Quick review – Giving an output

```
// Give some output:
System.out.println("In this computer light travels "
 + number*1000*299792.458 + " meters per second.");
```

Quick review – Switching values

```
int tmp1 = a;
int tmp2 = b;
a = tmp2;
b = tmp1;

int tmp = a;
a = b;
b = tmp;
```

Quick review – Basic structure

```
public class MyProgram {

  public static void method() {
     // Body of the method

  }

  public static void main(String[] args) {
    // Body of the main method

  }
}
```

Quick review – Methods

Methods are named modules of code. Their syntax is:

<scope-indicator> <return-indicator> <name>(<parameter list>)

{ <body of the method>}

where

<scope-indicator> can be private, public, static, etc.;

<return-indicator> can be some data type or void.

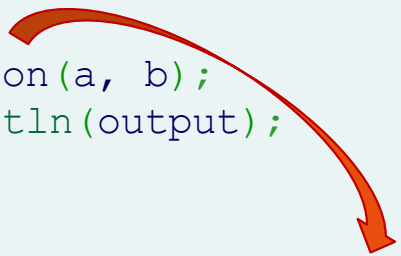
<name> is the name of the method. It can be any valid Java identifier.

<parameter list> is a list of declarations of variables used;

<body of the method> is a list of valid Java statements. **If <return-indicator> is some data type, then <body of the method> has to contain return statement!**

Quick review – Example: Method

```
public static void main(String[] args) {
    double output;
    int a = 12;
    int b = 3;
    output = division(a, b);
    System.out.println(output);
}

public static double division (int dividend, int divisor)
{
    double result;
    result = dividend/divisor;
    return result;
}
```



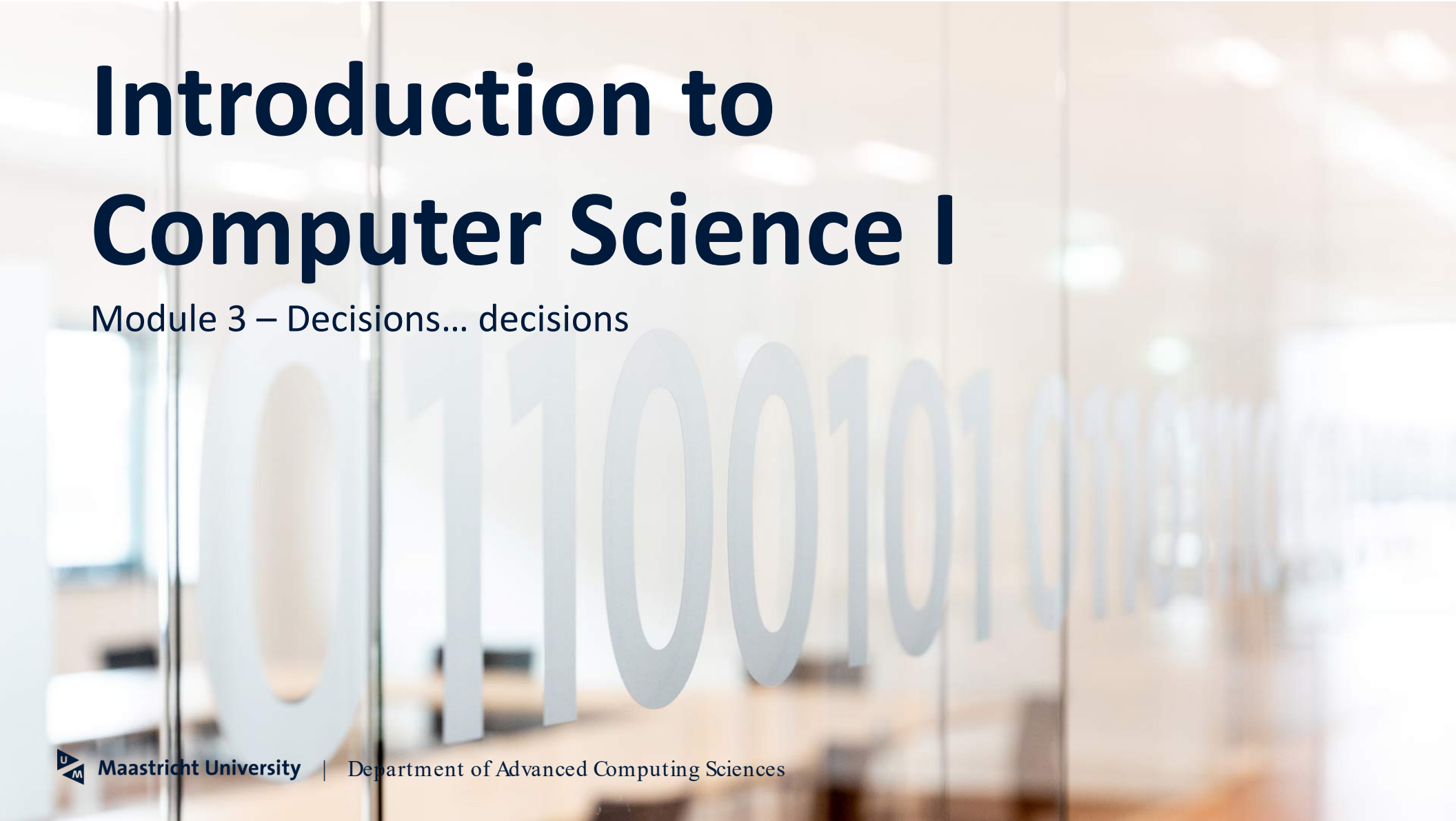
Quick review – Example: Variable scope

- We can use the same variable name with different scopes depending on where it is declared

```
public class Main {
  static int a; // Global variable: Class level scope

  public static void myMethod() {
    int a;  // Local variable: Method (myMethod) level scope
  }

  public static void main(String[] args) {
    int a;  // Local variable: Method (main) level scope

  }
}
```

