Building Java Programs

Lecture 1: Java Review

reading: Ch. 1-9

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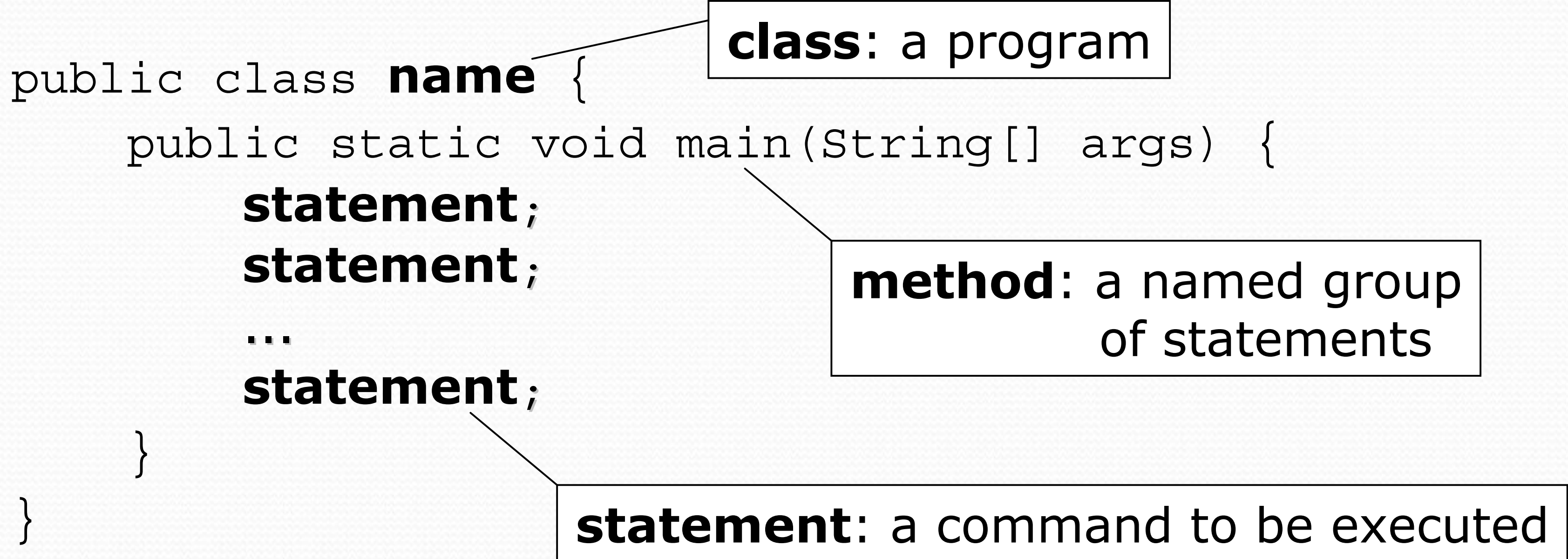
A Java program (1.2)



- Every executable Java program consists of a **class**,
  - that contains a **method** named `main`,
    - that contains the **statements** (commands) to be executed.

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`System.out.println`

- A statement that prints a line of output on the console.
  - pronounced "print-linn"
  - sometimes called a "println statement" for short

- Two ways to use `System.out.println` :
  - `System.out.println("`**text**`");`

    Prints the given message as output.

  - `System.out.println();`

    Prints a blank line of output.

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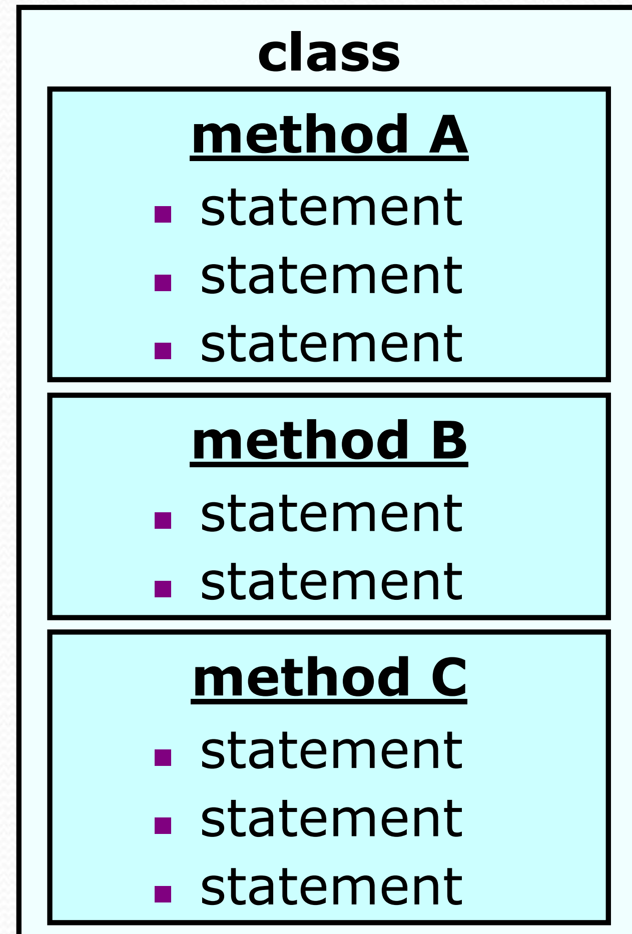
Static methods (1.4)

- **static method**: A named group of statements.
  - denotes the *structure* of a program
  - eliminates *redundancy* by code reuse

  - **procedural decomposition**: dividing a problem into methods

- Writing a static method is like adding a new command to Java.



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Declaring a method

Gives your method a name so it can be executed

- Syntax:

```
public static void name() {
    statement;
    statement;
    ...
    statement;
}
```

- Example:

```
public static void printWarning() {
    System.out.println("This product causes cancer");
    System.out.println("in lab rats and humans.");
}
```

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Calling a method

Executes the method's code

- Syntax:

```
name();
```

  - You can call the same method many times if you like.

- Example:

```
printWarning();
```

  - Output:

```
This product causes cancer
in lab rats and humans.
```

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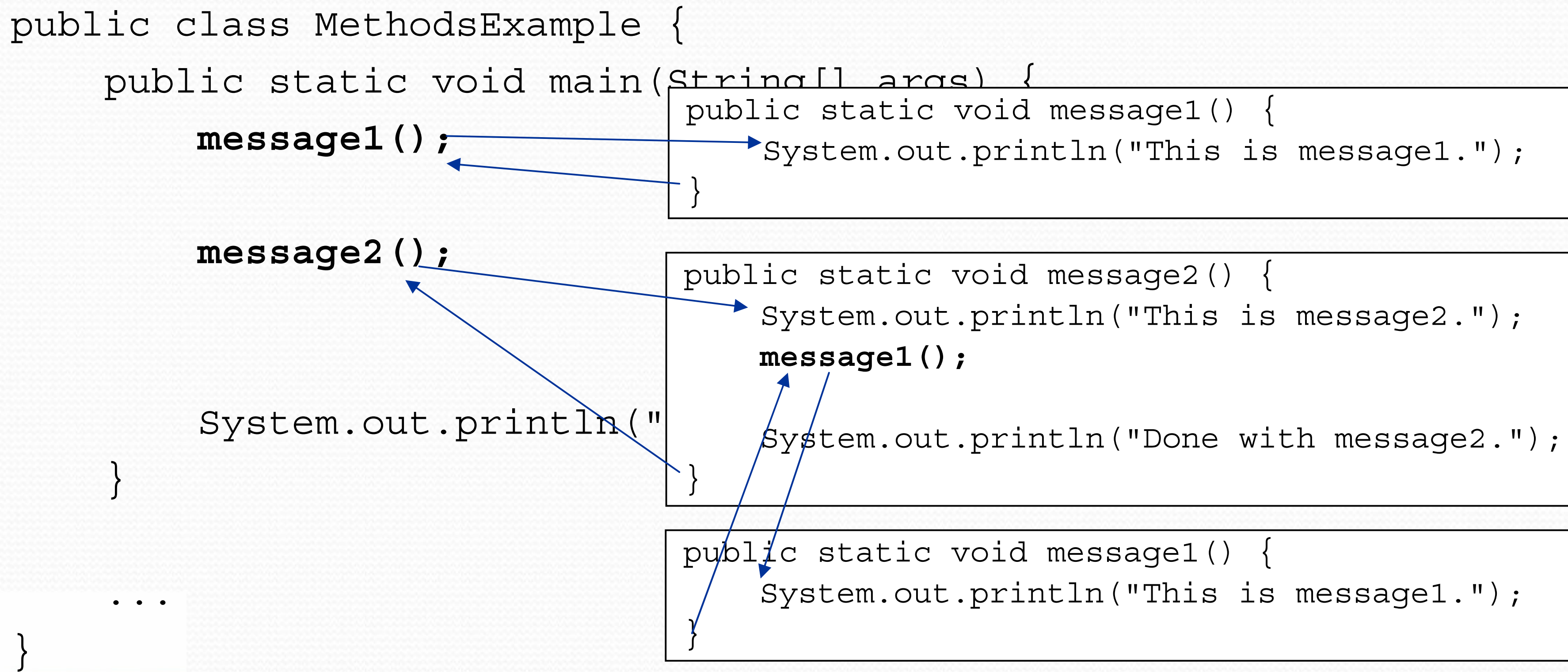
Control flow

