Chapter 4

Mathematical Functions, Characters, and Strings

4.1 Introduction

- The focus of this chapter is to introduce **mathematical functions, characters, string** objects, and use them to develop programs.

4.2 Common Mathematical Functions

- Java provides many useful methods in the **Math** class for performing common mathematical functions.
- The Math Class
  - Class constants:
    - PI
    - E (the base of natural logarithms)
  - Class methods:
    - Trigonometric Methods
    - Exponent Methods
    - Rounding Methods
    - min, max, abs, and random Methods
    - random Method

4.2.1 Trigonometric Methods

- Trigonometric Methods:
  - sin(double a)
  - cos(double a)
  - tan(double a)
  - acos(double a)
  - asin(double a)
  - atan(double a)

- Examples:

```
Math.sin(0)             returns 0.0
Math.sin(Math.PI / 6)   returns 0.5
Math.sin(Math.PI / 2)   returns 1.0

Math.cos(0)             returns 1.0
Math.cos(Math.PI / 6)   returns 0.866
Math.cos(Math.PI / 2)   returns 0
```

4.2.2 Exponent Methods

- Exponent Methods:
  - exp(double a)
    Returns e raised to the power of a.
  - log(double a)
    Returns the natural logarithm of a.
  - log10(double a)
    Returns the 10-based logarithm of a.
  - pow(double a, double b)
    Returns a raised to the power of b.
  - sqrt(double a)
    Returns the square root of a.)
- Examples:

```
Math.exp(1)          returns 2.71
Math.log(2.71)       returns 1.0
Math.pow(2, 3)       returns 8.0
Math.pow(3, 2)       returns 9.0
Math.pow(3.5, 2.5)   returns 22.91765
Math.sqrt(4)         returns 2.0
Math.sqrt(10.5)      returns 3.24
```

4.2.3 The Rounding Methods

- Rounding Methods
  - double ceil(double x)
    x rounded up to its nearest integer. This integer is returned as a double value.
  - double floor(double x)
    x is rounded down to its nearest integer. This integer is returned as a double value.
  - double rint(double x)
    x is rounded to its nearest integer. If x is equally close to two integers, the even one is returned as a double.
  - int round(float x)
    Return (int)Math.floor(x+0.5).
  - long round(double x)
    Return (long)Math.floor(x+0.5).
- Examples:

```
Math.ceil(2.1)     returns 3.0
Math.ceil(2.0)     returns 2.0
Math.ceil(-2.0)    returns -2.0
Math.ceil(-2.1)    returns -2.0

Math.floor(2.1)    returns 2.0
Math.floor(2.0)    returns 2.0
Math.floor(-2.0)   returns -2.0
Math.floor(-2.1)   returns -3.0
```

```
Math.rint(2.1)     returns 2.0
Math.rint(2.0)     returns 2.0
Math.rint(-2.0)    returns -2.0
Math.rint(-2.1)    returns -2.0
Math.rint(2.5)     returns 2.0
Math.rint(-2.5)    returns -2.0

Math.round(2.6f)   returns 3
Math.round(2.0)    returns 2
Math.round(-2.0f)  returns -2
Math.round(-2.6)   returns -3
```

4.2.4 The min, max, and abs Methods

- Methods:
  - max(a, b)and min(a, b)
    Returns the maximum or minimum of two parameters.
  - abs(a)
    Returns the absolute value of the parameter.
- Examples:

```
Math.max(2, 3)       returns 3
Math.max(2.5, 3)     returns 3.0
Math.min(2.5, 3.6)   returns 2.5
Math.abs(-2)         returns 2
Math.abs(-2.1)       returns 2.1
```

4.2.5 The random Method

- Methods:
  - random()
    Returns a random double value in the range [0.0, 1.0).

  Generates a random double value greater than or equal to 0.0 and less than 1.0 (0 <= Math.random() < 1.0).
- Examples:

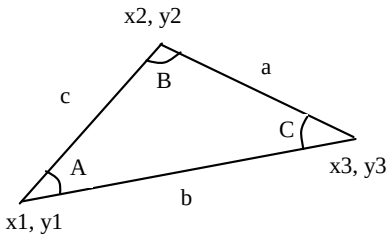
```
(int)(Math.random() * 10)  ──→  Returns a random integer
                                between 0 and 9.

50 + (int)(Math.random() * 50)  ──→  Returns a random integer
                                     between 50 and 99.
```

In general,

```
a + Math.random() * b  ──→  Returns a random number between
                            a and a + b, excluding a + b.
```

4.2.6 Case Study: Computing Angles of a Triangle

- Write a program that prompts the user to enter the x- and y-coordinates of the three corner points in a triangle and then displays the triangle's angles.




```
A = acos((a * a - b * b - c * c) / (-2 * b * c))
B = acos((b * b - a * a - c * c) / (-2 * a * c))
C = acos((c * c - b * b - a * a) / (-2 * a * b))
```

