Outline

1. **Java Class Library**
2. **Class *Math***
3. **`Character` Data Type**
4. **Class *String***
5. **`printf` Statement**

1. Java Class Library

- **A *class library* is a collection of classes that we use when developing programs**
- **The *Java standard class library* is part of any Java development environment**
- **The library classes are not part of the Java language per se, but we rely on them heavily**
- **Various library classes we've already used in our programs, such as `System`, `Scanner`, and `Random`**
- **Other class libraries can be obtained through third party vendors, or you can create them yourself**
- **Classes must be imported into the program**

Packages

- **The classes of the Java standard class library are organized into *packages***
- **Some of the packages in the standard class library are:**

Package	Purpose
java.lang	General support (*Character, Math, System, Number, …*)
java.util	Utilities (*Date, Random, Calendar, …*)
java.applet	Creating applets for the web
java.awt	Graphics and graphical user interfaces
javax.swing	Additional graphics capabilities
java.net	Network communication
javax.xml.parsers	XML document processing

`import` Declaration

- **When you want to use a class from a package, you could use its *fully qualified name***

```
java.util.Scanner
```

- **Or you can *import* the class, and then use just the class name**

```
import java.util.Scanner;
```

- **To import all classes in a particular package, you can use the * wildcard character**

```
import java.util.*;  // wildcard
```

`import` Declaration

- **All classes of the `java.lang` package are imported automatically into all programs**
- **It's as if all programs contain the following line:**

```
import java.lang.*;
```

- **That's why we didn't have to import the `System` or `String` classes explicitly in earlier programs**
- **The `Scanner` class, on the other hand, is part of the `java.util` package, and therefore must be imported**

2. Class *Math*

- **The `Math` class is part of the `java.lang` package**
- **The `Math` class contains methods (called *class methods)* that perform various mathematical functions:**
  - `PI constant`
  - `E (base of natural logarithms) constant`
  - `Trigonometric Methods`
  - `Exponent Methods`
  - `Rounding Methods`
  - `min, max, abs, and random Methods`
- **Methods in the `Math` class are called *static methods***
- **Static methods can be invoked through the class name – no object of the `Math` class is needed**

```
Double value = Math.cos(90) + Math.sqrt(delta);
```

Example

```
import java.util.Scanner;
public class Quadratic
{
   public static void main (String[] args)
   {
      int a, b, c;  // ax^2 + bx + c
      double discriminant, root1, root2;
      Scanner scan = new Scanner (System.in);

      System.out.print ("Enter the coefficient of x squared: ");
      a = scan.nextInt();
      System.out.print ("Enter the coefficient of x: ");
      b = scan.nextInt();
      System.out.print ("Enter the constant: ");
      c = scan.nextInt();

      // Use quadratic formula to compute the roots.

      discriminant = Math.pow(b, 2) - (4 * a * c);
      root1 = ((-1 * b) + Math.sqrt(discriminant)) / (2 * a);
      root2 = ((-1 * b) - Math.sqrt(discriminant)) / (2 * a);

      System.out.println ("Root #1: " + root1);
      System.out.println ("Root #2: " + root2);
   }
}
```

Example

Output:

```
Enter the coefficient of x squared: 3
Enter the coefficient of x: 8
Enter the constant: 4
Root #1: -0.666666666666666
Root #2: -2.0

Enter the coefficient of x squared: 2
Enter the coefficient of x: 4
Enter the constant: 8
Root #1: NaN
Root #2: NaN
```

NaN indicates undefined root due to square root of negative value (sqrt of b^2-4ac)

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

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
```

Rounding Methods

- **`double ceil(double x)`**

  x is 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)`**

  returns **`(int)Math.floor(x+0.5)`**

- **`long round(double x)`**

  returns **`(long)Math.floor(x+0.5)`**

Rounding Methods 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  //returns even value as double
Math.rint(-2.5) returns -2.0
Math.round(2.6f) returns 3  //round returns integers
Math.round(2.0) returns 2
Math.round(-2.0f) returns -2
Math.round(-2.6) returns -3
```

Min(), max(), and abs()

- **`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
```

Method `random()`

Generates a random double value greater than or equal to 0.0 and less than 1.0 **(`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.

Generating Random Characters

Each character has a unique Unicode between 0 and FFFF in hexadecimal (65535 in decimal).

To generate a random character is to generate a random integer between 0 and 65535 using the following expression:

```
(int)(Math.random() * (65535 + 1))
```

Note:

Since `0.0 <= Math.random() <1.0`, you have to add 1 to 65535

Generating Random Characters

Lowercase letter: The Unicode for lowercase letters are consecutive integers starting from the Unicode for 'a', 'b', 'c', ..., and 'z'.

The Unicode for 'a' is `(int)'a'`

A random integer between (int)'a' and (int)'z' is