Introduction to Computer Science I

Module 3 – Decisions… decisions

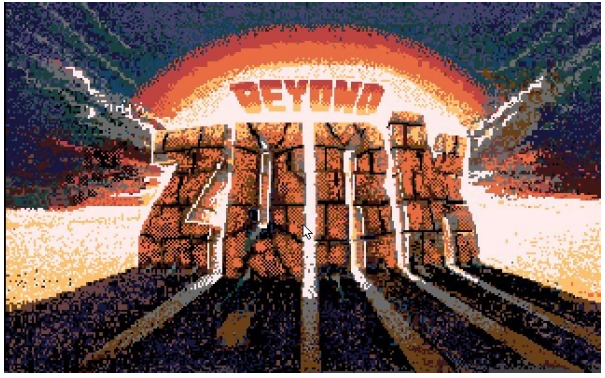


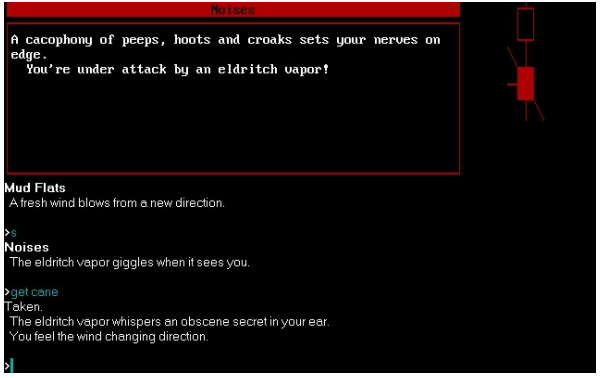
Maastricht University | Department of Advanced Computing Sciences

Overview

- Control flow
- Flowcharts
- if, if-else, if-else-if
- Conditions
  - Boolean expressions
  - Lazy evaluation
- Switch-case
- Enumerated Types
- Tracing and logging
- BONUS TRACKS:
  - More on Scanner
  - More on String

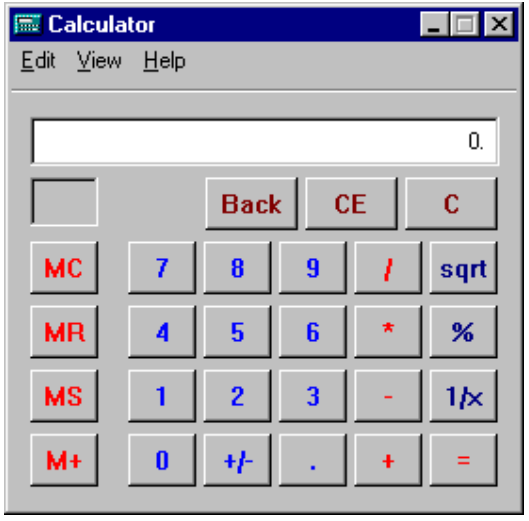
Control Flow





Control Flow

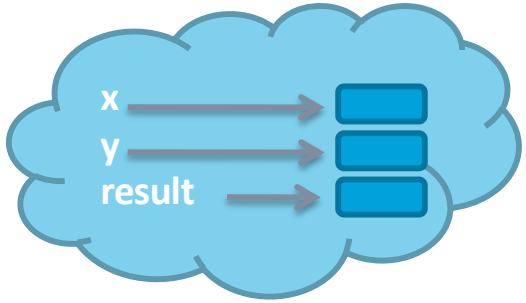
Your amazing DIY software
to perform
basic mathematical operations



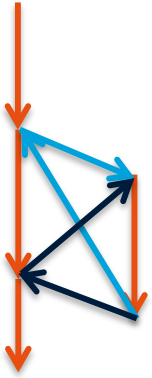

```
if key_pressed is “+” then
     result = a + b
else if key_pressed is “-” then
     result = a - b
…
```

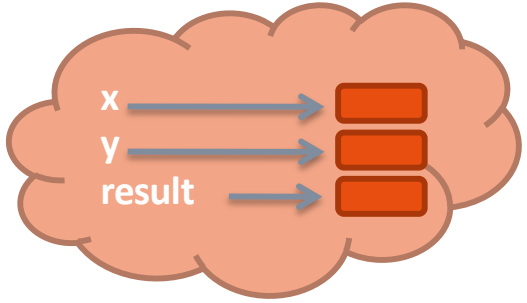
Pseudo-code!

Control Flow – Refreshing your knowledge



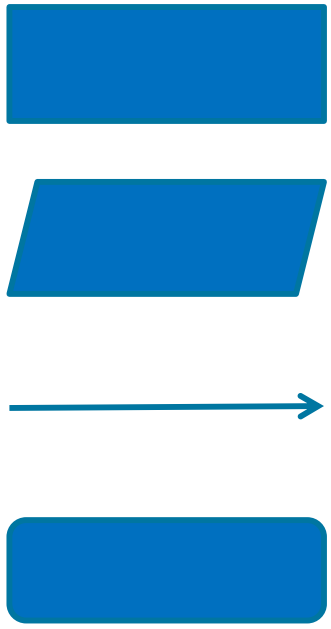

```
public static void main(String[] args) {
    double x = 5.0;
    double y = 12.3;
    double result = function(x,y);
    System.out.println("The functionvalue at");
    System.out.println("the point (" + x + "," + y + ")");
    System.out.println("is " + result);

    x = -15;
    y = 2.34;
    result = function(x,y);
    System.out.println("The functionvalue at");
    System.out.println("the point (" + x + "," + y + ")");
    System.out.println("is " + result);

}

public static double function(double x, double y) {
    double result;
    result = Math.exp(x) + y*y;
    return result;
}
```