- When a method is called, the program's execution...
  - "jumps" into that method, executing its statements, then
  - "jumps" back to the point where the method was called.



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Java's primitive types (2.1)

- **primitive types**: 8 simple types for numbers, text, etc.
  - Java also has **object types**, which we'll talk about later

Name	**Description**	**Examples**
`int`	integers	`42, -3, 0, 926394`
`double`	real numbers	`3.1, -0.25, 9.4e3`
`char`	single text characters	`'a', 'X', '?', '\n'`
`boolean`	logical values	`true, false`

  - Why does Java distinguish integers vs. real numbers?

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Expressions

- **expression**: A value or operation that computes a value.
  - Examples:
    ```
    1 + 4 * 5
    (7 + 2) * 6 / 3
    42
    ```
  - The simplest expression is a *literal value*.
  - A complex expression can use operators and parentheses.

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Integer division with /

- When we divide integers, the quotient is also an integer.
  - `14 / 4` is `3`, not `3.5`

```
       3              4               52
   ----           ----            ------
4 ) 14      10 ) 45      27 ) 1425
    12           40            135
    --           --            ---
     2            5             75
                                54
                                --
                                21
```

- More examples:
  - `32 / 5` is `6`
  - `84 / 10` is `8`
  - `156 / 100` is `1`

  - Dividing by 0 causes an error when your program runs.

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Integer remainder with `%`

- The `%` operator computes the remainder from integer division.
  - `14 % 4` is `2`
  - `218 % 5` is `3`

```
      3
4 ) 14
    12
     2
```

```
      43
5 ) 218
    20
     18
     15
      3
```

What is the result?

```
45 % 6
2 % 2
8 % 20
11 % 0
```

- Applications of `%` operator:
  - Obtain last digit of a number: `230857 % 10` is `7`
  - Obtain last 4 digits: `658236489 % 10000` is `6489`
  - See whether a number is odd: `7 % 2` is `1`, `42 % 2` is `0`

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Precedence

- **precedence**: Order in which operators are evaluated.
  - Generally operators evaluate left-to-right.

    `1 - 2 - 3` is `(1 - 2) - 3` which is `-4`

  - But `*/%` have a higher level of precedence than `+-`

```
1 + 3 * 4                 is 13

6 + 8 / 2 * 3
6 +   4   * 3
6 +     12                is 18
```

  - Parentheses can force a certain order of evaluation:

```
(1 + 3) * 4               is 16
```

  - Spacing does not affect order of evaluation

```
1+3 * 4-2                 is 11
```

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String concatenation

- **string concatenation**: Using `+` between a string and another value to make a longer string.

```
"hello" + 42        is "hello42"
1 + "abc" + 2       is "1abc2"
"abc" + 1 + 2       is "abc12"
1 + 2 + "abc"       is "3abc"
"abc" + 9 * 3       is "abc27"
"1" + 1             is "11"
4 - 1 + "abc"       is "3abc"
```

- Use `+` to print a string and an expression's value together.
  - `System.out.println(`**`"Grade: " +`**` (95.1 + 71.9) / 2);`
  - Output: `Grade: 83.5`

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Variables (2.2)

- **variable**: A piece of the computer's memory that is given a name and type, and can store a value.

- A variable can be declared/initialized in one statement.

- Syntax:

  type name = **value**;

  - `double myGPA = 3.95;`
  - `int x = (11 % 3) + 12;`

x	14

myGPA	3.95

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Type casting

- **type cast**: A conversion from one type to another.
  - To promote an `int` into a `double` to get exact division from `/`
  - To truncate a `double` from a real number to an integer

- Syntax:

  (**type**) **expression**

  Examples:

```
double result = (double) 19 / 5;       // 3.8
int result2 = (int) result;            // 3
int x = (int) Math.pow(10, 3);         // 1000
```

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Increment and decrement

shortcuts to increase or decrease a variable's value by 1

Shorthand	Equivalent longer version
variable++;	**variable** = **variable** + 1;
variable--;	**variable** = **variable** - 1;

```
int x = 2;
x++;                    // x = x + 1;
                        // x now stores 3

double gpa = 2.5;
gpa--;                  // gpa = gpa - 1;
                        // gpa now stores 1.5
```

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Modify-and-assign operators

shortcuts to modify a variable's value

Shorthand	Equivalent longer version
variable `+=` **value**`;`	**variable** `=` **variable** `+` **value**`;`
variable `-=` **value**`;`	**variable** `=` **variable** `-` **value**`;`
variable `*=` **value**`;`	**variable** `=` **variable** `*` **value**`;`
variable `/=` **value**`;`	**variable** `=` **variable** `/` **value**`;`
variable `%=` **value**`;`	**variable** `=` **variable** `%` **value**`;`

```
x += 3;                // x = x + 3;

gpa -= 0.5;            // gpa = gpa - 0.5;

number *= 2;           // number = number * 2;
```

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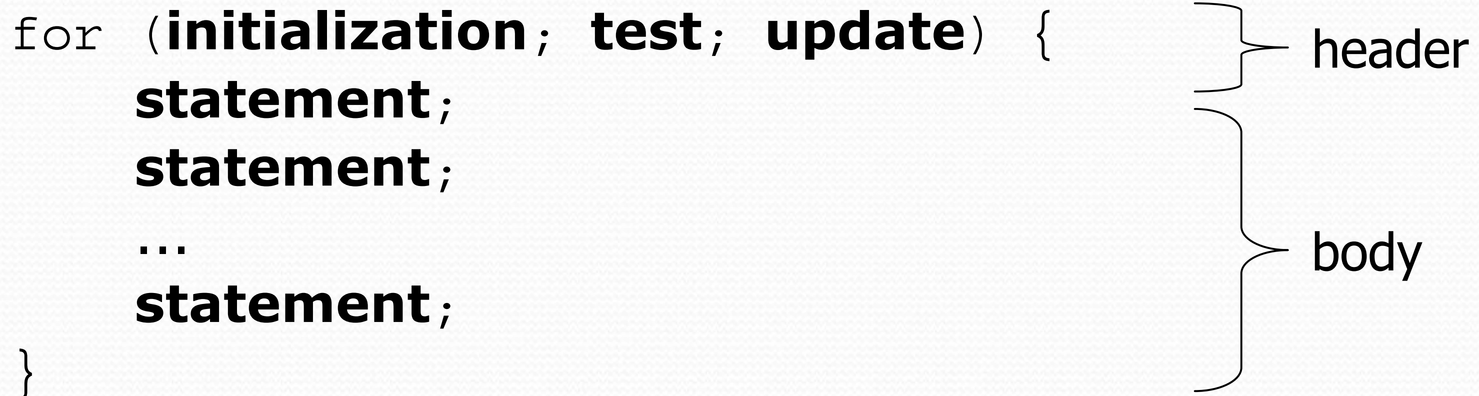
for loops (2.3)



- Perform **initialization** once.
- Repeat the following:
  - Check if the **test** is true. If not, stop.
  - Execute the **statement**s.
  - Perform the **update**.

