Data types

JC08-4.1

(A. Nguyen)

Values in Java

- A value in Java is:
  - A reference to an object, or
  - One of 8 primitive data types
- We will concentrate on 4 primitive data types:

TYPE	DESCRIPTION	SIZE
`int`	The integer type, with range -2,147,483,648 (`Integer.MIN_VALUE`)`...` 2,147,483,647 (`Integer.MAX_VALUE`)	4 bytes
`double`	The double-precision floating-point type, with a range of about $\pm 10^{308}$, and about 15 significant decimal digits	8 bytes
`char`	The character type, representing code units in the Unicode encoding scheme	2 bytes
`boolean`	The type with the two truth values falseand true	1 bit

- Note: a 10-digit phone number would **overflow** an `int` – will need `long`

[1.5]

`int` in Java

	VALUE	COMMENTS
`Integer.MIN_VALUE`	-2^{31} or -2,147,483,648	
`Integer.MIN_VALUE-1`	2147483647	Overflow, becoming positive!
`Integer.MIN_VALUE+1`	-2,147,483,647	
`Integer.MAX_VALUE`	2^{31}-1 or 2,147,483,647	
`Integer.MAX_VALUE-1`	2147483646	
`Integer.MAX_VALUE+1`	-2147483648	Overflow, becoming negative!

Number Literals (& errors)