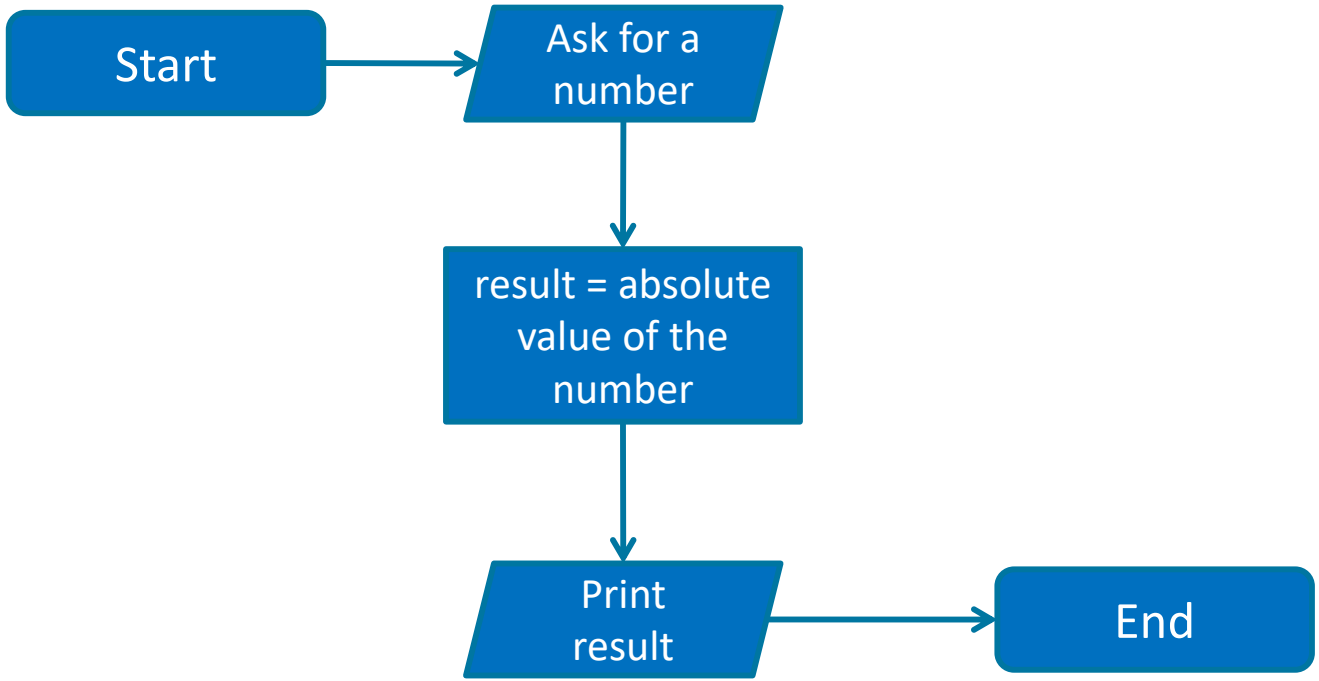


Flowcharts

- Generic steps
- Input/Output
- Arrows: control flow
- (Begin and end symbols)

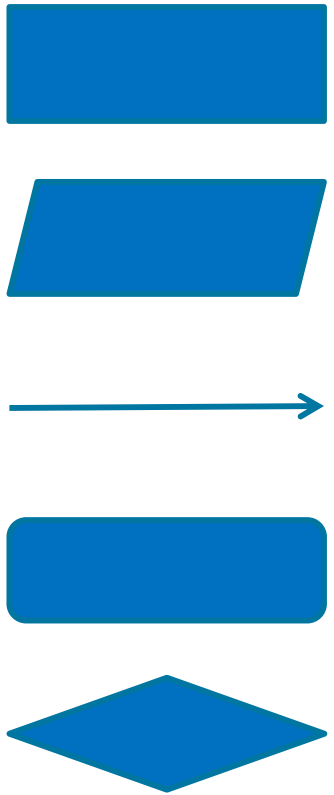


Example flowchart

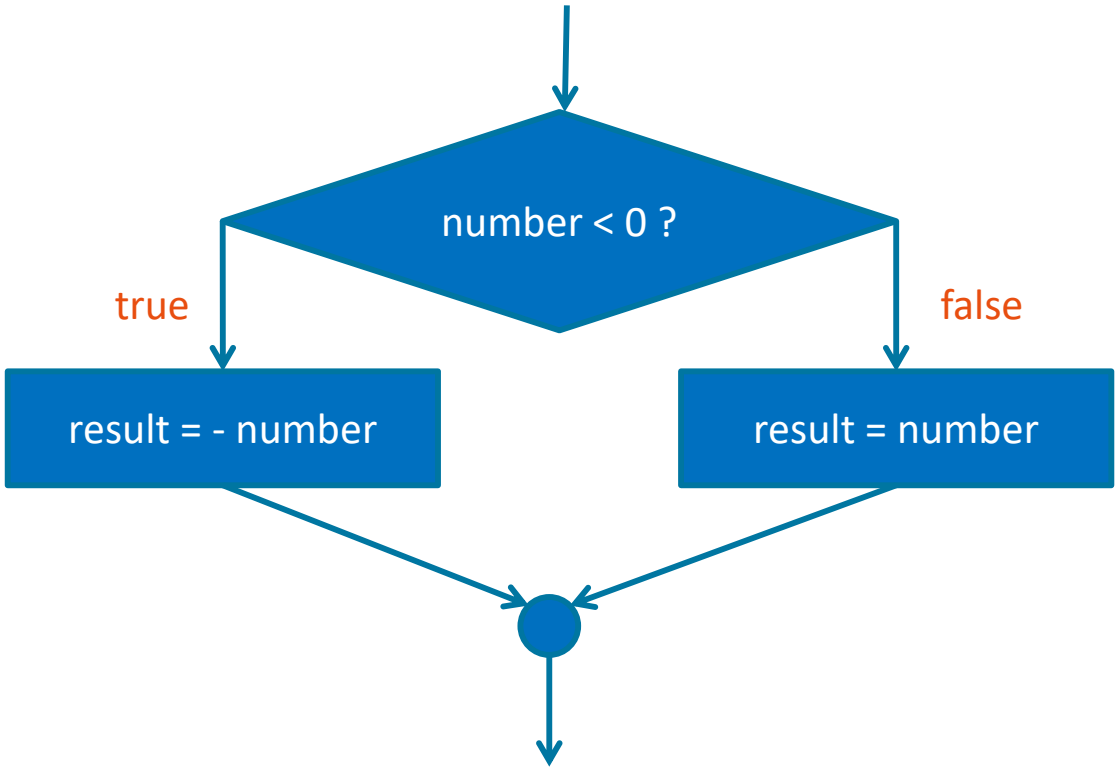


Flowcharts

- Generic steps
- Input/Output
- Arrows: control flow
- (Begin and end symbols)
- Condition