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System.out.print

- Prints without moving to a new line
  - allows you to print partial messages on the same line

```
int highestTemp = 5;
for (int i = -3; i <= highestTemp / 2; i++) {
    System.out.print((i * 1.8 + 32) + "  ");
}
```

  - Output:

```
26.6  28.4  30.2  32.0  33.8  35.6
```

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Nested loops

- **nested loop**: A loop placed inside another loop.

```
for (int i = 1; i <= 4; i++) {
    for (int j = 1; j <= 5; j++) {
        System.out.print((i * j) + "\t");
    }
    System.out.println();  // to end the line
}
```

- Output:

```
1       2       3       4       5
2       4       6       8       10
3       6       9       12      15
4       8       12      16      20
```

- Statements in the outer loop's body are executed 4 times.
  - The inner loop prints 5 numbers each time it is run.

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Variable scope

- **scope**: The part of a program where a variable exists.
  - From its declaration to the end of the { } braces
    - A variable declared in a `for` loop exists only in that loop.
    - A variable declared in a method exists only in that method.

```
public static void example() {
    int x = 3;
    for (int i = 1; i <= 10; i++) {
        System.out.println(x);
    }
    // i no longer exists here
} // x ceases to exist here
```

i's scope

x's scope

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Class constants (2.4)

- **class constant**: A value visible to the whole program.
  - value can only be set at declaration
  - value can't be changed while the program is running

- Syntax:

  `public static final` **type name** `=` **value**`;`

  - name is usually in ALL_UPPER_CASE

  - Examples:

```
public static final int DAYS_IN_WEEK = 7;
public static final double INTEREST_RATE = 3.5;
public static final int SSN = 658234569;
```

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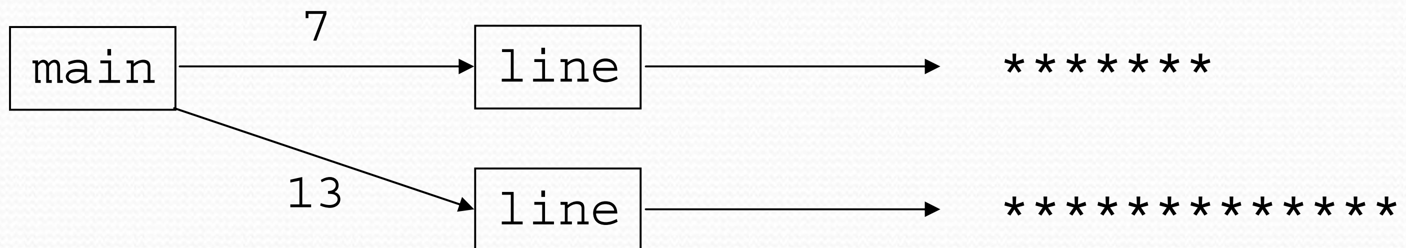
Parameters (3.1)

- **parameter**: A value passed to a method by its caller.

  - Instead of `lineOf7`, `lineOf13`, write `line` to draw any length.
    - When *declaring* the method, we will state that it requires a parameter for the number of stars.
    - When *calling* the method, we will specify how many stars to draw.



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Passing parameters

- Declaration:

```
public static void name (type name, ..., type name) {
      statement(s);
}
```

- Call:

```
methodName (value, value, ..., value);
```

- Example:

```
public static void main(String[] args) {
    sayPassword(42);          // The password is: 42
    sayPassword(12345);       // The password is: 12345
}

public static void sayPassword(int code) {
    System.out.println("The password is: " + code);
}
```

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Java's `Math` class (3.2)

Method name	Description
`Math.abs(`*value*`)`	absolute value
`Math.round(`*value*`)`	nearest whole number
`Math.ceil(`*value*`)`	rounds up
`Math.floor(`*value*`)`	rounds down
`Math.log10(`*value*`)`	logarithm, base 10
`Math.max(`*value1*`, `*value2*`)`	larger of two values
`Math.min(`*value1*`, `*value2*`)`	smaller of two values
`Math.pow(`*base*`, `*exp*`)`	*base* to the *exp* power
`Math.sqrt(`*value*`)`	square root

`Math.sin(`*value*`)`
`Math.cos(`*value*`)`
`Math.tan(`*value*`)`
	sine/cosine/tangent of an angle in radians

`Math.toDegrees(`*value*`)` `Math.toRadians(`*value*`)`	convert degrees to radians and back
`Math.random()`	random `double` between 0 and 1

Constant	Description
`Math.E`	2.7182818...
`Math.PI`	3.1415926...

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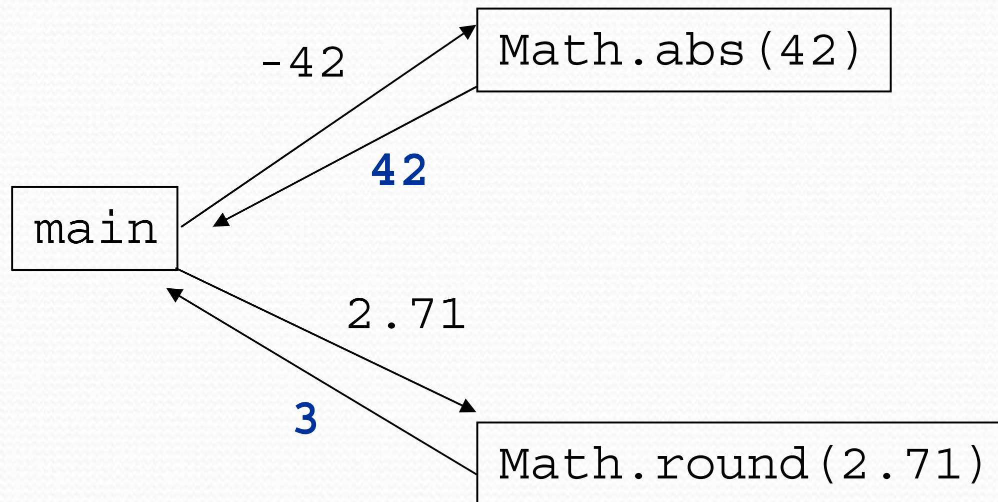
Return (3.2)

- **return**: To send out a value as the result of a method.
  - The opposite of a parameter:
    - Parameters send information *in* from the caller to the method.
    - Return values send information *out* from a method to its caller.



