Floating point numbers, methods and arrays

Repeat ..

```
/**
 * Check for primes, simple version ...
 */
public class Primes {
   public static void main(String[] args) {
      int maxPrime = 1000;
      // iterate candidates
      for (int candidate = 3; candidate <= maxPrime; candidate++) {
         boolean isPrime = true;
         // iterate potential dividers
         for (int divider = 2; divider < candidate; divider++) {
            // check for division without rest
            if (candidate % divider == 0) {
               isPrime = false;
            }
         }
         if (isPrime)
            System.out.println("prime = " + candidate);
      }
   }
}
```

- Find prime numbers < maxPrime

Floating Point Numbers

- Two data types
  - float ... 32 Bit precision (24/8 in Java 8)
  - double ... 64 bit precision (53/11 in Java 8)
- Syntax

```
FloatConstant = [Digits] "." [Digits] [Exponent] [FloatSuffix].
Digits = Digit {Digit}.
Exponent = ("e" | "E") ["+" | "-"] Digits.
FloatSuffix = "f" | "F" | "d" | "D".
```

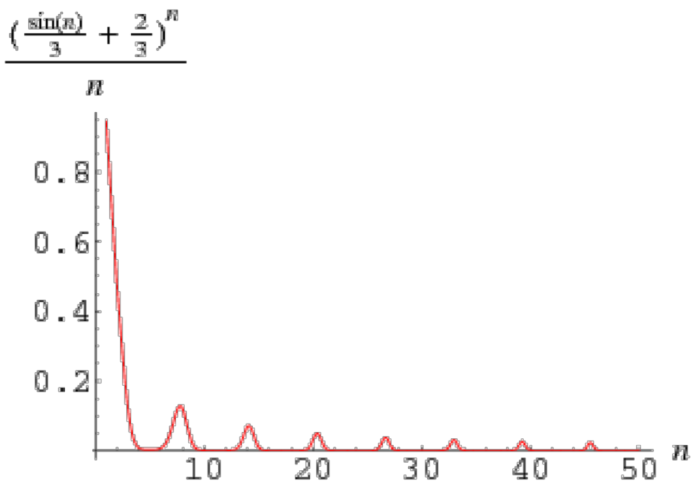
Floating Point Numbers

- **Variables**
  - float x, y;
  - double z;
- **Constants**
  - 3.14 // type double
  - 3.14f // type float
  - 3.14E0 // 3.14 * 10^0
  - 0.314E1 // 0.314 * 10^1
  - 31.4E-1 // 31.4 * 10^{-1}
  - .23
  - 1.E2 // 100

Harmonic Series

```
public class HarmonicSequence {
    public static void main (String[] arg) {
        float sum = 0;
        int n = 10;
        for (int i = n; i > 0; i--)
            sum += 1.0f / i;
        System.out.println("sum = " + sum);
    }
}
```

- Exchanging 1.0f / i what would happen?
  - 1 / i ... 0 (integer divison)
  - 1.0 / i ... a double value



Float vs. Double

```
public class HarmonicSequence {
    public static void main (String[] arg) {
        float sum = 0;
        int n = 10;
        for (int i = n; i > 0; i--)
            sum += 1.0f / i;
        System.out.println("sum = " + sum);
    }
}
```

```
public class HarmonicSequence {
    public static void main (String[] arg) {
        double sum = 0;
        int n = 10;
        for (int i = n; i > 0; i--)
            sum += 1.0d / i;
        System.out.println("sum = " + sum);
    }
}
```

Assignments and Operations

- Type compatibility
  - double $\supseteq$ float $\supseteq$ long $\supseteq$ int $\supseteq$ short $\supseteq$ byte
- Operators possible
  - Arithmetic operators (+,-,*,/)
  - Comparison (==, !=, <, <=, >, >=)
    Note! Do not check floating point values for equality!

