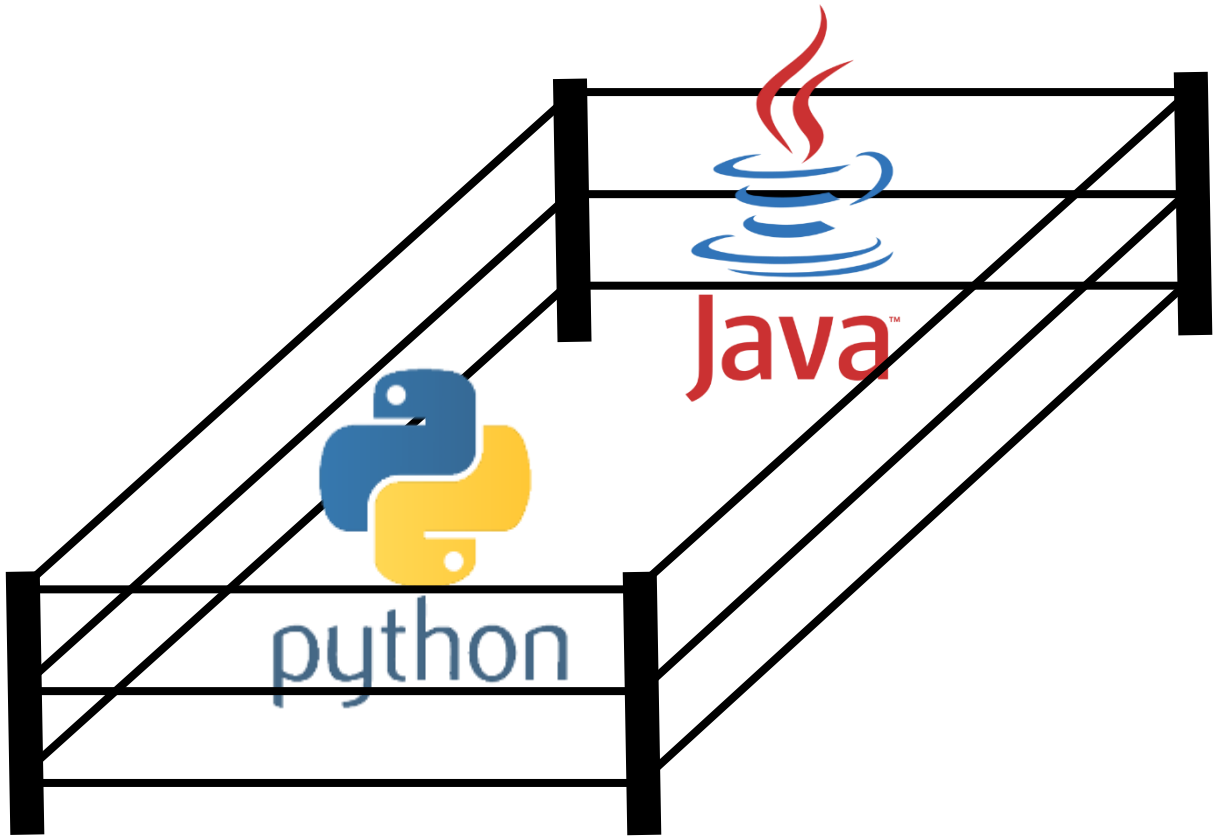
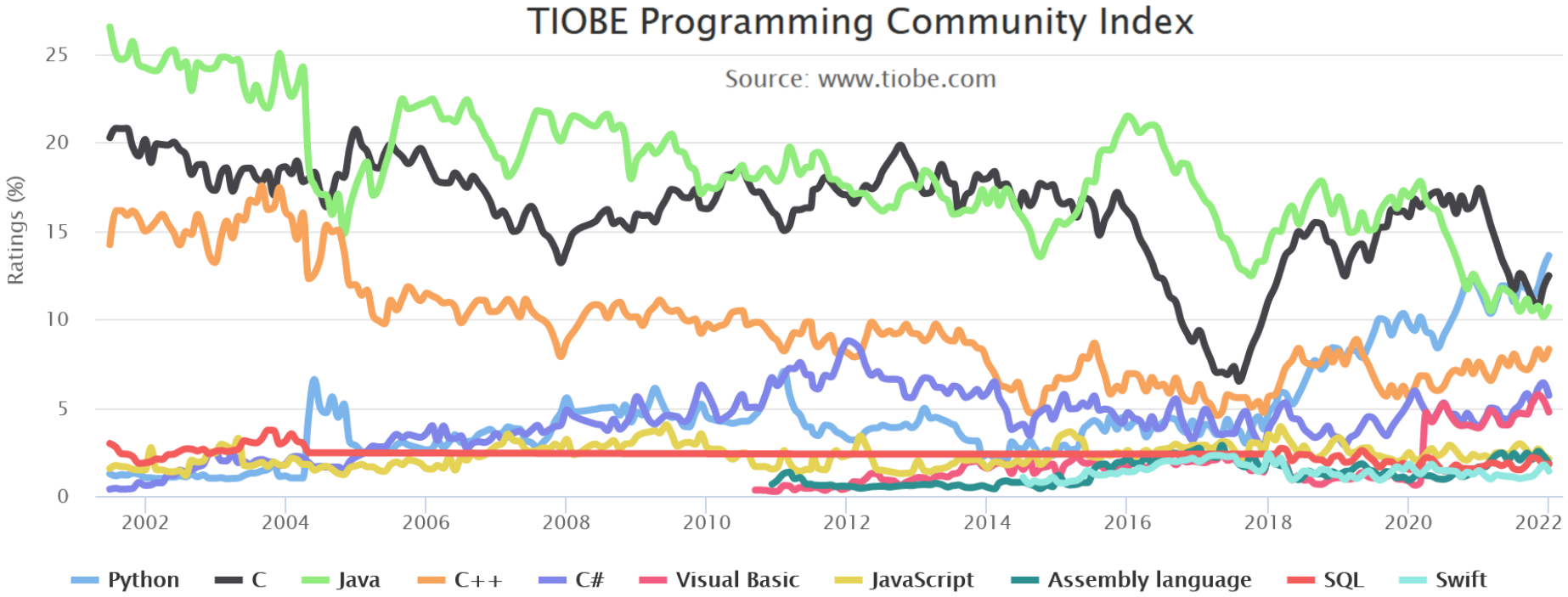


