(remedial) Java

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Remedial Java class

- Objective:
  - Cover the fundamentals of the Java programming language.
  - Designed for students with some programming experience, but …
- Practical info:

  contact Anastasia by email, using [RJ] in the title

  www.lri.fr/~anab/teaching/remedial-java/
- 6 sessions of 3h (theory + practice):
  - Programming basics (Mon 2/9, pm)
  - Java Language basics (Tue 3/9, am)
  - Object oriented programming (Tue 3/9, pm)
  - Inheritance (Tue 5/9 am)
  - Packages and Exceptions (Tue 5/9 am)
  - Independent work (Wed 6/9 – no class)
  - I/O (Thu 7/9 pm)

Programming basics

What is a program

- Algorithm: A recipe / sequence of steps to follow. *"A step-by-step procedure for solving a problem or accomplishing some end, especially by a computer" (Merriam-Webster Online)*
- Program: A sequence of instructions in a programming language that perform a task (e.g., follow an algorithm)

(pseudo-code)

```
get from user a first number
get from user a second number
add the first and second number
return to user the result
add to the result 2 and return the new result
```

The two numbers are not known a-priori

The number 2 is known

Each of the steps are called **instructions** of the program

What is a program

```
> Please give a number:
 2
> Please give a second number:
 3
> Result is 5
> New result is 7
```

```
> Please give a number:
 7
> Please give a second number:
 6
> Result is 13
> New result is 15
```

Same Program, two runs

```
get from user a first number
get from user a second number
add the first and second number
return to user the result
add to the result 2 and return the new result
```


What is a variable

- a variable is a storage space for keeping information that may change every time we run the program, or even during the same program (thus their name
- they are *temporary* and store additional information the algorithm needs to function

variables are "shortcuts" to numbers we stored

```
get from user a first number
let variable1 = first number
get from user a second number
let variable2 = second number
let variable3 = variable1 + variable2
return to user variable3
let variable3 = variable3 + 2
return to user variable3
```

What is a variable

```
> Please give a number:
 2
> Please give a second number:
 3

> Result is 5

> New result is 7
```

value 2 stored in variable1

value 3 stored in variable2
variable3 used to do the sum

variable3 updated

Same output as before, different structure (use of variables)

```
get from user a first number
let variable1 = first number
get from user a second number
let variable2 = second number
let variable3 = variable1 + variable2
return to user variable3
let variable3 = variable3 + 2
return to user variable3
```


What is a function / method

- It is a sub-algorithm that does a specific task, to help break down large programs into small parts
- It is a group of steps, to which we assign a name
- We can call these steps with their name

set of steps with name **add**, that we can call multiple times (and may return different results

```
function add (variable1, variable2)
   let variable3 = variable1 + variable2
   return to user variable3
```

```
get from user first number and second number (e.g, 3 and 4)
let variable1= first number and variable2 = second number
add (variable1, variable2)
get from user first number and second number(now 6 and 5)
let variable1= first number and variable2 = second number
add (variable1, variable2)
```

What is a function / method

```
> Please give two numbers:
 3,4

> Result is 7

> Please give two numbers:
6,5
> Result is 11
```

value 2 and stored in variable1 and variable2

add is called, with variable1=3 and variable2=4
inside add the sum is performed
and returned

value 2 and stored in variable1 and variable2

add is called, with variable1=6 and variable2=5
inside add the sum is performed
and returned

```
function add (variable1, variable2)
   let variable3 = variable1 + variable2
   return to user variable3


get from user firs number and second number (e.g, 3 and 4)
let variable1= first number and variable2 = second number
add (variable1, variable2)
get from user firs number and second number(now 6 and 5)
let variable1= first number and variable2 = second number
add (variable1, variable2)
```


conditionals

- When an algorithm needs to make a decision we use condition statements

if the condition is met
the line after “if” is executed,
if not the line after "else"

```
function add (variable1, variable2)
   variable3 = variable1 + variable2
    if (variable3 > 10)
        return to user “Too big !!!”
    else
       return to user variable3

get from user firs number and second number (e.g, 3 and 4)
let variable1= first number and variable2 = second number
add (variable1, variable2)
get from user firs number and second number(now 6 and 5)
let variable1= first number and variable2 = second number
add (variable1, variable2)
```

conditionals

```
> Please give two numbers:
 3,4

> Result is 7

> Please give two numbers:
6,5
> Result is “Too big !!!”
```

add is called, with variable1=3 and variable2=4
inside add the sum is performed
then the the conditional is tested (if)
here variable3 is less than 10 so returned