Assignments and Casts

```
float f; int i;
f = i;     // works
i = f;     // does not work
i = (int) f;   // works, but cuts after comma;
           // too large or too small lead to
           // Integer.MAX_VALUE, Integer.MIN_VALUE
f = 1.0;   // does not work, 1.0 is type double
```

Review: Data Types

- Integer Types: `byte, short, int, long`
- Floating point types: `float, double`
- Characters / Text: char, `String`
- Boolean: `boolean`

See also https://docs.oracle.com/javase/tutorial/java/nutsandbolts/datatypes.html

Review: Data Types

- Integer expressions are of type `int`
  - ie. byte, short, ...
- Floating point and scientific number expressions are type `double`
- Explicit type with suffix
  - „L“ or „l“ -> `long`
  - „d“ -> `double`
  - „f“ -> `float`

Review: Data Types

Data Type	Default Value (for fields)
byte	0
short	0
int	0
long	0L
float	0.0f
double	0.0d
char	'\u0000'
String (or any object)	null
boolean	false

Review: Data Types

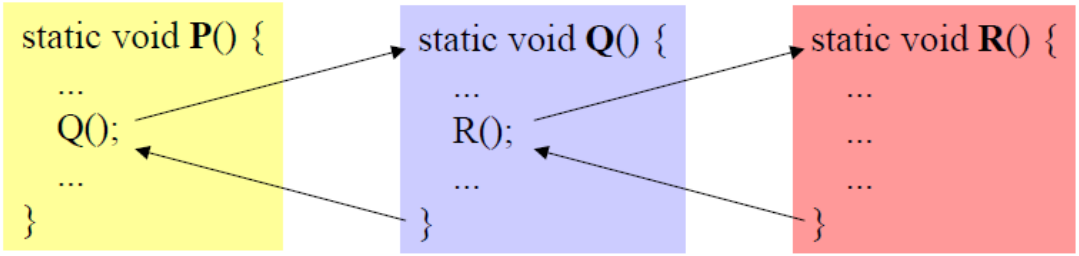
- IDEA – IDE supports you by pointing out problems and types
- Suffix for explicit type
  - `120L // that‘s a long`

Methods

- Core of functional programming languages
  - subroutines, functions, ...
- Goal is to re-use code
  - Code that would otherwise show up more than once.
- All in all: less to write
  - less lines of code, less work
  - easier to find errors and maintain.

Methods in Java

- Can be functions or procedures (sub routines)
- Name conventions for methods
  - start with verb and lower case letter
  - examples:
    - printHeader, findMaximum, traverseList, ...



Methods in Java

```
public class SubroutineExample {
    private static void printRule() {  // method head
        System.out.println("-------------"); // method body
    }

    public static void main(String[] args) {
        printRule();                    // method call
        System.out.println("Header 1");
        printRule();
    }

}
```

Parameters

- Input of values supported by methods

```
class Sample {

   static void printMax (int x, int y) {
      if (x > y) Out.print(x); else Out.print(y);
   }

   public static void main (String[] arg) {
      ...
      printMax(100, 2 * i);
   }
}
```

formal parameters
- in the method head
- are the variables in the method body

actual parameters
- in the method call
- can be expressions

Parameters

- Actual parameters are stored in the variables defined by the formal parameters.
- `x = 100; y = 2 * i;`
  - actual parameters need to be type compatible with the formal parameters.

```
class Sample {

  static void printMax (int x, int y) {
    if (x > y) Out.print(x); else Out.print(y);
  }

  public static void main (String[] arg) {
    ...
    printMax(100, 2 * i);
  }
}
```

Functions

- Functions are methods that return a value.

```
class Sample {

   static int max (int x, int y) {
      if (x > y) return x; else return y;
   }

   public static void main (String[] arg) {
      ...
      int result = 3 * max(100, i + j) + 1;
      ...
   }
}
```

- They have a return type, eg. `int` instead of `void`
- They use the `return` keyword to exit
- Can be used in expressions

Functions vs. Procedures

- Functions
  - methods with return values
  - `static int max (int x, int y) {...}`
- Procedures
  - methods without return values
  - `static void printMax (int x, int y) {...}`

Example

```
public class BinomialCoefficient {
    public static void main(String[] args) {
        int n = 5, k = 3;
        int result = factorial(n) /
                (factorial(k) * factorial(n - k));
        System.out.println("result = " + result);
    }

    public static int factorial(int k) {
        int result = 1;
        for (int i = 2; i <= k; i++) {
            result *= i;
        }
        return result;
    }
}
```

$$\binom{n}{k} = \frac{n!}{k! \cdot (n-k)!}.$$

Return & Rekursion

```
public class BinomialCoefficient {
    static int n = 5, k = 3;

    public static void main(String[] args) {
        int result = factorial(n) /
                (factorial(k) * factorial(n - k));
        System.out.println("result = " + result);
    }

    public static int factorial(int k) {
        if (k>1) {
            return factorial(k-1)*k;
        }
        else {
            return 1;
        }
    }
}
```