Java vs Python

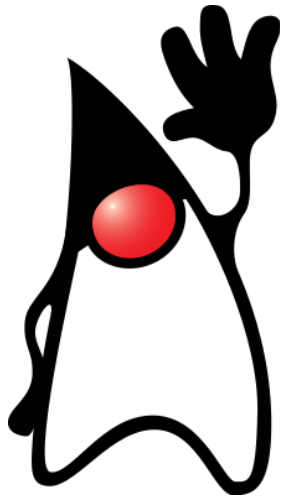
runestone.academy/ns/books/published/java4python/

Why should you know something about Java?

- Java is an example of a statically typed object oriented language (like C and C++) opposed to Python's being dynamically typed
- One of the most widespread used programming languages
- Used in other courses at the Department of Computer Science



Java history



- Java 1.0 released 1995 by Sun Microsystems (acquired by Oracle 2010)
- ”Write Once, Run Anywhere”
- 1999 improved performance by the **Java HotSpot Performance Engine**
- Current version Java 18 (released March 2022)
- Java compiler generates **Java bytecode** that is executed on a **Java virtual machine** (**JVM**)

PyPy is adopting the same ideas to Python (Just-in-Time compilation)

Installing Java

- To compile Java programs into **bytecode** you need a compiler, e.g. from Java SE Development Kit (**JDK**):

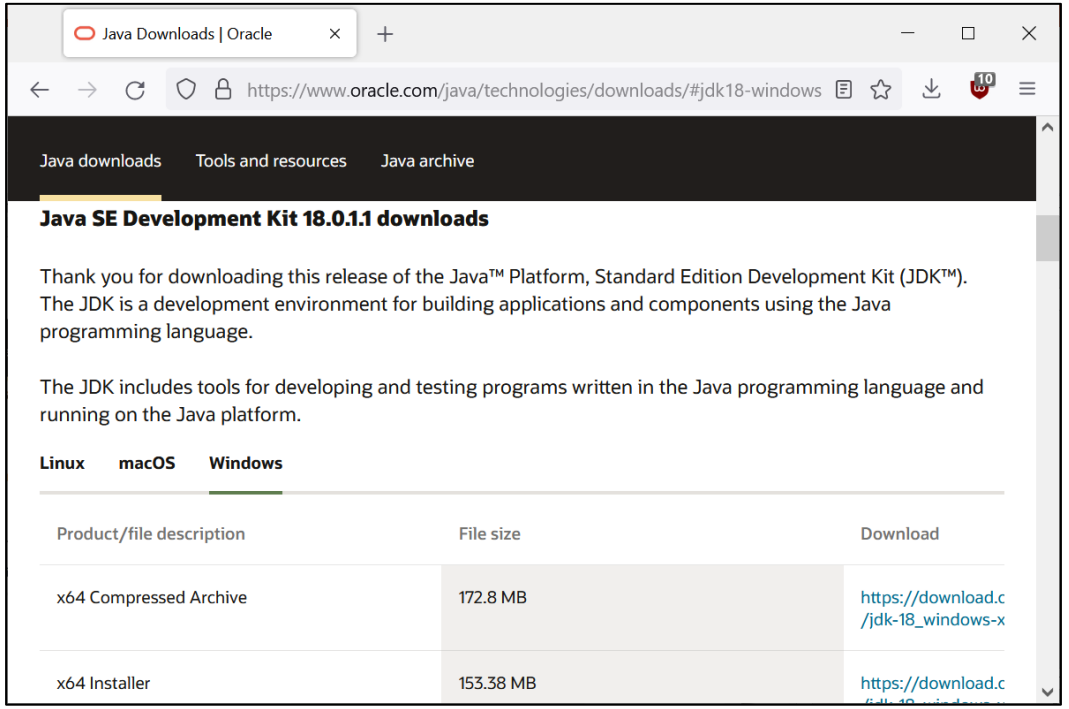
  www.oracle.com/java/technologies/downloads/

