String

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: -0.6666666666666666
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.

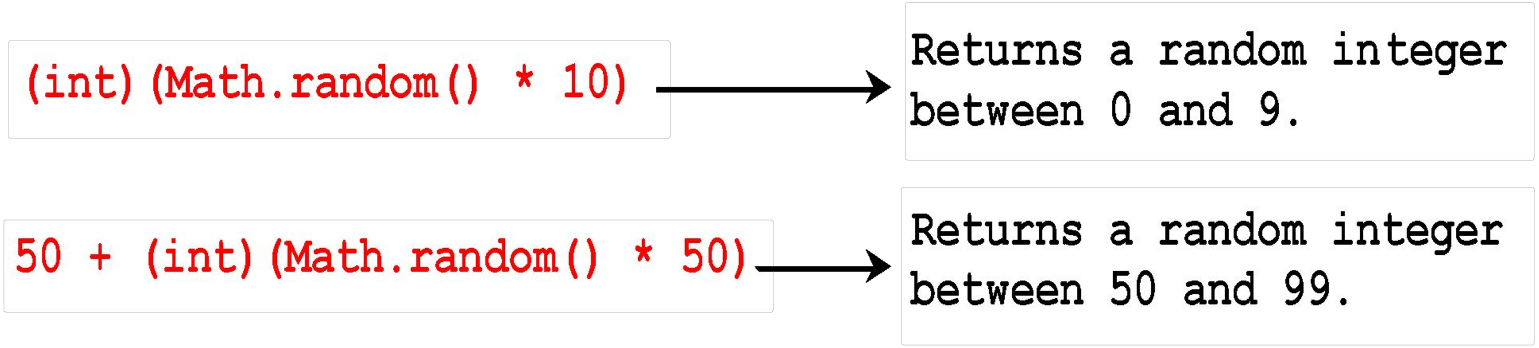
Examples:

```
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:



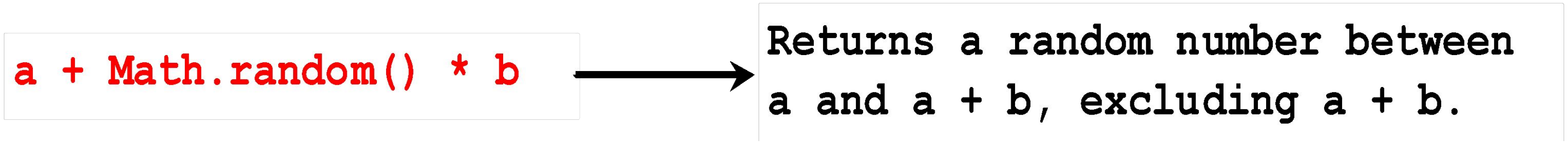
```
(int)(Math.random() * 10)
```

→ 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.

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

Four hexadecimal digits.