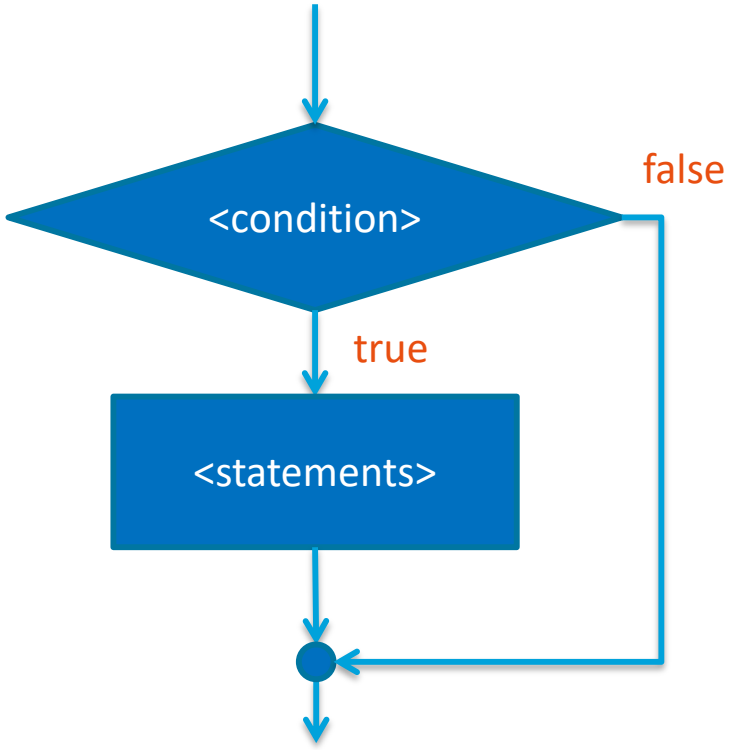


Conditional control flow



IF

Conditional execution of statements

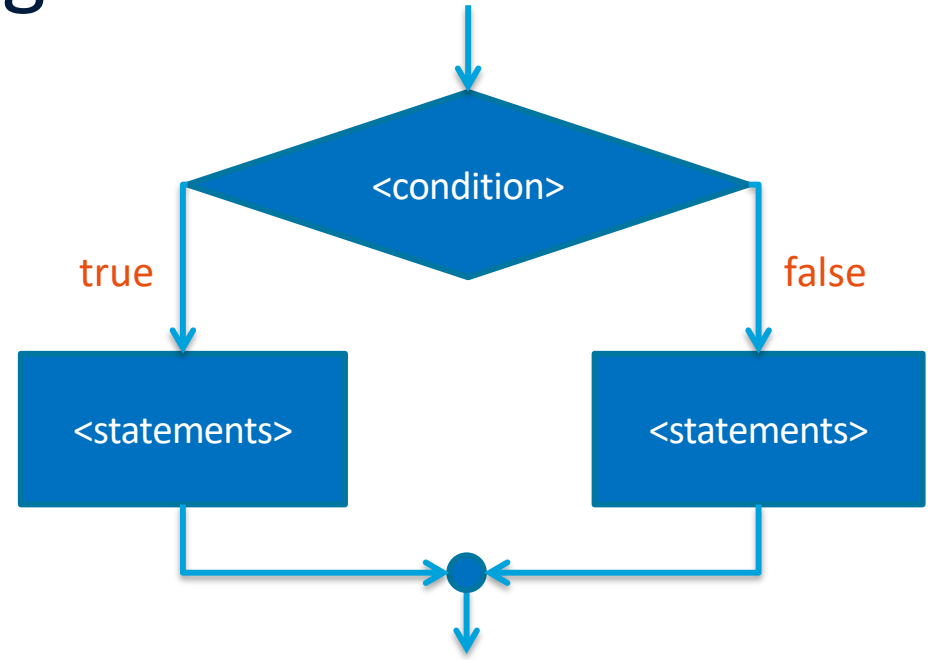



```
if (<condition>) {
    <statements>
}
```

```
if (password == "Help1234") {
    access_granted = true;
}
```

IF – ELSE

When there is also something to do under a failing condition




```
if (<condition>) {
    <statements>
} else {
    <statements>
}
```

Conditions

Boolean expressions
- Evaluate true or false

1. Boolean variables
2. Relational operators
   == != < <= > >=
3. Boolean operators
   && || !
4. Methods that return a Boolean value

Operator Precedence in Java:
https://introcs.cs.princeton.edu/java/11precedence/

E.g. (a != 4) && (b-5.6 <= a)

- Evaluation from left to right
- Importance of parenthesis

Example code

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

    Scanner in = new Scanner(System.in);
    double number = in.nextDouble();
    double result = 0.0;

    if (number >= 0){
        result = number;
    } else {
        result = -number;
    }
    System.out.println(result);
}
```

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

    Scanner in = new Scanner(System.in);
    double number = in.nextDouble();
    double result = 0.0;

    if (number >= 0)
        result = number;
    else
        result = -number;

    System.out.println(result);
}
```

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

    Scanner in = new Scanner(System.in);

    double result = in.nextDouble();

    if (result < 0)
        result = - result;

    System.out.println(result);
}
```

Floating point comparisons

Be careful with floating point precision!

```
double a = 2.0;
double b = Math.sqrt(a);

if (a == b*b) {
    System.out.println("Equal!");
} else {
    System.out.println("Not Equal!");
    System.out.println(a + " != " + b*b);
}
```

```
wopr: java$ java Main
Not Equal!
2.0 != 2.0000000000000004
wopr: java$
```

Floating point comparisons (2)

Solution: allow some error for doubles, use for example 1E-14

```
final double EPSILON = 1E-14;

double a = 2.0;
double b = Math.sqrt(a);

if (Math.abs(a - b*b) <= EPSILON) {
    System.out.println("Equal!");
} else {
    System.out.println("Not Equal!");
}
```

```
wopr: java$ java Main
Equal!
wopr: java$
```

String comparisons

Strings are not a basic type!

Do NOT use == to compare String type variables

Use the method “equals”:

```
String a = "Joe";
String b = "J";
b = b+"oe";
if (a == b) System.out.println("== works fine.");
else if (a.equals(b)) System.out.println("Better use equals");
else System.out.println("Typo?");
```

```
wopr: java$ java Main
Better use equals
wopr: java$
```

Pay attention to method call!!!!

String comparisons

```
String a = "Joe";