From Java Concepts, 8e, C. Horstmann

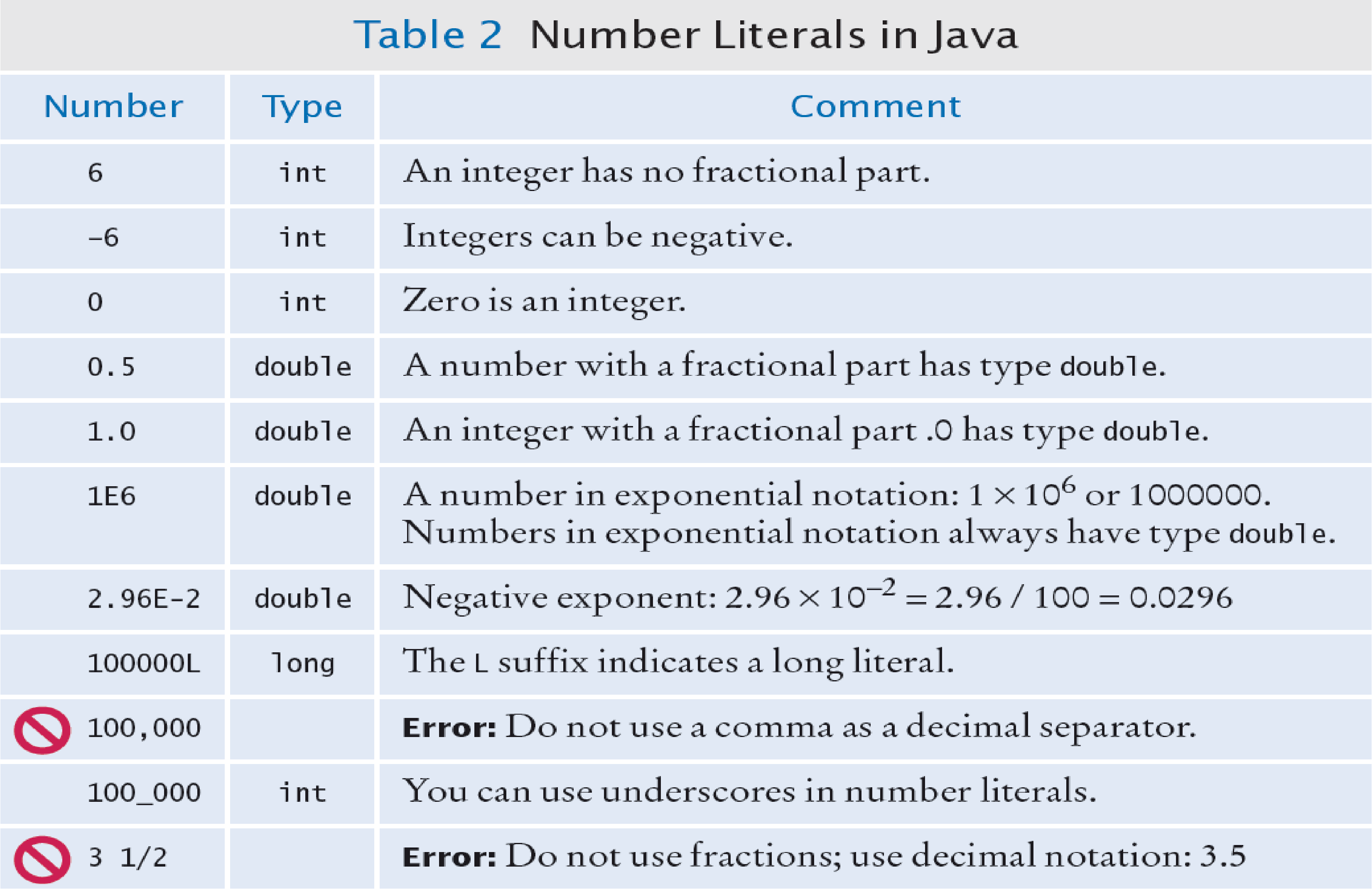


Table 2 Number Literals in Java

Number	Type	Comment
6	int	An integer has no fractional part.
-6	int	Integers can be negative.
0	int	Zero is an integer.
0.5	double	A number with a fractional part has type double.
1.0	double	An integer with a fractional part .0 has type double.
1E6	double	A number in exponential notation: 1×10^6 or 1000000. Numbers in exponential notation always have type double.
2.96E-2	double	Negative exponent: $2.96 \times 10^{-2} = 2.96 / 100 = 0.0296$
100000L	long	The L suffix indicates a long literal.
🚫 100,000		**Error:** Do not use a comma as a decimal separator.
100_000	int	You can use underscores in number literals.
🚫 3 1/2		**Error:** Do not use fractions; use decimal notation: 3.5

From Java Concepts, 8e, C. Horstmann

Rounding Errors

© caracterdesign/iStockphoto.

- Rounding errors occur when an exact representation of a floating-point number is not possible.
- Floating-point numbers have limited precision. Not every value can be represented precisely, and roundoff errors can occur.
- Example

```
double f = 4.35;
System.out.println(100 * f); // Prints 434.99999999999994
```

JM02-6.4

Convert between data types, or cast

- The quickest way to convert a number to a string is to concatenate (i.e., with addition symbol) it with an empty string (i.e., a pair of double quotes): `"" + 2 + 3` is the string `23` (i.e., not integer 23)
- Java *automatically* converts a "smaller" number to a "larger" one:

```
int n = 2;
double x = n; // OK to put an int into a double
```

- The programmer must *explicitly* convert or cast a "larger" number to a "smaller" one:

```
double x = 3.6;
int n = (int)x; // cast a double to an int
// n has value of 3 now
```

final and static

- Reserved word `final` indicates that the value is a constant, i.e., once assigned, the value cannot be changed (or else syntax error) – note that the reserved word is NOT `const`:

```
final static double QUARTER_VALUE = 0.25;
double circumference = Math.PI * diameter;
```

- Final values are named with upper-case letters and underscores
- Reserved word `static` indicates that the value ***belongs to the class***; i.e., only ***one slot of RAM to be shared by all live objects***:

```
final static double QUARTER_VALUE = 0.25;
static Color.BLACK
```

[6.5]

Why Symbolic Constants?

- Easy (for the programmer) to change the value throughout the program, if necessary
- Easy to change into a variable
- More readable, self-documenting code; e.g., `QUARTER_VALUE` is meaningful, but not .25, embedded in the middle of the code
- Additional data type checking by the compiler

3 kinds of variables: comparison

	FIELD	LOCAL VARIABLE	(FORMAL) PARAMETER
pubic vs. private	must be specified; if not, same as public	not specified, or else compile error	not specified; or else compile error
initial value	defaulted as zero or null if not explicitly initialized	must be initialized before used, or else compile error	value same as passed from caller
assigned	assigned by any method in the class (if private); assigned by any method constructing the object (if public)	assigned after declared, within its scope	used (but not reassigned) by the called method Note: a copy of the param is made locally
scope (shown in different color boxes in BlueJ)	if private, scope is the entire class; if public, accessible & modifiable by clients (i.e., objects of other classes)	scope is from the declaration time until the ending brace of the block containing the declaration	scope is the called method (i.e., the method where the parameter is passed to)