- Listing 4.1 ComputeAngles.java

```
import java.util.Scanner;

public class ComputeAngles {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);

    // Prompt the user to enter three points
    System.out.print("Enter three points: ");
    double x1 = input.nextDouble();
    double y1 = input.nextDouble();
    double x2 = input.nextDouble();
    double y2 = input.nextDouble();
    double x3 = input.nextDouble();
    double y3 = input.nextDouble();

    // Compute three sides
    double a = Math.sqrt((x2 - x3) * (x2 - x3)
        + (y2 - y3) * (y2 - y3));
    double b = Math.sqrt((x1 - x3) * (x1 - x3)
        + (y1 - y3) * (y1 - y3));
    double c = Math.sqrt((x1 - x2) * (x1 - x2)
        + (y1 - y2) * (y1 - y2));

    // Compute three angles
    double A = Math.toDegrees(Math.acos((a * a - b * b - c * c)
        / (-2 * b * c)));
    double B = Math.toDegrees(Math.acos((b * b - a * a - c * c)
        / (-2 * a * c)));
    double C = Math.toDegrees(Math.acos((c * c - b * b - a * a)
        / (-2 * a * b)));

    // Display results
    System.out.println("The three angles are " +
        Math.round(A * 100) / 100.0 + " " +
        Math.round(B * 100) / 100.0 + " " +
        Math.round(C * 100) / 100.0);
  }
}
```

```
Enter three points: 1 1 6.5 1 6.5 2.5
The three angles are 15.26 90.0 74.74
```

4.3 Character Data Type and Operations

- The character data type, char, is used to represent a single character.
- A character literal is enclosed in **single** quotation marks.

```
char letter = 'A';    // Assigns A to char variable letter (ASCII)
char numChar = '4';   // Assigns numeric character 4 to numChar (ASCII)
```

- **Caution:** A string literal must be enclosed in quotation marks. A character literal is a single chaaracter enclosed in single quotation marks. So **"A" is a string, and 'A' is a character**.

4.3.1 Unicode and ASCII code

- Java uses Unicode, a **16-bit** encoding scheme established by the Unicode Consortium to support the interchange, processing, and display of written texts in the world's diverse languages (See the Unicdoe Web sit at www.unicode.org for more information.)
- Unicode takes **two** bytes, preceded by \u, expressed in four hexadecimal digits that run from '\u0000' to '\uFFFF'. For example, the "coffee" is translated into Chinese using two characters. The Unicode of these two characters are "\u5496\u5561".

```
char letter = 'A';
char letter = '\u0041';    // Character A's Unicode is 0041
```

- Unicode can represent 65,536 characters, since FFFF in hexadecimal is 65535.
- Most computer ASCII (American Standard Code for Information Interchange), a **7-bit** encoding scheme for representing all uppercase and lowercase letter, digits, punctuation marks, and control characters.
- Unicode includes ASCII code with '\u0000' to '\u007F' corresponding to **128** ASCII characters. (See Appendix B).
- ASCII Code for Commonly Used Characters

Characters	Code Value in Decimal	Unicode Value
'0' to '9'	48 to 57	\u0030 to \u0039
'A' to 'Z'	65 to 90	\u0041 to \u005A
'a' to 'z'	97 to 122	\u0061 to \u007A

- **Note:** The increment and decrement operators can also be used on char variables to get the next or preceding Unicode character.
- For example, the following statements display character **b**:

```
char ch = 'a';
System.out.println(++ch);
```

Appendix B: ASCII Character Set

TABLE B.1 ASCII Character Set in the Decimal Index

	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
0	nul	soh	stx	etx	eot	enq	ack	bel	bs	ht
1	nl	vt	ff	cr	so	si	dle	dcl	dc2	dc3
2	dc4	nak	syn	etb	can	em	sub	esc	fs	gs
3	rs	us	sp	!	"	#	$	%	&	'
4	(	)	*	+	,	-	.	/	0	1
5	2	3	4	5	6	7	8	9	:	;
6	<	=	>	?	@	A	B	C	D	E
7	F	G	H	I	J	K	L	M	N	O
8	P	Q	R	S	T	U	V	W	X	Y
9	Z	[	\	]	^	_	`	a	b	c
10	d	e	f	g	h	i	j	k	l	m
11	n	o	p	q	r	s	t	u	v	w
12	x	y	z	{	|	}	~	del		

4.3.2 Escape Sequences for Special Characters

Escape Sequence	*Name*	*Unicode Code*	*Decimal Value*
`\b`	Backspace	`\u0008`	8
`\t`	Tab	`\u0009`	9
`\n`	Linefeed	`\u000A`	10
`\f`	Formfeed	`\u000C`	12
`\r`	Carriage Return	`\u000D`	13
`\\`	Backslash	`\u005C`	92
`\"`	Double Quote	`\u0022`	34