```
(int)((int)'a'+ Math.random()*((int)'z'-(int)'a'+1)
```

So, a random lowercase letter is:

```
(char)('a' + Math.random() * ('z' - 'a' + 1))
```

To generalize, a random character between any two characters ch1 and ch2 with ch1 < ch2 can be generated as follows:

```
(char)(ch1 + Math.random() * (ch2 – ch1 + 1))
```

See Appendix B, page 1266, for character set order.

Class RandomCharacter

```
// RandomCharacter.java: Generate random characters
public class RandomCharacter {
  /** Generate a random character between ch1 and ch2 */
  public static char getRandomCharacter(char ch1, char ch2) {
    return (char)(ch1 + Math.random() * (ch2 - ch1 + 1)); }

  /** Generate a random lowercase letter */
  public static char getRandomLowerCaseLetter() {
    return getRandomCharacter('a', 'z'); }

  /** Generate a random uppercase letter */
  public static char getRandomUpperCaseLetter() {
    return getRandomCharacter('A', 'Z'); }

  /** Generate a random digit character */
  public static char getRandomDigitCharacter() {
    return getRandomCharacter('0', '9'); }

  /** Generate a random character */
  public static char getRandomCharacter() {
    return getRandomCharacter('\u0000', '\uFFFF'); }
}
```

Class RandomCharacter

```
// Test class RandomCharacters
// class RandomCharacters methods are all static
public class TestRandomCharacters
{
  public static void main(String[] args)
  {
    System.out.print("A random character between 'a' and 'z' is: ");
    System.out.println(RandomCharacter.getRandomLowerCaseLetter());

    System.out.print("A random character between 'A' and 'Z' is: ");
    System.out.println(RandomCharacter.getRandomUpperCaseLetter());

    System.out.print("A random character between '0' and '9' is: ");
    System.out.println(RandomCharacter.getRandomDigitCharacter());

    System.out.print("A random character between 'g' and 'm' is: ");
    System.out.println(RandomCharacter.getRandomCharacter('g', 'm'));

    System.out.print("A random character between '3' and '7' is: ");
    System.out.println(RandomCharacter.getRandomCharacter('3', '7'));

    System.out.print("A random character between '!' and '*' is: ");
    System.out.println(RandomCharacter.getRandomCharacter('!', '*'));
  }
}
```

3. Character Data Type

Stop and Record…

3. Character Data Type

A `char` variable stores a single character.

Character literals are delimited by single quotes:

```
'a'   'X'   '7'   '$'   ','   '\n'   '\t'
```

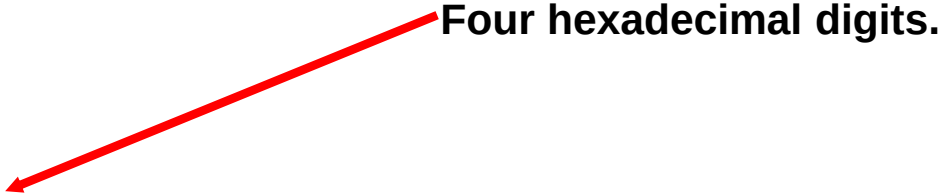
Example declarations:

```
char topGrade = 'A';

char terminator = ';', separator = ' ';
```

Note the distinction between a primitive `char` variable, which holds only one character, and a `String` object, which can hold multiple characters.

Character Type - Revisited

```
char letter = 'A';
char numChar = '4';
char letter = '\u0041';   //Unicode for A
char numChar = '\u0034';   //Unicode for character 4
```



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 = 'c';
ch = ch + 1;
System.out.println(ch); //prints character d
ch = ch - 2;
System.out.println(ch); //prints character b
```

ASCII Code in Decimal

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		

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

Casting `char` Type

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

char ch = 97; //Same as char ch = (char)97; which is 'a'
```

Comparing `char` Type

```
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");
```

Class `Character` Methods

Method	Description
`isDigit(ch)`	Returns true if the specified character is a digit.
`isLetter(ch)`	Returns true if the specified character is a letter.
`isLetterOrDigit(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.

Class `Character` Methods

```
Character ch1 = new Character('b'); //object NOT char type
Character ch2 = new Character('9'); //object NOT char type

Character.isLowerCase(ch1)          returns true
Character.isLetterOrDigit(ch1)      returns true
Character.isDigit(ch1)              returns false
Character.isDigit(ch2)              returns true
Character.toUpperCase(ch1)          returns B
```

Class `Character` Test

```
// Class Character Test
import java.util.Scanner;
public class CharacterTest
{
   public static void main (String[] args)
   {
      Character ch1 = new Character('b'); //object NOT char type
      Character ch2 = new Character('9'); //object NOT char type