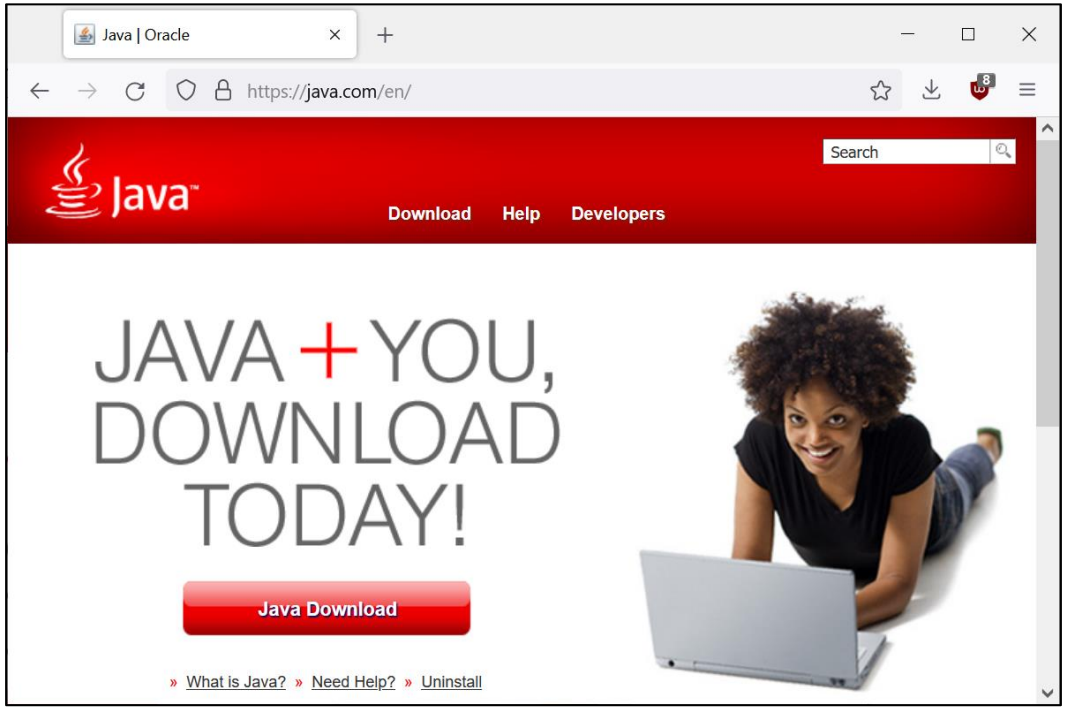
  (you might need to add the JDK directory to your PATH, e.g. C:\Program Files\Java\jdk-18.0.1.1\bin)

- To only run compiled Java programs:

  java.com/download

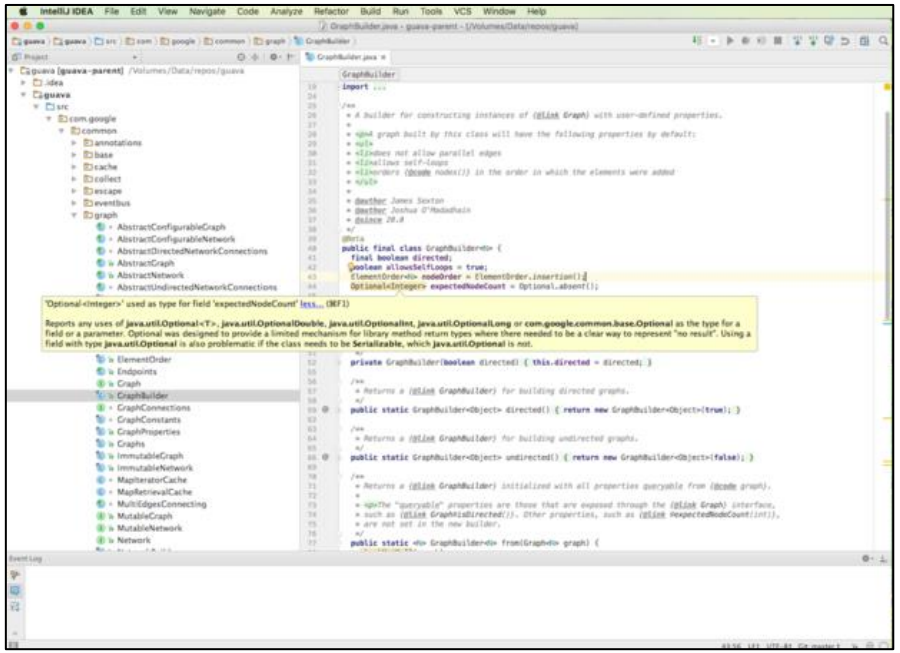
  (If you use JDK, you should not download this)