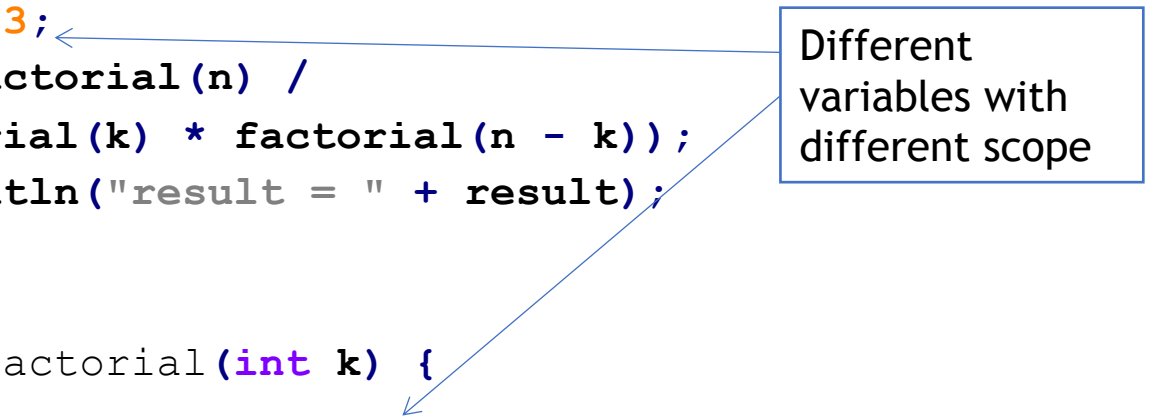
- Return ends method
- Can be called at any place
- Method calling itself -> direct recursion

Scope of Variables

- Based on groups of statements -> blocks
  - { ... },
  - for (int i; ...) {...}
- A variable defined in a block is not known outside

Example

```
public class BinomialCoefficient {
    public static void main(String[] args) {
        int n = 5, k = 3;
        int result = factorial(n) /
                (factorial(k) * factorial(n - k));
        System.out.println("result = " + result);
    }

    public static int factorial(int k) {
        int result = 1;
        for (int i = 2; i <= k; i++) {
            result *= i;
        }
        return result;
    }
}
```



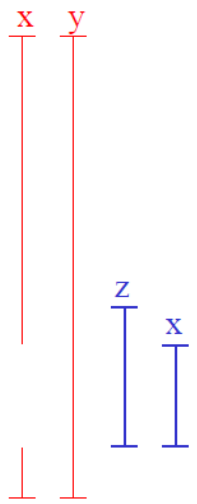
Example: Scope

```
public class BinomialCoefficient {
  static int n = 5, k = 3;

    public static void main(String[] args) {
        int result = factorial(n) /
                (factorial(k) * factorial(n - k));
        System.out.println("result = " + result);
    }

    public static int factorial(int k) {
        int result = 1;
        for (int i = 2; i <= k; i++) {
            result *= i;
        }
        return result;
    }
}
```

Smallest scope is the actual one.

Visibility of Names: Local Variables

```
class Sample {
   static void P() {
      ...
   }
   static int x;
   static int y;
   static void Q(int z) {
      int x;
      ...
   }
}
```



Rules

1. A name can only be declared once within a scope.
2. locale names are prioritized over class scope names.
3. Visibility of a local name starts with ist declaration and ends with the method.
4. Variables in class scope are visible in all methods.

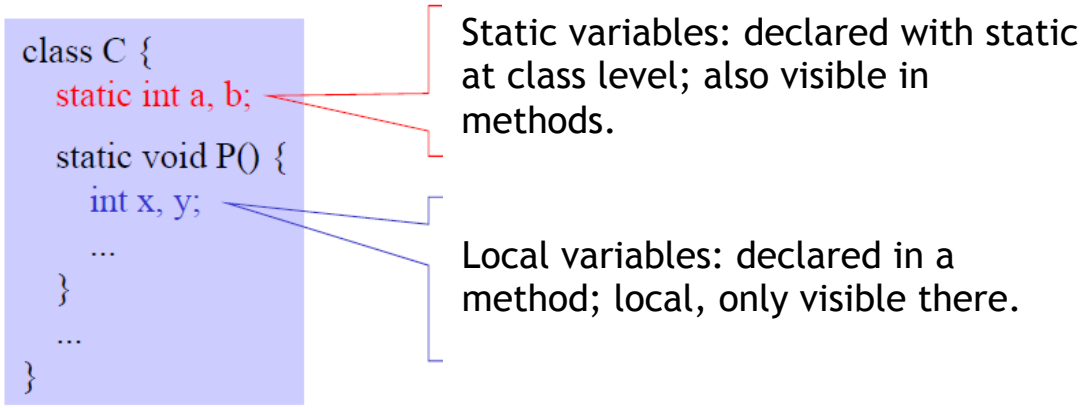
Local & Static

Static Variables

- Are initialized at program start
- Are released upon program termination

Local Variables

- Are initialized at each method call
- Are released upon termination of method.