add is called, with variable1=6 and variable2=5
inside add the sum is performed
then the conditional is tested (if)
but not met, so return “Too Big"

```
function add (variable1, variable2)
   variable3 = variable1 + variable2
    if (variable3 > 10)
        return to user “Too big !!!”
    else
       return to user variable3

get from user firs number and second number (e.g, 3 and 4)
let variable1= first number and variable2 = second number
add (variable1, variable2)
get from user firs number and second number(now 6 and 5)
let variable1= first number and variable2 = second number
add (variable1, variable2)
```


repetitions

- An action performed multiple times, either while a condition holds, or for a specific number of times

function that loops (iterates)
for as many times as the
variable *iterations* states

```
function loop (variable iterations)
   for iterations times
       say Hi!

get from user (variable) iterations(e.g, 3)
loop (iterations)
loop (iterations + 1)
```

repetitions

```
> Please give iterations:
 3


> Hi!
> Hi!
> Hi!

> Hi!
...
```

value 3 stored in variable *iterations*

function loop is called with argument *iterations*

first time
second time
third time (that is equal to *iterations*)

function loop called again with argument
iterations +1
How many Hi! 's will we see?

```
function loop (variable iterations)
   for iterations times
       say Hi!

get from user (variable) iterations(e.g, 3)
loop (iterations)
loop (iterations + 1)
```


Java basics

Java

- Multi-platform “Pure” object-oriented language and application runtime environment
- Language syntax based on C/C++ to be familiar
  - with simplifications: no unsigned values, pointers, …
  - developers not responsible for memory management

- Pure object-oriented language:
  - build from the ground up with OOP design in mind
  - programs are completely constructed with objects

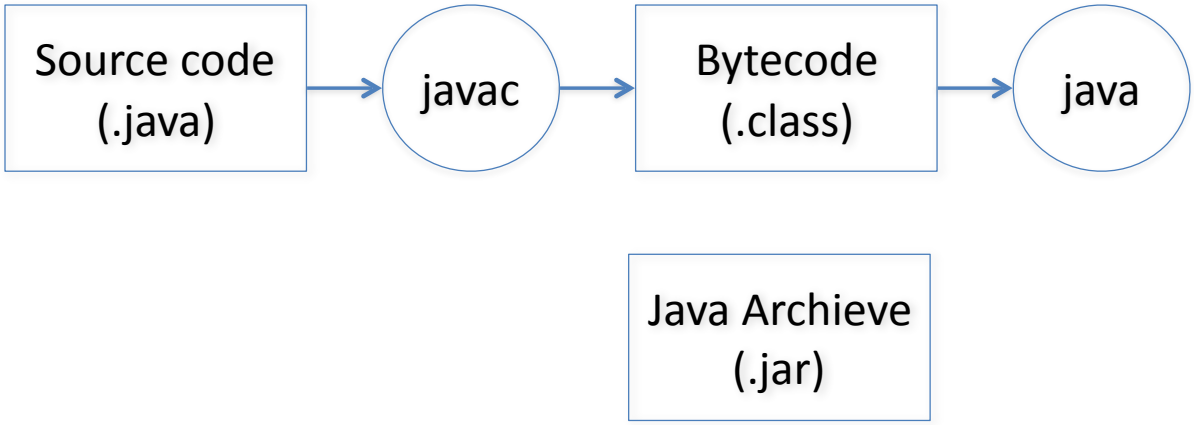
  (as opposed to Bolt-on languages, like C++, where OO structures are an enhancement to the language, and there is a mix of procedural and OO)

Java and JVM

- Code in Java does not compile to machine code directly, but to a specific type of Bytecode
  - Bytecode executable on any architecture
  - Write once, run anywhere (WORA)
- Java bytecode runs through a Java Virtual Machine (JVM), achieving cross-platform support

- Different platforms have their implementation of the JVM (included in the Java Runtime Environments JRE). The Java Development Kit (JDK) also includes the Java JRE.

Compiling Java



First Java program

In a simple text editor (Notepad, TextEdit, Emacs) write the following and save in HelloWorld.java

```
class HelloWorld {

    public static void main (String[] arguments){

        System.out.println("Hello World !");

    }
}
```

This is a class declaration, more on that later.