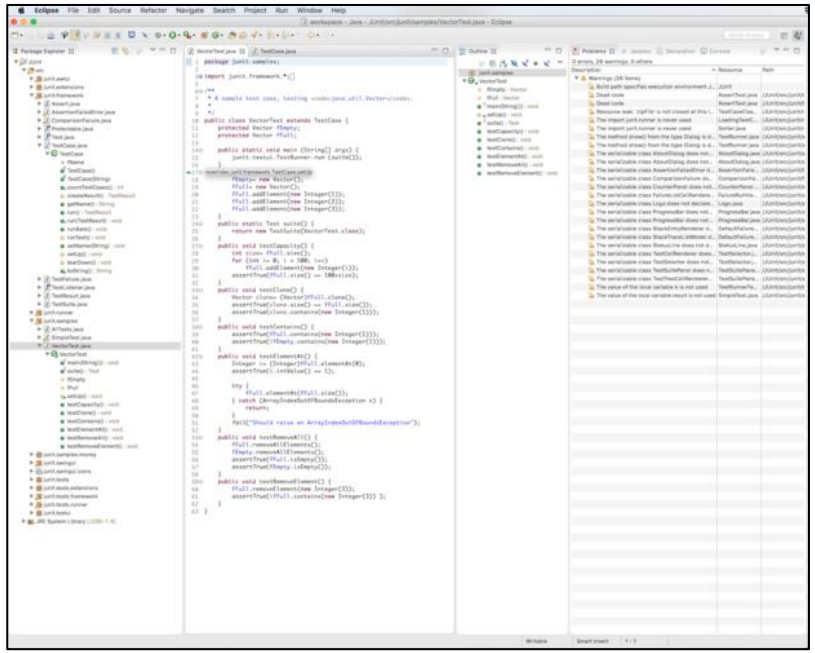


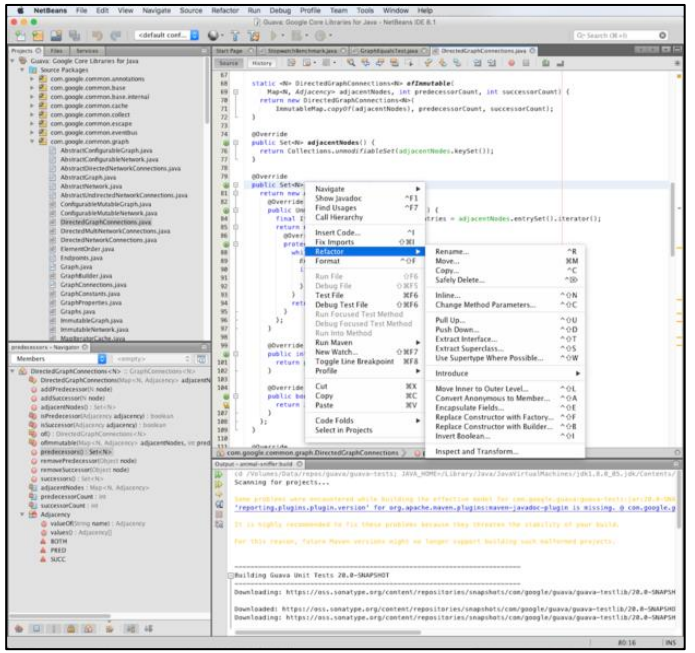


Java IDE

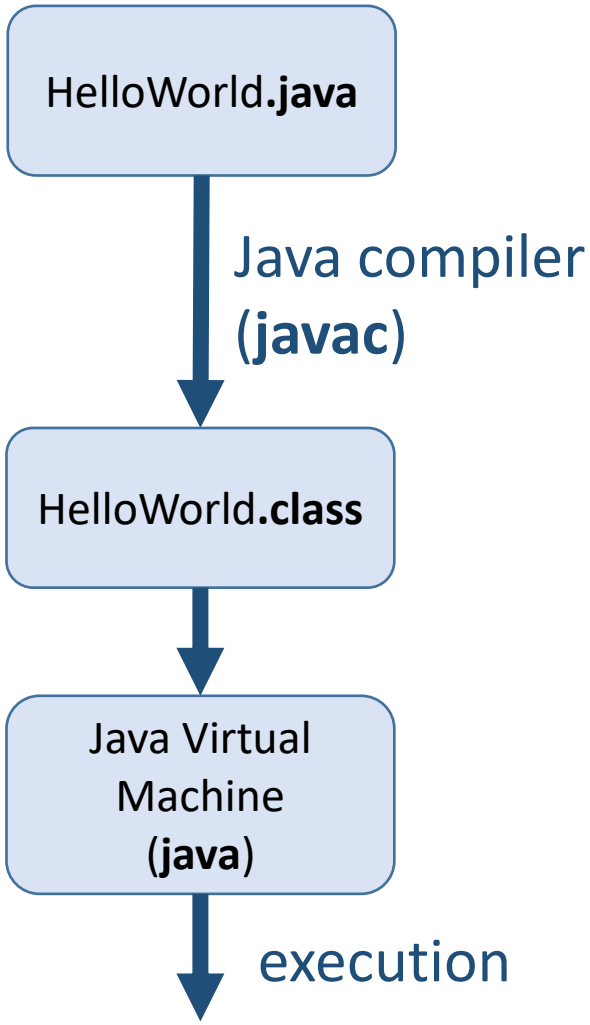
- Many available, some popular:
  Visual Studie Code, IntelliJ IDEA, Eclipse, and NetBeans
- An IDE for beginners: BlueJ







Compiling and running a Java program



HelloWorld.java

```
public class HelloWorld {
    public static void main( String[] args ) {
        System.out.println( "Hello World!" );
    }
}
```

Command Prompt

```
C:\Users\au121\Desktop>javac HelloWorld.java

C:\Users\au121\Desktop>dir HelloWorld*
 Volume in drive C is OSDisk
 Volume Serial Number is 3CDB-90D8

 Directory of C:\Users\au121\Desktop

04-05-2020  17:40               426 HelloWorld.class
09-05-2019  21:18               132 HelloWorld.java
               2 File(s)            558 bytes
               0 Dir(s)  372.191.944.704 bytes free

C:\Users\au121\Desktop>java HelloWorld
Hello World!

C:\Users\au121\Desktop>
```

Java : `main`

- *name*`.java` must be equal to the `public class` *name*
- A class can only be excuted using `java` *name* (without `.class`) if the class has a class method `main` with signature

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

- (`main` is inherited from C and C++ sharing a lot of syntax with Java)
- Java convention is that class names should use CamelCase

PrintArguments.java

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

shell

```
> java PrintArguments x y z
| x
| y
| z
```

a `static` method in a class is a class method (exists without creating objects)

method name

there can be several classes in a file – but only one class should be `public` and have same name as file

type of return value (`void` = no return value)

class name containing `main` must have same name as file

PrintArguments.java

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

type of argument, array of `String` values

the main method must be `public` to be visible outside class