Locality

Best Practice: declare variables as local as possible. Don‘t use static unless there is no other way.

Benefits:

- Clarity: bring together declaration and usage
- Security: Local variables can not be overwritten by other methods
- Efficiency: access to local variable is often faster

Method Overloading

- Methods can be declared multiple times with different sets of formal parameters (difference in type, not names)

```
static void write (int i) {...}
static void write (float f) {...}
static void write (int i, int width) {...}
```

- At call time method implementation fitting to actual parameters is chosen.

```
write(100);        ⇒   write (int i)
write(3.14f);      ⇒   write (float f)
write(100, 5);     ⇒   write (int i, int width)
short s = 17;
write(s);          ⇒   write (int i);
```

Varargs

- In Java methods with an arbitrary number of arguments can be declared.

```
public class VarargExample {
    public static void main(String[] args) {
        printList("one", "two", "three");
    }

    public static void printList(String... list) {
        System.out.println("list[0] = " + list[0]);
        System.out.println("list[1] = " + list[1]);
        System.out.println("list[2] = " + list[2]);
    }
}
```

Arrays

- Combination of data of the same type
- Arrays have a fixed length
  - which is given at the time of instatiation
- Array variables are references
  - In Java! cp. int, float, etc. -> base types
- Access uses index values
  - first element at index 0

One-Dimensional Arrays

- Name a for the whole array
- elements are accessed by their index
- indexing starts with 0
- elements are „nameless“ variables

	a[0]	a[1]	a[2]	a[3]	. . .
a					

Declaration

- declares array with name and type
- length is not (yet) known

```
int[] a;
float[] b;
```

Instantiation

- creates a new int array with 5 elements
- assigns adress a

```
a = new int[5];
b = new float[10];
```

Accessing Arrays

- array elemts are just like variables
- index can be expression
- run time error if array is not instantiated
- run time error if index < 0 oder >= length

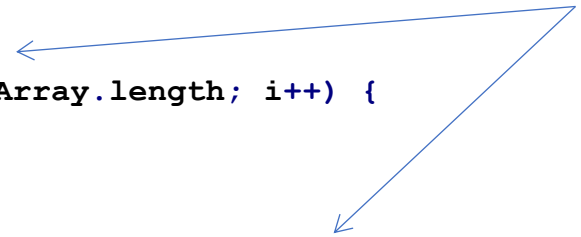
```
a[3] = 0;
a[2*i+1] = a[i] * 3;
```

- *length* is pre-defined operator
- returns number of elements

```
int len = a.length;
```

Example

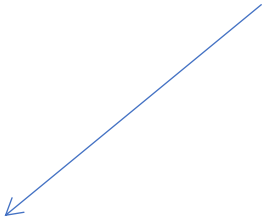
```
public class ArrayExample {
    public static void main(String[] args) {
        int[] myArray = new int[5];
        // Initialise Array: {1, 2, 3, 4, 5}
        for (int i = 0; i < myArray.length; i++) {
            myArray[i] = i+1;
        }
        // Calculate the average:
        float sum = 0;
        for (int i = 0; i < myArray.length; i++) {
            sum += myArray[i];
        }
        System.out.println(sum/myArray.length);
    }
}
```



- Computes mean
- implicit cast to float!

Example: While, For Each

```
public class ArrayExample {
    public static void main(String[] args) {
        int[] myArray = new int[5];
        // Initialise Array : {1, 2, 3, 4, 5}
        int i = 0;
        while (i < myArray.length) { // while
            myArray[i] = i+1;
            i++;
        }
        // Calculate the average:
        float sum = 0;
        for (int myInt : myArray) { // for each
            sum += myInt;
        }
        System.out.println(sum/myArray.length);
    }
}
```



- Other loop constructs
- „for each“

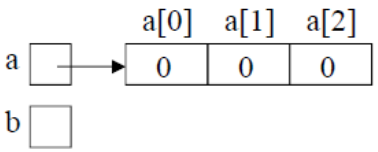
Example: Instantiation

```
public class ArrayExample {
    public static void main(String[] args) {
        // Initialise Array: {1, 2, 3, 4, 5}
        int[] myArray = {1, 2, 3, 4, 5};
        // Calculate Average:
        float sum = 0;
        for (int myInt : myArray) { // for each
            sum += myInt;
        }
        System.out.println(sum/myArray.length);
    }
}
```

- Different way to create!