- Suppose you want to print the **quoted** message show below:

  He said “Java is fun”

  Here is how to write the statement:

  System.out.println(“He said \”Java is fun\””);

4.3.3 Casting between char and Numeric Types

- A char can be cast into **any** numeric type, and vice versa.
- Implicit casting can be used if the result of a casting **fits** into the target variable. Otherwise explicit casting must be used.
- **All** numeric operation can be applied to the char operands.
- The char operand is cast into a number if the other operand is a number or a character.
- If the other operand is a string, the character is concatenated with the string.

```
int i = 'a'; // Same as int i = (int)'a'; // (int) a is 97

char c = 99; // Same as char c = (char)99;

int i = '1' + '2';// (int) 1 is 49 and (int) 2 is 50
System.out.println("i is " + i);

int j = 1 + 'a'; // (int) a is 97
System.out.println("j is " + 98);
System.out.println(j + " is the Unicode for character " + (char) j);
System.out.println("Chapter " + 2);

Output is:
i is 99
j is 98
98 is the Unicode for character b
Chapter 2
```

4.3.4 Comparing and Testing Characters

- The following code tests whether a character ch is an uppercase letter, a lowercase letter, or a digital character.

```
if (ch >= 'A' && ch <= 'Z')
  System.out.println(ch + " is an uppercase letter");
else if (ch >= 'a' && ch <= 'z')
  System.out.println(ch + " is a lowercase letter");
else if (ch >= '0' && ch <= '9')
  System.out.println(ch + " is a numeric character");
```

TABLE 4.6 Methods in the Character Class

Method	Description
`isDigit(ch)`	Returns true if the specified character is a digit.
`isLetter(ch)`	Returns true if the specified character is a letter.
`isLetterOfDigit(ch)`	Returns true if the specified character is a letter or digit.
`isLowerCase(ch)`	Returns true if the specified character is a lowercase letter.
`isUpperCase(ch)`	Returns true if the specified character is an uppercase letter.
`toLowerCase(ch)`	Returns the lowercase of the specified character.
`toUpperCase(ch)`	Returns the uppercase of the specified character.

4.4 The String Type

- The char type only represents **one character**. To represent a string of **characters**, use the data type called String. For example,

```
String message = "Welcome to Java";
```

- String is actually a **predefined class** in the Java library just like the System class and Scanner class.
- The String type is not a **primitive** type. It is known as a **reference** type. Any Java class can be used as a reference type for a variable.
- Reference data types will be thoroughly discussed in Chapter 9, "Classes and Objects." For the time being, you just need to know how to declare a String variable, how to assign a string to the variable, how to concatenate strings, and to perform simple operations for strings.

TABLE 4.7 Simple Methods for String Objects

Method	Description
`length()`	Returns the number of characters in this string.
`charAt(index)`	Returns the character at the specified index from this string.
`concat(s1)`	Returns a new string that concatenates this string with string s1.
`toUpperCase()`	Returns a new string with all letters in uppercase.
`toLowerCase()`	Returns a new string with all letters in lowercase.
`trim()`	Returns a new string with whitespace characters trimmed on both sides.

4.4.1 Getting String Length

- You can use the length() method to return the number of characters in a string. For example,

```
String message = "Welcome to Java";
System.out.println("The length of " + message + " is "
  + message.length());

Display:
  The length of Welcome to Java is 15
```

4.4.2 Getting Characters from a String

- The s.charAt(index) method can be used to retrieve a specific character in a string s, where the index is between 0 and s.length()–1.
- For example, message.charAt(0) returns the character W, as shown in Figure 4.1. Note that the index for the first character in the string is 0.

```
String message = "Welcome to Java";
System.out.println("The first character in message is "
   + message.charAt(0));
```

```
Display:
  The first character in message is W
```

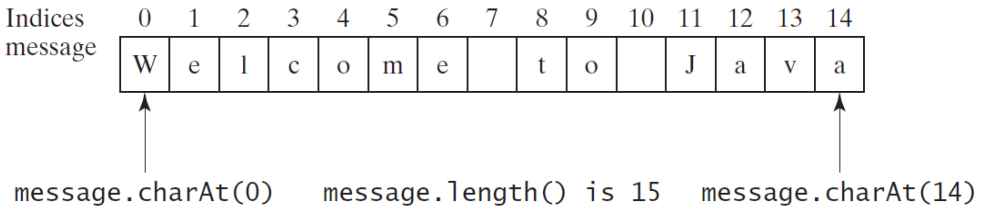


FIGURE 4.1 The characters in a String object can be accessed using its index.

