+" to output multiple values in one println command.**

```
float value = 12.34;
System.out.print("value = " + value);
```

  - This will print "value = 12.34" and go to the next line
  - This only works when print contains at least one string
  - System.out.println(12+34) will output "46".
  - System.out.println(12 + " " + 34) will output "12 34".

FORMATTED OUTPUT

- **In many applications, the program output must be in a specific format to users to read and understand.**
  - Example: Bank statements showing dates, transactions and the current balance in separate columns

- **The System.out.print function can produce simple formatted output by printing spaces between data fields to get columns to line up correctly**
  - This process is tedious and time consuming.

- **A better option is to print tabs to line up columns.**

FORMATTED OUTPUT

- **Java uses the following symbols to print tabs and other special characters inside a string**

\n	Carriage return
\t	Tab character
\b	Back space
\f	Form feed
\a	Bell sound
\’	Single quote
\”	Double quote
\\	Backslash character

FORMATTED OUTPUT

Example:

```
String first = "John";
String last = "Smith";
int age = 42;
double gpa = 3.14;

System.out.println("First Name:\t”  + first);
System.out.println("Last Name:\t” + last);
System.out.println("Age:\t\t” + age);
System.out.println("GPA:\t\t” + gpa);
```

Here we print tab characters inside the message string

FORMATTED OUTPUT

Sample program output:

```
First Name:   John
Last Name:    Smith
Age:          42
GPA:          3.14
```

Notice how all output is nicely aligned with each other

FORMATTED OUTPUT

- **Java also provides the System.out.printf function to print out data according to a “format” string.**
  - This format string can contain textual information and format commands that specify how and where the variables should be displayed

    %d – print an integer

    %f – print a float

    %s – print a String

  - The width of the display field can be specified by putting integers between the % and the letter

FORMATTED OUTPUT

- **Example:**

```
String name = “John”;
int age = 42;
float GPA = 3.14;

System.out.printf( “Name:  %10s\n”,    name );
System.out.printf( “Age:      %10d\n”,   age );
System.out.printf( “GPA:      %10.2f\n”,  GPA );
```

Format strings

FORMATTED OUTPUT

- **Example:**

```
String name = “John”;
int age = 42;
float GPA = 3.14;

System.out.printf( “Name:  %10s\n”,    name );
System.out.printf( “Age:      %10d\n”,  age );
System.out.printf( “GPA:     %10.2f\n”, GPA );
```

Variables
to print

FORMATTED OUTPUT

- **Example:**

```
String name = “John”;
int age = 42;
float GPA = 3.14;

System.out.printf( “Name:  %10s\n”,    name );
System.out.printf( “Age:    %10d\n”,   age );
System.out.printf( “GPA:    %10.2f\n”, GPA );
```

The string and integer are printed in fields 10 chars wide

Float is printed in field 10 chars wide and 2 digits after decimal

FORMATTED OUTPUT

Sample program output:

```
Name:     John
Age:        42
GPA:      3.14
```

Notice that all three data fields are right justified (which is ideal for columns of numbers)

CODE DEMO

Compile and run Name.java

COMMENTS

- **Comments are an essential part of all programs**
  - Comments are used to explain the design and implementation of a program to other programmers
  - They are human readable and are ignored by the compiler
  - Programmers should write comments as the program is being written and when major changes are made

- **You should NOT "wait until the program is finished" to write your comments**
  - Comments are there to help you write the program
  - In real life, programs are never "finished", there are always security updates and new features added

COMMENTS

- **Java supports two types of comments in programs**

- **C++ style comments are a single line long**
  - These comments start with // and go to end of the line

```
// Here is a new C++ style comment
// This is the second line of the comment
```

- **C style comments can span multiple lines**
  - These comments start with /* and end with */

```
/* Here is an old C style comment
   This is the second line of the comment */
```

SUMMARY

- In this section we have shown how the “Scanner” object can be used to read and store information from users
- We also shown how System.out” commands can be used to write variables and other information to the screen
- Finally, have described how Java comments are formed and their importance in writing clear programs

PROGRAMMING BASICS

PART 4

NUMERICAL CALCULATIONS

ARITHMETIC EXPRESSIONS

- Arithmetic expressions are used to perform numerical calculations using variables and arithmetic operators

- Once the values of arithmetic expressions are evaluated, they can be printed, or stored in variables using the assignment operator

- The rules for arithmetic expressions in Java are very similar to the rules we learn in mathematics, but there are some subtle differences we will discuss below

ARITHMETIC EXPRESSIONS

- **What is the syntax for arithmetic expressions?**
  - Arithmetic expressions consist of an alternating sequence of values and arithmetic operators
  - Values can be numerical literals, variables, or constants
  - Arithmetic operators include