How to choose data type

- For info that is integers (e.g., student ID, room number), choose `int`
- For info that is floating-point (e.g., money amount, GPA), choose `double`
- For info that is one-character text (e.g., initial of middle name), choose `char`
- For info that represents 2 possible values such as true/false or yes/no (e.g., whether an item has been found), choose `boolean`
- **NOTE**: Make sure that the info will fit into the storage by the data type; an `int` is sufficient for a social security number, but not for area code + phone number

Math class – see Java API

- Values (name in upper case only) – static:
  - pi value: **`Math.PI`**
  - Euler's number e: **`Math.E`**
- Some methods (name starts with lower case), returning `double`:
  - Get power value: **`Math.pow`**`(double base, double exponent)`
  - Get random number in [0, 1) interval: **`Math.random`**`()`
  - Get square root value: **`Math.sqrt`**`(double someNumber)`
  - Get rounded value: **`Math.round`**`(double someNumber)`
  - Get natural log value: **`Math.log`**`(double someNumber)`
  - Get common log value: **`Math.log10`**`(double someNumber)`
  - Get sin value: **`Math.sin`**`(double someAngle)`

Math class (cont.) – see Java API

- For absolute value, returning the appropriate data type:
  - **`Math.abs`**(…)

return statement

JC08-4.1

(A. Nguyen)

JM02-_7_

Characteristics of `return`

- When a program encounters a `return` statement, it quits that method.
- If the method does not require an output (i.e., `void`), then
  - `return;` simply quits the method
  - `return;` is NOT REQUIRED if the method ends at the closing brace of the method’s body.
- If the method requires an output/return, then
  - `return …;` must be followed by a value of the output/return data type
  - `return …;` is REQUIRED, and is the last statement of the method for normal end
- A statement that follows a `return` statement (in the same block) will cause a syntax error.
- A method that is supposed to “return” something means a method WITH OUTPUT to its caller; it does NOT mean a method that `print` or `println` something to the console window.

Example of `return` in a method w/o output

```
public void doSomething()  ← void indicates no output
{
     …
     if ( … )
     {
          …
          return;  ← special-case return, in the middle of a method body
          // no more statements here, or syntax error
     }
     else
        …
     …
} ← normal return, at the ending brace of a method body; statement is not required
```

Example of **`return`** in a method w/ output

```
public double calcArea(double radius) ← double indicates with output, of type double
{
   double area = 0.0;
   if (radius < 0.0 )
      area = -1.0; // neg. area to indicate bad input
   else
     area = Math.PI * radius * radius;
   return area; ← REQUIRED return, and WITH output
   // no more statements here, or syntax error
}
```

Operations

JC08-4.2

(A. Nguyen)

[6.7]

Arithmetic

- Operators: +, –, /, * , %
- The precedence of operators & parentheses is the same as in algebra (PMDAS) – See App B – Java Operator Summary
- Exp. is `Math.pow(double base, double exp)`
- `m % n` means the remainder when m is divided by n:
  - 17 % 5 is 2
  - 3 % 8 is 3
- To check whether an integer `n` is even: `if (n % 2 == 0)`
- % has the same rank as * and /
- Same-rank binary operators are performed in order from left to right

[6.7]

Arithmetic (cont.)

- The type of the result is determined by the types of the operands, not their values; this rule applies to all intermediate results in expressions. If both operands are of the same type, then the result is that type; otherwise, it is of the “larger” type.
- If one operand is an `int` and another is a `double`, the result is a `double`; if both operands are `int`s, the result is an `int`.

[6.7]

Arithmetic (cont.)

- **Caution**: if a and b are ints, then a / b is ***truncated*** to an int…

  17 / 5 gives 3

  3 / 4 gives 0

- …even if you assign the result to a double:

  double ratio = 2 / 3; // this is `int` division, then assigned to `double`

The **double** type of the result doesn’t help: **ratio** still gets the value **0.0**.

[6.7]

Arithmetic (cont.)

