

Introduction to programming and computer science

Lecture 2: constants, booleans loops, control structures

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Recap of Lecture 1



Variables, Assignments, Expressions

TDs: Frequently Asked Questions (FAQs)



TD: travaux dirigés

FAQs: Foire aux questions



Upper case versus Lower case

Java **distinguishes** between

uppercases (A..Z) and lowercases (a..z)



 Unix *differentiates* upper/lower case filenames

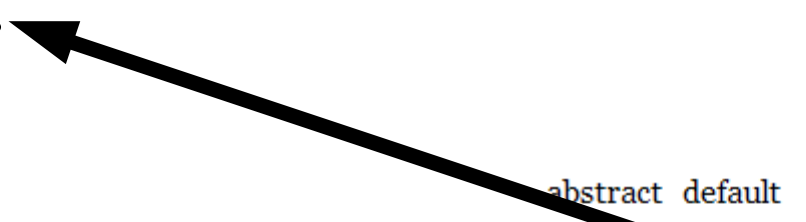
```
class UpperLowerCase
{
    public static void main (String arguments[])
    {
        int MyVar;
        // this variable is different from MyVar
        int myvar;

        // Generate a syntax error at compile time:
        // cannot find symbol variable myVar
        System.out.println(myVar);
    }
}
```

Reserved keywords

You *cannot* choose reserved keywords for variable names:

```
class ReservedKeyword
{public static void main (String arg[]) {
    double x,y;
    // Generate a syntax error:
    // "not a statement"
    int import;
  }
}
```



abstract	default	if	private	throw
boolean	do	implements	protected	throws
break	double	<u>import</u>	public	transient
byte	else	instanceof	return	try
case	extends	int	short	void
catch	final	interface	static	volatile
char	finally	long	super	while
class	float	native	switch	
const	for	new	synchronized	
continue	goto	package	this	

Reserved keywords in Java:

Displaying versus Computing

- You need to display if you'd like to see the result of evaluating an expression
- `System.out.println` displays on the console *with* a return carriage
- `System.out.print` displays on the console *without* a return carriage

> 2 + 2;

4

> ifactor(203490);

(2) (3)² (5) (7) (17) (19)

Confusing in Maple:
Interpreter: compute:display

Java is not Maple nor SciLab!



Output: Displaying values & messages

- `System.out.println(stringname)` : displays a string with a return carriage
- `System.out.print(stringname)` : displays a string *without* return line
- `System.out.println(value)` : converts (cast) numerical value into a string and displays it
- `System.out.println(' 'The value of x is ' '+x)` :
Converts the numerical value of x into a string and concatenate that string with the constant string " The value of x is "

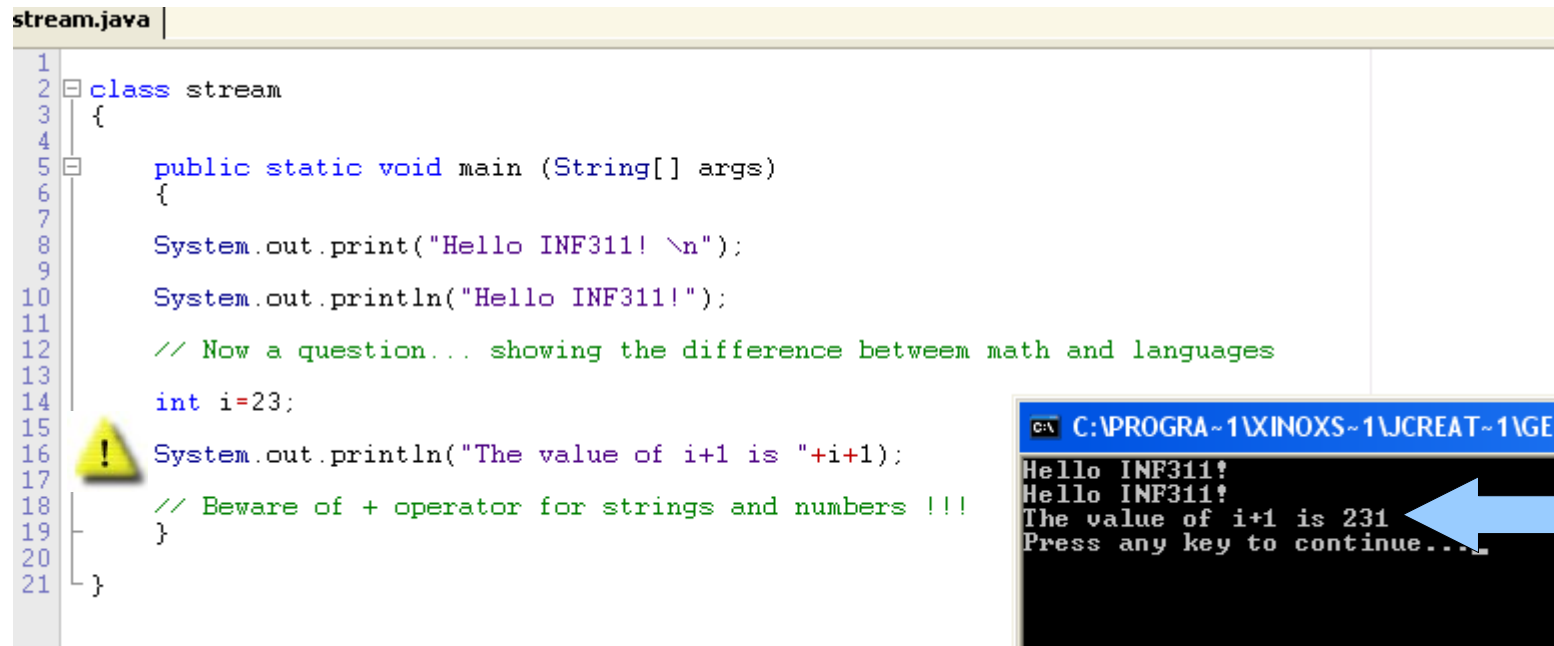
```
println.java
1 class println
2 {
3
4     public static void main (String[] args)
5     {
6         double x=Math.E;
7         int i=23;
8         int a=25;
9         int b=1024;
10
11         System.out.println(x);
12         System.out.println(i);
13
14         System.out.print(a); System.out.print(b);
15
16         System.out.print("\n");
17
18         System.out.print("The value of x is "+x);
19
20     }
21 }
22
23 }
```

```
C:\PROGRA~1\XINXS~1\JCREAT~1\GE2001.exe
2.718281828459045
23
251024
The value of x is 2.718281828459045Press any key to continue...
```

More on `System.out.println`

Equivalences of stream output:

`System.out.print('\n') = System.out.println('');`
`System.out.print('Hello INF311 \n') = System.out.println('INF311');`



The screenshot shows a Java IDE with a file named `stream.java`. The code is as follows:

```
1
2 class stream
3 {
4
5     public static void main (String[] args)
6     {
7
8         System.out.print("Hello INF311! \n");
9
10        System.out.println("Hello INF311!");
11
12        // Now a question... showing the difference between math and languages
13
14        int i=23;
15
16        System.out.println("The value of i+1 is "+i+1);
17
18        // Beware of + operator for strings and numbers !!!
19    }
20
21 }
```

The output window shows the following text:

```
C:\PROGRA~1\XINOS~1\JCREAT~1\GE2
Hello INF311!
Hello INF311!
The value of i+1 is 231
Press any key to continue...
```

A blue arrow points from the output window to the line `System.out.println("The value of i+1 is "+i+1);` in the code, which is marked with a yellow warning icon. Another yellow warning icon is present at the bottom right of the output window.

Priority order+casting operations...

Display: **String concatenations...**

Cumbersome to type several

`System.out.println` and `System.out.print`



Shortcut: **String concatenations** « + »...

Operator (expression)

```
int a=1, b=-2;
    System.out.print("a="); System.out.print(a);
    System.out.print(" b="); System.out.println(b);

System.out.println("a="+a+" b="+b);


String s1="Lecture in", s2=" Java";
String s=s1+s2; // string concatenation
System.out.println(s);
```

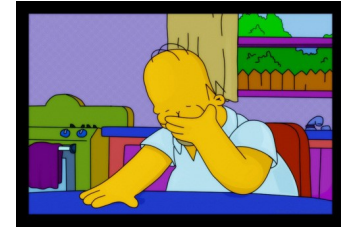
```
a=1 b=-2
a=1 b=-2
Lecture in Java
```


Reading input in Java: Class TC

Writing on the console using `System.out.println`

But unfortunately no equivalent for `System.in` !!!

 There are good reasons that you'll understand once you master Java...