First Java program

In a simple text editor (Notepad, TextEdit, Emacs) write the following and save in HelloWorld.java

```
class HelloWorld {

    public static void main (String[] arguments){

        System.out.println("Hello World !");

    }
}
```

Main method: entry point to the program (public + static) and <u>needs to be inside a class</u>

First Java program

In a simple text editor (Notepad, TextEdit, Emacs) write the following and save in HelloWorld.java

```
class HelloWorld {

    public static void main (String[] arguments){

        System.out.println("Hello World !");

    }
}
```

System is a class, that calls **out** that represents the stdout (here output to console). Method **println** prints the text argument, and adds a newline character.

First Java program

In a simple text editor (Notepad, TextEdit, Emacs) write the following and save in HelloWorld.java

```
class HelloWorld {

    public static void main (String[] arguments){

        System.out.println("Hello World !");

    }
}
```

Lets compile and run it!

```
> javac HelloWorld.java
> java HelloWorld
```


Program structure

```
class CLASSNAME {

    public static void main (String[] arguments){

        STATEMENTS
        // comments
    }
}
```

Main function is needed to run a program

It is always inside a class

It is always public static

Let's move to our IDE

- Run Eclipse, and File→New→Java Project
  - Name your project: `RemedialJava` and click finish
- Select in the Package Explorer your project RemedialJava, and File → New → Package
  - Name your package: `session1.introduction`
- Finally, select your package in the Package Explorer, File → New → Java Class
  - Name your class `HelloWorld`
- Copy paste the code from HelloWold example
- Project→Build and Run→Run your code (or select the HelloWorld class and Run → Run As → Java Application)

Types

- As in all programming languages, Java has some basic types, the kinds of values that can be stored and manipulated:

boolean: Truth value (**true** or **false**).

int: Integer (0, 1, -30).

double: Real number (3.14, 2.0, -4.1).

String: Text ("hello", "cat").

Variables

- Variable: location that stores a value of a type.
  The form is: **TYPE NAME;**
  e.g., `String cat;`
- We use **=** to make variable assignments.
  e.g., `String cat;`
  `cat = “Garfield”;`
- Can combine declaration and assignment
  e.g., `String cat = “Garfield”;`

Variables of different Types

- example

```
class HelloWorld {

    public static void main (String[] arguments){

        System.out.println("Hello World !");

        String cat = "Garfield";
        int age = 3;

        System.out.println(
        "My cat is " + cat + ” and he is " + age);

    }
}
```

Operators

- Symbols:
  - Assignment: =
  - Operators: +,-,*,/,%
  - Combined: +=, -=, *=, /=
- Ordering:
  1. left to right, () increase precedence
  2. multiplication/division
  3. addition/substraction

```
class SomeMath {

    public static void main (String[] arguments){
        double calculate = 1.0 + 2.0 * 3.0;
        // different from (1.0 + 2.0) * 3.0
        System.out.println(calculate);
        calculate = calculate * 2.0;
        // calculate *= 2.0; would work too
        System.out.println(calculate);
    }
}
```


Division

- Division ("/") operates differently on integers and doubles

Example

```
double a = 5.0/2.0;  // a = 2.5
int b = 4/2;         // b = 2
int c = 5/2;         // c = 2
double d = 5/2;      // d = 2.0
```

types

- Java verifies that types match:

  String five = 5; // ERROR!

- Can convert types by casting

```
int a = 2; // a = 2
double a = 2; // a = 2.0 (Implicit)

int a = 18.7; // ERROR
int a = (int)18.7; // a = 18

double a = 2/3; // a = 0.0
double a = (double)2/3; // a = 0.6666...
```


String concatenation

- Basic concatenation

```
String text = "hello" + " world,";
text = text + " times " + 6;
// text = "hello world, times 6"
```

- Can also create formatted strings

```
String text = String.format("Printing a
string variable %s, and an integer one %d",
 stringVar, intVar);
```

- To check equality: `string1.equals(string2)`
- Many methods available !!!

Exercise 1

www.lri.fr/~anab/teaching/remedialJava/ex-session1.pdf

Reminder:

- Types (boolean, int, double, String)
- Operators +,-,*,/,%
- Assignment =, +=, *=, -=, /=
- Standard output `System.out.println("some text");`

Methods

- A method is similar to a function
- A section of a program that is given a name, and that that performs a specific task
- It may take some input parameters and may return a value
- It can be called from elsewhere in the program to be executed

Methods

```
public static void main(String[] arguments){
    System.out.println("hi");
}
```

```
public static void NAME (TYPE NAME) {
    STATEMENTS;
}
```

To call a method:

```
NAME (EXPRESSION);
```


Methods example (1)

```
class Square {

    public static void printSquare (int x) {
          System.out.println (x * x);
    }

    public static void main(String[] arguments){
          int value = 2;
          printSquare (value);
          printSquare(value*2);
          printSquare(3);
    }
}
```

Methods example (2)

```
class Square {

    public static void printSquare (int x) {
          System.out.println (x * x);
    }

    public static void main(String[] arguments){
          printSquare ("Hello World");
          printSquare(5.5);
    }
}
```

What is wrong here ?