- To get the correct double result, use double constants or the *cast* operator:

```
double ratio = 2.0 / 3;
double ratio = 2 / 3.0;
 int m = ..., n = ...;
double factor = (double)m / (double)n;
double factor = (double)m / n;
double r2 = n / 2.0;
```

Casts

[6.8]

Arithmetic (cont’d)

- Compound assignment operators:

a = a + b; ↔ a += b;

a = a − b; ↔ a −= b;

a = a * b; ↔ a *= b;

a = a / b; ↔ a /= b;

a = a % b; ↔ a %= b;

- Increment and decrement operators:

a = a + 1; ↔ a++;

a = a − 1; ↔ a−−;

Do not use these in longer expressions

Formatted “print”: printf

- There is `printf` (“f” is for formatted)
- For example:

```
int m = 5, d = 19, y = 2007;
double amt = 123.5;
System.out.printf (
         "Date: %02d/%02d/%d  Amount = %7.2f\n", m, d, y, amt);
```

displays:

```
         Date: 05/19/2007  Amount =  123.50
```

- %2d asks for 2 spaces for a decimal (i.e., base 10), or integer; %d asks for enough spaces to display an integer
- %7.2f asks for 7 spaces for floating-point number, *including the decimal point* and 2 places for the decimal part

Scope

JC08-4.3

(A. Nguyen)

About variables (review)

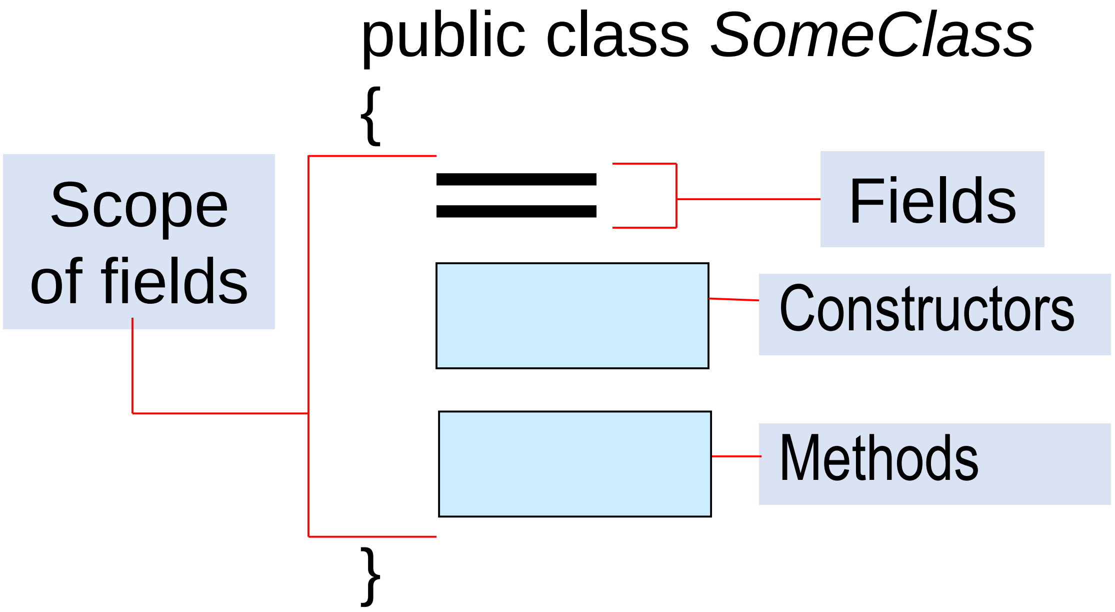
- There are 3 kinds of variables:
  - Instance variables or fields, belonging to a class – declared inside the body of the class and outside all constructors and methods
  - Parameters or parameter variables, belonging to a constructor or method – declared in the header/signature of a constructor or method
  - Local variables, belonging to a constructor or method – declared inside a constructor or method – Example: method **applyFine** in **BankAccount**
- Each kind of variable has a different life span, called scope
- A variable can be used or reassigned only <u>within</u> its scope, i.e., only when it is alive

Scope of variables (review)

- The scope of a field is the entire class; therefore,
  - any constructor or method in the class can use or change it
  - an object carries the values in its field throughout – you can inspect/verify in the debugger
- The scope of a parameter is the entire constructor or method
- The scope of a local variable is from the point it is declared until the end of the block where it is declared (at closing brace)

[6.2]

Scope of fields



[6.2]

Error

- Example: class Circle w/ field `radius`:

```
private double radius; // auto. assigned: 0.0
...
public Circle (...)       // constructor
{
   double  radius = 5;
   ...
}
```

Declares a local variable **radius**; the value of field **radius** remains 0.0

[6.2]