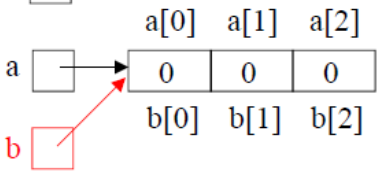
Arrays

```
int[] a, b;
a = new int[3];
```



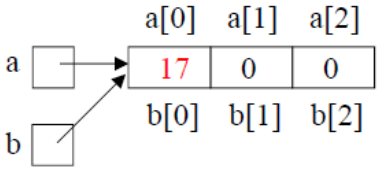
array elements in Java are initialized with 0

```
b = a;
```



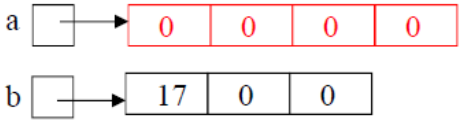
`b` gets the same value as `a`. It‘s a reference!!!

```
a[0] = 17;
```



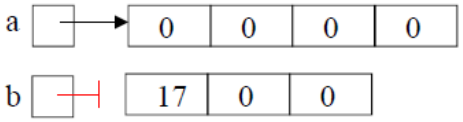
changes `b[0]` too!

```
a = new int[4];
```



a now points to new array.

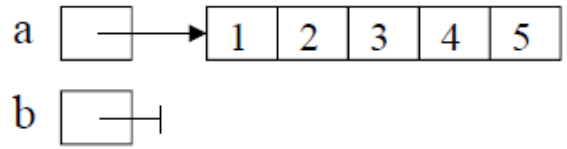
```
b = null;
```



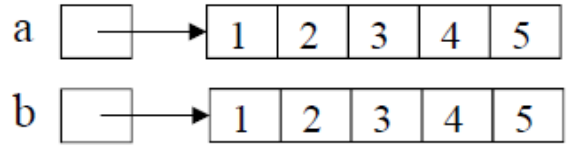
`null` is a special value, which can be assigned to all reference data type variables.

Copying Arrays

```
int[] a = {1, 2, 3, 4, 5};
int[] b;
```




```
b = (int[]) a.clone();
```



- Cast necessary, `a.clone()` returns type `Object[]`

Command Line Parameters

- Calling a program with parameters
  - java <program> par1 par2 par3 ...
- Parameters are in a String-Array
  - main(String[] args) method of the program.

Command Line Parameters

```
public class ArrayExample {
    public static void main(String[] args) {
        for (int i = 0; i < args.length; i++) {
            String arg = args[i];
            System.out.println(arg);
        }
    }
}
```

$> java ArrayExample one two three

one

two

three

Example: Linear Search

```
public class ArrayExample {
    public static void main(String[] args) {
        int[] myArray = {12, 2, 32, 74, 26, 42, 53, 22};
        int query = 22;
        for (int i = 0; i < myArray.length; i++) {
            if (query == myArray[i]) {
                System.out.println("Found at position " + i);
            }
        }
    }
}
```

- Each element is touched -> linear
- Needs *n* steps – What is the size of *n*?

Example: Sorting

- How does one sort an array *a*?
- Naive approach:
    1. Create array *b* of the same size and type.
    2. Move minimum of a to next free position of b
    3. If a is not empty start over with step 2.

Example: Sorting

```
public class ArrayExample {
    public static void main(String[] args) {
        // o.b.d.A. a[k] > 0 & a[k] < 100
        int[] a = {12, 2, 32, 74, 26, 42, 53, 22};
        // create result array
        int[] b = new int[a.length];
        for (int i = 0; i < b.length; i++) { // set each item of b
            int minimum = 100;
            int pos = 0;
            for (int j = 0; j < a.length; j++) { // find minimum
                if (a[j] < minimum) {
                    minimum = a[j];
                    pos = j;
                }
            }
            b[i] = minimum;
            a[pos] = 100; // set visited.
        }

        for (int i = 0; i < b.length; i++) {
            System.out.print(b[i] + ", ");
        }
```

- Can be solved in many different ways.