Methods example (3)

```
class Square {

    public static void printSquare (double x) {
          System.out.println (x * x);
    }

    public static void main(String[] arguments){
          printSquare(5);
    }
}
```

What is wrong here ?

Methods example (4)

```
class Square {

    public static void printSquare (double x) {
          System.out.println (x * x);
    }
    public static void printSquare (String x) {
          System.out.println (x + x);
    }

    public static void main(String[] arguments){
          printSquare(5.0);
          printSquare("Hello");
    }
}
```


Methods example (4)

```
class Square {

    public static void printSquare (double x) {
          System.out.println (x * x);
    }
```

Method overloading: a class can have two or more methods having same name, if their argument lists are different.

Method return values

```
public static TYPE NAME (TYPE NAME, TYPE NAME, ...) {
    STATEMENTS;
    return EXPRESSION;
}
```

- void means “no type”, ie nothing returned

Methods example (5)

```
class Square {

    public static double square (double x) {
          return x * x;
    }

    public static void main(String[] arguments){
          System.out.println( square(5) );
    }
}
```

Variable Scope

- Variables live in the block {} where they are defined (**scope**)
- Method input parameters are like defining a new variable in the method

Variable scope example (1)

```
class SquareChange {

    public static void printSquare(int x) {
          System.out.println("printSquare x = " + x);
          x = x * x;
          System.out.println("printSquare x = " + x);
    }

    public static void main(String[] arguments) {
          int x = 5;
          System.out.println("main x = " + x);
          printSquare(x);
          System.out.println("main x = " + x);
    }
}
```

Note: this is for basic types …

Methods

You should know this, but repetition is good ☺️

- Big programs are built out of small methods
- Methods can be individually developed, tested and reused
- The user of method does not need to know how it works (this is called "abstraction")

Conditionals

```
if (CONDITION) {
    STATEMENTS
}
```

```
if (CONDITION) {
    STATEMENTS 1
} else {
    STATEMENTS 2
}
```

```
if (CONDITION) {
    STATEMENTS 1
} else if (CONDITION) {
    STATEMENTS 2
} else if (CONDITION) {
    STATEMENTS 3
} else {
    STATEMENTS 4
}
```

Conditions …

Are a combination of:

- Comparison operators:

  x > y , x >= y : x is greater than y, x is greater or equal to y
  x < y , x <= y : x is less than y, x is less than or equal to y
  x == y : x equals y (equality: ==, assignment: =)
  (NOT for Strings, non basic types or doubles)

- Boolean operators:

  && : logical AND
  || : logical OR
  ! : logical NOT

Conditions …

- Comparison operators:
  - Do not call == for String

    String is an object, so Java will look at its memory (more later)
    Instead use **equals** (e.g., s1.equals(s2))

  - Do not call **==** for doubles

    ```
    double a = Math.cos (Math.PI / 2);
    double b = 0.0;
    ```

    a = 6.123233995736766E-17

    `a == b` will return FALSE

    use Math.abs(a-b) < somethingSmall

Conditional Switch …

```
switch (variable) {
    case value1:
            STATEMENTS
            break;
    case value2:
            STATEMENTS
            break;
    …
    default:
            STATEMENTS
            break;
}
```


Exercise 2

www.lri.fr/~anab/teaching/remedialJava/ex-session1.pdf

Reminder:

- if (cond) {
  } else if (cond) {
  } else {
  }
- Condition operators: x > y, x >= y, x < y, x <= y, x == y
- Boolean operators: **&&** (AND), **||** (OR), **!** (NOT)

Loops (1)

while (***CONDITION***) {
    STATEMENTS
}

do{
    STATEMENTS
} while (***CONDITION***)

```
int i = 0;
while (i < 3) {
   System.out.println("Counting #" + i);
   i += 1;
}
```

- Make sure that your loop has a chance to finish (especially if you cannot count a-priori)

Loops (2)

for (***intialization; CONDITION; update***) {
    STATEMENTS
}

```
for(int i = 0; i < 5; i=i+1) {
   System.out.println("Counting #" + i);
}
```