Scope of local variables

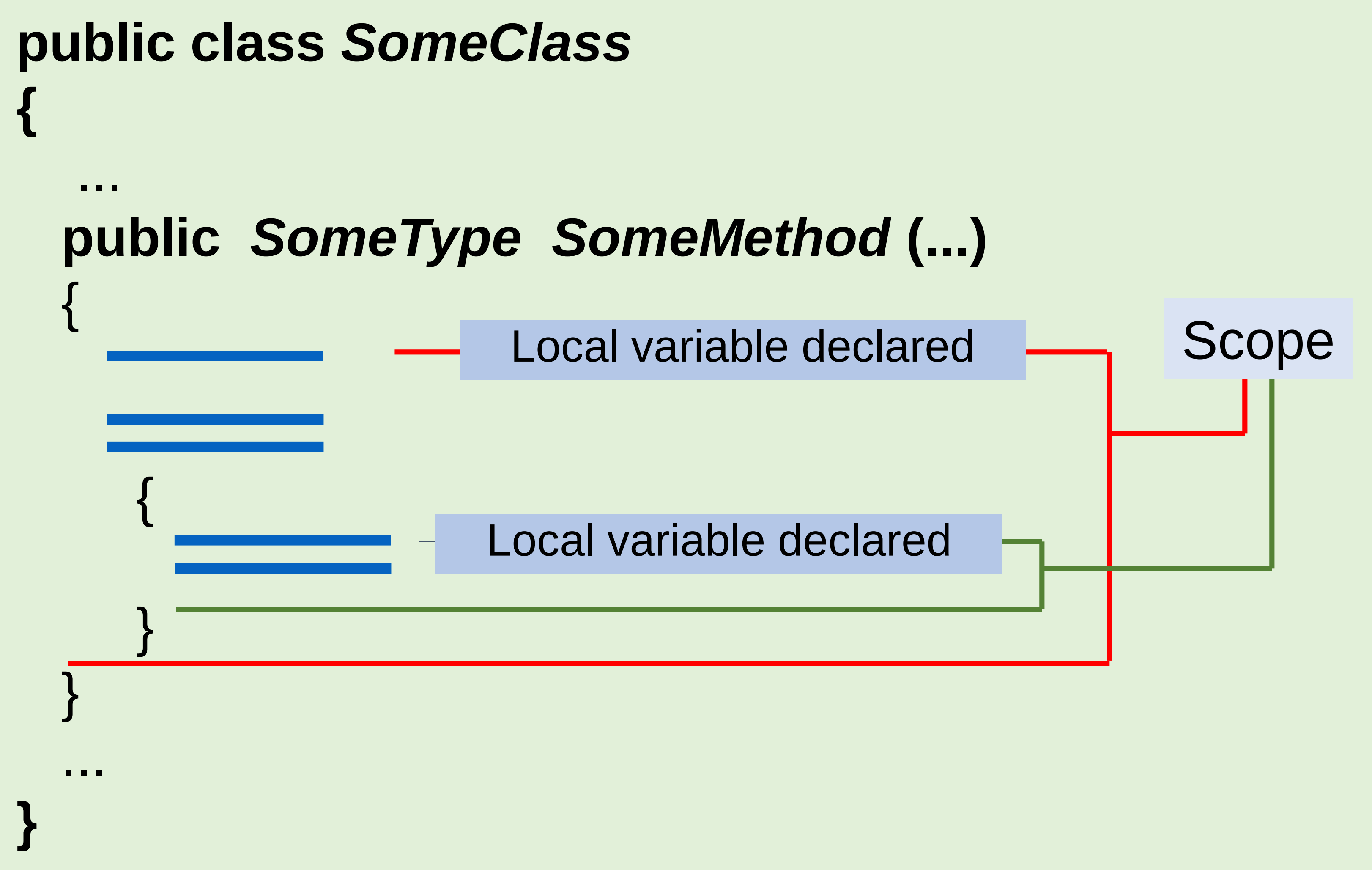
- Each variable has a scope — the area in the source code where it is "visible."
- If you use a variable outside its scope, the compiler reports a syntax error.
- Variables can have the same name when their scopes do NOT overlap.

```
{
   int  k = ...;
   ...
}

for (int k = ...)
{
   ...
}
```

[6.2]

Scope of local variables (cont.)



```
public class SomeClass
{
   ...
  public  SomeType  SomeMethod (...)
  {



     {


     }
  }
  ...
}
```

Local variable declared

Local variable declared

Scope

Writing a program vs. a class

JC08-4.3

(A. Nguyen)