```
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

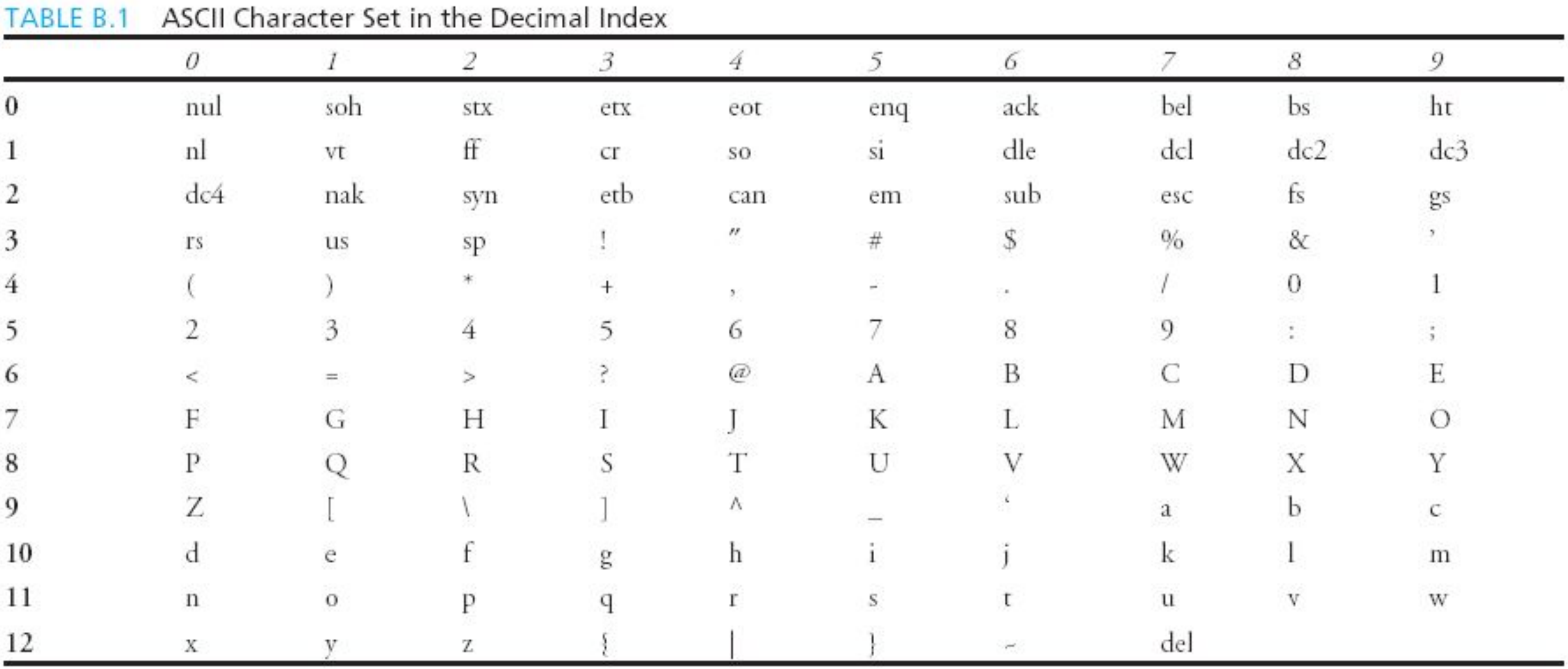
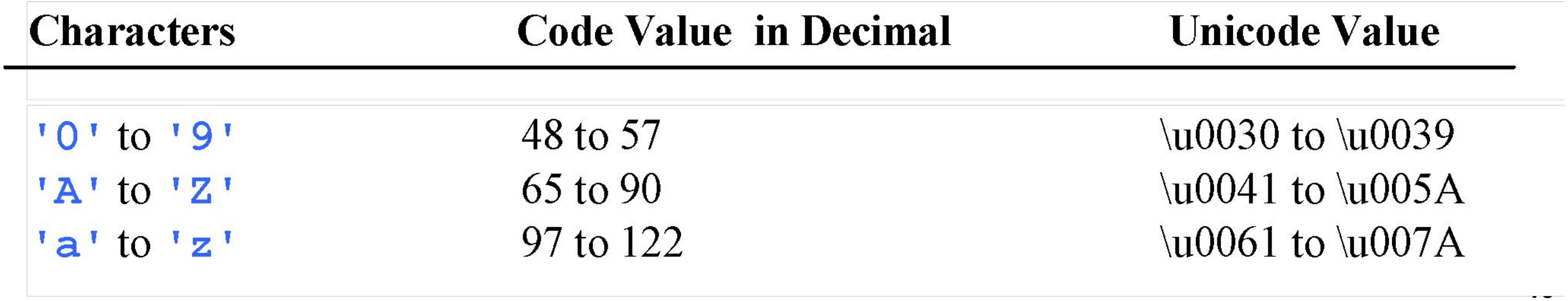