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Returning a value

```
public static type name(parameters) {
    statements;
    ...
    return expression;
}
```

- Example:

```
// Returns the slope of the line between the given points.
public static double slope(int x1, int y1, int x2, int y2) {
    double dy = y2 - y1;
    double dx = x2 - x1;
    return dy / dx;
}
```

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Strings (3.3)

- **string**: An object storing a sequence of text characters.

```
String name = "text";
String name = expression;
```

  - Characters of a string are numbered with 0-based *indexes*:

```
String name = "P. Diddy";
```

index	0	1	2	3	4	5	6	7
char	P	.		D	i	d	d	y

  - The first character's index is always 0
  - The last character's index is 1 less than the string's length
  - The individual characters are values of type `char`

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`String` methods

Method name	Description
`indexOf(`**`str`**`)`	index where the start of the given string appears in this string (-1 if it is not there)
`length()`	number of characters in this string
`substring(`**`index1`**`, `**`index2`**`)` or `substring(`**`index1`**`)`	the characters in this string from *index1* (inclusive) to *index2* (exclusive); if *index2* omitted, grabs till end of string
`toLowerCase()`	a new string with all lowercase letters
`toUpperCase()`	a new string with all uppercase letters

- These methods are called using the dot notation:

```
String gangsta = "Dr. Dre";
System.out.println(gangsta.length());   // 7
```

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String test methods

Method	Description
`equals(`**str**`)`	whether two strings contain the same characters
`equalsIgnoreCase(`**str**`)`	whether two strings contain the same characters, ignoring upper vs. lower case
`startsWith(`**str**`)`	whether one contains other's characters at start
`endsWith(`**str**`)`	whether one contains other's characters at end
`contains(`**str**`)`	whether the given string is found within this one

```
String name = console.next();
if (name.startsWith("Dr.")) {
    System.out.println("Are you single?");
} else if (name.equalsIgnoreCase("LUMBERG")) {
    System.out.println("I need your TPS reports.");
}
```

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The `equals` method

- Objects are compared using a method named `equals`.

```
Scanner console = new Scanner(System.in);
System.out.print("What is your name? ");
String name = console.next();
if (name.equals("Barney")) {
    System.out.println("I love you, you love me,");
    System.out.println("We're a happy family!");
}
```

  - Technically this is a method that returns a value of type `boolean`, the type used in logical tests.

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Type `char` (4.4)

- `char` : A primitive type representing single characters.
  - Each character inside a `String` is stored as a `char` value.
  - Literal `char` values are surrounded with apostrophe (single-quote) marks, such as `'a'` or `'4'` or `'\n'` or `'\''`
  - It is legal to have variables, parameters, returns of type `char`

```
char letter = 'S';
System.out.println(letter);              // S
```

- `char` values can be concatenated with strings.

```
char initial = 'P';
System.out.println(initial + " Diddy");  // P Diddy
```

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char vs. String

- "h" is a String
  'h' is a char (the two behave differently)

- String is an object; it contains methods

```
String s = "h";
s = s.toUpperCase();          // 'H'
int len = s.length();         //  1
char first = s.charAt(0);     // 'H'
```

- char is primitive; you can't call methods on it

```
char c = 'h';
c = c.toUpperCase();    // ERROR: "cannot be dereferenced"
```

- What is s + 1 ? What is c + 1 ?
- What is s + s ? What is c + c ?

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System.out.printf (4.4)

`System.out.printf("`**format string**`",` **parameters**`);`

- A format string contains *placeholders* to insert parameters into it:
  - `%d` an integer
  - `%f` a real number
  - `%s` a string
  - `%8d` an integer, 8 characters wide, right-aligned
  - `%-8d` an integer, 8 characters wide, left-aligned
  - `%.4f` a real number, 4 characters after decimal
  - `%6.2f` a real number, 6 characters wide, 2 after decimal
  - Example:

```
int x = 3, y = 2;
System.out.printf("(%d, %d)\n", x, y);  // (3, 2)
System.out.printf("%4d %4.2f\n", x, y); //    3 2.00
```


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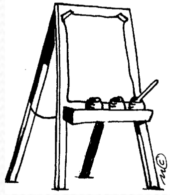
DrawingPanel (3G)



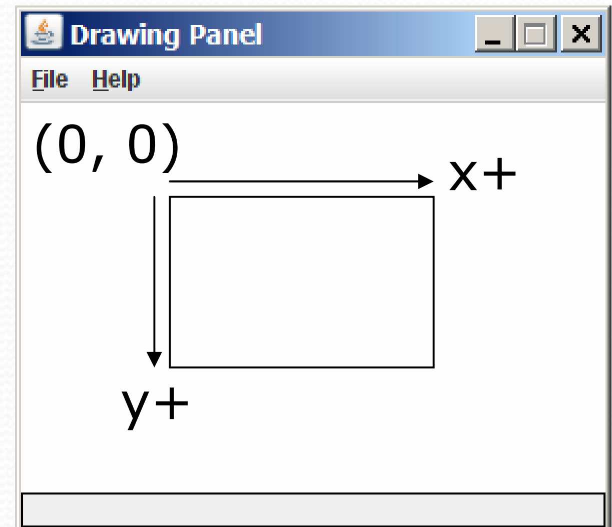
"Canvas" objects that represents windows/drawing surfaces

- To create a window:

  DrawingPanel **name** = new DrawingPanel(**width**, **height**);

  Example:

```
DrawingPanel panel = new DrawingPanel(300, 200);
```



- The window has nothing on it.
  - We can draw shapes and lines on it using another object of type `Graphics`.

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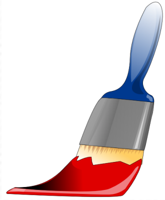
Graphics



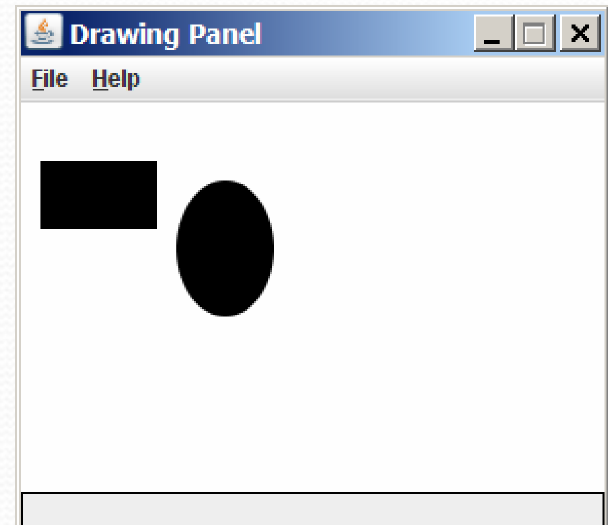
"Pen" objects that can draw lines and shapes

- Access it by calling `getGraphics` on your `DrawingPanel`.

```
Graphics g = panel.getGraphics();
```

- Draw shapes by calling methods on the `Graphics` object.

```
g.fillRect(10, 30, 60, 35);
g.fillOval(80, 40, 50, 70);
```



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`Graphics` methods

Method name	Description
`g.drawLine(`**x1**, **y1**, **x2**, **y2**`);`	line between points (*x1*, *y1*), (*x2*, *y2*)
`g.drawOval(`**x**, **y**, **width**, **height**`);`	outline largest oval that fits in a box of size *width* * *height* with top-left at (*x*, *y*)
`g.drawRect(`**x**, **y**, **width**, **height**`);`	outline of rectangle of size *width* * *height* with top-left at (*x*, *y*)
`g.drawString(`**text**, **x**, **y**`);`	text with bottom-left at *(x, y)*
`g.fillOval(`**x**, **y**, **width**, **height**`);`	fill largest oval that fits in a box of size *width* * *height* with top-left at (*x*, *y*)
`g.fillRect(`**x**, **y**, **width**, **height**`);`	fill rectangle of size *width* * *height* with top-left at (*x*, *y*)
`g.setColor(`**Color**`);`	set `Graphics` to paint any following shapes in the given color

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Color

- Create one using Red-Green-Blue (RGB) values from 0-255

  `Color` **name** `= new Color(`**red**`,` **green**`,` **blue**`);`

  - Example:

```
Color brown = new Color(192, 128, 64);
```

- Or use a predefined `Color` class constant (more common)

  `Color.`**CONSTANT_NAME**

  where **CONSTANT_NAME** is one of:

  - `BLACK`, `BLUE`, `CYAN`, `DARK_GRAY`, `GRAY`, `GREEN`, `LIGHT_GRAY`, `MAGENTA`, `ORANGE`, `PINK`, `RED`, `WHITE`, or `YELLOW`

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Scanner (3.3)

- `System.out`
  - An object with methods named `println` and `print`
- `System.in`
  - not intended to be used directly
  - We use a second object, from a class `Scanner`, to help us.