We created tailored *input functions* for reading int, double, etc.
(proprietary code of Ecole Polytechnique)

```
System.out.print("Input an integer (+<Enter>):");  
int a=TC.lireInt();
```

```
System.out.print("Input a real (+<Enter>):");  
double b=TC.lireDouble();
```

```
System.out.println("I read:"+a+" "+b);
```

 http://www.enseignement.polytechnique.fr/informatique/INF311/TD_08/index.html

General purpose class TC

1. Download the class TC from:

http://www.enseignement.polytechnique.fr/informatique/INF311/TD_08/index.html

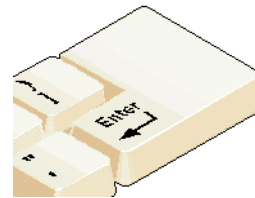
Courtesy of Julien Cervelle (and many others):

<http://www.enseignement.polytechnique.fr/profs/informatique/Julien.Cervelle/TC/>

<http://www.enseignement.polytechnique.fr/profs/informatique/Julien.Cervelle/TC/TC.html>

2. Compile it:

prompt% javac TC.java



Press Enter!!!

It produces a file named **TC.class**
(Java byte code)

Class TC

```
java.lang.Object
└ TC
```

```
public class TC
extends java.lang.Object
```

Classe regroupant les fonctions pratiques pour le Tronc Commun.

Constructor Summary

[TC\(\)](#)

Method Summary

static void	afficherChar (char c) affiche un caractère sur la sortie
static void	afficherDouble (double d) affiche un double sur la sortie
static void	afficherInt (int i) affiche un int sur la sortie

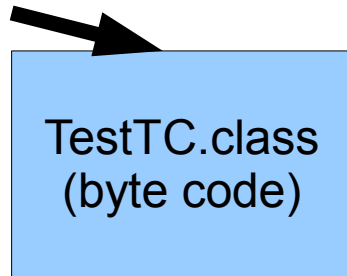
Java source code are in ***.java**, compiled code in ***.class**

Source code `.java` vs byte code `.class`

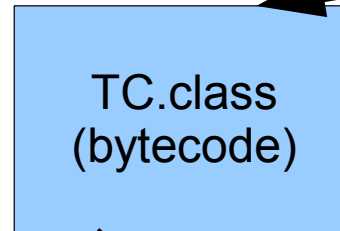


Java source code are in `*.java`, compiled code in `*.class`
Always upload in TD the java source code: File.java !!!

```
%prompt javac TestTC.java
```



```
%prompt javac TC.java
```



```
%prompt java TestTC
```



Microprocessor

Executing a java program invokes loading the java byte code `.class` to the JVM
The Java Virtual Machine (JVM) translates instructions to microprocessor instructions

Java programs with input and output

I/O = Input/output

More with **class TC : TC.lireLigne();**

(gestions des entrees/sorties simplifiees en francais)

```
askname.java
1 class askname
2 {
3     public static void main (String[] args)
4     {
5         // String a type in Java for manipulating strings of characters
6
7         String firstname, lastname;
8
9
10        System.out.print("What is your family name ?");
11        lastname=TC.lireLigne();
12
13        System.out.print("What is your first name ?");
14        firstname=TC.lireLigne();
15
16        System.out.println("Welcome to INF311 "+firstname+" "+lastname);
17
18    }
19
20
21
22 }
```

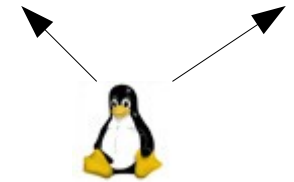
```
What is your family name ?Nielsen
What is your first name ?Frank
Welcome to INF311 Frank Nielsen
Press any key to continue...
```

Input/output (I/O) redirections

The **console** is the *default* for both input and output

Redirect input/output from/to text files as well using « < » and « > »

```
class Redirection{
public static void main(String args[])
{
int integer=TC.lireInt();
double real=TC.lireDouble();
System.out.println("Integer="+integer);
System.out.println("Real="+real);
}
}
```



Unix philosophy
(redirections+pipes)

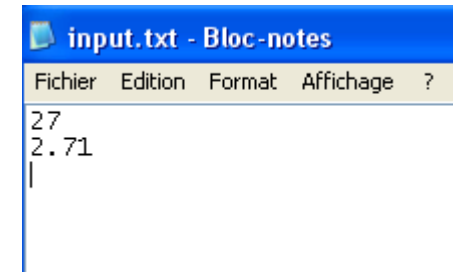
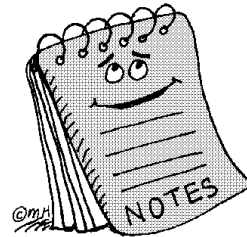
Console: prompt% java Redirection

```
5
223.2
Integer=5
Real=223.2
```

Input/output (I/O) redirections

Redirect input/output from/to text files as well using « < » and « > »

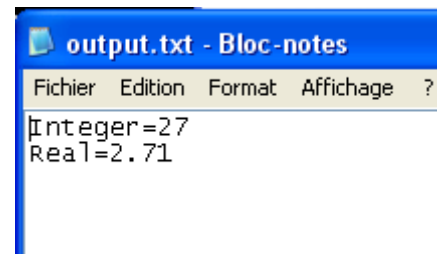
Create a file text input.txt and type an integer followed by a real



```
[user%machine] java Redirection < input.txt
```

```
prompt%java Redirection < input.txt > output.txt
```

Evaluation for
TDs/Pales



output.txt

Conditional structure: IF ... ELSE ...

From Exercice 3 of TD1

```
int h1 = 1, m1 = 56, s1 = 15;
System.out.print("hh mm ss : ");
int h2 = TC.lireInt();
int m2 = TC.lireInt();
int s2 = TC.lireInt();
int hs1 = 3600*h1 + 60*m1 + s1;
int hs2 = 3600*h2 + 60*m2 + s2;
int d=hs2-hs1;
```

Boolean predicate

true or false

```
if (d>0) System.out.println("larger");
else
    if (d<0) System.out.println("smaller");
    else System.out.println("identical");
```

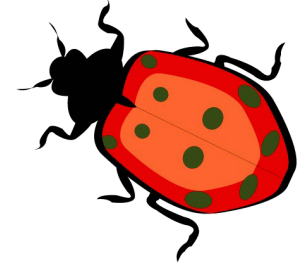
Parenthesis (blocks) of IF

Elif in Maple **is** « else if » in Java (no shortcut)

Syntax, compilation, and bugs

A syntactically correct program compiled *but*:

- It does not mean that it is bug free!
- A bug yield an **unexpected result**, or worse a **system crash**



```
class QuadraticEquation
{
public static void main(String[] arg)
{
    double a,b,c; // choose a=1, b=1, c=1

    a=TC.lireInt();
    b=TC.lireInt();
    c=TC.lireInt();

    double delta=b*b-4.0*a*c;
    double root1, root2;

    // BEWARE: potentially Not a Number (NaN) for neg. discriminant!
    root1= (-b-Math.sqrt(delta))/(2.0*a);
    root2= (-b+Math.sqrt(delta))/(2.0*a);
}
}
```


Declaring constants

```
/* Declare a constant (not a variable)
   to bypass using Math.PI */
```

```
final double PI = 3.14; // constant
```

Numeric bug in predicate !



```
// Constant
final double PI = 3.14;
```

```
int a=1;
double b=a+PI;
```

```
Incorrect result
a=1 b=4.1400000000000001 PI=3.14
```

```
if (b==4.14) // Equality test are dangerous!!!
    System.out.println("Correct result");
else
{
    System.out.println("Incorrect result");
    System.out.println("a="+a+" b="+b+" PI="+PI);
}
```

Syntax and compilation

Syntax errors are easy program bugs (mistyping?)

...But *syntactically correct* program may be difficult to understand

```
int i=3;  
// syntax below is valid!  
int var=i+++i;
```

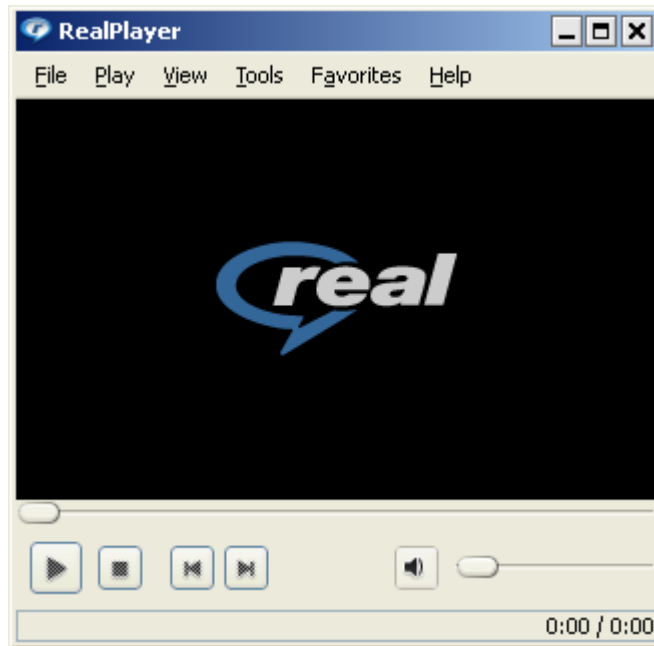
What is the value of var?