if (a == a) System.out.println("== works fine.");
else if (a.equals(a)) System.out.println("Better use
equals");
else System.out.println("Typo?");
```

But… wait. Why is this statement returning "*== works fine.*"?

Dolion
McMitchell

DACS
student = “Dolion”

Someone named
Dolion studies at DACS

Yes sir, Dolion works
here

student == employee
False

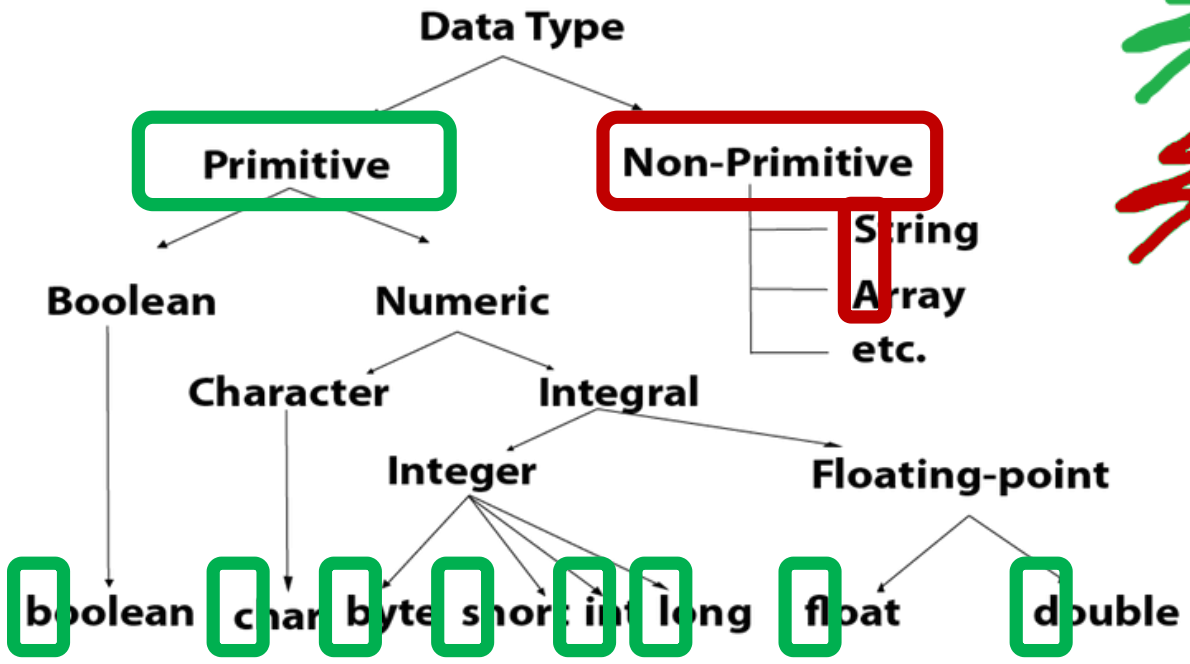
MASA
employee = “Dolion”

Mnemonic trick

==?

Yes

No



https://www.javatpoint.com/java-data-types

More String comparisons

...

if (a.equals(b))

- Checks equality

if (a.equalsIgnoreCase(b))

- Checks equality but ignores case differences

if (a.compareTo(b) < 0)
> 0
== 0

- Lexicographic ordering
  - < 0 ➔ a comes before b
  - > 0 ➔ b comes before a
  - == 0 ➔ a.equals(b) == true
  - (all capital letters come before non-capitals)

Check homework/quiz

Math.random()

Generates a (pseudo-)random double in

[0.0, 1.0 [

Can be used to make your program act stochastically.

E.g. execute code with 50% probability

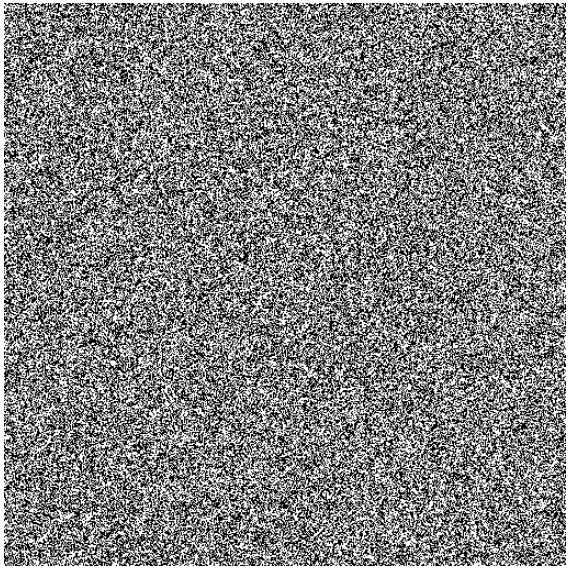
```
if (Math.random() < 0.5)
    ...
```

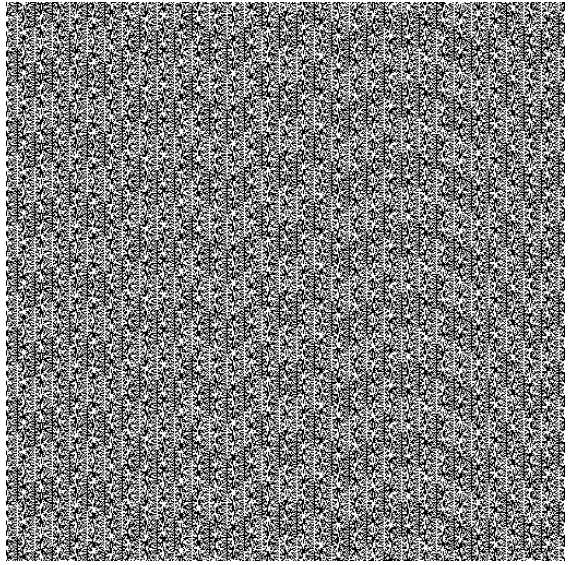
Why (pseudo-)random values?

- Computers are deterministic (its behaviour is completely predictable)
- They cannot generate random numbers
- Use of mathematical algorithms to produce “random enough” values
- Use of a seed as starting point (e.g. date)

Why (pseudo-)random values?

- Extreme example: Unfortunate combination of programming language, operating system, and function:





https://boallen.com/random-numbers.html

Multiple relational operators

```
if (0 < a < b)
```

Syntax error!

```
int a = 5;
int b = 8;
```

```
int a = 5;
int b = 3;
```

Why?

Trace the evaluation

1. `0 < a` => resolves to boolean
2. <boolean> < <int> => no such operator!

Combine multiple operators through && and ||

Instead:

```
if (0 < a && a < b)
```

or

```
if ((0 < a) && (a < b))
```

https://introcs.cs.princeton.edu/java/11precedence/

Boolean expression evaluation

… where being lazy can give you the best performance …

```
double a = 2.0;
double b = Math.sqrt(a);

if (a < 0.0 &&
    Math.abs(a - b*b) <= EPSILON &&
    b == Math.PI &&
    b <= a) {
```

Left to right evaluation;
stop as soon as possible!

```
if (a == 2.0 ||
    Math.abs(a - b*b) <= EPSILON ||
    b == Math.PI ||
    b <= a) {
```

Exploiting lazy evaluation

Division by 0

- runtime error that often can not be predicted

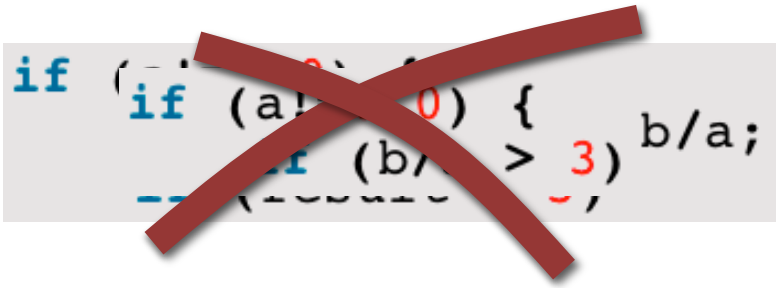
```
wopr: java$ java Division
Give divident
13
Give divisor
0.0
Exception in thread "main" java.lang.ArithmeticException: / by zero
        at Division.integerDivision(Division.java:25)
        at Division.main(Division.java:13)
wopr: java$
```

Avoid by testing:

```
if (a!=0.0) {

    result = b/a;
    ...
```

Exploiting lazy evaluation (2)

What if condition on the result?