TABLE B.1 ASCII Character Set in the Decimal Index

	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		



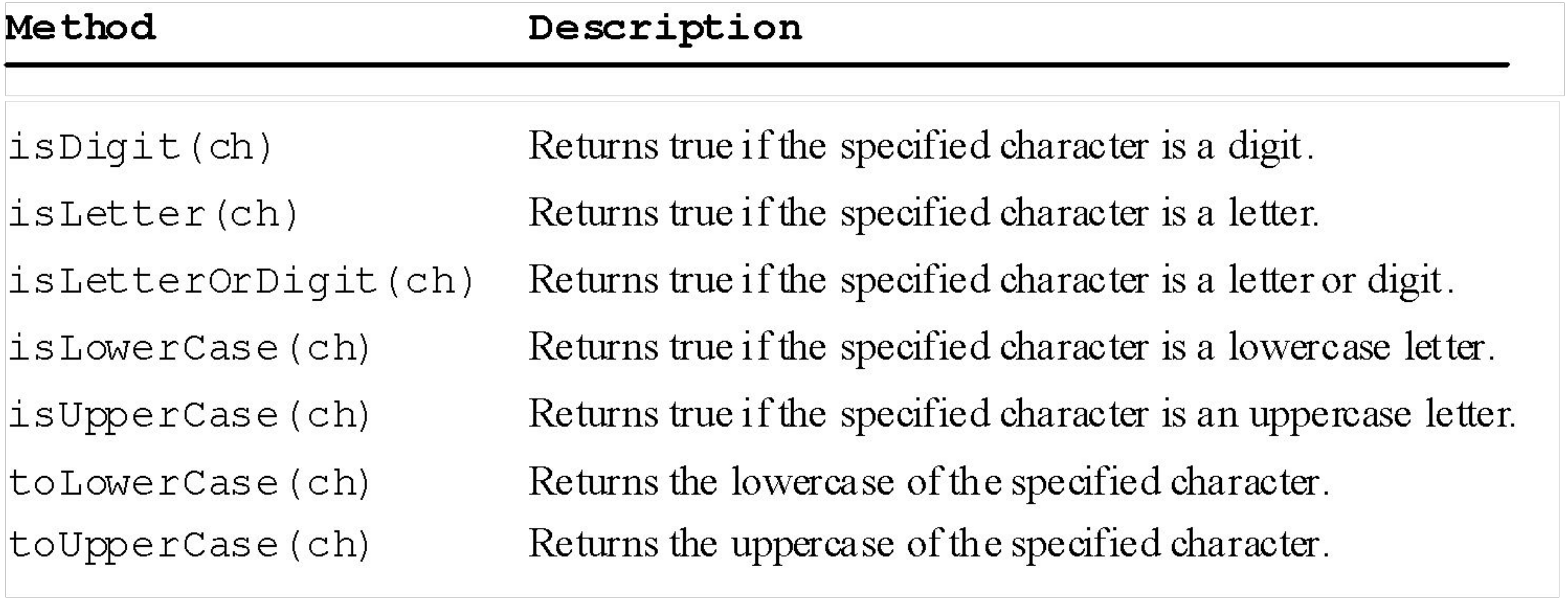
Characters	Code Value in Decimal	Unicode Value
'0' to '9'	48 to 57	\u0030 to \u0039
'A' to 'Z'	65 to 90	\u0041 to \u005A
'a' to 'z'	97 to 122	\u0061 to \u007A

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'
```

```
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).

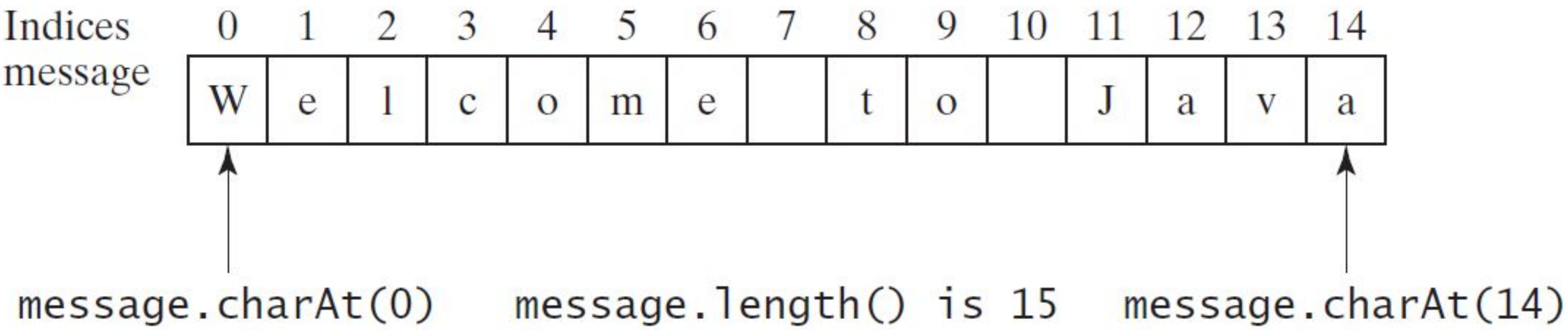
```
String courseName = "CS 2301";
```

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



Indices	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
message	W	e	l	c	o	m	e		t	o		J	a	v	a