Writing a program

- When you are asked to write a (console) program, you create a “class” with just the main program, then write the body of the main program
- Example: `HelloWorld`

Writing a class

- When you are asked to write a class, you create a class with 3 main parts: fields, constructors, methods
- Example: `BankAccount`
- You will need to write a client program (like a Tester, Viewer, etc.) with the main program to test/use that class

Problem Solving: By Hand

JC08-4.5

(A. Nguyen)

Design

- Given a problem to solve,
  - Think of an algorithm, and write it using pseudocode (or flowchart) – if there are calculations to do, make sure that the calculations are correct by doing by hand
  - Create a test script, i.e., a list of test cases to verify the algorithm (& the code later)
  - Use each test case, and "trace" the algorithm, i.e., apply the instructions in the algorithm on the data from the test case
- Do all the design ***before*** coding

Example

- See book pgs. 152-154

String

JC08-4.5

(A. Nguyen)

JM02-6.9

String operations

- Concatenation operator is +
- Automatic conversion is done for a non-string if concatenated with a string (including an empty string ""); e.g., "" + 17 → "17", as used in `System.out.println( … );`
- Compound assignment operator is permissible: +=
- Concatenation (if 1 or 2 strings) & addition (if both numeric) are done from left to right:
  - "" + 2 + 3 → "23"
  - 2 + 3 + "" → "5"
- Any object has a `toString` method, which can be overridden by any class

JM02-8

Some popular methods of **`String`**

Given: **`String aStr = “The quick brown fox jumps over the lazy dog.”`**

METHOD SIGNATURE:	EXAMPLE:
`boolean contains(CharSequence s)` returns **`true`** if the String contains **`s`**	`if (aStr.contains(“fox”)) ...`
`boolean equals(Object anObject)` returns **`true`** if **(String)`anObject`** has the same contents as self	`if (aStr.equals(otherStr)) ...`

`int length()`
returns the length of the **`String`**
	`for (int i = 0; i < aStr.length(); i++)`
	`...`

`String substring(int beginIndex, int endIndex)` returns a **`String`** with the contents from location `beginIndex` to location `endIndex -1`, inclusively	`aStr.substring(1, 2)` returns `h` **NOTE: this does NOT return `he`** NOTE: `aStr.substring(4, 4)` returns an empty String.

`String toLowerCase()`
`String toUpperCase()`
converts to lower or upper case, and return a new/different **`String`**
	`aStr.toLowerCase()`
	returns `the quick brown fox jumps over the lazy dog.`
	NOTE: this does NOT change `aStr`

JM02-8

Some popular methods of **`String`** (cont.)

There are also these popular methods – check the Java API for details:

- `charAt`: gives the character at the given index/location
- `lastIndexOf`: gives the last index/location of the given character/string – NOTE: there is no `firstIndexOf`, only `indexOf`
- `trim`: eliminate white spaces at the beginning & ending (but not inside) of a string
- `replace`: replace all occurrences of a char/string with another
- `replaceFirst`: replace the first occurrence of a string (not `char`) with another

The toString method

- The `toString` method is in the `Object` class, which is the highest superclass of every Java object
- The `toString` method returns the ***text*** that ***best represents*** the object; for example, a `Student` class may have `toString` return the student name and/or ID
- The signature of the method is `String toString()`
- The `println` or `print` method calls the `toString` of the class
- If a class does NOT override the `toString` method, then `println` or `print` will display the hex value of the object; otherwise, the text representing the object will be displayed

The toString method: example

- Given a class called `Student` (with field `theID`, etc.), and an object called `aStudent` of type `Student` created in a client
- If `Student` does NOT override the `toString` method, then the statement in the client:

  ```
  System.out.print(aStudent);
  ```

  will display the hex value of object `aStudent`
- If `Student` overrides the `toString` method, then

  ```
  System.out.print(aStudent);
  ```

  will display `theID` of object `aStudent`

```
public String toString()
{
    return "" + theID;
}
```

Errors about String

- The entire String class is immutable, i.e., the original text is ***never*** changed; the method returns a new String, which the programmer can assign to a new String or back to the original String
- For the `substring` method with 2 `int`s as parameters, the character at `beginIndex` is included, but the character at `endIndex` is EXCLUDED

```
String substring(int beginIndex, int endIndex)
```

- Below, s2 will have "h", not "he":

```
String s1 = "The";
String s2= s1.substring(1, 2)
```

THE END