- Constructing a `Scanner` object to read console input:

  `Scanner` **name** `= new Scanner(System.in);`

  - Example:

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

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`Scanner` methods

Method	Description
`nextInt()`	reads a token of user input as an `int`
`nextDouble()`	reads a token of user input as a `double`
`next()`	reads a token of user input as a `String`
`nextLine()`	reads a *line* of user input as a `String`

- Each method waits until the user presses Enter.
  - The value typed is returned.

```
System.out.print("How old are you? ");     // prompt
int age = console.nextInt();
System.out.println("You'll be 40 in " +
        (40 - age) + " years.");
```

  - **prompt**: A message telling the user what input to type.

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Testing for valid input (5.3)

- `Scanner` methods to see what the next token will be:

Method	Description
`hasNext()`	returns `true` if there are any more tokens of input to read *(always true for console input)*
`hasNextInt()`	returns `true` if there is a next token and it can be read as an `int`
`hasNextDouble()`	returns `true` if there is a next token and it can be read as a `double`
`hasNextLine()`	returns `true` if there are any more lines of input to read (always true for console input)

- These methods do not consume input; they just give information about the next token.
  - Useful to see what input is coming, and to avoid crashes.

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Cumulative sum (4.1)

- A loop that adds the numbers from 1-1000:

```
int sum = 0;
for (int i = 1; i <= 1000; i++) {
    sum = sum + i;
}
System.out.println("The sum is " + sum);
```

Key idea:

- Cumulative sum variables must be declared *outside* the loops that update them, so that they will exist after the loop.

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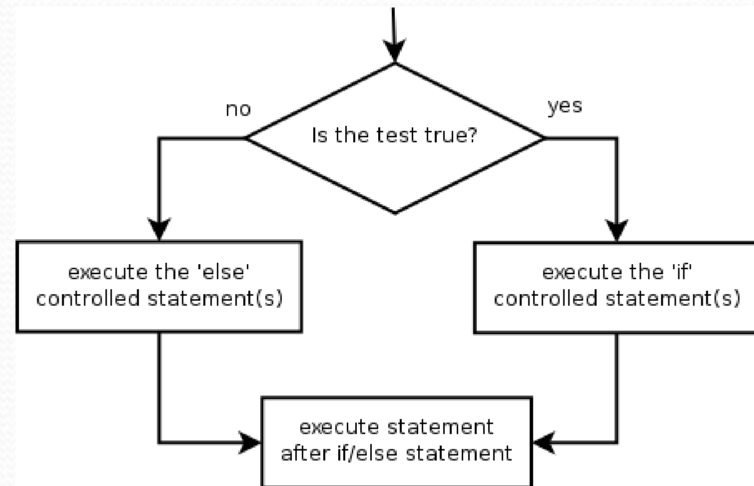
if/else (4.2)

Executes one block if a test is true, another if false

```
if (test) {
    statement(s);
} else {
    statement(s);
}
```



- Example:

```
double gpa = console.nextDouble();
if (gpa >= 2.0) {
    System.out.println("Welcome to Mars University!");
} else {
    System.out.println("Application denied.");
}
```

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Relational expressions

- A **test** in an `if` is the same as in a `for` loop.

```
for (int i = 1; i <= 10; i++) { ...
if (i <= 10) { ...
```

  - These are `boolean` expressions, seen in Ch. 5.

- Tests use *relational operators*:

Operator	Meaning	Example	Value
`==`	equals	`1 + 1 == 2`	`true`
`!=`	does not equal	`3.2 != 2.5`	`true`
`<`	less than	`10 < 5`	`false`
`>`	greater than	`10 > 5`	`true`
`<=`	less than or equal to	`126 <= 100`	`false`
`>=`	greater than or equal to	`5.0 >= 5.0`	`true`

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Logical operators: `&&`, `||`, `!`

- Conditions can be combined using *logical operators*:

<table>
<tr><th>Operator</th><th>Description</th><th>Example</th><th>Result</th></tr>
<tr><td>&&</td><td>and</td><td>(2 == 3) && (-1 < 5)</td><td>false</td></tr>
<tr><td>||</td><td>or</td><td>(2 == 3) || (-1 < 5)</td><td>true</td></tr>
<tr><td>!</td><td>not</td><td>!(2 == 3)</td><td>true</td></tr>
</table>

- "Truth tables" for each, used with logical values *p* and *q*:

<table>
<tr><th>p</th><th>q</th><th>p && q</th><th>p || q</th></tr>
<tr><td>true</td><td>true</td><td>true</td><td>true</td></tr>
<tr><td>true</td><td>false</td><td>false</td><td>true</td></tr>
<tr><td>false</td><td>true</td><td>false</td><td>true</td></tr>
<tr><td>false</td><td>false</td><td>false</td><td>false</td></tr>
</table>

p	!p
true	false
false	true

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Type `boolean` (5.2)

- **`boolean`**: A logical type whose values are `true` and `false`.
  - A **test** in an `if`, `for`, or `while` is a `boolean` expression.
  - You can create `boolean` variables, pass `boolean` parameters, return `boolean` values from methods, ...

```
boolean minor = (age < 21);
boolean expensive = iPhonePrice > 200.00;
boolean iLoveCS = true;

if (minor) {
    System.out.println("Can't purchase alcohol!");
}
if (iLoveCS || !expensive) {
    System.out.println("Buying an iPhone");
}
```

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De Morgan's Law

- **De Morgan's Law**:
  Rules used to *negate* or *reverse* boolean expressions.
  - Useful when you want the opposite of a known boolean test.

Original Expression	Negated Expression	Alternative
`a && b`	`!a || !b`	`!(a && b)`
`a || b`	`!a && !b`	`!(a || b)`

  - Example:

Original Code	Negated Code

`if (x == 7 && y > 3) {`
`    ...`
`}`
	`if (x != 7 || y <= 3) {`
	`    ...`
	`}`

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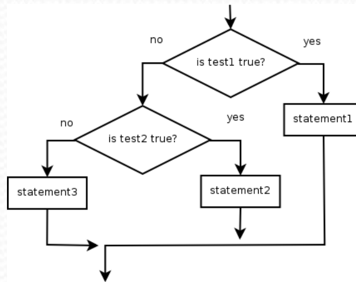
`if/else` Structures

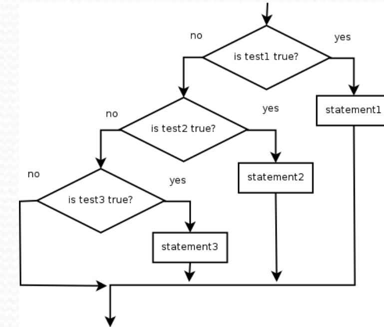
- Exactly 1 path: (mutually exclusive)

```
if (test) {
    statement(s);
} else if (test) {
    statement(s);
} else {
    statement(s);
}
```



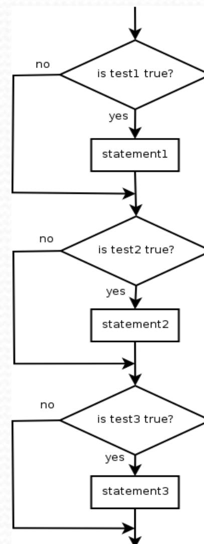
- 0 or 1 path:

```
if (test) {
    statement(s);
} else if (test) {
    statement(s);
} else if (test) {
    statement(s);
}
```



- 0, 1, or many paths: (independent tests, not exclusive)

```
if (test) {
    statement(s);
}
if (test) {
    statement(s);
}
if (test) {
    statement(s);
}
```



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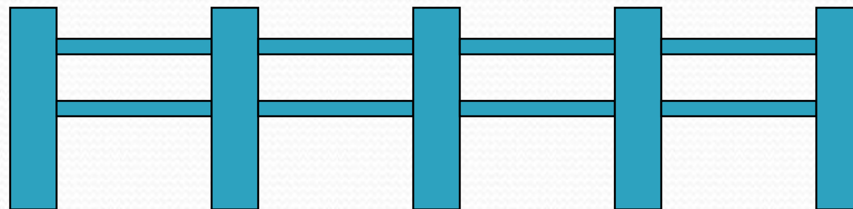
Fencepost loops (4.1)

- **fencepost problem**: When we want to repeat two tasks, one of them *n* times, another *n-1* or *n+1* times.
  - Add a statement outside the loop to place the initial "post."
  - Also called a *fencepost loop* or a "loop-and-a-half" solution.