message.charAt(0)   message.length() is 15   message.charAt(14)

```
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

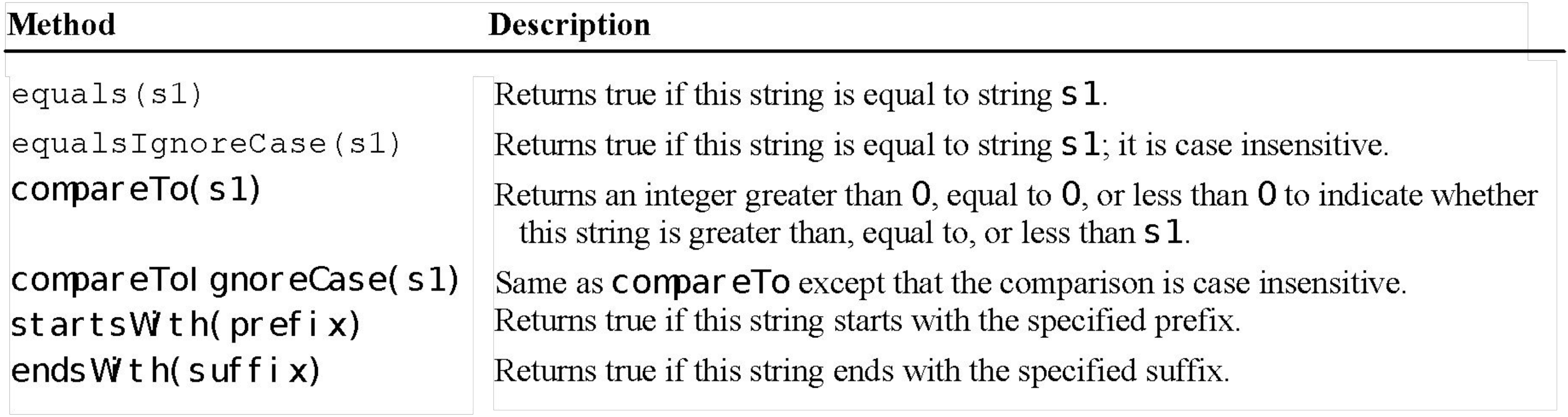
```
String s1 = input.nextLine();
```

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

Reading Characters

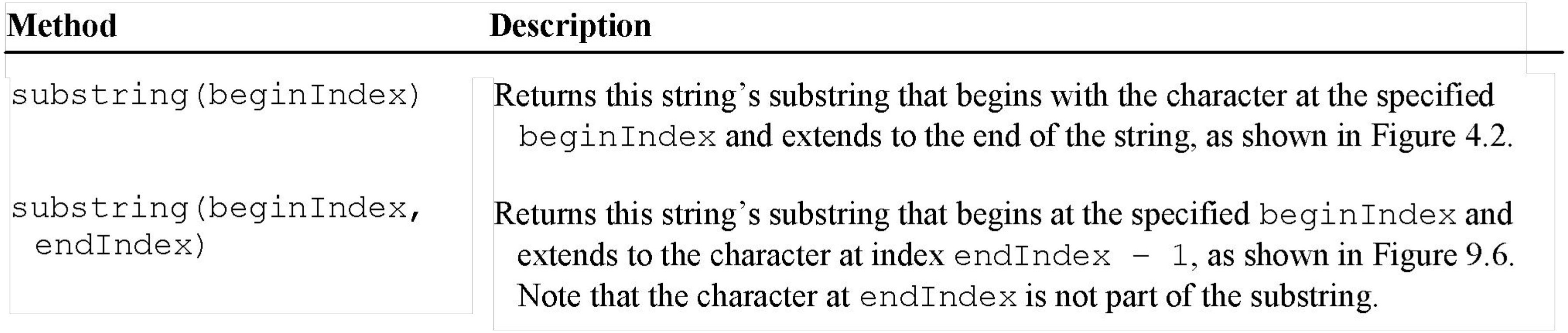
```
//Characters are read as strings