- Note: i = i+1 may be replaced by i++ (or ++i)

Loops (3)

Embedded loops

```
for(int i = 0; i < 5; i=i+1) {
  for (int j = 0; j < 7; j=j+1) {
      System.out.println(i + " " + j);
  }
}
```

- Scope of variables defined inside loop exist in the respective *for* block
- Scope of the iterating variable (e.g., *i,j*) defined in the initialization (also exist in the respective *for* block)

Loops (4)

Jumping loops (brunching statements):

- You can terminate a loop by using **break**, this will move to the first instruction after the loop
- You can skip the current iteration of a loop using **continue**, which moves you to the next iteration

```
for(int i = 0; i < 5; i=i+1) {
  for (int j = 0; j < 7; j=j+1) {
      if (j == 3) continue; // go to j 4
      if (j == 5) break; // stop the inner loop
      System.out.println(i + " " + j);
  }
}
```

Exercise 3

www.lri.fr/~anab/teaching/remedialJava/ex-session1.pdf

Reminder:

- for (i=1; i <= 10; ++i) { … }
- double a = (double) 1/2;

Exercise 4 - Homework

www.lri.fr/~anab/teaching/remedialJava/ex-session1.pdf

Reminder:

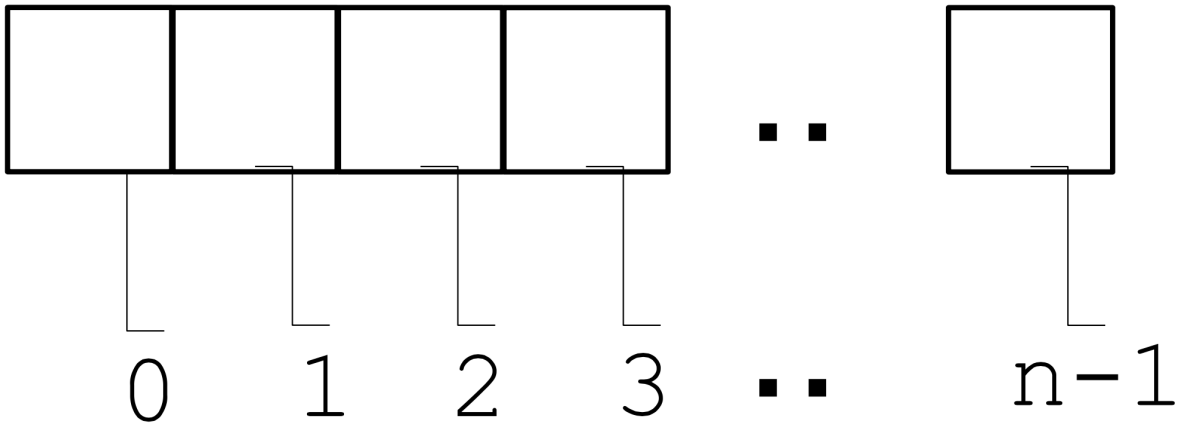
- for (i=1; i <= 10; ++i) { … }
- System.out.print() prints in the same line
- System.out.println() adds a new line at the end

Java basics, Arrays

Arrays

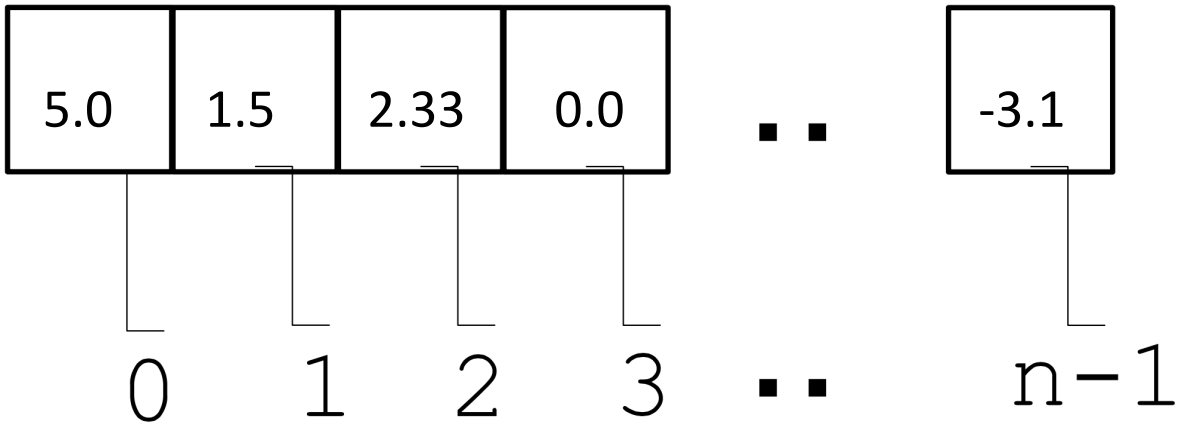
- An array is an indexed list of values.
- You can make an array of any type
  - int, double, String, etc.
- All elements of an array must have the same type.