4.4.3 Concatenating Strings

- The plus sign (+) is the **concatenation** operator if one of the operands is a string.
- If one of the operands is a non-string (e.g. a number), the non-string value is **converted** into a string and concatenated with the other string.

```
String s3 = s1.concat(s2); or String s3 = s1 + s2;

// Three strings are concatenated
String message = "Welcome " + "to " + "Java";
message += " and Java is fun"; // message = Welcome to Java and Java is fun

// String Chapter is concatenated with number 2
String s = "Chapter" + 2;         // s becomes Chapter2

// String Supplement is concatenated with character B
String s1 = "Supplement" + 'B'; // s becomes SupplementB

i = 1; j = 3;
System.out.println("i + j is " + i + j);   → i + j is 13
System.out.println("i + j is " + (i + j)); → i + j is 4
```

4.4.4 Converting Strings

- The toLowerCase() method returns a new string with all lowercase letters and the toUpperCase() method returns a new string with all uppercase letters. For example,

```
"Welcome".toLowerCase() returns a new string, welcome.
"Welcome".toUpperCase() returns a new string, WELCOME.
"  Welcome  ".trim() returns a new string, Welcome.
```

4.4.5 Reading a String from the Console

- To read a string from the console, invoke the next() method on a Scanner object. For example, the following code reads three strings from the keyboard:

```
Scanner input = new Scanner(System.in);
System.out.print("Enter three words separated by spaces: ");
String s1 = input.next();
String s2 = input.next();
String s3 = input.next();
System.out.println("s1 is " + s1);
System.out.println("s2 is " + s2);
System.out.println("s3 is " + s3);
```

```
Enter three words separated by spaces: Welcome to Java
s1 is Welcome
s2 is to
s3 is Java
```

- The next() method reads a string that ends with a whitespace character. You can use the nextLine() method to read an entire line of text. The nextLine() method reads a string that ends with the Enter key pressed. For example, the following statements read a line of text.

```
Scanner input = new Scanner(System.in);
System.out.println("Enter a line: ");
String s = input.nextLine();
System.out.println("The line entered is " + s);
```

```
Enter a line: Welcome to Java
The line entered is Welcome to Java
```

4.4.6 Reading a Character from the Console

- To read a character from the console, use the nextLine() method to read a string and then invoke the charAt(0) method on the string to return a character. For example, the following code reads a character from the keyboard:

```
Scanner input = new Scanner(System.in);
System.out.print("Enter a character: ");
String s = input.nextLine();
char ch = s.charAt(0);
System.out.println("The character entered is " + ch);
```

4.4.7 Comparing Strings

- The String class contains the methods as shown in Table 4.8 for comparing two strings.

TABLE 4.8 Comparison Methods for String Objects

Method	Description
`equals(s1)`	Returns true if this string is equal to string `s1`.
`equalsIgnoreCase(s1)`	Returns true if this string is equal to string `s1`; it is case insensitive.
`compareTo(s1)`	Returns an integer greater than `0`, equal to `0`, or less than `0` to indicate whether this string is greater than, equal to, or less than `s1`.
`compareToIgnoreCase(s1)`	Same as `compareTo` except that the comparison is case insensitive.
`startsWith(prefix)`	Returns true if this string starts with the specified prefix.
`endsWith(suffix)`	Returns true if this string ends with the specified suffix.
`contains(s1)`	Returns true if s1 is a substring in this string.

- The == operator checks only whether string1 and string2 refer to **the same object**; it does **not** tell you whether they have **the same contents**.

```
if (string1 == string2)
  System.out.println("string1 and string2 are the same object");
else
  System.out.println("string1 and string2 are different objects");
```

- The **equals** method is used to compare two strings:

```
if (string1.equals(string2))
  System.out.println("string1 and string2 have the same contents");
else
  System.out.println("string1 and string2 are not equal");
```

- For example, the following statements display true and then false.

```
String s1 = "Welcome to Java";
String s2 = "Welcome to Java";
String s3 = "Welcome to C++";
System.out.println(s1.equals(s2)); // true
System.out.println(s1.equals(s3)); // false
```

- The **compareTo** method can also be used to compare two strings. For example,

```
s1.compareTo(s2)
```

- The method returns the value 0 if s1 is equal to s2, a value less than 0 if s1 is lexicographically less than s2, and a value greater than 0 if s1 is lexicographically greater than s2. For example,

```
String s1 = "abc";
String s2 = "abg";
s1.compareTo(s2); // returns -4.
```

- You can also use str.**startsWith**(prefix) to check whether string str starts with a specified prefix, str.**endsWith**(suffix) to check whether string str ends with a specified suffix, and str.**contains**(s1) to check whether string str contains string s1 . For example,

```
"Welcome to Java".startsWith("We") returns true.
"Welcome to Java".startsWith("we") returns false.

"Welcome to Java".endsWith("va") returns true.
"Welcome to Java".endsWith("v") returns false.

"Welcome to Java".contains("to") returns true.
"Welcome to Java".contains("To") returns false.
```