name of argument

For-loop equivalent to

```
int i=0
while (i<args.length) {
    code
    i++;
}
```

i += 1

declare new `int` variable locally inside for-loop

the print statement is found in the `System` class

java arrays are indexed from `0` to `args.length - 1` and the length of an array object is fixed once created

Argument list also exists in Python...

PrintArguments.py

```
import sys
print(sys.argv)
```

shell

```
> python PrintArguments.py a b 42
| ['PrintArguments.py', 'a', 'b', '42']
```

Primitive.java

```
/**
 * A Java docstring to be processed using 'javadoc'
 */
// comment until end-of-line
public class Primitive {
    public static void main( String[] args ) {
        int x;  // type of variable must be declared before used
        x = 1;  // remember ';' after each statement
           int y=2;  // indentation does not matter
    int a=3, b=4;  // multiple declarations and initialization
        System.out.println(x + y + a + b);
        int[] v={1, 2, 42, 3};  // array of four int
        System.out.println(v[2]);  // prints 42, arrays 0-indexed
/* multi-line comment
       that continues until here */
        v = new int[3];  // new array of size three, containing zeros
        System.out.println(v[2]);  // prints 0
        if (x == y) {  // if-syntax '(' and ')' mandatory
             a = 1;
             b = 2;
        } else {  // use '{' and '}' to create block of statements
             a = 4; b = 3;  // two statements on one line
        }
}}
```

Why state types – Python works without…

- Just enforcing a different programming style (also C and C++)
- Helps users to avoid mixing up values of different types
- (Some) type errors can be caught at compile time
- More efficient code execution

type_error.py

```
x = 3
y = "abc"
print("program running...")
print(x / y)
```

Python shell

```
| program running...
...
| ----> 4 print(x / y)
| TypeError: unsupported operand type(s) for
  /: 'int' and 'str'
```