Protecting Java Source with Code obfuscation
Avoid reverse engineering of applications



Lecture videos on Internet

`rtsp://helixium.polytechnique.fr/ecole/tc/Nielsen_amphi1.rm`



Download free Real Player

Java at home (in the dorms, caserts)



Poll ! ... (laptop, Java, Windows)

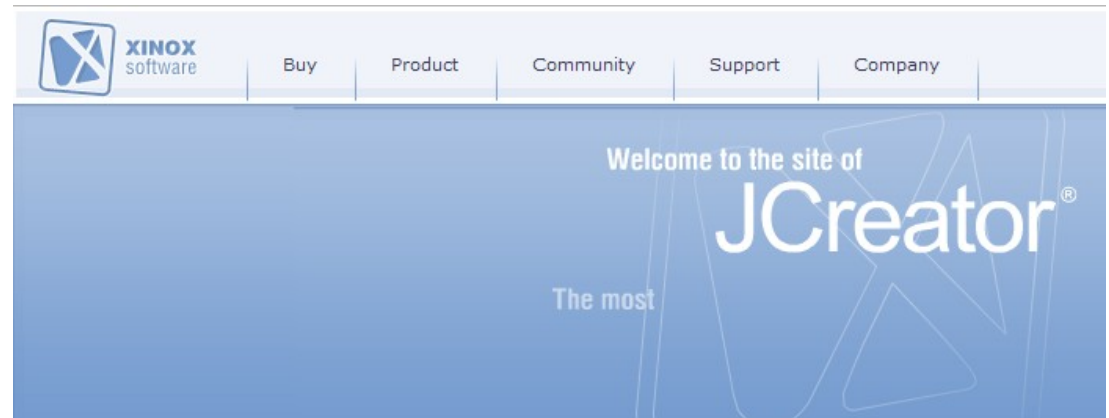
1. Install the **free** Java Development Kit (JDK)



<http://java.sun.com/javase/downloads/index.jsp>

2. Install Integrated Development Env. Jcreator v3.5

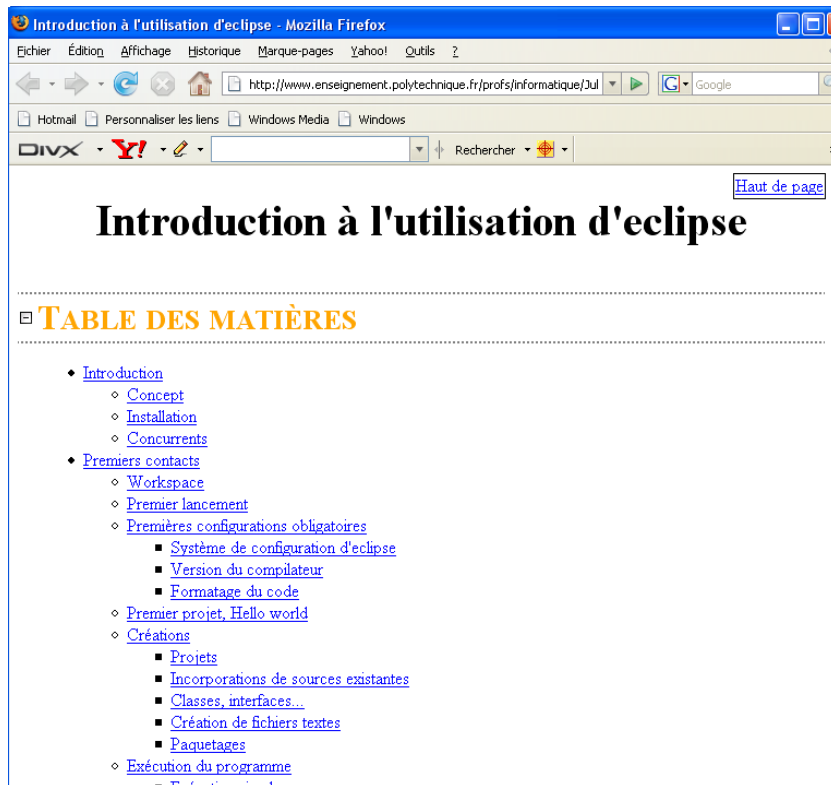
Live Demo!



<http://www.jcreator.com/>

Basic guide at <http://www.dix.polytechnique.fr/INF311/>

Click on telecharger (download)



Frankiz

Le serveur des élèves de l'École Polytechnique

Navigation dans le site

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- Annonces
- Activités
- Trombino
- Télécharger
- Wikix
- Binets
- Sites élèves
- Météo

Liens Utiles

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- Docs BR
- Site de l'école
- Site de la DE
- Orientation 4ème année
- Intranet
- Polytechnique.org
- Polytechnique.net
- Partenariats
- Autres liens
- Ancienne FAQ

JOYEUX ANNIVERSAIRE:

2006: Benoit MALAPERT

Important

Nouvelles Fraîches

Demain c'est fini

En attendant...

Forum des binets

Et C Parti pour le WE!

Profadom recrute

FBSA Alumni meeting à Londres!

Respo bars d'étage jônes

Challenge Borotra

Dernières places pour le CNAM!

Sortie Karting

Ivanov de Tchekhov au Théâtre de l'Odéon

Soirée X-Tra : achète ta place!

Affiches Bal de l'X 2008 à récupérer

Le Point Gamma 2008 needs you

Visite de l'usine moteur ING Renault F1 Team

Pour les 2K6 : le gag du 14 Juillet

Souvenirs de l'incorpo-Barcelo X2007

TOS, le binet rock est là pour toi!

Conférence à Supop

Finale du championnat de France Grandes Ecoles de courses de galop

XForum : Rejoins-nous le mercredi 14 mai à 17h45 en Pierre Faure

Le binet.XS t'informe



<http://www.polytechnique.fr/eleves/>

Introduction to Eclipse

<http://www.enseignement.polytechnique.fr/profs/informatique/Julien.Cervelle/eclipse/>



Points Administratifs

- Utiliser le tutorat, semaine prochaine

Jeudi 22 Mai, 13h30-15h30

Jeudi 5 Juin, 13h30-15h30

Jeudi 12 Juin, 13h30-15h30

Jeudi 19 Juin, 13h30-15h30

- Choisir les delegates

nielsen@lix.polytechnique.fr

- INF311 <-> INF321

Today...

Lecture 2: constants, booleans loops, control structures

Program: Data, computations + workflow

The **control structures** define the set of instructions being executed (aiguillage des trains)



For example, a branching condition:

In Java, we do not use the word `then`

```
if (a < b) [then]
    c = a; // Do-something-1
else
    c = b; // Do-something-2
```

There are two potential instructions paths depending on the predicate:

- $a < b$, $\rightarrow c = a$;
- or
- $a \geq b$, $\rightarrow c = b$;



c is selected as
the **minimum**
of a and b

Controlling program **workflow**

Two kinds:

- **Branching** tests: (if else, switch)
- **Repeat** structure: Loop (while, for)



```
1 class branchingprog
2 {
3
4     public static void main (String[] args){
5
6         int a,b,c;
7
8
9         a=3;
10        b=15;
11
12
13        if (a<b) // Predicate
14            c=a; // Block true
15        else
16            c=b; // Block false
17
18
19        System.out.println("c has value:"+c);
20
21
22    }
23
24
25
26
27
28 }
29
```

Predicate: **true** or **false**
if there is a numerical error at that stage we take the wrong flow and this yields a bug, with potential disastrous effects.

Key difference with maths.

```
c has value:3
Press any key to continue...
```



Annotating programs: **comments!**

Writing comments is good for (1) **yourself** and for (2) **others** to proofread and debug your code



D. Knuth

In fact, there are some *paradigms* to write in a *single file* both

- the clean documentations, and
- the code.

Exempla gratia (e.g.) cweb, **Literate programming**, etc.