  - Algorithm template:

place a post.
for (length of fence ***- 1****) {*
    place some wire.
    place a post.
}



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Fencepost method solution

- Write a method `printNumbers` that prints each number from 1 to a given maximum, separated by commas.

  For example, the call:

  ```
  printNumbers(5);
  ```

  should print:

  ```
  1, 2, 3, 4, 5
  ```

- Solution:

  ```
  public static void printNumbers(int max) {
      System.out.print(1);
      for (int i = 2; i <= max; i++) {
          System.out.print(", " + i);
      }
      System.out.println();     // to end the line
  }
  ```

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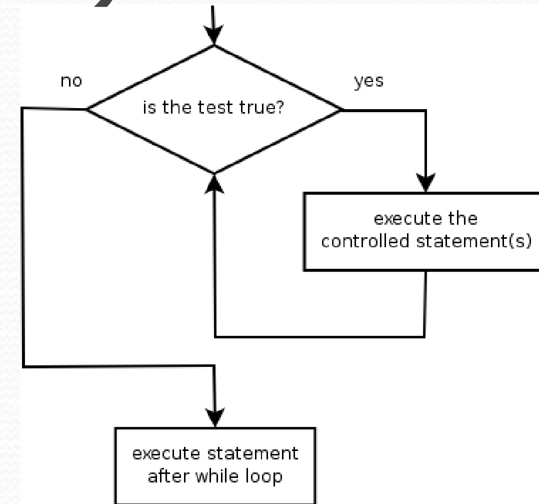
`while` loops (5.1)

- **`while` loop**: Repeatedly executes its body as long as a logical test is true.

```
while (test) {
    statement(s);
}
```



- Example:

```
int num = 1;                         // initialization
while (num <= 200) {                 // test
    System.out.print(num + " ");
    num = num * 2;                   // update
}
```

  - OUTPUT:

```
1 2 4 8 16 32 64 128
```

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do/while loops (5.4)

- **do/while loop**: Executes statements repeatedly while a condition is `true`, testing it at the *end* of each repetition.

```
do {
    statement(s);
} while (test);
```

  - Example:

```
// prompt until the user gets the right password
String phrase;
do {
    System.out.print("Password: ");
    phrase = console.next();
} while (!phrase.equals("abracadabra"));
```

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The `Random` class (5.1)

- A `Random` object generates pseudo-random* numbers.
  - Class `Random` is found in the `java.util` package.

```
import java.util.*;
```

Method name	Description
`nextInt()`	returns a random integer
`nextInt(`**max**`)`	returns a random integer in the range [0, *max*) in other words, 0 to *max*-1 inclusive
`nextDouble()`	returns a random real number in the range [0.0, 1.0)

- Example:

```
Random rand = new Random();
int randomNumber = rand.nextInt(10);    // 0-9
```

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"Boolean Zen"

- Students new to `boolean` often test if a result is `true`:

```
if (bothOdd(7, 13) == true) {     // bad
    ...
}
```

- But this is unnecessary and redundant. Preferred:

```
if (bothOdd(7, 13)) {             // good
    ...
}
```

- A similar pattern can be used for a `false` test:

```
if (bothOdd(7, 13) == false) {    // bad
if (!bothOdd(7, 13)) {            // good
```

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"Boolean Zen", part 2

- Methods that return `boolean` often have an `if/else` that returns `true` or `false`:

```
public static boolean bothOdd(int n1, int n2) {
    if (n1 % 2 != 0 && n2 % 2 != 0) {
        return true;
    } else {
        return false;
    }
}
```

- Observation: The `if/else` is unnecessary.
  - Our logical test is itself a `boolean` value; so return that!

```
public static boolean bothOdd(int n1, int n2) {
    return (n1 % 2 != 0 && n2 % 2 != 0);
}
```

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break (5.4)

- **`break`** statement: Immediately exits a loop.
  - Can be used to write a loop whose test is in the middle.
  - Such loops are often called *"forever" loops* because their header's boolean test is often changed to a trivial `true`.

```
while (true) {
    statement(s);

    if (test) {
        break;
    }

    statement(s);
}
```

  - Some programmers consider `break` to be bad style.

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Reading files (6.1)

- To read a file, pass a `File` when constructing a `Scanner`.

```
Scanner name = new Scanner(new File("file name"));
```

Example:

```
File file = new File("mydata.txt");
Scanner input = new Scanner(file);
```

or, better yet:

```
Scanner input = new Scanner(new File("mydata.txt"));
```

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The `throws` clause

- **`throws` clause**: Keywords on a method's header that state that it may generate an exception.

- Syntax:

```
public static type name(params) throws type {
```

  - Example:

```
public class ReadFile {
    public static void main(String[] args)
            throws FileNotFoundException {
```

  - Like saying, *"I hereby announce that this method might throw an exception, and I accept the consequences if it happens."*

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Input tokens (6.2)

- **token**: A unit of user input, separated by whitespace.
  - A `Scanner` splits a file's contents into tokens.

- If an input file contains the following:

```
23    3.14
  "John Smith"
```

The `Scanner` can interpret the tokens as the following types:

Token	Type(s)
`23`	`int, double, String`
`3.14`	`double, String`
`"John`	`String`
`Smith"`	`String`

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Files and input cursor

- Consider a file `numbers.txt` that contains this text:

```
308.2
   14.9 7.4  2.8


3.9 4.7    -15.4
    2.8
```

- A `Scanner` views all input as a stream of characters:

```
308.2\n   14.9 7.4  2.8\n\n3.9 4.7   -15.4\n  2.8\n
^
```

- **input cursor**: The current position of the `Scanner`.

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Consuming tokens

- **consuming input**: Reading input and advancing the cursor.
  - Calling `nextInt` etc. moves the cursor past the current token.

```
308.2\n    14.9 7.4   2.8\n\n3.9 4.7    -15.4\n   2.8\n
^
```

```
double x = input.nextDouble();      // 308.2
308.2\n    14.9 7.4   2.8\n\n3.9 4.7    -15.4\n   2.8\n
     ^
```

```
String s = input.next();            // "14.9"
308.2\n    14.9 7.4   2.8\n\n3.9 4.7    -15.4\n   2.8\n
                ^
```

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`Scanner` exceptions

- `InputMismatchException`
  - You read the wrong type of token (e.g. read `"hi"` as `int`).

- `NoSuchElementException`
  - You read past the end of the input.

- Finding and fixing these exceptions:
  - Read the exception text for line numbers in your code (the first line that mentions your file; often near the bottom):

```
Exception in thread "main" java.util.NoSuchElementException
    at java.util.Scanner.throwFor(Scanner.java:838)
    at java.util.Scanner.next(Scanner.java:1347)
    at CountTokens.sillyMethod(CountTokens.java:19)
    at CountTokens.main(CountTokens.java:6)
```

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Output to files (6.4)

- **`PrintStream`**: An object in the `java.io` package that lets you print output to a destination such as a file.
  - Any methods you have used on `System.out` (such as `print`, `println`) will work on a `PrintStream`.