+	Addition
-	Subtraction
*	Multiplication
/	Division
%	Modulo (remainder after integer division)

  - Parentheses ( ) can be used to control the order of evaluation of sub-expressions

ARITHMETIC EXPRESSIONS

- **Examples of valid arithmetic expressions:**
  - 7 + 2 * 5
  - 21 - num / 2
  - (2 + 2 + 2) / (3 - 3 - 3)

- **Examples of invalid arithmetic expressions:**
  - 17 * ← missing value after * operator
  - (num - 9 * 5 ← missing closing parenthesis
  - int + 42 ← int is not a valid variable name

ARITHMETIC EXPRESSIONS

- **How are expressions evaluated?**
  - We follow the “natural” rules of mathematics
  - Multiplication, division, modulo have high precedence
  - Addition, subtraction have low precedence
  - The result of high precedence operations are calculated before low precedence operations (i.e. * before +)
  - Operations in the expression are calculated left to right at same precedence level
  - Parenthesized expressions ( ) are calculated first, and are evaluated from the inside out

ARITHMETIC EXPRESSIONS

- **Evaluation examples:**
  - 7 + 2 * 5
    = 7 + 10 ← perform multiplication
    = 17 ← perform addition

  - 21 - num / 2
    = 21 - 10 / 2 ← substitute variable value
    = 21 - 5 ← perform division
    = 16 ← perform subtraction

ARITHMETIC EXPRESSIONS

- **Evaluation examples:**
  - (2 + 2 + 2) / (3 - 3 - 3)

= (4 + 2) / (3 - 3 - 3)	← perform leftmost addition
= 6 / (3 - 3 - 3)	← perform addition
= 6 / (0 - 3)	← perform leftmost subtraction
= 6 / -3	← perform subtraction
= -2	← perform division

ARITHMETIC EXPRESSIONS

- **What happens if we mix data types in expressions?**
- **Java will look at the data types and choose the most accurate data type for each arithmetic operation**
- **The ordering of data types from least accurate to most accurate is: byte, short, int, long, float, double**

int OP int	← int result
byte OP int	← int result
int OP float	← float result
float OP double	← double result

ARITHMETIC EXPRESSIONS

- **Evaluation examples:**
  - (2 + 2 + 2.0) / (3 - 3 - 3)

    = (4 + 2.0) / (3 - 3 - 3) ← perform leftmost addition

    = 6.0 / (3 - 3 - 3) ← perform addition

    = 6.0 / (0 - 3) ← perform leftmost subtraction

    = 6.0 / -3 ← perform subtraction

    = -2.0 ← perform division

ARITHMETIC EXPRESSIONS

- **Mixed type examples:**
  - 3 * 5 + 4.2
    = 15 + 4.2 ← integer multiplication
    = 19.2 ← float addition

  - (16 - num) / 4.0
    = (16 - 10) / 4.0 ← variable substitution
    = 6 / 4.0 ← integer subtraction
    = 1.5 ← float division

ARITHMETIC EXPRESSIONS

- **In Java there is an important difference between float division and integer division**

- **Float division always returns a <u>float</u> result**
  - 3.0 / 2.0 = 1.5

- **Integer division always returns an <u>integer</u> result**
  - 3 / 2 = 1 ← the 0.5 is discarded !!

ARITHMETIC EXPRESSIONS

- **Integer division examples:**
  - (16 - num) / 4

    = (16 - 10) / 4 ← variable substitution

    = 6 / 4 ← integer subtraction

    = 1 ← integer division (0.5 discarded)
  - (1 + 2) / (3 + 6)

    = 3 / (3 + 6) ← integer addition

    = 3 / 9 ← integer addition

    = 0 ← integer division (0.333 discarded)

ARITHMETIC EXPRESSIONS

- **In Java modulo operator % is used to calculate the value of the remainder after an integer division**
  - Both arguments to the % operator must be integers
  - If not the compiler will give error messages

- **Modulo operator examples:**
  - 285 % 10
    = 5 ← 285 / 10 = 28, remainder is 5
  - 285 % 100
    = 85 ← 285 / 100 = 2, remainder is 85

TYPE CASTING

- **Java will do implicit type conversion in assignment statements if the value type does not match variable type**
  - The value is converted to match the variable type
  - Sometimes compilers will warn of possible loss of data

- **Examples:**
  - int num = 4.2;   // value 4 is stored
  - float val = 17;   // value 17.0 is stored
  - int sum = 1 + 2.0;   // value 3 is stored
  - float total = num + sum;   // value of 7.0 is stored