TypeError.java

```
public class TypeError {
    public static void main( String[] args ) {
        int x = 3;
        String y = "abc";
        System.out.println(x / y);
    }
}
```

shell

```
> javac TypeError.java
| javac TypeError.java
| TypeError.java:5: error: bad operand types for
  binary operator '/'
|         System.out.println(x / y);
|                            ^
|   first type:  int
|   second type: String
| 1 error
```

Basic Java types

Type	Values
`boolean`	`true` or `false`
`byte`	8 bit integer
`char`	character (16-bit UTF)
`short`	16 bit integer
`int`	32 bit integer
`long`	64 bit integer
`float`	32 bit floating bout
`double`	64 bit floating point
`class BigInteger`	arbitrary precision integers
`class String`	strings

BigIntegerTest.java

```
import java.math.*;  // import everything
// import java.math.BigInteger;  // alternativ

public class BigIntegerTest {
    public static void main( String[] args ) {
        BigInteger x = new BigInteger("2");
        while (true) {
            // BigIntegers are immutable
            x = x.multiply(x);
            // java.math.BigInteger.toString()
            System.out.println(x);
        }
    }
}
```

shell

```
4
16
256
65536
4294967296
18446744073709551616
340282366920938463463374607431768211456
...
```

Java arrays

- The size of a builtin Java array can not be modified when first created.
  If you need a bigger array you have to instantiate a new array.
- Or better use a standard collection class like **ArrayList**
- **ArrayList** is a generic class (type of content is given by <*element type*>; generics available since Java 5, 2004)
- The for-each loop was introduced in Java 5

ConcatenateArrayLists.java

```
import java.util.*;  // java.util contains ArrayList

public class ConcatenateArrayList {
    public static void main( String[] args ) {
        // ArrayList is a generic container
        ArrayList<String> a = new ArrayList<String>();
        ArrayList<String> b = new ArrayList<String>();
        ArrayList<String> c = new ArrayList<String>();

        a.add("A1");  // in Python .append
        a.add("A2");
        b.add("B1");

        c.addAll(a);  // in Python .extend
        c.addAll(b);

        for (String e : c) {  // foreach over iterator
            System.out.println(e);
        }
    }
}
```

shell

```
A1
A2
B1
```

Tired of writing all these types…

- In Java 7 (2011) the "diamond operator" **<>** was introduced for type inference for generic instance creation to reduce verbosity
- In Java 10 (2018) the **`var`** keyword was introduced to type infer variables

ArrayListTest.java

```
import java.util.*;  // java.util contains ArrayList

public class ArrayListTest {
    public static void main( String[] args ) {
        // ArrayList is a generic container
        ArrayList<String> a = new ArrayList<String>(); // Full types
        List<String> b = new ArrayList<String>();      // ArrayList is subclass of class List
        ArrayList<String> c = new ArrayList<>();       // <> uses type inference
        List<String> d = new ArrayList<>();            // <> and ArrayList subclass of List
        var e = new ArrayList<String>();               // use var to infer type of variable
    ⚠   var v = Math.floor(1.5);                       // not obvious what type v is (double)
}}
```

Function arguments

- Must declare the number of arguments and their types, and the return type
- The argument types are part of the *signature* of the function
- Several functions can have the same name, but different type signatures
- Python keyword arguments, * and ** do not exist in Java 

Functions.java

```
public class Functions {
    private static int f(int x) {
        return x * x;
    }
    private static int f(int x, int y) {
        return x * y;
    }
    private static String f(String a, String b) {
        return a + b; // string concatenation
    }

    public static void main( String[] args ) {
        System.out.println(f(7));
        System.out.println(f(3, 4));
        System.out.println(f("abc", "def"));
    }
}
```

shell

```
49
12
abcdef
```

functions.py

```
def f(x, y=None):
    if y == None:
        y = x
    if type(x) is int:
        return x * y
    else:
        return x + y
print(f(7), f(3, 4), f('abc', 'def'))
```

Class

- Constructor = method with name equal to class name (no return type)
- `this` = referes to current object (Python “self”)
- Use `private` / `public` on attributes / methods to give access outside class
- Use `new` *name*(arguments) to create new objects

- There can be multiple constructors, but with distinct type signatures

AClass.java

```
class Rectangle {
    private int width, height;  // declare attributes
    // constructor, class name, no return type
    public Rectangle(int width, int height) {
        this.width = width;
        this.height = height;
    }
    public Rectangle(int side) {
        width = side;  // same as this.width = side
        height = side;
    }
    public int area() {
        return width * height;
    }
}
public class AClass {
    public static void main( String[] args ) {
        Rectangle r = new Rectangle(6, 7);
        System.out.println(r.area());
    }
}
```

shell

```
42
```

Inheritance

- Java supports single inheritance using `extends`
- Attributes and methods that should be accessible in a subclass must be declared protected (or public)
- Constructors are not inherited but can be called using `super`