- Syntax:

  PrintStream **name** = new PrintStream(new File("**file name**"));

  Example:

```
PrintStream output = new PrintStream(new File("out.txt"));
output.println("Hello, file!");
output.println("This is a second line of output.");
```

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`System.out` and `PrintStream`

- The console output object, `System.out`, is a `PrintStream`.

```
PrintStream out1 = System.out;
PrintStream out2 = new PrintStream(new File("data.txt"));
out1.println("Hello, console!");   // goes to console
out2.println("Hello, file!");      // goes to file
```

- A reference to it can be stored in a `PrintStream` variable.
  - Printing to that variable causes console output to appear.
- You can pass `System.out` as a parameter to a method expecting a `PrintStream`.
  - Allows methods that can send output to the console or a file.

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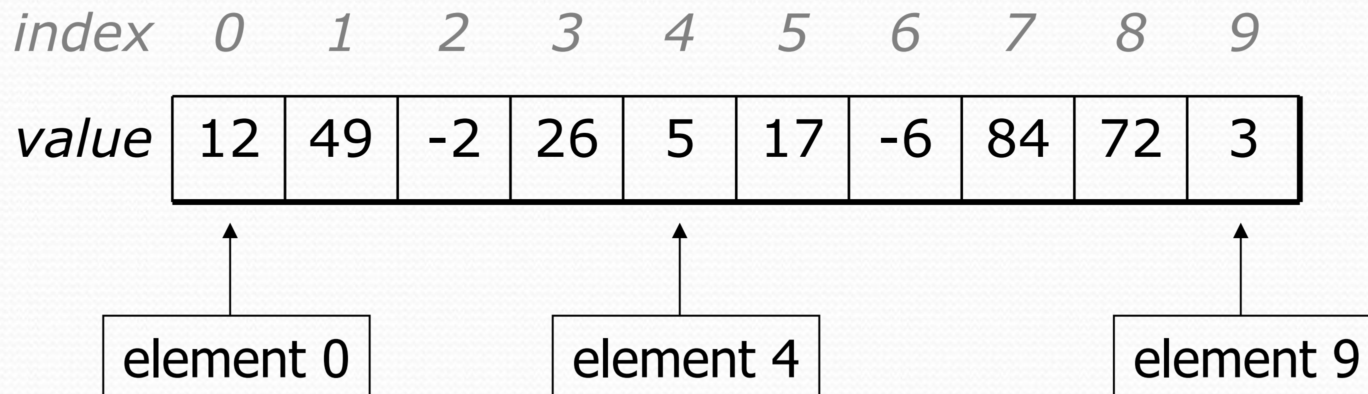
Arrays (7.1)

- **array**: object that stores many values of the same type.
  - **element**: One value in an array.
  - **index**: A 0-based integer to access an element from an array.



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Array declaration

type`[]` **name** `= new` **type**`[`**length**`];`

- Example:

```
int[] numbers = new int[10];
```

index	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
value	0	0	0	0	0	0	0	0	0	0

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Accessing elements

```
name[index]                      // access
name[index] = value;             // modify
```

- Example:

```
numbers[0] = 27;
numbers[3] = -6;

System.out.println(numbers[0]);
if (numbers[3] < 0) {
    System.out.println("Element 3 is negative.");
}
```

index	0	1	2	3	4	5	6	7	8	9
value	27	0	0	-6	0	0	0	0	0	0

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Out-of-bounds

- Legal indexes: between **0** and the **array's length - 1**.
  - Reading or writing any index outside this range will throw an `ArrayIndexOutOfBoundsException`.
- Example:

```
int[] data = new int[10];
System.out.println(data[0]);        // okay
System.out.println(data[9]);        // okay
System.out.println(data[-1]);       // exception
System.out.println(data[10]);       // exception
```

index	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
value	0	0	0	0	0	0	0	0	0	0

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The `length` field

- An array's `length` field stores its number of elements.

```
name.length

for (int i = 0; i < numbers.length; i++) {
    System.out.print(numbers[i] + " ");
}
// output: 0 2 4 6 8 10 12 14
```

  - It does not use parentheses like a String's `.length()`.

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Quick array initialization

type`[]` **name** `=` `{`**value**`,` **value**`, …` **value**`};`

- Example:

```
int[] numbers = {12, 49, -2, 26, 5, 17, -6};
```

index	*0*	*1*	*2*	*3*	*4*	*5*	*6*
value	12	49	-2	26	5	17	-6

- Useful when you know what the array's elements will be.
- The compiler figures out the size by counting the values.

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The `Arrays` class

- Class `Arrays` in package `java.util` has useful static methods for manipulating arrays:

Method name	Description
`binarySearch(`**array**`, `**value**`)`	returns the index of the given value in a sorted array (< 0 if not found)
`equals(`**array1**`, `**array2**`)`	returns `true` if the two arrays contain the same elements in the same order
`fill(`**array**`, `**value**`)`	sets every element in the array to have the given value
`sort(`**array**`)`	arranges the elements in the array into ascending order
`toString(`**array**`)`	returns a string representing the array, such as `"[10, 30, 17]"`

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Arrays as parameters

- Declaration:

```
public static type methodName(type[] name) {
```

  - Example:

```
public static double average(int[] numbers) {
    ...
}
```

- Call:

```
methodName(arrayName);
```

  - Example:

```
int[] scores = {13, 17, 12, 15, 11};
double avg = average(scores);
```

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Arrays as return

- Declaring:

```
public static type[] methodName(parameters) {
```

  - Example:

```
public static int[] countDigits(int n) {
    int[] counts = new int[10];
    ...
    return counts;
}
```

- Calling:

```
type[] name = methodName(parameters);
```

  - Example:

```
public static void main(String[] args) {
    int[] tally = countDigits(229231007);
    System.out.println(Arrays.toString(tally));
}
```

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Value semantics (primitives)

- **value semantics**: Behavior where values are copied when assigned to each other or passed as parameters.
  - When one primitive variable is assigned to another, its value is copied.
  - Modifying the value of one variable does not affect others.

```
int x = 5;
int y = x;          // x = 5, y = 5
y = 17;             // x = 5, y = 17
x = 8;              // x = 8, y = 17
```

x

y

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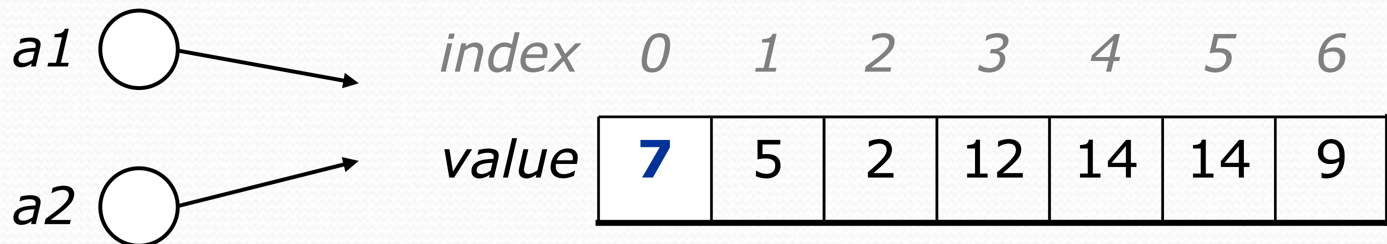
Reference semantics (objects)

- **reference semantics**: Behavior where variables actually store the address of an object in memory.
  - When one reference variable is assigned to another, the object is *not* copied; both variables refer to the *same object*.
  - Modifying the value of one variable *will* affect others.

```
int[] a1 = {4, 5, 2, 12, 14, 14, 9};
int[] a2 = a1;       // refer to same array as a1
a2[0] = 7;
System.out.println(a1[0]);    // 7
```