<http://www.literateprogramming.com/>

In INF311, we rather write short programs, so we consider the [standard comments](#):

// This is a single line comment

/* I can also write comments on
several lines
by using these delimiters ***/**

Comments: single versus multiple lines (Jcreator IDE)

```
1 class comments{
2
3
4     // This is a comment of my program stored in filename comments.java
5
6
7     // This is the *** magic formula that we will explain later on ***
8
9     public static void main (String[] args)
10    {
11        double a,b;
12
13        double x,y;
14
15
16        /* The equation of a non vertical line is y=ax+b
17           If, I need vertical lines too, I rather choose
18           to write the equation as ax+by+c=0 as the equation
19           with homogeneous coordinates (a,b,c)
20        */
21
22        x=3;
23        a=1;
24        b=-2;
25
26        y=a*x+b;
27
28        /* My editor in Java
29           * just add the * in from of any newline automatically so that
30           * comments look prettier
31        */
32        |
33        System.out.println("ax+b=y="+y+" for x="+x+" with a="+a+" b="+b);
34
35    }
36
37
38
39
40 }
```

```
ax+b=y=1.0 for x=3.0 with a=1.0 b=-2.0
Press any key to continue...
```

Comments... with errors!



```
1 class commenterror
2 {
3
4     public static void main (String[] args)
5     {
6
7         // I like to write /* many programs
8         sometimes it is disturbing for the compiler */
9
10
11         /*
12          This comment further shows that we cannot imbricate
13          other complex comments in a several-line comment structure
14          /* it does not work,
15          it yields a syntactical error
16          */
17         */
18     }
19 }
```

The compiler is **verbose**: Try to fix the first error first (greedy approach)

```
-----Configuration: <Default>-----
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:8: ';' expected
    sometimes it is disturbing for the compiler */
                           ^
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:8: ';' expected
    sometimes it is disturbing for the compiler */
                           ^
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:8: '(' expected
    sometimes it is disturbing for the compiler */
                           ^
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:8: ';' expected
    sometimes it is disturbing for the compiler */
                           ^
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:8: illegal start of expression
    sometimes it is disturbing for the compiler */
                           ^
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:17: illegal start of expression
    */
    ^
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:17: illegal start of expression
    */
    ^
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:18: illegal start of expression
    }
    ^
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\commenterror.java:19: illegal start of expression
}→
Process completed.
```

Comments...

repaired... = *Syntactically correct program*

```
commentnoerror.java
1 class commentnoerror
2 {
3
4     public static void main (String[] args)
5     {
6
7         // I like to write
8         /* many programs
9         sometimes it is disturbing for the compiler */
10
11
12         /*
13          This comment further shows that we cannot imbricate
14          other complex comments in a several-line comment structure
15          */
16         // it does not work,
17         // it yields a syntactical error
18
19     }
20 }
```



Do not forget:

Writing good comments is as important as writing source code

You will thank yourself for doing this once you look back at your programs **months later**

Structures of Java programs



- Comments `//` or `/* */`
- Constants (`Math.PI`, etc.)
- Variables (typed) with valid identifiers (not reserved keyword)
- Operators `+`, `-`, `/`, `%`, etc. for expressions
- Reserved language keywords: `if`, `for`, `while`, etc.

A **set of instructions** is called a **block**

Blocks can be delimited by *parenthesis* **{Block}**

```
{ // This is a block
// (non control structure inside it)
var1=Expression1;
var2=Expression2;
var3=Expression3;
...
}
```

Structures of java programs: **Blocks**

```
blocks.java
1 class blocks{
2
3
4     public static void main (String[] arguments)
5     {
6         // This is the main block for the procedure called "main"
7         // observe the parenthesis that delimit the block
8
9         double a,b,c;
10
11         a=2;
12         b=3;
13         c=5;
14
15
16         if (a+b==c)
17         {
18             // This is a block delimited by parenthesis
19             System.out.println("a+b=c");
20
21         }
22         else
23         {
24
25             // This is another block
26             System.out.println("a+b is not equal to c");
27         }
28
29     }
30
31 }
32
33
34 }
```

Principal block

Block 1

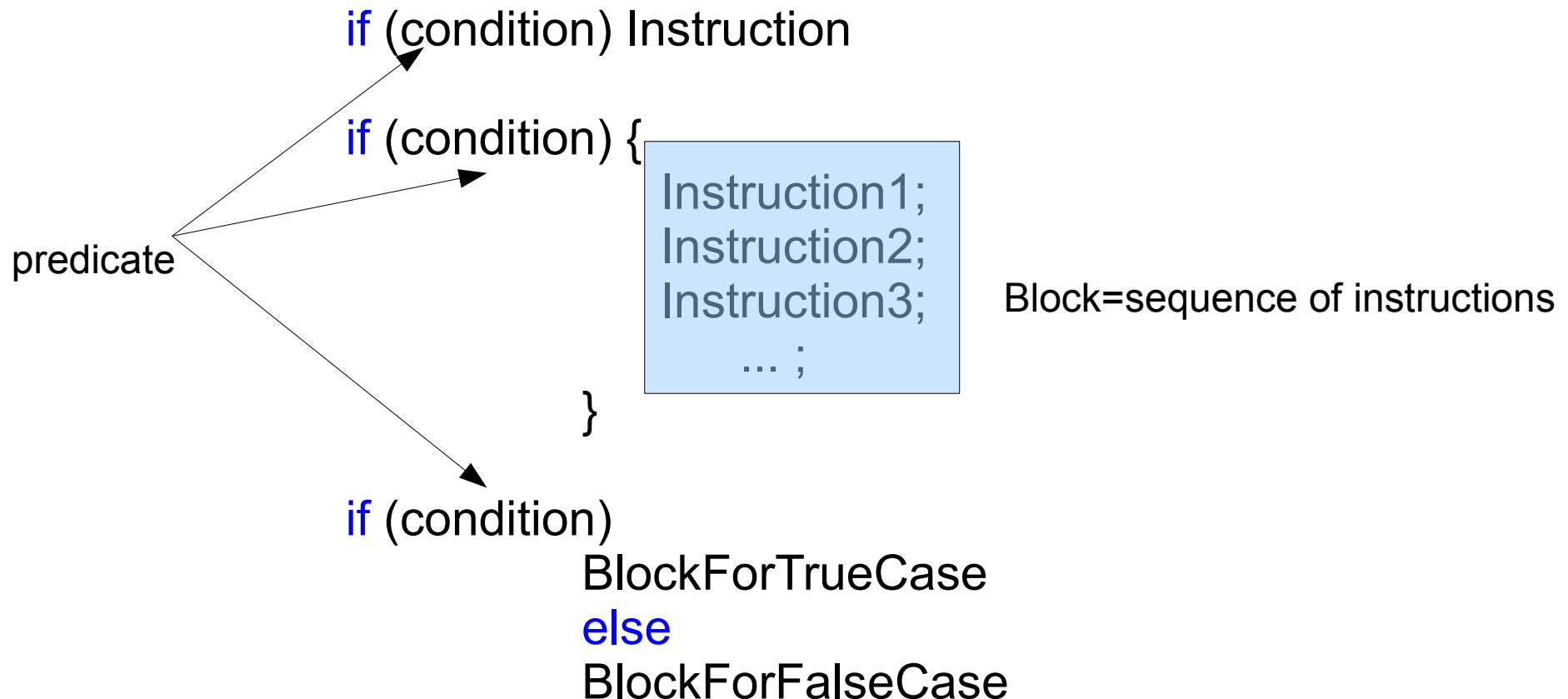
Block 2

```
a+b=c
Press any key to continue..._
```

Conditional structures:

if (predicate) Block1 else Block2

Essential control structure for executing a (block of) operations if a condition is `true` (or false for the else-Block)



Conditional structures: **Compact form** **if (predicate) Inst1 else Inst2**

Conditional instruction for single instruction block can be called using the ternary operator (3 operands) « ? : »

BoolOperand1 ? TypeOperandTrue2 : TypeOperandFalse3

```
double x1=Math.PI;  
double x2=Math.E;
```

```
double min=(x1>x2)? x2 : x1; // min value  
double diff= (x1>x2)? x1-x2 : x2-x1; // absolute val.  
System.out.println(min+" difference with max="+diff);
```

2.718281828459045 difference with max=0.423310825130748

Instructions and conditions

Instructions always terminate with a semi colon ;
(except potentially the last one in a block)

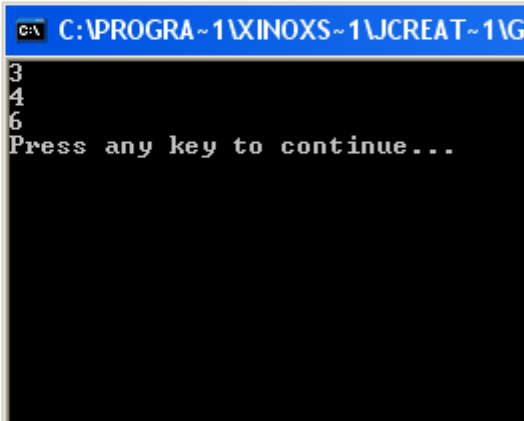
A set of instructions encapsulated in { } is a **block**
The block has the **same** syntax as an instruction

Variables can be declared in a block

A condition is a **boolean expression**
that returns either **true** or **false** :
= A predicate

Variables and blocks

```
scope.java
1 class scope
2 {
3     public static void main (String[] args)
4     {
5         int i=3;
6         int j=4;
7
8         System.out.println(i);
9
10        {
11            int ii=4;
12
13            System.out.println(ii);
14
15            j=6;
16        }
17
18        System.out.println(j);
19
20    }
21 }
22 }
23 }
```



Very different from C++!