```
if (a!=0.0 && b/a > 3) {
```

if == false then never executed

Nested conditionals

Conditional statements can appear as statements of conditional statements

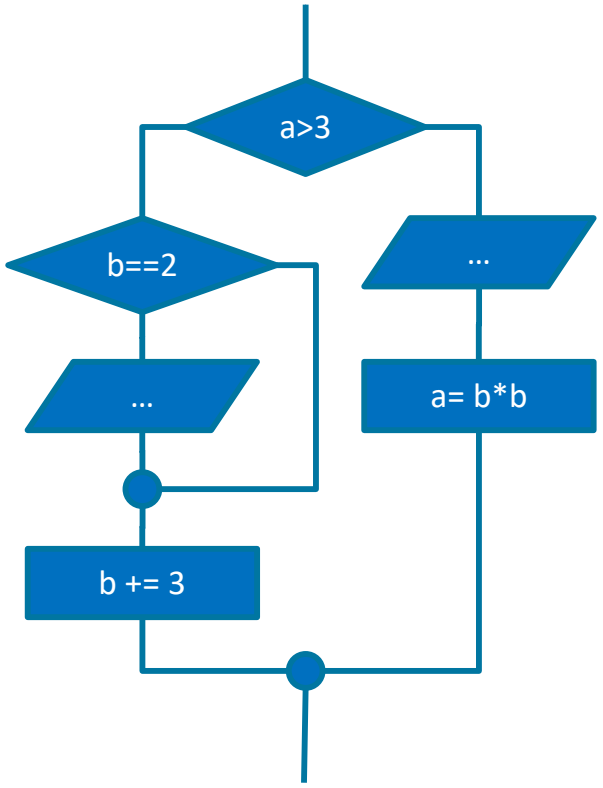
of conditional statements

of conditional statements

of conditional statements

of conditional statements

```
if (a > 3) {
    if (b == 2) {
        System.out.println(" ... ");
    }
    b +=3;
} else {
    System.out.println(" ... ");
    a = b*b;
}
```



Special Case: Decision List

When dealing with number of mutually exclusive conditions:

```
if (<condition>) {
    <statements>
} else {
    if (<condition>) {
        <statements>
    } else {
        if (<condition>) {
            <statements>
        } else {
            ...
        }
    }
}
```

```
if (<condition>) {
    <statements>
} else if (<condition>) {
    <statements>
} else if (<condition>) {
    <statements>
} else if (<condition>) {
...
}
```

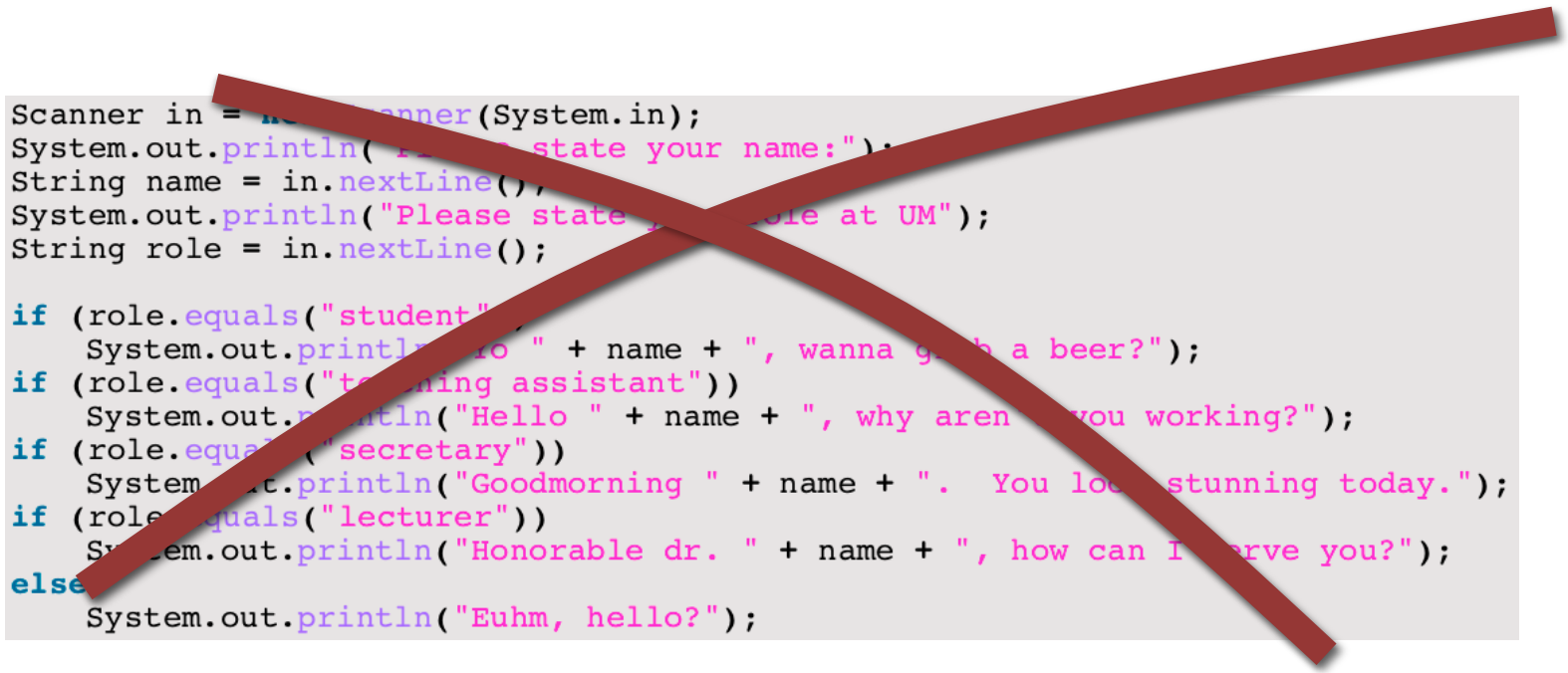
An example

```
Scanner in = new Scanner(System.in);
System.out.println("Please state your name:");
String name = in.nextLine();
System.out.println("Please state your role at UM");
String role = in.nextLine();

if (role.equals("student")) {
    System.out.println("Yo " + name + ", wanna grab a beer?");
} else if (role.equals("teaching assistant")) {
    System.out.println("Hello " + name + ", why aren't you working?");
} else if (role.equals("secretary")) {
    System.out.println("Goodmorning " + name + ".  You look stunning today.");
} else if (role.equals("lecturer")) {
    System.out.println("Honorable dr. " + name + ", how can I serve you?");
} else {
    System.out.println("Euhm, hello?");
}
```

An example simplified