Inheritance.java

```
class BasicRectangle {
    // protected allows subclass to access attributes
    protected int width, height;
    public BasicRectangle(int width, int height) {
        this.width = width; this.height = height;
    }
}
class Rectangle extends BasicRectangle {
    public Rectangle(int width, int height) {
        // call constructor of super class
        super(width, height);
    }
    public int area() {
        return width * height;
    }
}
public class Inheritance {
    public static void main( String[] args ) {
        Rectangle r = new Rectangle(6, 7);
        System.out.println(r.area());
    }
}
```

shell

```
42
```

Generic class

- Class that is parameterized by one or more types (comma separated)
- Primitive types cannot be type parameters
- Instead use *wrappers*, like Integer for int

GenericPair.java

```
class Pair<element> {
    private element x, y;
    public Pair(element x, element y) {
        this.x = x; this.y = y;
    }
    element first() { return x; }
    element second() { return y; }
}
public class GenericPair {
    public static void main( String[] args ) {
        var p = new Pair<Integer>(6, 7);
        System.out.println(p.first() * p.second());
    }
}
```

shell

```
| 42
```

Interface

- Java does not support multiple inheritance like Python
- But a class can implement an arbitrary number of interfaces
- An interface specifices a set of attributes and methods a class must have
- The type of a variable can be an interface, and the variable can hold any object where the class is stated to implement the interface

RectangleInterface.java

```
interface Shape {
    public int area(); // method declaration
}
class Rectangle implements Shape {
    private int width, height;
    // constructor, class name, no return type
    public Rectangle(int width, int height) {
        this.width = width; this.height = height;
    }
    public int area() {
        return width * height;
    }
}
public class RectangleInterface {
    public static void main( String[] args ) {
        Shape r = new Rectangle(6, 7);
        System.out.println(r.area());
    }
}
```

Abstract classes

- Abstract class = class that cannot be instantiated, labeled `abstract`
- Abstract method = method declared without definition, labeled `abstract`, must be in abstract class
- An abstract class can be extended to a non-abstract class by providing the missing method definitions

AbstractRectangle.java

```
abstract class Shape {
    abstract public int circumference();
    abstract public int area();
    public double fatness() {
        // convert int from area() to double before /
        return (double)area() / circumference();
    }
}
class Rectangle extends Shape {
    private int width, height;
    // constructor, class name, no return type
    public Rectangle(int width, int height) {
        this.width = width; this.height = height;
    }
    public int area() {
        return width * height;
    }
    public int circumference() {
        return 2 * (width + height);
    }
}
public class AbstractRectangle {
    public static void main( String[] args ) {
        Shape r = new Rectangle(6, 7);
        System.out.println(r.fatness());
    }
}
```

Default methods in interfaces

- Before Java 8 all methods in an interface were abstract (no definition)
- Since Java 8 interfaces can have **`default`** methods with definition
- The distinction between abstract classes and interfaces gets blurred
  - a class can only extend one abstract class
  - a class can implement more interfaces

  ⇒ multiple “inheritance” is possible in Java

DefaultInterface.java

```
interface Shape {
    public int circumference();
    public int area();
    default public double fatness() {
        // convert int from area() to double before /
        return (double)area() / circumference();
    }
}
class Rectangle implements Shape {
    private int width, height;
    // constructor, class name, no return type
    public Rectangle(int width, int height) {
        this.width = width; this.height = height;
    }
    public int area() {
        return width * height;
    }
    public int circumference() {
        return 2 * (width + height);
    }
}
public class DefaultRectangle {
    public static void main( String[] args ) {
        Shape r = new Rectangle(6, 7);
        System.out.println(r.fatness());
    }
}
```

Multiple Inheritance

- Class `C` implements both interfaces `A` and `B`
- Inherits default methods `sayA` and `sayB`
- Cannot inherit `sayHi`, since in both `A` and `B`. Must be overriden in `C`.
- Can use `@override` to enforce compiler to check if method exists in super class
- `new A(){}` creates an instance of an *anonymous class* (extending or implementing A)

MultipleInheritance.java

```
interface A {
    default public void sayA() { System.out.println("say A"); }
    default public void sayHi() { System.out.println("A say's Hi"); }
}

interface B {
    default public void sayB() { System.out.println("say B"); }
    default public void sayHi() { System.out.println("B say's Hi"); }
}

class C implements A, B {
    @Override // (optional) requests compiler to
              // check if sayHi exists in supertype
    public void sayHi() {
        System.out.println("C say's Hi");
        (new A(){}).sayHi();  // instantiate an anonymous class
    }

    public void test() {
        sayA();
        sayB();
        sayHi();
    }
}

public class MultipleInheritance {
    public static void main( String[] args ) {
        new C().test();
    }
}
```