(Java better controls the syntax of programs, **better semantic**)

We cannot declare twice a same variable in encapsulated block

Variables and blocks: **Scopes**

```
scope.java
1 class scope
2 {
3     public static void main (String[] args)
4     {
5         int i=3;
6         int j=4;
7
8         System.out.println(i);
9
10        {
11            int ii=4;
12
13            System.out.println(ii);
14
15            j=6;
16
17            int l=3;
18        }
19
20        System.out.println(j);
21
22        System.out.println(l);
23
24    }
25 }
26
27 }
```

Error!!! Variable l is not defined in the block it here

```
-----Configuration: <Default>-----
D:\Enseignements\INF311\Lectures2008\prog-inf311.2\scope.java:22: cannot find symbol
symbol  : variable l
location: class scope
        System.out.println(l);
                        ^
1 error
Process completed.
```

Boolean operators for comparisons

a==b Test of equality (for basic types)

a!=b Test for difference [equivalent to **! (a==b)**]

Inequalities:

a<b True if and only if (iff.) $a < b$

a<=b True iff. $a < b$ or $a = b$

a>b True iff. $a > b$

a>=b True iff. $a > b$ or $a = b$

Beware: $a=b$ is assignment not test (test of equality is $==$)



Typing helps you avoid this mistake:

```
int a=3;  
if (a=3) System.out.println("THEN-PART");  
else System.out.println("ELSE-PART");
```

**incompatible types found : int
required: boolean**

Boolean operators for comparisons

eqineq.java

```
1 class eqineq
2 {
3
4     public static void main (String[] args)
5     {
6         int a=2008;
7         int b=2007;
8         int c=2008;
9
10        boolean test1, test2;
11
12
13        if (a==b) System.out.println("Equality of a=b");
14        else
15            System.out.println("a is different from b");
16
17
18        if (a==c) System.out.println("Equality of a=c");
19        else
20            System.out.println("a is different from c");
21
22
23        test1=(a==b);
24        test2=(!(a!=b));
25
26
27        System.out.println("test1 "+test1+" should be equivalent to test2:"+test2);
28
29
30
31        if (c>=a) System.out.println("c>=a");
32        if (b<=a) System.out.println("b<=a");
33
34        System.out.println("That is all folks!");
35
36
37    }
38
39 }
40 }
```

```
a is different from b
Equality of a=c
test1 false should be equivalent to test2:false
c>=a
b<=a
That is all folks!
Press any key to continue..._
```

Boolean operators for comparisons

Boolean comparisons are of type `boolean`

```
class Boolean{
    public static void main(String[] args)
    {
        boolean b1    = (6-2) == 4;
        boolean b2    = 22/7 == 3+1/7.0 ;
        boolean b3    = 22/7 == 3+ 1/7;

        System.out.println(b1); // true
        System.out.println(b2); // false
        System.out.println(b3); // true
    }
}
```

`(6-2) == 4` evaluates to true but `22/7 == 3+1.0/7` evaluates to false

More on boolean operators: **Tables**

Unary operator:
NOT !

!	
true	false
false	true

Binary **connector operators**:
AND &&

&&	true	false
true	true	false
false	false	false

OR ||

	true	false
true	true	true
false	true	false

Priority order for boolean expressions

Lazy evaluation of boolean binary operators:

- If a is **false** we do *not need* to evaluate b in `a && b`
- If a is **true** we do *not need* either to evaluate b in `a || b`

lazyevaluation.java

```
1 class lazyeval{
2     public static void main (String[] args)
3     {
4         double x=3.14, y=0.0;
5         boolean test1, test2;
6
7
8
9         // Here division by zero yields a problem
10        // But this is prevented in the && by first checking whether the denominator is
11        // zero or not
12        if ((y!=0.0) && (x/y>2.0))
13            { // Do nothing
14                ; }
15        else
16            { // Block
17
18                test1=(y!=0.0);
19                test2=(x/y>2.0);
20
21                System.out.println("Test1:"+test1+" Test2:"+test2);
22                System.out.println("We did not evaluate x/y that is equal to "+(x/y));
23            }
24
25
26        // Here, again we do not compute x/y since the first term is true
27        if ((y==0.0) || (x/y>2.0))
28            { // Block
29                System.out.println("Actually, again, we did not evaluate x/y that is equal to "+(x/y));
30            }
31
32
33    }
34
35 }
36
37
38 }
```

C:\PROGRA~1\XINOS~1\JCREAT~1\GE2001.exe

```
Test1:false Test2:true
We did not evaluate x/y that is equal to Infinity
Actually, again, we did not evaluate x/y that is equal to Infinity
Press any key to continue...
```

Few remarks

Key difference between **assignment (=)** and **logical test ==**

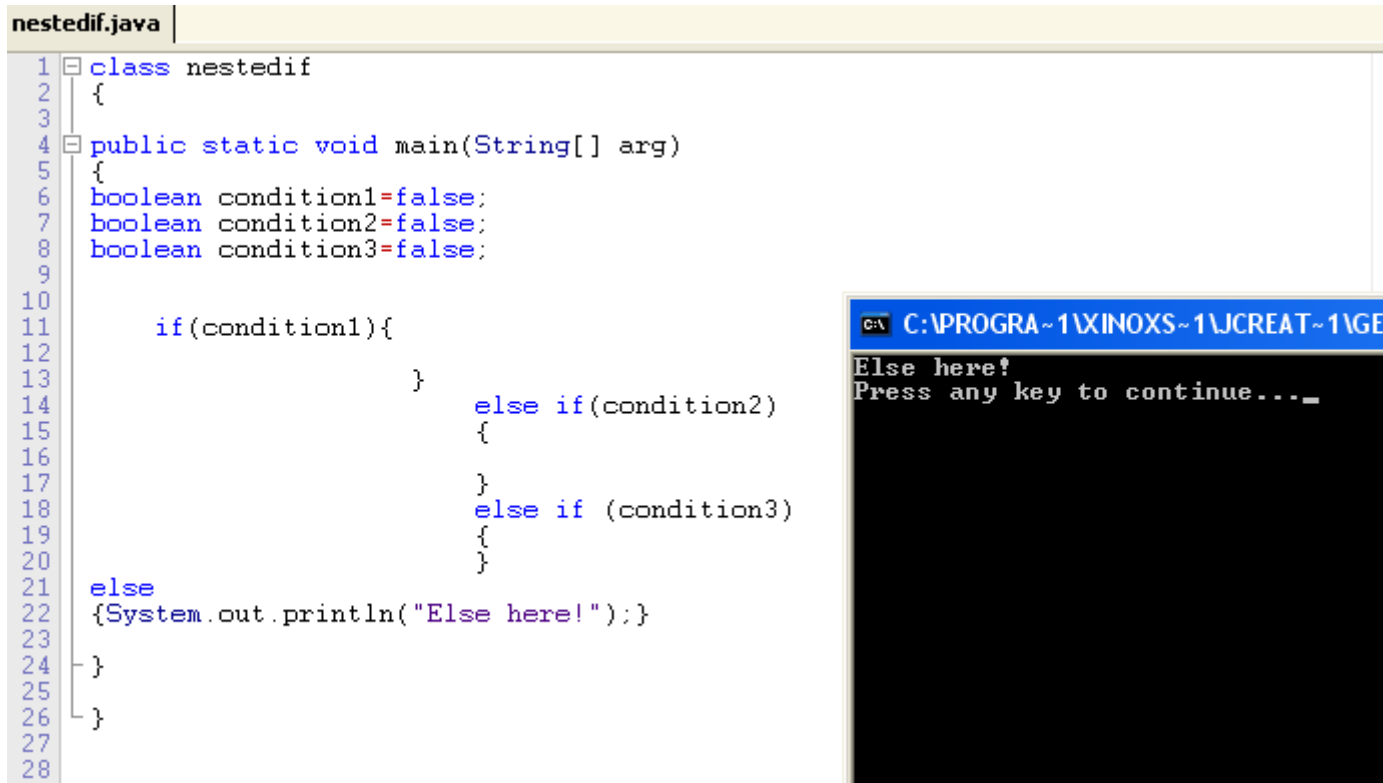
Do not forget the semi-colon at the end of **Instructions;**

✓ **Indent** your code and structure it into blocks for clarity
Think of **nested if** control structures

```
if (condition1)
    {BlockT1;}
else
    {
        if (condition2)
            {BlockT2;}
        else {BlockF2;}
    }
```

Nested if

Nested conditionals (nested if)



The screenshot shows a Java IDE with a file named `nestedif.java`. The code defines a class `nestedif` with a `main` method. Inside `main`, three boolean variables (`condition1`, `condition2`, `condition3`) are initialized to `false`. A series of nested `if` and `else if` statements follow, but none are executed because all conditions are false. Finally, an `else` block prints the message "Else here!". To the right, a terminal window shows the output of the program: "Else here!" followed by a prompt "Press any key to continue..." with a cursor.

```
1 class nestedif
2 {
3
4 public static void main(String[] arg)
5 {
6     boolean condition1=false;
7     boolean condition2=false;
8     boolean condition3=false;
9
10
11     if(condition1){
12
13     }
14         else if(condition2)
15         {
16
17         }
18         else if (condition3)
19         {
20
21         }
22     else
23     {System.out.println("Else here!");}
24 }
25
26 }
27
28
```

C:\PROGRA~1\XINOX~1\JCREAT~1\GE2
Else here!
Press any key to continue..._

Set *curly brackets* { } to increase code readability

Loops: While/do for iterations

Structure for iterating

- Process a **single instruction** or a **block** until the given boolean expression is **true** (thus may loop forever... and program may not terminate)
- **Boolean expression is re-evaluated at each round**
- We can exit the loop at any time using the keyword **break**;

```
while (boolean_expression)  
    single_instruction;
```

```
while (boolean_expression)  
{ block_instruction;}
```

```
do  
    { block_instruction; }  
while (boolean_expression);
```

← At least, the loop is executed once.