TYPE CASTING

- **Type casting in lets us convert a value from one data type to another in the middle of arithmetic expressions**
  - This is very useful if we want to force the expression to use integer operations or float operations

- **We specify the desired data type <u>before</u> the variable or expression we want to convert**
  - (data_type) value

- **Type casting has the highest precedence, so the type conversion is done <u>before</u> the next arithmetic operation**

TYPE CASTING

- **Type casting examples:**
  - 2 / 3

    = 0 ← integer division
  - (float) 2 / 3

    = 2.0 / 3 ← converts 2 value to float

    = 0.666 ← float division
  - 1 / (float) 3

    = 1 / 3.0 ← converts 3 value to float

    = 0.333 ← float division

SPHERE EXAMPLE

- **Assume we want to calculate the volume and surface area of a sphere of any size**

- **How can we perform this calculation?**
  - Look up formulas for sphere volume and surface area

- **How can we implement this?**
  - Write a program to prompt user for sphere radius
  - Calculate sphere volume and surface area
  - Print the results of these calculations

SPHERE EXAMPLE

```
import java.util.Scanner;
public class Sphere
{
    public static void main(String[] args)
    {
        // Read sphere radius
        // Calculate volume
        // Calculate surface area
        // Print output
    }
}
```

With the first version of the program we just type in comments to describe our approach

SPHERE EXAMPLE

```
…
  // Read sphere radius
  Scanner scanner = new Scanner(System.in);
  System.out.print("Enter sphere radius: ");
  double radius = scanner.nextDouble();
  System.out.println("Radius = " + radius);
…
```

It is always a good idea to print the values you have read from the user to verify input worked as expected

SPHERE EXAMPLE

```
…
  // Calculate sphere volume
  Volume = (4.0 / 3.0) * Math.PI * Radius * Radius * Radius;

  // Calculate sphere surface area
  Area = 4.0 * Math.PI * Radius * Radius;
…
```

We are using float literals here to force the result to be a float value (using 4/3 would produce incorrect result due to integer division)

Math.PI = 3.141592653
is a constant defined in
the Math library

SPHERE EXAMPLE

```
…
   // Print output
   System.out.println("Radius = " + radius);
   System.out.println("Volume = " + volume);
   System.out.println("Area = " + area);}
 …
```

Finally we add code to output our answers

SPHERE EXAMPLE

To compile on a Linux or MacOS system:

```
javac Sphere.java
```

To run on a Linux or MacOS system:

```
java Sphere
```

SPHERE EXAMPLE

Sample program output:

```
Enter sphere radius: 1.0
Radius = 1.0
Volume = 4.1887902047863905
Area = 12.566370614359172

Enter sphere radius: 10
Radius = 10.0
Volume = 4188.790204786391
Area = 1256.6370614359173
```

CODE DEMO

Compile and run Cube.java

Compile and run Sphere.java

Compile and run Temperature.java

Compile and run Statistics.java

SOFTWARE ENGINEERING TIPS

- **Think about the problem you are trying to solve before you start writing your program**
  - What data do you need to solve problem?
  - What formulas are you going to use?
  - Work out a few examples by hand to be sure you understand the process you are going to use

- **Start your program by writing your comments**
  - Add your name and date at top of program
  - Describe steps in program in point form
  - Add code to your program a little at a time
  - Compile and test program incrementally

SOFTWARE ENGINEERING TIPS

- **Top-down problem solving has the following steps:**
  - Understand the problem to be solved
  - Decompose problem into smaller pieces you can solve
  - Write computer instructions for each piece
  - Combine pieces into a single program
  - Compile, test, and debug program
  - Use program to solve initial problem

SOFTWARE ENGINEERING TIPS

- **Bottom-up problem solving has the following steps:**
  - Understand the problem to be solved
  - Look at similar problems to identify common components
  - Design and implement general purpose components
  - Combine components into a single program
  - Compile, test, and debug program
  - Use program to solve initial problem

SOFTWARE ENGINEERING TIPS

- **Make your program easy to read and understand**
  - Pick variable names that are meaningful to you and others
  - Add blank lines and white space to separate calculations
  - Indent your code using a consistent convention

- **Make sure your program is running correctly**
  - Initialize all variables before you use their values
  - Print out intermediate results as you debug code
  - Test with “normal” and “unexpected” input values
  - Document all known bugs/limitations in the code

SUMMARY

- In this section we have studied the syntax and use of arithmetic expressions to do numerical calculations
- We also showed an example program demonstrating the use of arithmetic expressions and input/output
- Finally, have discussed several software engineering tips for creating and debugging programs