- Listing 4.2 OrderTwoCities.java

```
import java.util.Scanner;

public class OrderTwoCities {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);

    // Prompt the user to enter two cities
    System.out.print("Enter the first city: ");
    String city1 = input.nextLine();
    System.out.print("Enter the second city: ");
    String city2 = input.nextLine();

    if (city1.compareTo(city2) < 0)
      System.out.println("The cities in alphabetical order are " +
         city1 + " " + city2);
    else
      System.out.println("The cities in alphabetical order are " +
          city2 + " " + city1);
  }
}
```

```
Enter the first city: New York
Enter the second city: Boston
The cities in alphabetical order are Boston New York
```

4.4.8 Obtaining Substrings

- You can obtain a substring from a string using the **substring** method in the String class, as shown in Table 4.9. For example,

```
String message = "Welcome to Java";
String message = message.substring(0, 11) + "HTML";

// The string message now becomes Welcome to HTML.
```

TABLE 4.9 The String class contains the method for obtaining substrings.

Method	Description
`substring(beginIndex)`	Returns this string's substring that begins with the character at the specified `beginIndex` and extends to the end of the string, as shown in Figure 4.2.
`substring(beginIndex, endIndex)`	Returns this string's substring that begins at the specified `beginIndex` and extends to the character at index `endIndex - 1`, as shown in Figure 9.6. Note that the character at `endIndex` is not part of the substring.

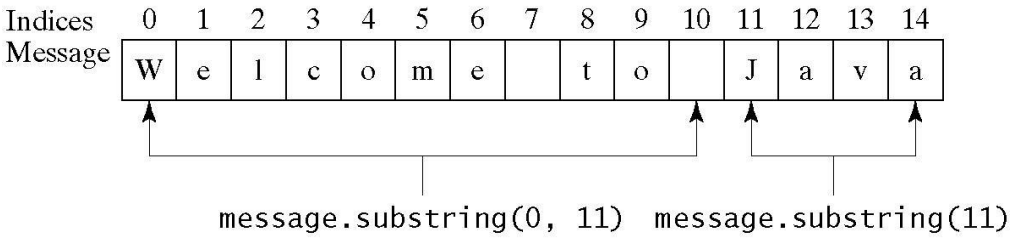


FIGURE 4.2 The substring method obtains a substring from a string.

4.4.9 Finding a Character or a Substring in a String

- The String class provides several versions of **indexOf** and **lastIndexOf** methods to find a character or a substring in a string.

TABLE 4.10 The String class contains the methods for finding substrings.

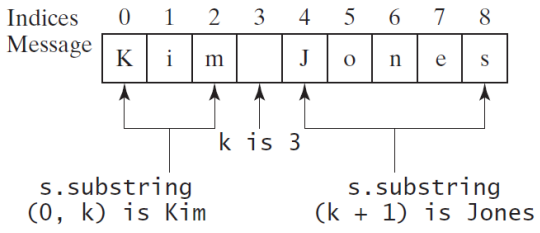
Method	Description
`indexOf(ch)`	Returns the index of the first occurrence of `ch` in the string. Returns `-1` if not matched.
`indexOf(ch, fromIndex)`	Returns the index of the first occurrence of `ch` after `fromIndex` in the string. Returns `-1` if not matched.
`indexOf(s)`	Returns the index of the first occurrence of string `s` in this string. Returns `-1` if not matched.
`indexOf(s, fromIndex)`	Returns the index of the first occurrence of string `s` in this string after `fromIndex`. Returns `-1` if not matched.
`lastIndexOf(ch)`	Returns the index of the last occurrence of `ch` in the string. Returns `-1` if not matched.
`lastIndexOf(ch, fromIndex)`	Returns the index of the last occurrence of `ch` before `fromIndex` in this string. Returns `-1` if not matched.
`lastIndexOf(s)`	Returns the index of the last occurrence of string `s`. Returns `-1` if not matched.
`lastIndexOf(s, fromIndex)`	Returns the index of the last occurrence of string `s` before `fromIndex`. Returns `-1` if not matched.