Loops: Euclid' GCD algorithm

Greatest common divisor of two integers a and b

While

Do

```
gcd2.java
1 class gcd2{
2
3
4     public static void main(String[] arg)
5     {
6
7         int a= 231232*4*5*11;
8         int b= 123*4*5*11;
9
10        while (a!=b)
11        {
12            if (a>b) a=a-b;
13            else b=b-a;
14        }
15
16        System.out.println(a);
17
18        a= 231232*4*5*11;
19        b= 123*4*5*11;
20
21        // Now use the do expression in java to perform the same task
22
23
24        do
25        {
26            if (a>b) a=a-b;
27            else b=b-a;
28        }
29        while (a!=b);
30
31        System.out.println(a);
32
33
34
35    }
```

```
C:\PROGRA~1\XINXS~1\JCREAT~1\GE2001.exe
220
220
Press any key to continue....
```

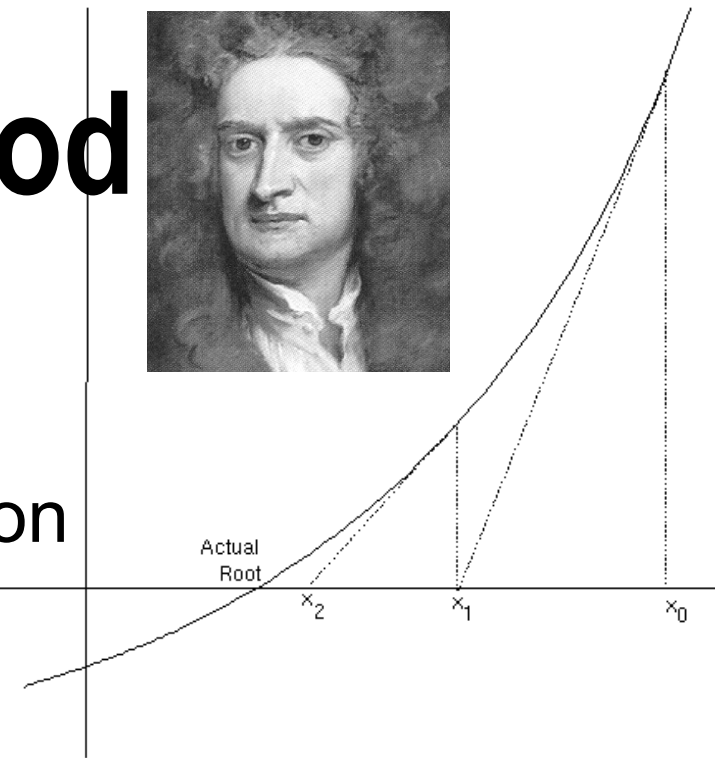
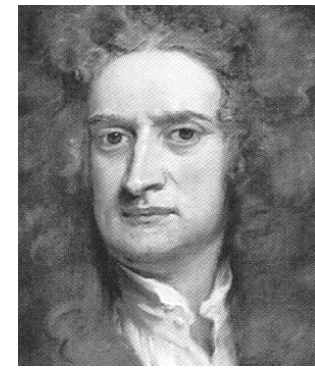
Loops: Newton's method

Converge to a root of the function f

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

Use to calculate the *square root* function

$$f(x) = x^2 - a$$



```
double a = 2.0, x, xold;
```

```
x = a;  
do {  
    xold = x;  
    // compute one iteration  
    x = (xold + a/xold) / 2;  
    System.out.println(x);  
} while (Math.abs(x - xold) > 1e-10);
```

Setting

$y = f'(x_{prev})(x - x_{prev}) + f(x_{prev}) = 0$
give new value for x

```
1.5  
1.4166666666666665  
1.4142156862745097  
1.4142135623746899  
1.4142135623730949
```

Loops:

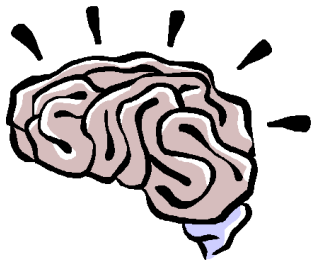
```
do
    { block_instruction; }
while (boolean_expression);
```

Syracuse and termination conjecture

Replace x by $x/2$ (for x odd) and x by $3x+1$ (for x even)

Start from any given x , does the replacing always terminate ($x=1$)

```
do {
    if ( (n%2) == 0 )
        n/=2; // divide by 2
    else
        n=3*n+1;
} while (n>1);
```

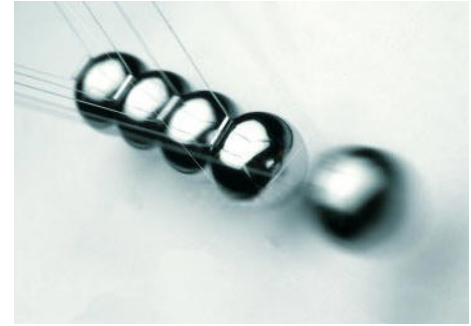


Nobody knows whether this programs stops for any given input (open problem)
No counter example from simulation so far but no termination proof too!



Loops: Perpetual movements...

Easy to do when programming.... ESC key or Control-C to escape!



Always ensure that loops terminate when programming

```
int i=0;
while (true)
    i++;
```

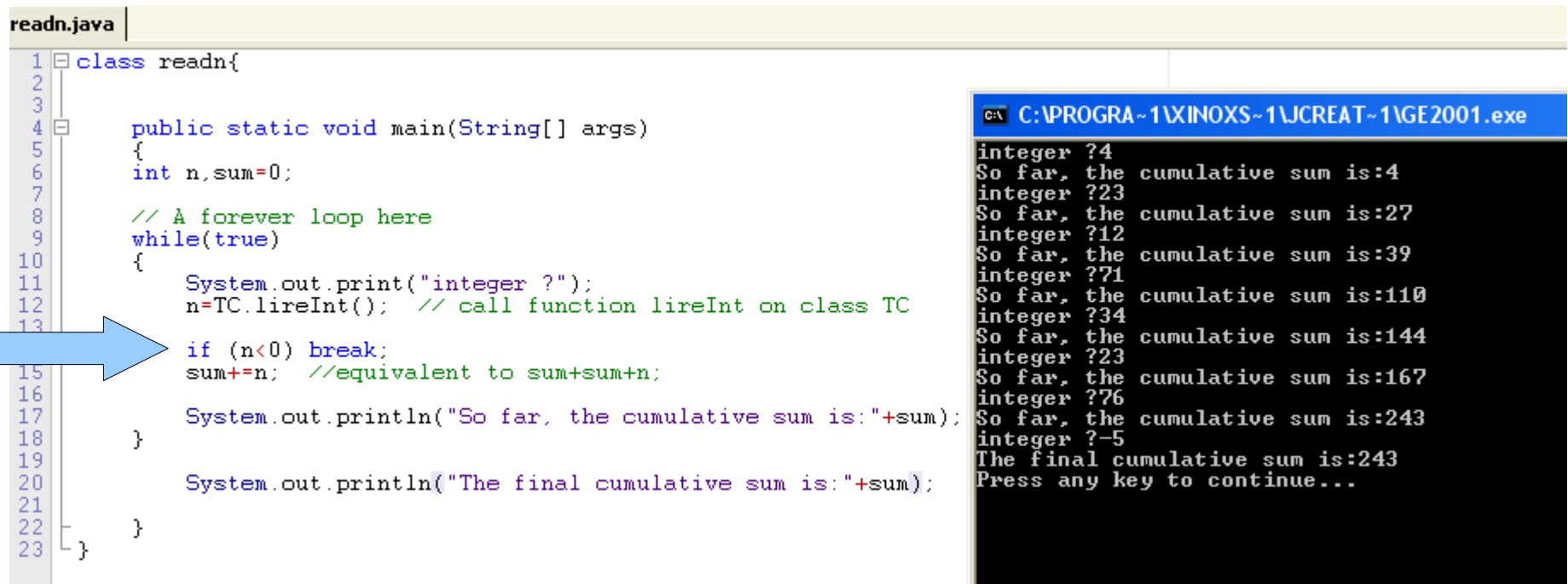
```
for (i=0; i>=0; i++)
    ; // common mistyping error
```

```
for (i=0; i>=0; i++)
{ }
```