```
Scanner in = new Scanner(System.in);
System.out.println("Please state your name:");
String name = in.nextLine();
System.out.println("Please state your role at UM");
String role = in.nextLine();

if (role.equals("student"))
    System.out.println("Yo " + name + ", wanna grab a beer?");
else if (role.equals("teaching assistant"))
    System.out.println("Hello " + name + ", why aren't you working?");
else if (role.equals("secretary"))
    System.out.println("Goodmorning " + name + ".  You look stunning today.");
else if (role.equals("lecturer"))
    System.out.println("Honorable dr. " + name + ", how can I serve you?");
else
    System.out.println("Euhm, hello?");
```

More simplification



Switch – case

Special case decision list: Tests equality

```
System.out.println("Choose from menu:");
int choice = in.nextInt();
if (choice == 1)
    doMenu1();
else if (choice == 2)
    doMenu2();
else if (choice == 3)
    doMenu3();
else if (choice == 4)
    doMenu4();
else
    doTheDefault();
```

```
switch (choice) {
case 1: doMenu1(); break;
case 2: doMenu2(); break;
case 3: doMenu3(); break;
case 4: doMenu4(); break;
default: doTheDefault(); break;
}
```

Can use

- byte, short, int, long and char
- Strings (since Java 7)
- Enumerated types
- Some wrapper classes

Enumerated Types

Since Java 5.0, you can declare your own enumerated types

```
public enum <typeName> {<value1>, …, <valueN>}
```

```
public class Schedule {
  public enum WeekDay {Monday, Tuesday, Wednesday, Thursday,
Friday};

  public static void main(String[] args) {
// ...
    WeekDay today = WeekDay.Wednesday;
// ...
    System.out.println("Today is " + today);
    System.out.println("Today is " + today.name());
    System.out.println("Today is " + today.ordinal());
  }
}
```

```
Today is Wednesday
Today is Wednesday
Today is 2
```

Switch –case with enumerated type

```
enumOperation{PLUS, MINUS, TIMES, DIVIDE}

public static void main(String[] args){
     int op1=10;
     int op2=2;
     Operation myOp = Operation.TIMES;

     System.out.println("The result of the " + myOp + " operation is ");

     switch(myOp){
          case PLUS:     System.out.println(op1+op2);  break;
          case MINUS:    System.out.println(op1-op2);  break;
          case TIMES:    System.out.println(op1*op2);  break;
          case DIVIDE:   System.out.println(op1/op2);  break;
     }
}
```

On breaking and falling through

```
switch (choice) {
case 1: System.out.println("1"); break;
case 2: System.out.println("2"); break;
case 3: System.out.println("3"); break;
case 4: System.out.println("4"); break;
default: System.out.println("D"); break;
}
```

(choice == 2) causes "2" to be printed

```
switch (choice) {
case 1: System.out.println("1");
case 2: System.out.println("2");
case 3: System.out.println("3");
case 4: System.out.println("4");
default: System.out.println("D");
}
```

(choice == 2) causes "2", "3", "4" and "D" to be printed

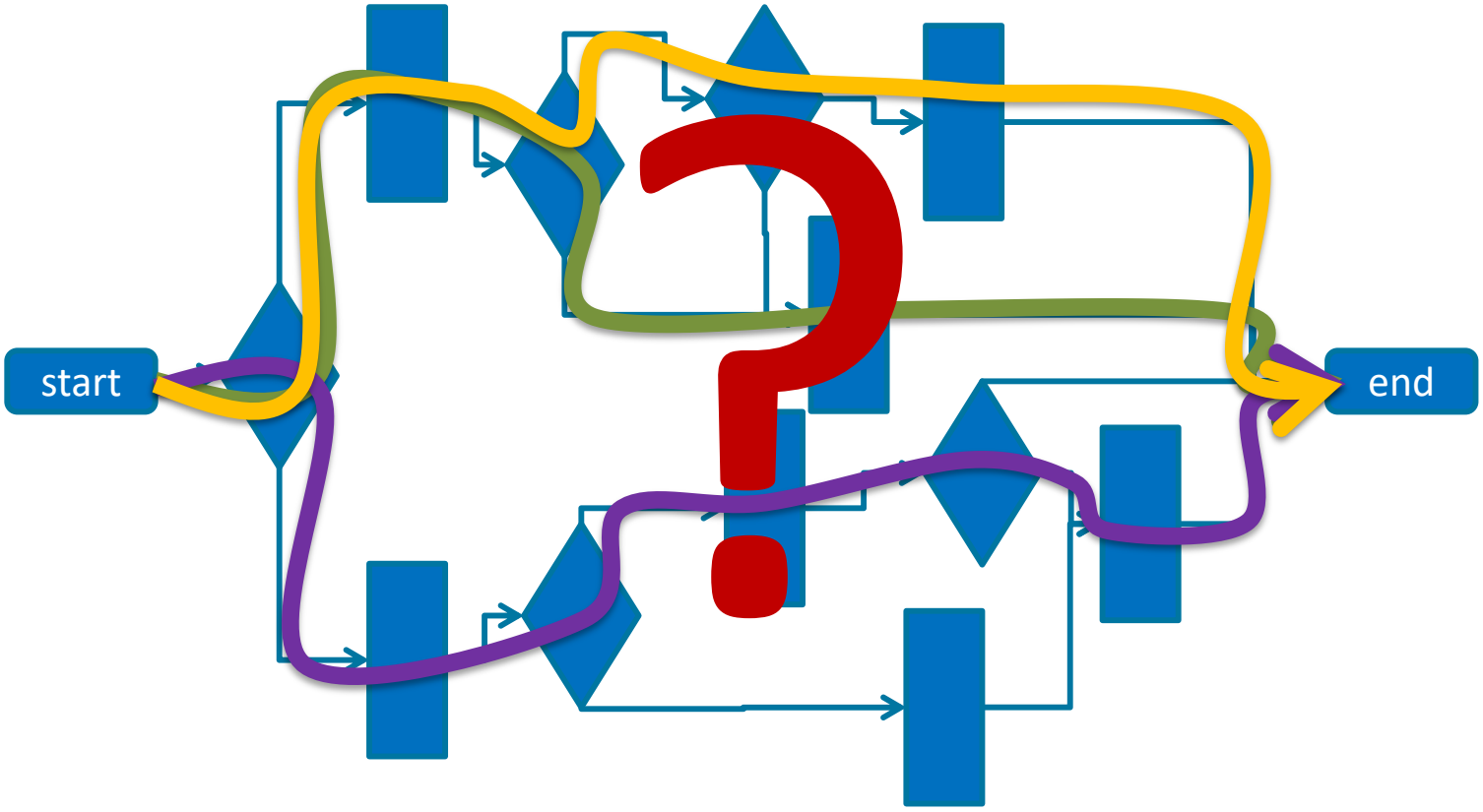
break; ends the executing of the switch and jumps to end

Not using **break;** causes a "*fallthrough*" where all code is executed from the successful case onwards

Sometimes using **break;** and sometimes not is possible