- For example,

```
"Welcome to Java".indexOf('W') returns 0.
"Welcome to Java".indexOf('o') returns 4.
"Welcome to Java".indexOf('o', 5) returns 9.
"Welcome to Java".indexOf("come") returns 3.
"Welcome to Java".indexOf("Java", 5) returns 11.
"Welcome to Java".indexOf("java", 5) returns -1.

"Welcome to Java".lastIndexOf('W') returns 0.
"Welcome to Java".lastIndexOf('o') returns 9.
"Welcome to Java".lastIndexOf('o', 5) returns 4.
"Welcome to Java".lastIndexOf("come") returns 3.
"Welcome to Java".lastIndexOf("Java", 5) returns -1.
"Welcome to Java".lastIndexOf("Java") returns 11.
```

- Suppose a string s contains the first name and last name separated by a space. You can use the following code to extract the first name and last name from the string:

```
int k = s.indexOf(' ');
String firstName = s.substring(0, k);
String lastName = s.substring(k + 1);
```



4.4.10 Converting between String and Numbers

Converting Strings to Integers

- The input returned from the input dialog box is a **string**. If you enter a numeric value such as 123, it returns "123". To obtain the input as a number, you have to convert a string into a number.

- To convert a string into an **int** value, you can use the **static parseInt** method in the **Integer** class as follows:

```
int intValue = Integer.parseInt(intString);

// where intString is a numeric string such as "123".
```

Converting Strings to Doubles

- To convert a string into a **double** value, you can use the **static parseDouble** method in the **Double** class as follows:

```
double doubleValue = Double.parseDouble(doubleString);

// where doubleString is a numeric string such as "123.45".
```

Converting Numbers to Strings

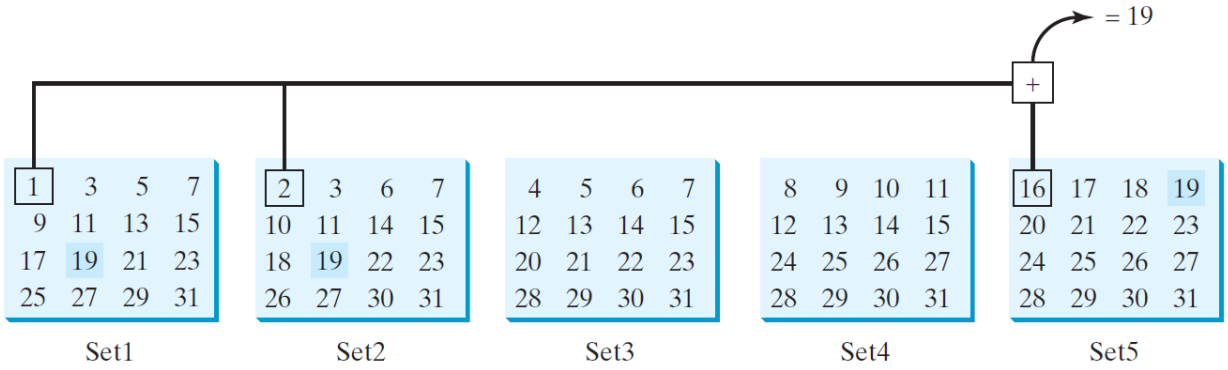
- Tonvert a number into a **string**, simply use the string **concatenating** operator as follows:

```
String s = number + "";
```

4.5 Case Studies

4.5.1 Case Study: Guessing Birthday

- The program can guess your birth date.



- Listing 4.3 GuessBirthday.java

```
import java.util.Scanner;

public class GuessBirthday {
  public static void main(String[] args) {
    String set1 =
      " 1  3  5  7\n" +
      " 9 11 13 15\n" +
      "17 19 21 23\n" +
      "25 27 29 31";

    String set2 =
      " 2  3  6  7\n" +
      "10 11 14 15\n" +
      "18 19 22 23\n" +
      "26 27 30 31";

    String set3 =
      " 4  5  6  7\n" +
      "12 13 14 15\n" +
      "20 21 22 23\n" +
      "28 29 30 31";

    String set4 =
      " 8  9 10 11\n" +
      "12 13 14 15\n" +
      "24 25 26 27\n" +
      "28 29 30 31";

    String set5 =
      "16 17 18 19\n" +
      "20 21 22 23\n" +
      "24 25 26 27\n" +
      "28 29 30 31";
```

```
    int day = 0;

    // Create a Scanner
    Scanner input = new Scanner(System.in);

    // Prompt the user to answer questions
    System.out.print("Is your birthday in Set1?\n");
    System.out.print(set1);
    System.out.print("\nEnter 0 for No and 1 for Yes: ");
    int answer = input.nextInt();

    if (answer == 1)
      day += 1;

    // Prompt the user to answer questions
    System.out.print("\nIs your birthday in Set2?\n");
    System.out.print(set2);
    System.out.print("\nEnter 0 for No and 1 for Yes: ");
    answer = input.nextInt();

    if (answer == 1)
      day += 2;

    // Prompt the user to answer questions
    System.out.print("Is your birthday in Set3?\n");
    System.out.print(set3);
    System.out.print("\nEnter 0 for No and 1 for Yes: ");
    answer = input.nextInt();

    if (answer == 1)
      day += 4;

    // Prompt the user to answer questions
    System.out.print("\nIs your birthday in Set4?\n");
    System.out.print(set4);
    System.out.print("\nEnter 0 for No and 1 for Yes: ");
    answer = input.nextInt();

    if (answer == 1)
      day += 8;

    // Prompt the user to answer questions
    System.out.print("\nIs your birthday in Set5?\n");
    System.out.print(set5);
    System.out.print("\nEnter 0 for No and 1 for Yes: ");
    answer = input.nextInt();

    if (answer == 1)
      day += 16;

    System.out.println("\nYour birthday is " + day + "!");
  }
}
```

```
The cities in alphabetical order are Boston New York
Is your birthday in Set1?
 1  3  5  7
 9 11 13 15
17 19 21 23
25 27 29 31
Enter 0 for No and 1 for Yes: 1

Is your birthday in Set2?
 2  3  6  7
10 11 14 15
18 19 22 23
26 27 30 31
Enter 0 for No and 1 for Yes: 1

Is your birthday in Set3?
 4  5  6  7
12 13 14 15
20 21 22 23
28 29 30 31
Enter 0 for No and 1 for Yes: 0

Is your birthday in Set4?
 8  9 10 11
12 13 14 15
24 25 26 27
28 29 30 31
Enter 0 for No and 1 for Yes: 0

Is your birthday in Set5?
16 17 18 19
20 21 22 23
24 25 26 27
28 29 30 31
Enter 0 for No and 1 for Yes: 1

Your birthday is 19!
```