Loops: Breaking the loop with break

Read a sequence of **non-negative natural integers** and compute the cumulative sum of the sequence.



```
readn.java
1 class readn{
2
3
4 public static void main(String[] args)
5 {
6     int n,sum=0;
7
8     // A forever loop here
9     while(true)
10    {
11        System.out.print("integer ?");
12        n=TC.lireInt(); // call function lireInt on class TC
13
14        if (n<0) break;
15        sum+=n; //equivalent to sum=sum+n;
16
17        System.out.println("So far, the cumulative sum is:"+sum);
18    }
19
20    System.out.println("The final cumulative sum is:"+sum);
21
22 }
23 }
```

```
C:\PROGRA~1\XINXS~1\JCREAT~1\GE2001.exe
integer ?4
So far, the cumulative sum is:4
integer ?23
So far, the cumulative sum is:27
integer ?12
So far, the cumulative sum is:39
integer ?71
So far, the cumulative sum is:110
integer ?34
So far, the cumulative sum is:144
integer ?23
So far, the cumulative sum is:167
integer ?76
So far, the cumulative sum is:243
integer ?-5
The final cumulative sum is:243
Press any key to continue...
```

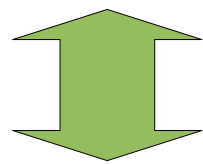
Observe the shortcut:

sum+=n; that is equivalent to assignment **sum=sum+n;**

Loops: For... iterations

- Allows one to execute a block of instructions, and
- Increment the counter at each round
- Semantically equivalent to a while loop
- Often used for program readability (e.g., for a range of integers)

```
for(instruction1; boolean_condition; instruction2)  
    block_instruction3;
```



Equivalence with While construction

```
instruction1;  
while (boolean_condition)  
{block_instruction3;  
  instruction2;}
```

Loops: For... iterations

```
for(instruction1; boolean_condition; instruction2)  
    block_instruction3;
```

```
class ForLoop  
{  
    public static void main(String args[])  
    {  
        int i, n=10;  
        int cumulLoop=0;  
  
        for(i=0; i<n; i++)    cumulLoop+=i;  
  
        int cumul=(n*(n-1))/2; // closed-form solution  
        System.out.println(cumulLoop+" closed-form:"+cumul);  
    }  
}
```

We get 45

Loops: For... iterations (unlooping)

```
int cumulLoop=0;  
for (i=0;i<n;i++) cumulLoop+=i;
```

Unlooping...



```
int cumulLoop=0;  
i=0; // Initialization  
cumulLoop+=i;  
i++; // i=1 now  
// i<n so we continue...  
cumulLoop+=i;  
i++; // i=2 now  
// i<n so we continue...  
cumulLoop+=i;  
...  
cumulLoop+=i; // i=n-1  
i++; // i=n now  
// i is not i<n so we stop...
```

Examples of for loop: IsPrime

Program that determines whether a given integer is prime or not.

```
isprime.java
1 class isprime{
2     public static void main(String[] args)
3     {
4         System.out.print("Enter an integer please:");
5         long k=0,n=TC.lireLong(); // reads a long number
6         boolean prime=true;
7
8         if ((n==1) || (n>2 && n%2 ==0) || (n>3 && n%3==0))
9             prime=false;
10        else
11        {
12            k=(long)(Math.sqrt(n)+1);
13
14            for(long i=5; i<k;i=i+6)
15                if ((n%i==0) || n%(i+2)==0)
16                {
17                    prime=false;
18                    System.out.println("Exit the loop with k="+k);
19                    break;}
20
21        }
22
23        // Output result to console
24
25        if (prime)
26            System.out.println("Number "+n+" is prime");
27        else
28            System.out.println("Number "+n+" is NOT prime.");
29    }
30
31
32
33 }
```

```
C:\PROGRA~1\XINOS~1\JCREAT~1\GE2001...
Enter an integer please:23121971
Number 23121971 is prime
Press any key to continue...
```

```
Enter an integer please:209
Exit the loop with k=15
Number 209 is NOT prime.
Press any key to continue...
```

$$209=11 \times 19$$



Multiple choices: switch

Avoid nested if-else structures for multiple choices

```
class ProgSwitch
{public static void main(String arg[]) {
    System.out.print("Input a digit in [0..9]:");
    int n=TC.lireInt();

    switch (n)
    {
    case 0: System.out.println("zero"); break;
    case 1: System.out.println("one"); break;
    case 2: System.out.println("two"); break;
    case 3: System.out.println("three"); break;
    default: System.out.println("Above three!");
              break;
    } } }
```

Natural integers and **int**

Difference between mathematics (**infinite precision**) and computing.

Computing: **discrete algorithms** working on **finite representations**
of numbers

Source of many bugs !!!

Typically, an algorithm can be correct but its implementation buggy because of *numerical errors*.

int: maximum machine-representable int is $2^{31}-1$
(in the old days, written as $2^{**31}-1$)

long: maximum machine-representable long is $2^{63}-1$

Overflow problems...

A toy example



```
overint.java
1 class overint{
2
3     public static void main(String[] args)
4     {
5
6         int n=64;
7
8         long s=1;
9         int i;
10
11         for(i=1; i<=n; i=i+1)
12         { s=2*s;
13           System.out.println(i+": "+s);
14         }
15     }
16
17
18
19 }
```

```
C:\PROGRA~1\XINOS~1\JCREAT~1\G
41:2199023255552
42:4398046511104
43:8796093022208
44:17592186044416
45:35184372088832
46:70368744177664
47:140737488355328
48:281474976710656
49:562949953421312
50:1125899906842624
51:2251799813685248
52:4503599627370496
53:9007199254740992
54:18014398509481984
55:36028797018963968
56:72057594037927936
57:144115188075855872
58:288230376151711744
59:576460752303423488
60:1152921504606846976
61:2305843009213693952
62:4611686018427387904
63:-9223372036854775808
64:0
Press any key to continue...
```

Computes 2^s , but at some point 2^{64} cannot fit 64-bit, we get first

- negative number (leading bit set to 1 by the arithmetic logic unit - ALU)
- then zero!!!!

Overflow problems: revisited

Increment:
i++
or
++i

```
overint2.java
1 class overint2{
2
3     public static void main(String[] args)
4     {
5
6         int n=64;
7         long s=1;
8
9
10        for(int i=1; i<=n; i++)
11        {
12            s=s<<1; // bit operation
13            System.out.println(i+": "+s);
14        }
15    }
16
17
18
19 }
```

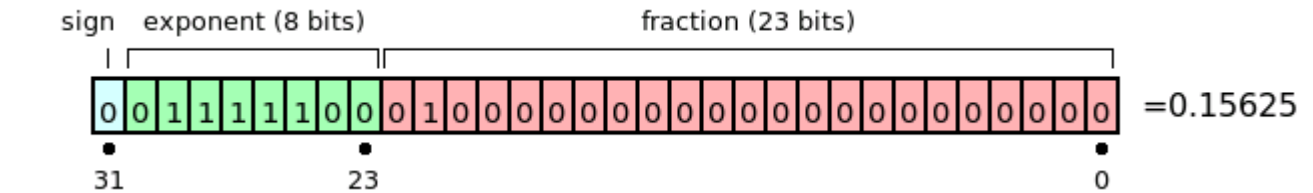
Declaration
inside the For

Multiplication is just
a *bit shift* << to the right

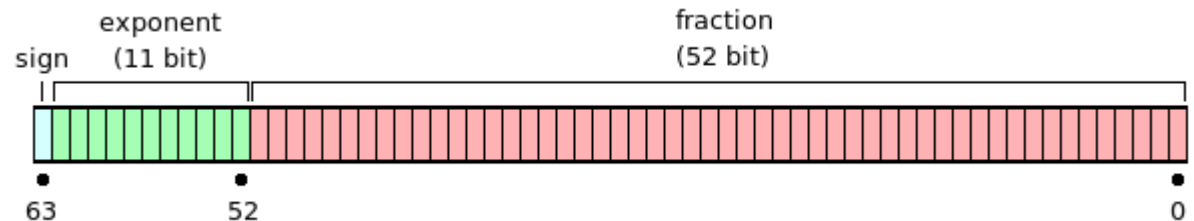
```
C:\PROGRA~1\XINOS~1\JCREAT~1\GE
41:2199023255552
42:4398046511104
43:8796093022208
44:17592186044416
45:35184372088832
46:70368744177664
47:140737488355328
48:281474976710656
49:562949953421312
50:1125899906842624
51:2251799813685248
52:4503599627370496
53:9007199254740992
54:18014398509481984
55:36028797018963968
56:72057594037927936
57:144115188075855872
58:288230376151711744
59:576460752303423488
60:1152921504606846976
61:2305843009213693952
62:4611686018427387904
63:-9223372036854775808
64:0
Press any key to continue...
```

Floating points & numerical precisions

32-bit IEEE 754 floating point.



64-bit IEEE 754 floating point.