Shell output

```
say A
say B
C say's Hi
A say's Hi
```

Lambda expression

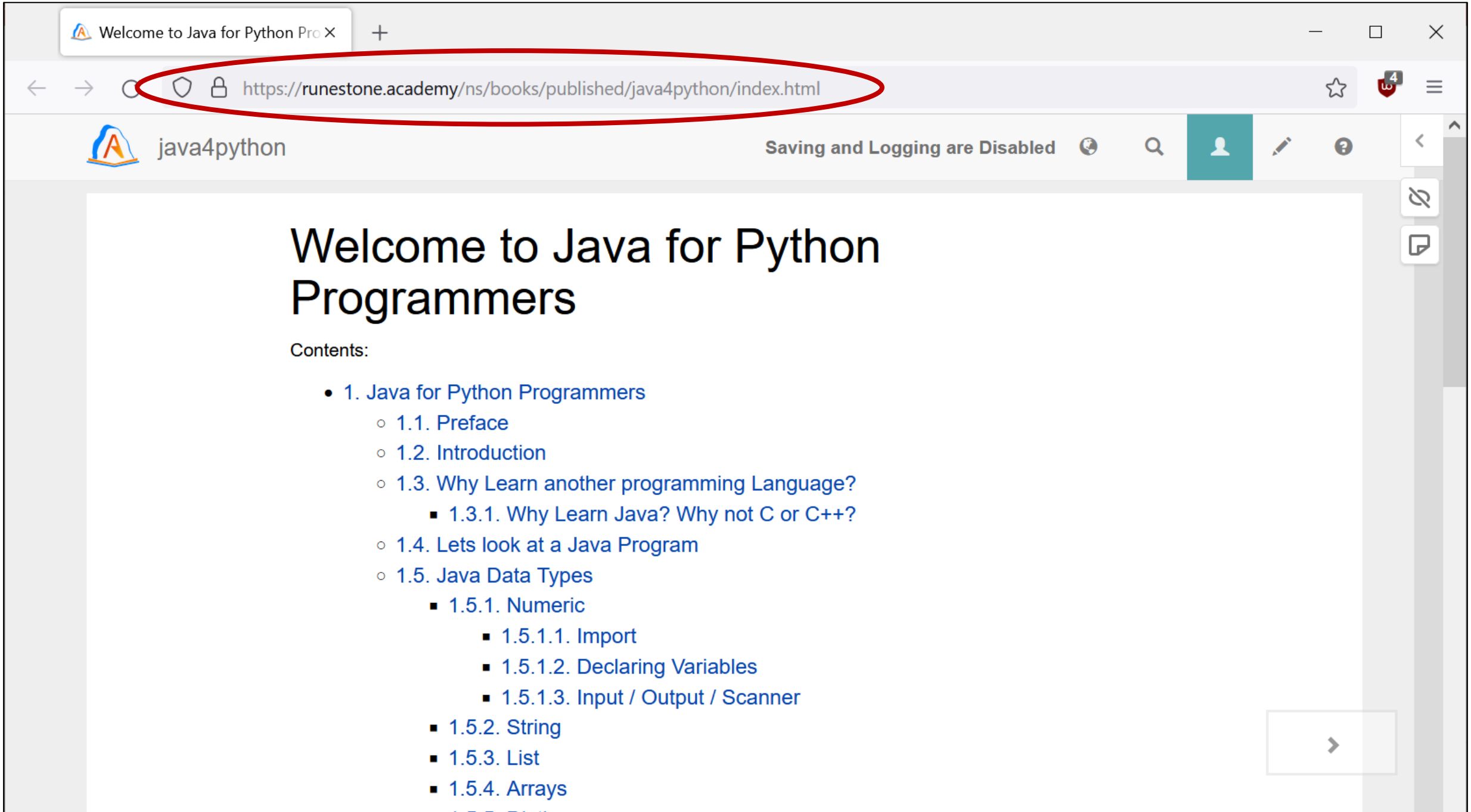
- Lambda expressions are possible since Java 8
- Syntax : *argument -> expression*

LambdaPrinting.java

```
import java.util.*;  // ArrayList

public class LambdaPrinting {
    public static void main(String[] args) {
        var elements = new ArrayList<Integer>();

        for (int i = 1; i <= 3; i++)
            elements.add(i);

        elements.forEach(e -> System.out.println(e));
    };
}
```

LambdaPrinting.java

```
1
2
3
```



Welcome to Java for Python Programmers

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