- Mathematics Basis for the Game

```
  10000      00110      10000
     10         10       1000
+     1    +     1        100
-----      -----    +     1
  10011      00111      -----
                        11101

   19         7          23
```

Decimal	Binary
1	00001
2	00010
3	00011
...	
19	10011
...	
31	11111

$$
\begin{array}{r}
b_5\ 0\ 0\ 0\ 0 \\
b_4\ 0\ 0\ 0 \\
b_3\ 0\ 0 \\
b_2\ 0 \\
+\qquad b_1 \\
\hline
b_5 b_4 b_3 b_2 b_1
\end{array}
\qquad
\begin{array}{r}
10000 \\
10 \\
+\quad 1 \\
\hline
10011 \\
\\
19
\end{array}
\qquad
\begin{array}{r}
10000 \\
1000 \\
100 \\
10 \\
+\quad 1 \\
\hline
11111 \\
\\
31
\end{array}
$$

4.5.2 Case Study: Converting a Hexadecimal Digit to a Decimal Value

- Write a program that converts a hexadecimal digit into a decimal value. The hexadecimal number system has **16** digits: 0–9, A–F. The letters A, B, C, D, E, and F correspond to the decimal numbers 10, 11, 12, 13, 14, and 15.

- Listing 4.4 HexDigit2Dec.java

```
import java.util.Scanner;

public class HexDigit2Dec {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);
    System.out.print("Enter a hex digit: ");
    String hexString = input.nextLine();

    // Check if the hex string has exactly one character
    if (hexString.length() != 1) {
      System.out.println("You must enter exactly one character");
      System.exit(1);
    }

    // Display decimal value for the hex digit
    char ch = Character.toUpperCase(hexString.charAt(0));
    if (ch <= 'F' && ch >= 'A') {
      int value = ch - 'A' + 10;
      System.out.println("The decimal value for hex digit "
        + ch + " is " + value);
    }
    else if (Character.isDigit(ch)) {
      System.out.println("The decimal value for hex digit "
        + ch + " is " + ch);
    }
    else {
      System.out.println(ch + " is an invalid input");
    }
  }
}
```

```
Enter a hex digit: AB7C
You must enter exactly one character
```

```
Enter a hex digit: B
The decimal value for hex digit B is 11
```

```
Enter a hex digit: 8
The decimal value for hex digit 8 is 8
```

```
Enter a hex digit: T
T is an invalid input
```

4.5.3 Case Study: Revising the Lottery Program Using Strings

- The program in Listing 3.8 uses an integer to store the number. Listing 4.5 gives a new program that generates a random **two-digit string** instead of a number and receives the user input as a string instead of a number.

    1. If the user input matches the lottery number in the exact order, the award is $10,000.
    2. If all the digits in the user input match all the digits in the lottery number, the award is $3,000.
    3. If one digit in the user input matches a digit in the lottery number, the award is $1,000.