- **float** (32-bit) or **double** (64-bit) have sign, exponent and matissa parts
- Examples: float a=0.3; float b=2e-8 (scientific engineering); float c=1.1f;
- Math class contains important "constants": Math.PI, Math.E, etc. and transcendental functions: Math.log(), Math.exp(), Math.sin(), Math.cos()

```
mathfunc.java |
1 class transfunc{
2
3   public static void main (String[] args)
4   {
5
6     System.out.println(Math.log(Math.E));
7     System.out.println(Math.cos(Math.PI));
8
9   }
10
11 }
```

C:\PROGRA~1\XINXS~1\CREAT~1\GE2001.exe
1.0
-1.0
Press any key to continue...

http://en.wikipedia.org/wiki/IEEE_floating-point_standard

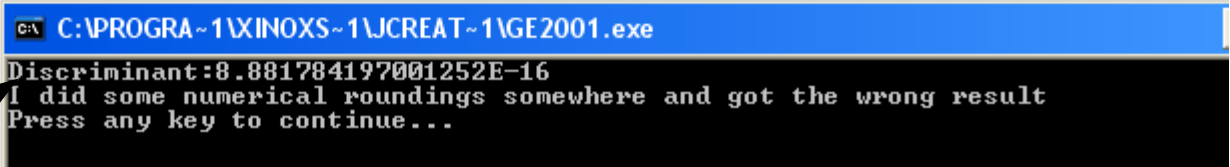
Loosing numerical precision...

A bug

$$ax^2 + bx + c = 0,$$

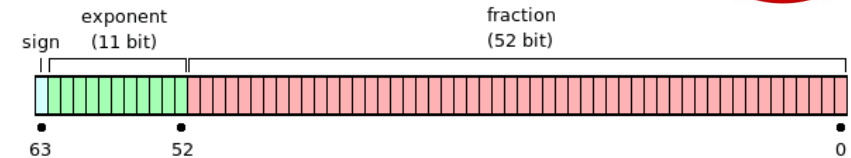
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a},$$

```
doubleprecision.java |
1 class doublepres{
2
3     public static void main (String[] args)
4     {
5         double a,b,c,d;
6
7         a=0.3;
8         b=2.1;
9         c=3.675;
10
11
12         // determinant:  $\Delta = b^2 - 4ac$ ,
13         d=b*b-4.0*a*c;
14
15         System.out.println("Discriminant: "+d);
16
17         if (d==0.0) System.out.println("Correct computation: double roots (discriminant is zero)");
18         else System.out.println("I did some numerical roundings somewhere and got the wrong result");
19
20     }
21 }
22
```



Usually, difficult to
test for the zero
(use threshold or better analysis)

Loosing associativity rule



Rounding & truncations to fit the standard yields the loss of associativity

```
looseassoc.java
1 class looseassoc{
2
3     public static void main (String[] args)
4     {
5         double x,y,z;
6         double u,v;
7
8         x=1.0e35; y=-1.0e35; z=-1.0;
9
10        u=x+(y+z); // overflow
11        v=(x+y)+z; // does not refit the mantissa
12
13        System.out.println("Value of u is:"+u);
14        System.out.println("Value of v is:"+v);
15    }
16 }
17 }
```

```
C:\PROGRA~1\XINXS~1\JCREAT~1\GE2001.exe
Value of u is:0.0
Value of v is:-1.0
Press any key to continue...
```

Better to add numbers having already the same exponent decomposition...

Computing Euler-Mascheroni 's constant

$$\gamma = \lim_{n \rightarrow \infty} \left[\left(\sum_{k=1}^n \frac{1}{k} \right) - \log(n) \right] = \int_1^{\infty} \left(\frac{1}{[x]} - \frac{1}{x} \right) dx.$$

$$\lim_{n \rightarrow \infty} (H_n - \ln n),$$

```
euler.java
1 class euler
2 {
3     public static void main (String[] args)
4     {
5         double cumul=0.0;
6         int n=1000000;
7         double ti;
8
9         for(int i=1;i<=n;i++)
10        {
11            ti=(double) i; // cast: We change format of numbers!!!
12            cumul=cumul+1.0/ti;
13        }
14
15        double gamma=cumul-Math.log(n);
16
17        System.out.println("Euler's constant:"+gamma);
18    }
19 }
20 }
```

```
C:\PROGRA~1\XINXS~1\JCREAT~1\GE2001.exe
Euler's constant:0.5772161649007153
Press any key to continue...
```

Number of known decimal digits of γ

Date	Decimal digits	Computation performed by
1734	5	Leonhard Euler
1736	15	Leonhard Euler



December 8, 2006	116,580,041	Alexander J. Yee ^[5]
July 15, 2007	5,000,000,000	Shigeru Kondo (claimed) ^[6]

Types and conversions: Cast operator

- All variables and constants are typed: Math.PI is a (static) double
- Variables should be declared according to their type: double x; int i; etc
- The type of variable **determines** the operator and meaning:
Exempla gratia, 3.0+2.1 (double) or "Hello "+" INF311" (String)
- The expression is also typed (by the compiler)
- For **assignment =**, the left-hand side (variable) and right-hand side (expression) should have the **same type**.

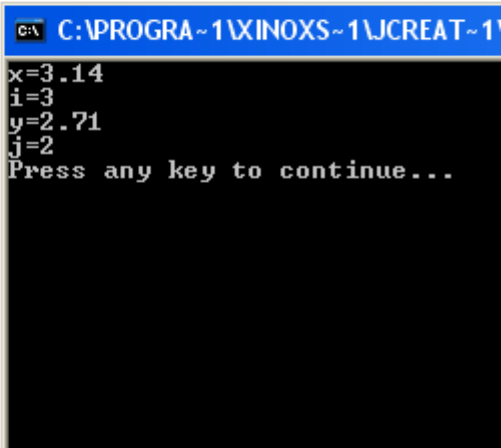
Casting types
with parenthesis (type):

double x=3.14;

int i=(int)x;

double x=(double)i;

```
casting.java
1 class casting{
2
3     public static void main(String[] args)
4     {
5         double x=3.14;
6         int i=(int)x;
7
8         System.out.println("x="+x);
9         System.out.println("i="+i);
10
11         // Does not round but truncate
12         double y=2.71;
13         int j=(int)y;
14
15         System.out.println("y="+y);
16         System.out.println("j="+j);
17
18     }
19
20 }
```



The screenshot shows a Windows command prompt window with the title "C:\PROGRA~1\XINXS~1\JCREAT~1". The output of the Java program is displayed as follows:

```
x=3.14
i=3
y=2.71
j=2
Press any key to continue...
```

Converting strings to numbers...

Use `Type.parseType(String stringtoparse)`

```
convertstring.java
1 class convertstring{
2
3     public static void main (String[] args){
4
5         String s1="23122008";
6         String s2="1234567890123456"; // if it is too long, it will produce an error!
7         String s3="6.02214179E-23";
8
9         // Parse strings to number according to selected type
10        int i=Integer.parseInt(s1);
11        long j=Long.parseLong(s2);
12        double x=Double.parseDouble(s3);
13
14        // Here, we do the converse: numbers to strings
15        System.out.println(i);
16        System.out.println(j);
17        System.out.println(x);
18
19    }
20 }
```

```
C:\PROGRA~1\XINXS~1\JCREAT~1\GE2001.exe
23122008
1234567890123456
6.02214179E-23
Press any key to continue...
```

A glimpse at **functions**



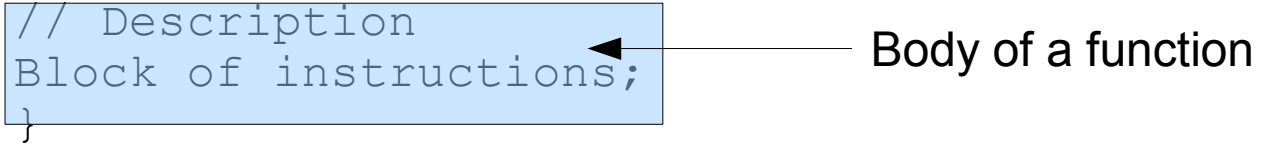
Declaring functions in Java

```
class INF311{  
  
    public static  typeF F(type1 arg1, ..., typeN argN)  
    {  
        // Description  
        Block of instructions;  
    }  
}
```

- This kind of function is also called a **static method**
- Functions must be defined **inside classes**
- A function not returning a result has type **void**
(also known as a procedure)

Defining the body of a function in Java

```
class INF311{  
    public static typeF F(type1 arg1, ..., typeN argN)  
    {  
        // Description  
        Block of instructions;  
    }  
}
```



Body should contain an instruction return to indicate the result
If branching structures are used (if or switch) ,
then a return should be written for all different branches.

Otherwise we get a compiler error! (why? => not type safe!)

A few examples of basic functions

```
class FuncDecl{
    public static int square(int x)
        {return x*x;}

    public static boolean isOdd(int p)
        {if ((p%2)==0) return false; else return true;}

    public static double distance(double x, double y)
        {if (x>y) return x-y; else return y-x;}

    public static void display(double x, double y)
        {System.out.println("(" + x + ", " + y + ")");
         return; // return void
        }

    public static void main (String[] args)
    {
        display(square(2), distance(5, 9));

        int p=123124345;
        if (isOdd(p)) System.out.println("p is odd");
        else System.out.println("p is even");
    }
}
```