      System.out.println(Character.isLowerCase(ch1));     //returns true
      System.out.println(Character.isLetterOrDigit(ch1)); //returns true
      System.out.println(Character.isDigit(ch1));         //returns false
      System.out.println(Character.isDigit(ch2));         //returns true
      System.out.println(Character.toUpperCase(ch1));     //returns B

      char ch3 = 'R'; // char type variable
      char ch4 = '7'; // char type variable
      char ch5 = '*'; // char type variable

      System.out.println(Character.isLowerCase(ch3));     //returns false
      System.out.println(Character.isLetterOrDigit(ch5)); //returns false
      System.out.println(Character.isDigit(ch4));         //returns true
      System.out.println(Character.isDigit(ch5));         //returns false
      System.out.println(Character.toLowerCase(ch3));     //returns r
   }
}
```

Escape Sequences

Description	*Escape Sequence*	*Unicode*
Backspace	`\b`	`\u0008`
Tab	`\t`	`\u0009`
Linefeed	`\n`	`\u000A`
Carriage return	`\r`	`\u000D`
Backslash	`\\`	`\u005C`
Single Quote	`\'`	`\u0027`
Double Quote	`\"`	`\u0022`

4. Class *String*

- To create a *String* object, we need to declare a variables of type *String*:

```
String title = "Java Software Solutions";
```

- Each string literal (enclosed in double quotes) represents a `String` object
- Once a `String` object has been created, neither its value nor its length can be changed. Thus, `String` objects are *immutable*
- The String type is not a primitive type. It is a class type and known as a *object* or *reference type*.

String Methods

- However, several methods of the `String` class return new `String` objects that are modified versions of the original string
- A String object is a sequence of characters (known as Single-Dimensional Array).

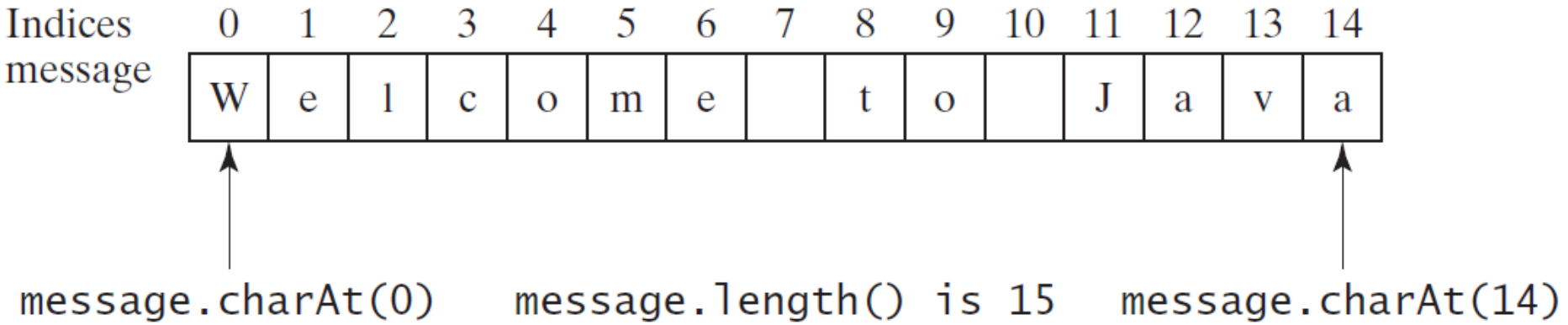
```
String courseName = "CS 2301";
```

0	1	2	3	4	5	6
C	S		2	3	0	1

String Index Values

- It is occasionally helpful to refer to a particular character within a string
- This can be done by specifying the character's numeric *index (position)*
- The indexes begin at zero in each string
- In the string `"Hello"`, the character `'H'` is at index 0 and the `'o'` is at index 4

Getting Characters from a String




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

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

String Concatenation

```
// Three strings are concatenated
String message = "Welcome " + "to " + "Java";

// 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'; // s1 becomes SupplementB
```

Example

```
public class StringMutation
{
   //  Prints a string and various mutations of it.
   public static void main (String[] args)
   {
      String phrase = "Change is inevitable";
      String mutation1, mutation2, mutation3, mutation4;

      System.out.println ("Original string: \"" + phrase + "\"");
      System.out.println ("Length of string: " + phrase.length());

      mutation1 = phrase.concat(", except from vending machines.");
      mutation2 = mutation1.toUpperCase();
      mutation3 = mutation2.replace ('E', 'X');
      mutation4 = mutation3.substring (3, 30); //excluding position 30
      System.out.println ("Mutation #1: " + mutation1);
      System.out.println ("Mutation #2: " + mutation2);
      System.out.println ("Mutation #3: " + mutation3);
      System.out.println ("Mutation #4: " + mutation4);

      System.out.println ("Mutated length: " + mutation4.length());
   }
}
```

Example

Output:

```
Original string: "Change is inevitable"
Length of string: 20
Mutation #1: Change is inevitable, except from vending machines.
Mutation #2: CHANGE IS INEVITABLE, EXCEPT FROM VENDING MACHINES.
Mutation #3: CHANGX IS INXVITABLX, XXCXPT FROM VXNDING MACHINXS.
Mutation #4: NGX IS INXVITABLX, XXCXPT F
Mutated length: 27
```

Other String Methods

```
String S1 = "Welcome";
String S2 = new String(char[]);
S2 = "   Hello!  ";
char ch = S1.charAt(index);
int length = S1.length();
int index = S1.indexOf(ch);
int index = S1.lastIndexOf(ch);
boolean b = S1.equals(S2);
boolean b = S1.equalsIgnoreCase(S2);
boolean b = S1.startsWith(S2);
Boolean b = S1.endsWith(S2);
String S = S1.toUpperCase();
String S = S2.toLowerCase();
String S = S2.substring(i); //from position i to last position
String S = S2.substring(i,j); //excluding j position
String S = S2.replace(ch1,ch2);
String S = S2.trim(); //returns "Hello!", no spaces
```

Reading Strings

```
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("First word is " + s1);
System.out.println("Second word is " + s2);
System.out.println("Third word is " + s3);
```

Note: If we use

```
String s1 = input.nextLine();
```

`s1` contains all typed characters until we press the "Enter" key.

Reading Characters

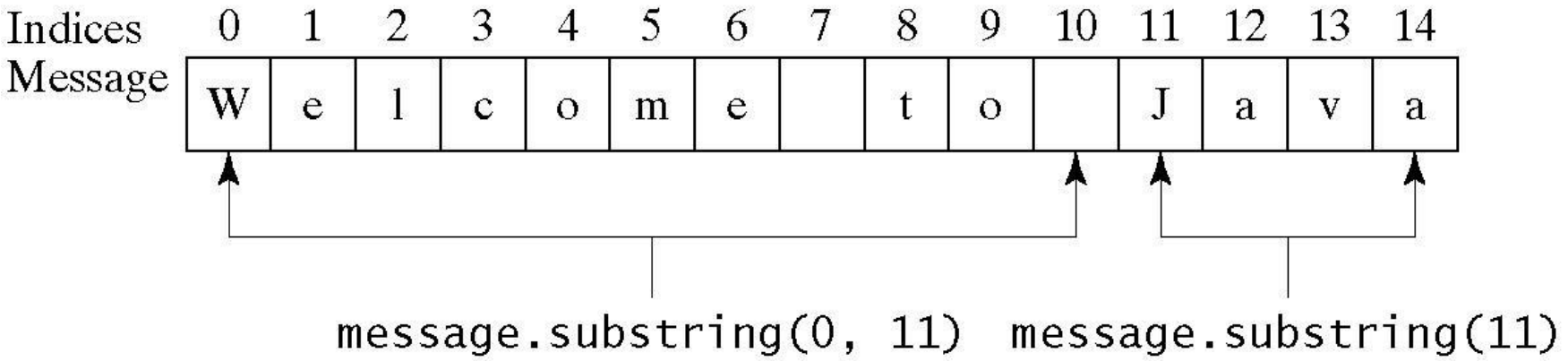
```
//Characters are read as strings

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

Comparing Strings

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.

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.



`indexOf()` method

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.

Conversion of Strings/Numbers

You can convert strings of digits to numbers:

```
String intString = "123";
int intValue = Integer.parseInt(intString);

String doubleString = "123.456";
double doubleValue = Double.parseDouble(doubleString);
```

You can convert numbers to strings:

```
int number = 123456;
String s = "" + number; //gives "123456"
```

5. `printf()` Statement

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.

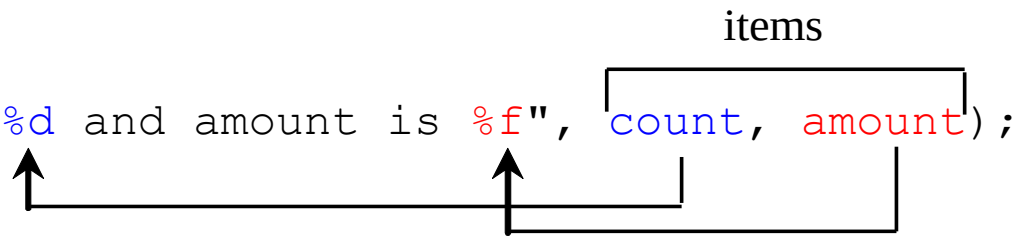
An item may be a numeric value, character, boolean value, or a string.

Each specifier begins with a percent (%) sign.

Frequently-Used 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	45.4600000
%e	a 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);
```




```
Output: count is 5 and amount is 45.5600000
```

Homework: Type and run program FormatDemo, listing 4.6, page 148. It shows how to display tabulated outputs using **`printf()`** statement.