- Listing 4.5 LotteryUsingStrings.java

```
import java.util.Scanner;

public class LotteryUsingStrings {
  public static void main(String[] args) {
    // Generate a lottery as a two-digit string
    String lottery = "" + (int)(Math.random() * 10)
      + (int)(Math.random() * 10);

    // Prompt the user to enter a guess
    Scanner input = new Scanner(System.in);
    System.out.print("Enter your lottery pick (two digits): ");
    String guess = input.nextLine();

    // Get digits from lottery
    int lotteryDigit1 = lottery.charAt(0);
    int lotteryDigit2 = lottery.charAt(1);

    // Get digits from guess
    int guessDigit1 = guess.charAt(0);
    int guessDigit2 = guess.charAt(1);

    System.out.println("The lottery number is " + lottery);

    // Check the guess
    if (guess.equals(lottery))
      System.out.println("Exact match: you win $10,000");
    else if (guessDigit2 == lotteryDigit1
          && guessDigit1 == lotteryDigit2)
      System.out.println("Match all digits: you win $3,000");
   else if (guessDigit1 == lotteryDigit1
          || guessDigit1 == lotteryDigit2
          || guessDigit2 == lotteryDigit1
          || guessDigit2 == lotteryDigit2)
      System.out.println("Match one digit: you win $1,000");
    else
      System.out.println("Sorry, no match");
  }
}
```

```
Enter your lottery pick (two digits): 00
The lottery number is 00
Exact match: you win $10,000
```

```
Enter your lottery pick (two digits): 45
The lottery number is 54
Match all digits: you win $3,000
```

```
Enter your lottery pick: 23
The lottery number is 34
Match one digit: you win $1,000
```

```
Enter your lottery pick: 23
The lottery number is 14
Sorry: no match
```

4.6 Formatting Console Outputs

- Use the **printf** statement.

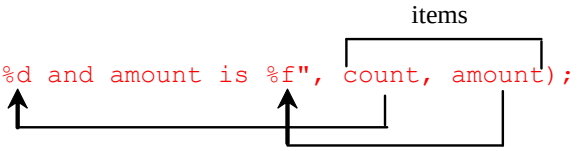
```
System.out.printf(format, items);
```

- Where format is a string that may consist of substrings and format specifiers.
- A format **specifier** specifies how an item should be displayed. An item may be a numeric value, character, boolean value, or a string. Each specifier begins with a percent sign.,

TABLE 4.11 Frequently Used Format Specifiers

Specifier	Output	Example
%b	a boolean value	true or false
%c	a character	'a'
%d	a decimal integer	200
%f	a floating-point number	45.460000
%e	a number in standard scientific notation	4.556000e+01
%s	a string	"Java is cool"

```
int count = 5;
double amount = 45.56;
System.out.printf("count is %d and amount is %f", count, amount);
```




```
display            count is 5 and amount is 45.560000
```

TABLE 4.12 Examples of Specifying Width and Precision

Example	Output
%5c	Output the character and add four spaces before the character item, because the width is 5.
%6b	Output the Boolean value and add one space before the false value and two space before the true value.
%5d	Output the integer item with width at least 5. If the number of digits in the item is 6 5, add spaces before the number. If the number of digits in the item is 7 5, the width is automatically increased.
%10.2f	Output the floating-point item with width at least 10 including a decimal point and two digits after the point. Thus, there are 7 digits allocated before the decimal point. If the number of digits before the decimal point in the item is 6 7, add spaces before the number. If the number of digits before the decimal point in the item is 7 7, the width is automatically increased.
%10.2e	Output the floating-point item with width at least 10 including a decimal point, two digits after the point and the exponent part. If the displayed number in scientific notation has width less than 10, add spaces before the number.
%12s	Output the string with width at least 12 characters. If the string item has fewer than 12 characters, add spaces before the string. If the string item has more than 12 characters, the width is automatically increased.

- Listing 4.6 FormatDemo.java

```
public class FormatDemo {
  public static void main(String[] args) {
  // Display the header of the table
  System.out.printf("%-10s%-10s%-10s%-10s%-10s\n", "Degrees",
      "Radians", "Sine", "Cosine", "Tangent");

  // Display values for 30 degrees
  int degrees = 30;
  double radians = Math.toRadians(degrees);
  System.out.printf("%-10d%-10.4f%-10.4f%-10.4f%-10.4f\n", degrees,
      radians, Math.sin(radians), Math.cos(radians),
      Math.tan(radians));

 // Display values for 60 degrees
  degrees = 60;
  radians = Math.toRadians(degrees);
  System.out.printf("%-10d%-10.4f%-10.4f%-10.4f%-10.4f\n", degrees,
      radians, Math.sin(radians), Math.cos(radians),
      Math.tan(radians));
  }
}
```

```
Degrees   Radians   Sine      Cosine    Tangent
30        0.5236    0.5000    0.8660    0.5774
60        1.0472    0.8660    0.5000    1.7321
```

- The column names are strings. Each string is displayed using the specifier %-10s, which **left-justifies** the string.
- The degrees as an integer and four float values. The integer is displayed using the specifier %-10d and each float is displayed using the specifier %-10.4f, which specifies **four** digits after the decimal point.