Arrays



Arrays

Example: double[]



Arrays

- The index starts at zero and ends at length-1.

Example:

```
int[] values = new int[5];
values[0] = 1;   // CORRECT
values[3] = 1;   // CORRECT
values[5] = 1;   // WRONG!! compiles but
                       // throws an Exception
                       // at run-time
```


Arrays

- An array is defined as **TYPE**[].
- They are themselves just another type (more advanced)

```
int[] values;    // array of int

int[][] values;  // array of int[]
                 // (array of arrays)
```

Arrays

- Arrays of a specific size created using new:

```
int[] values = new int[5];
```

- Or using a variable:

```
int arraySize = 5;
int[] values = new int[arraySize];
```

- Or using {} to initialize the array values. This can only be used in the array declaration:

```
int[] values = {2, 5, 3, 6, 6};
```


Array Access

- You can access elements in the array with

```
arrayName[index]
```

Example:

```
int[] values = {2, 5, 3, 6, 6};
values[2] = 12;  // assign value at position 2
                 // {2,5,12,6,6}
int x = values[3]/2;   // read value at pos 3
                       // {2,5,3,3,6}
```

Array Access

- Arrays have a `length` variable build-in

Example:

```
int[] values = new int[5];
int arraySize = values.length;    // 5

int[] values2 = {2, 5, 3, 6, 6};
int arraySize2 = values2.length;  // 5

public static void main (String[] arguments){
    if(arguments.lengh > 0)
        System.out.println("Passed " +
            arguments.length + " arguments");
}
```


Looping over Arrays

Examples:

```
int[] values = {2, 5, 3, 6, 6};
for (int i=0; i<values.length; ++i)
    values[i]= values[i]*values[i];


int[] values2 = new int[5];
int i = 0;
while (i < values2.length){
    values[i] = i;
    ++i;
}
```

Exercise 5

www.lri.fr/~anab/teaching/remedial-java/ex-session1.pdf

Reminders/aid:

```
int[] values = {2, 5, 3, 6, 6};
int[] values = new int[SIZE];
```

array[index] accesses value at index position, with index starting at 0

array.length gives the array size

for (***intialization; CONDITION; update***) {

STATEMENTS

}

You can get the max possible int with ***Integer.MAX_VALUE;***

Common problems

Common problems (1)

- Array Index vs Array Value

```
int[] values = {2, 5, 3, 6, 6};
System.out.println(values[0]);    // 2
```

- Curly braces {…} after if/else, while/for

```
for (int i = 0; i < 5; i++)
    System.out.println("Hi");
    System.out.println("Bye");
```

Output?

Common problems (2)

- Variable initialization

```
int getMinValue(int[] vals) {
  int min = 0;
  for (int i = 0; i < vals.length; i++) {
      if (vals[i] < min) {
       min = vals[i];
      }
   }
}
```

What if vals = {1,2,3}?

Set `min = Integer.MAX_VALUE` or `vals[0]`

Common problems (2)

- Defining method within method

```
public static void main (String[] args) {
    public static void foo (){
        …
    }
}
```

- General comment:
  - Use System.out.println throughout your code

(aside, in our IDE)

- Ctrl-Shift-L: show list of keyboard shortcuts
- Ctrl-S: save
- Ctrl-Shift-F: aligns code
- Ctrl-O: opens an autocomplete window to jump to a member definition for all members of the open type
- Ctrl-Shift-O: organize imports automatically
- Ctrl-Shift-T: opens a window to open a type via autocompletion
- Ctrl-Shift-R: opens an autocomplete window for resources (files)
- F3: jump to definition

(On a Mac, replace Ctrl above with Cmd.)

Java resources

Many resources online …

https://docs.oracle.com/javase/tutorial/tutorialLearningPaths.html

« Thinking in Java » by Bruce Eckel (older versions of the book available online)

Exercises 4,6,7

Homework (together with anything else you did not finish in class)

www.lri.fr/~anab/teaching/remedial-java/ex-session1.pdf