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

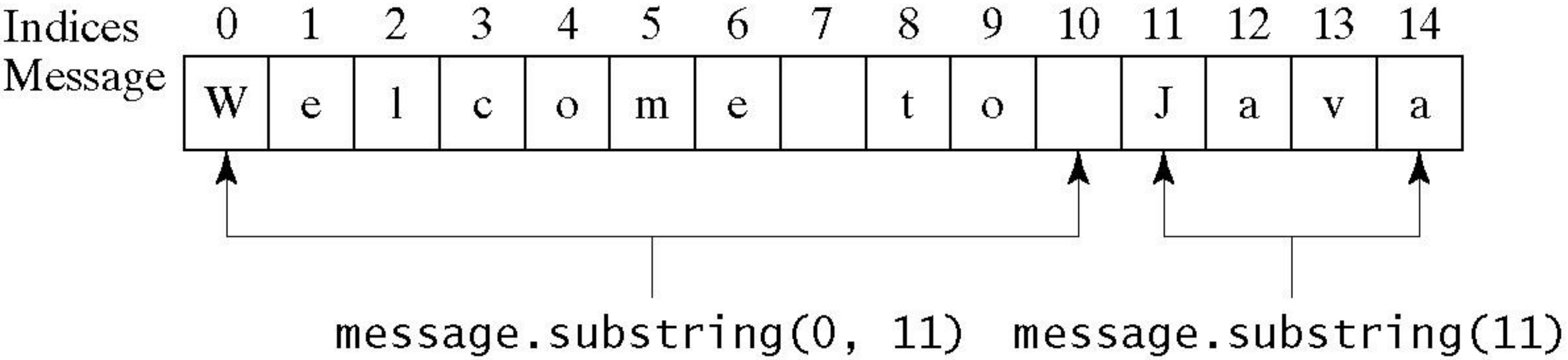


Method	Description
`equals(s1)`	Returns true if this string is equal to string `s1`.
`equalsIgnoreCase(s1)`	Returns true if this string is equal to string `s1`; it is case insensitive.
`compareTo(s1)`	Returns an integer greater than `0`, equal to `0`, or less than `0` to indicate whether this string 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.



Indices	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Message	W	e	l	c	o	m	e		t	o		J	a	v	a

`message.substring(0, 11)` `message.substring(11)`

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.

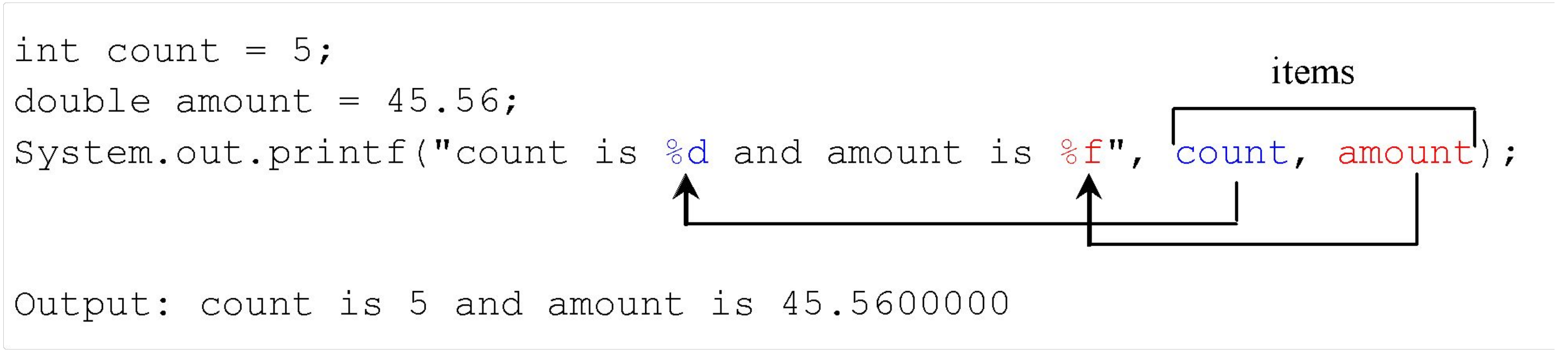
A format specifier specifies how an item should be displayed.

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.