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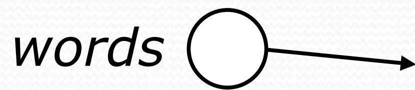
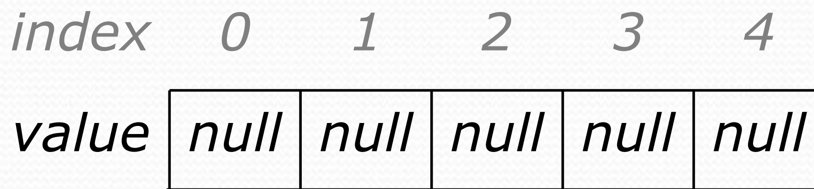
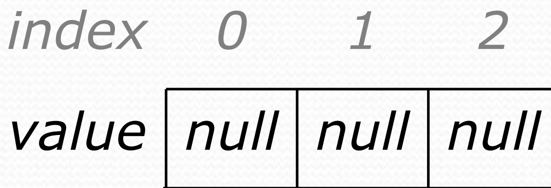
Null

- **`null`** : A reference that does not refer to any object.
  - Fields of an object that refer to objects are initialized to `null`.
  - The elements of an array of objects are initialized to `null`.

```
String[] words = new String[5];
DrawingPanel[] windows = new DrawingPanel[3];
```







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Null pointer exception

- **dereference**: To access data or methods of an object with the dot notation, such as `s.length()`.
  - It is illegal to dereference `null` (causes an exception).
  - `null` is not any object, so it has no methods or data.

```
String[] words = new String[5];
System.out.println("word is: " + words[0]);
words[0] = words[0].toUpperCase();
```

Output:

```
word is: null
Exception in thread "main"
java.lang.NullPointerException
        at Example.main(Example.java:8)
```

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Classes and objects (8.1)

- **class**: A program entity that represents either:
  1. A program / module, or
  2. **A template for a new type of objects.**

  - The `DrawingPanel` class is a template for creating `DrawingPanel` objects.

- **object**: An entity that combines state and behavior.
  - **object-oriented programming (OOP)**: Programs that perform their behavior as interactions between objects.

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Fields (8.2)

- **field**: A variable inside an object that is part of its state.
  - Each object has *its own copy* of each field.
  - **encapsulation**: Declaring fields `private` to hide their data.

- Declaration syntax:

  `private` **`type name`**`;`

  - Example:

```
public class Student {
    private String name;     // each object now has
    private double gpa;      // a name and gpa field
}
```

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Instance methods

- **instance method**: One that exists inside each object of a class and defines behavior of that object.

```
public type name(parameters) {
    statements;
}
```

  - same syntax as static methods, but without `static` keyword

Example:

```
public void shout() {
    System.out.println("HELLO THERE!");
}
```

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A `Point` class

```
public class Point {
    private int x;
    private int y;

    // Changes the location of this Point object.
    public void draw(Graphics g) {
        g.fillOval(x, y, 3, 3);
        g.drawString("(" + x + ", " + y + ")", x, y);
    }
}
```

- Each `Point` object contains data fields named `x` and `y`.
- Each `Point` object contains a method named `draw` that draws that point at its current `x`/`y` position.

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The implicit parameter

- **implicit parameter**:
  The object on which an instance method is called.

  - During the call `p1.draw(g);`
    the object referred to by `p1` is the implicit parameter.

  - During the call `p2.draw(g);`
    the object referred to by `p2` is the implicit parameter.

  - The instance method can refer to that object's fields.
    - We say that it executes in the *context* of a particular object.
    - `draw` can refer to the `x` and `y` of the object it was called on.

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Kinds of methods

- Instance methods take advantage of an object's state.
  - Some methods allow clients to access/modify its state.

- **accessor**: A method that lets clients examine object state.
  - Example: A `distanceFromOrigin` method that tells how far a `Point` is away from (0, 0).
  - Accessors often have a non-`void` return type.

- **mutator**: A method that modifies an object's state.
  - Example: A `translate` method that shifts the position of a `Point` by a given amount.

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Constructors (8.4)

- **constructor**: Initializes the state of new objects.

```
public type(parameters) {
     statements;
}
```

  - Example:

```
public Point(int initialX, int initialY) {
     x = initialX;
     y = initialY;
}
```

  - runs when the client uses the `new` keyword
  - does not specify a return type; implicitly returns a new object
  - If a class has no constructor, Java gives it a *default constructor* with no parameters that sets all fields to 0.

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`toString` method (8.6)

- tells Java how to convert an object into a `String`

```
public String toString() {
    code that returns a suitable String;
}
```

  - Example:

```
public String toString() {
    return "(" + x + ", " + y + ")";
}
```

- called when an object is printed/concatenated to a `String`:

```
Point p1 = new Point(7, 2);
System.out.println("p1: " + p1);
```

- Every class has a `toString`, even if it isn't in your code.
  - Default is class's name and a hex number: `Point@9e8c34`

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`this` keyword (8.7)

- **`this`** : A reference to the implicit parameter.
  - *implicit parameter:* object on which a method is called

- Syntax for using `this`:
  - To refer to a field:
    `this.`**field**
  - To call a method:
    `this.`**method**`(`**parameters**`);`
  - To call a constructor from another constructor:
    `this(`**parameters**`);`

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Static methods

- **static method**: Part of a class, not part of an object.
  - shared by all objects of that class
  - good for code related to a class but not to each object's state
  - does not understand the *implicit parameter*, `this`; therefore, cannot access an object's fields directly
  - if `public`, can be called from inside or outside the class

- Declaration syntax:

```
public static type name(parameters) {
    statements;
}
```

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Inheritance (9.1)

- **inheritance**: A way to form new classes based on existing classes, taking on their attributes/behavior.
  - a way to group related classes
  - a way to share code between two or more classes

- One class can *extend* another, absorbing its data/behavior.
  - **superclass**: The parent class that is being extended.
  - **subclass**: The child class that extends the superclass and inherits its behavior.
    - Subclass gets a copy of every field and method from superclass

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Inheritance syntax (9.1)

```
public class name extends superclass {
```

- Example:

```
public class Secretary extends Employee {
    ...
}
```

- By extending `Employee`, each `Secretary` object now:
  - receives a `getHours`, `getSalary`, `getVacationDays`, and `getVacationForm` method automatically
  - can be treated as an `Employee` by client code (seen later)

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Overriding methods (9.1)

- **override**: To write a new version of a method in a subclass that replaces the superclass's version.
  - No special syntax required to override a superclass method. Just write a new version of it in the subclass.

```
public class Secretary extends Employee {
    // overrides getVacationForm in Employee class
    public String getVacationForm() {
        return "pink";
    }
    ...
}
```

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`super` keyword (9.3)

- Subclasses can call overridden methods with `super`

  `super.`**method**`(`**parameters**`)`

  - Example:

```
public class LegalSecretary extends Secretary {
    public double getSalary() {
        double baseSalary = super.getSalary();
        return baseSalary + 5000.0;
    }
    ...
}
```

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Polymorphism

- **polymorphism**: Ability for the same code to be used with different types of objects and behave differently with each.
  - Example: `System.out.println` can print any type of object.
    - Each one displays in its own way on the console.

- A variable of type *T* can hold an object of any subclass of *T*.

```
Employee ed = new LegalSecretary();
```

  - You can call any methods from `Employee` on `ed`.
  - You can *not* call any methods specific to `LegalSecretary`.

- When a method is called, it behaves as a `LegalSecretary`.

```
System.out.println(ed.getSalary());          // 55000.0
System.out.println(ed.getVacationForm());    // pink
```


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