```
public class Main{
	public static void main(String[] args){
		int position=1;

		switch(position){
		case1:
			System.out.println("Your team won the tournament");
		case2:
		case3:
			System.out.println("Your team will move into the next division");
			break;
		case4:
		case5:
		case6:
			System.out.println("Your team will play in this division next season");
			break;
		case7:
		case8:
		case9:
			System.out.println("Your team will descend for the next season");
			break;
		default:
			System.out.println("Invalid position");
		break;
		}
	}
}
```

Tracing



Tracing (2)

Following the execution flow by hand

- Write out values of variables
- Evaluate conditions by hand
- Follow the control flow as defined by your program

Very informative procedure

Can be a lot of work, and next to impossible for large programs

Logging

Using **print** and **println** statements to track program executing

```
...
if (choice == 5) {
    System.out.println("Choice is 5");
    ...
}
...
```

- need to be removed at the end
- there are ways around this

```
final boolean DEBUG = true;
...
if (choice == 5) {
    if (DEBUG) System.out.println("Choice is 5");
    ...
}
...
```

More on Scanner

Entering a line of input:

1 2 3 4 5 6 7 8 99 <enter>

- nextInt(), nextDouble(), next() only read until space
- hasNextInt(), hasNextDouble(), hasNext() check to see if there is a next item (of the correct form) available
  - always returns a boolean: true or false

More on String

More methods can be called on Strings
similar to equals(String a) and compareTo(String a)

- startsWith(String a) returns boolean
- endsWith(String a) returns boolean
- length() returns int
- charAt(int index) returns char; starts counting from 0 to length()-1!
- substring(int begin, int end) returns String; again counting from 0!

You can practice some of them in codingbat (warmup2)

Example

```
public class StringFun {

    public static void main(String[] args) {

        String a = "Apple";
        String b = "Microsoft";

        if (a.startsWith("App"))
            System.out.println("Apple started with Apps.");

        String c = b.substring(2,6);

        System.out.print("The string " + c);
        System.out.println(" contains " + c.length() + " characters");
        System.out.print("of which " + c.charAt(c.length()-1));
        System.out.println(" is the last.");
    }
}
```

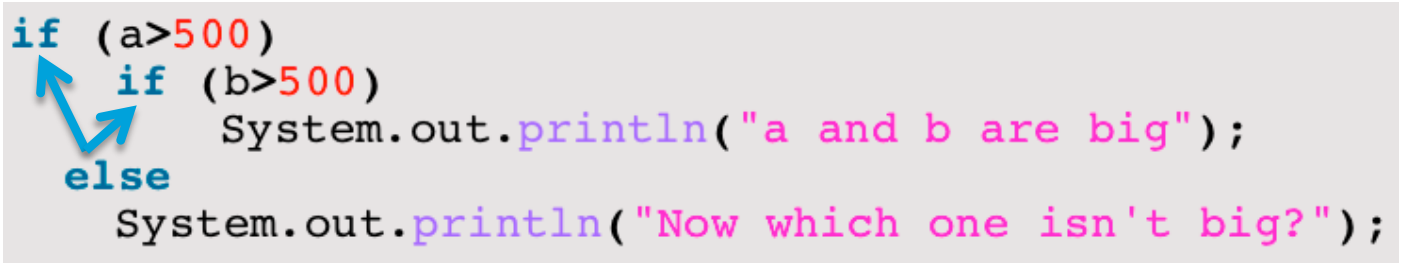
```
wopr: java$ javac StringFun.java
wopr: java$ java StringFun
Apple started with Apps.
The string cros contains 4 characters
of which s is the last.
wopr: java$
```

Problem with Scanner and Doubles

```
import java.util.Scanner;  // Import the Scanner class
import java.util.Locale;

public class Main {
  static int a; // Global variable: Class level scope

  public static void main(String[] args) {
    double a;  // Local variable: Method (main) level scope
    Scanner scanner = new Scanner(System.in);
    Locale locale = Locale.US;
    scanner.useLocale(locale);
    System.out.println("Enter a number: ");

    a = scanner.nextDouble();
    System.out.println("Your number was: " + a);

  }
}
```

Frequent Errors

1. Dangling else



Correct syntax, but bad form!

Use { and } for clarity!

Frequent Errors (2)

2. < or <= ?

   Don’t forget to think when programming.

   Don’t simply use trial and error.

```
if (a < 2)    ≡    if (!(a >= 2))
```

Frequent Errors (3)

3. Incorrect use of && and ||

```
if (a == 2 || 3 || 5 || 7)
    System.out.println("a is prime and a < 10");
```

```
Main.java:6: error: bad operand types for binary operator '||'
    if(a == 2 || 3 || 5 || 7)
              ^
  first type:  boolean
  second type: int
1 error
compiler exit status 1
```

```
if (a == 2 || a == 3 || a == 5 || a == 7)
    System.out.println("a is prime and a < 10");
```

Frequent Errors (4)

4. Confusing && and || in long expressions
   E.g. De Morgan's Law

$$not(A \vee B) = not(A) \wedge not(B)$$
$$not(A \wedge B) = not(A) \vee not(B)$$

in Java

```
!(a || b)     (!a && !b)

!(a && b)     (!a || !b)
```

Don't forget to think!

Short exercise

```
!(a || b) ==  (!a && !b)

!(a && b) ==  (!a || !b)
```

	!(a || b)	(!a && !b)	!(a && b)	(!a || !b)
a = true b = true	false	false	false	false
a = true b = false	false	false	true	true
a = false b = true	false	false	true	true
a = false b = false	true	true	true	true

Frequent Errors (5)

5. In decision lists, it is the combination of order and conditions that defines the semantics

```
if (numberOfBeers < 1)
    System.out.println("Feel free to drive");
else if (numberOfBeers < 8)
    System.out.println("Feel free to ride with me");
else if (numberOfBeers < 16)
    System.out.println("Try not to be sick on the bus");
else if (numberOfBeers < 32)
    System.out.println("I think you might have a problem");
else
    System.out.println("The paramedics have been called");
```

```
if (numberOfBeers < 32)
    System.out.println("I think you might have a problem");
else if (numberOfBeers < 16)
    System.out.println("Try not to be sick on the bus");
else if (numberOfBeers < 8)
    System.out.println("Feel free to ride with me");
else if (numberOfBeers < 1)
    System.out.println("Feel free to drive");
...
```