JÖNKÖPING UNIVERSITY

School of Engineering

JAVA

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JAVA DESIGN GOALS

1. Simple, Object Oriented and Familiar.
2. Robust and Secure.
3. Architecture Neutral and Portable
4. High Performance.
5. Interpreted, Threaded, Dynamic.

Syntax similar to C-family.

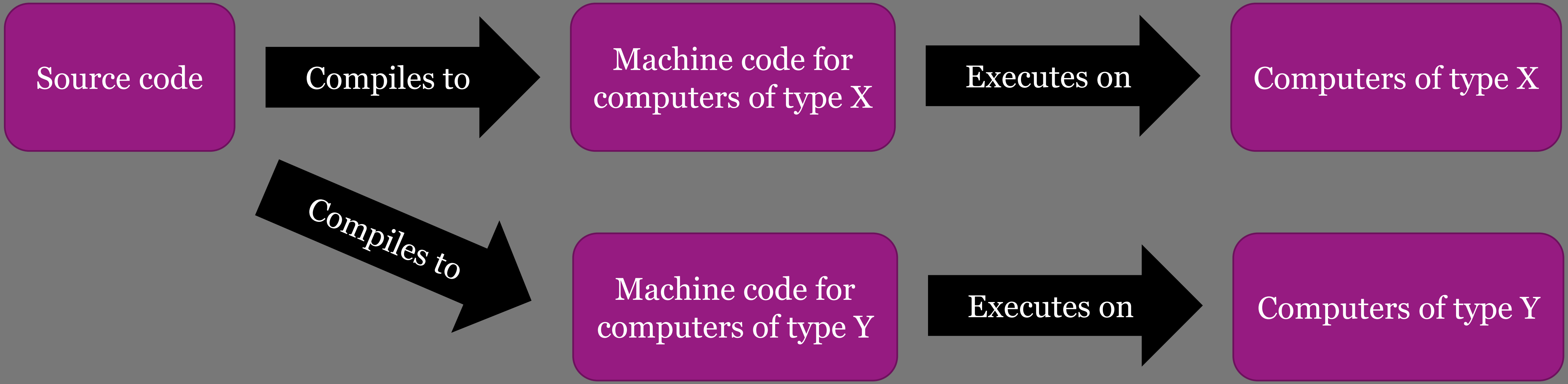
Garbage collection.

Java Virtual Machine.

ARCHITECTURE DEPENDENT

How it works for some languages (C, C++, etcetera).

Drawback: need to compile to multiple targets ☹



Source code

Compiles to

Machine code for computers of type X

Executes on

Computers of type X

Compiles to

Machine code for computers of type Y

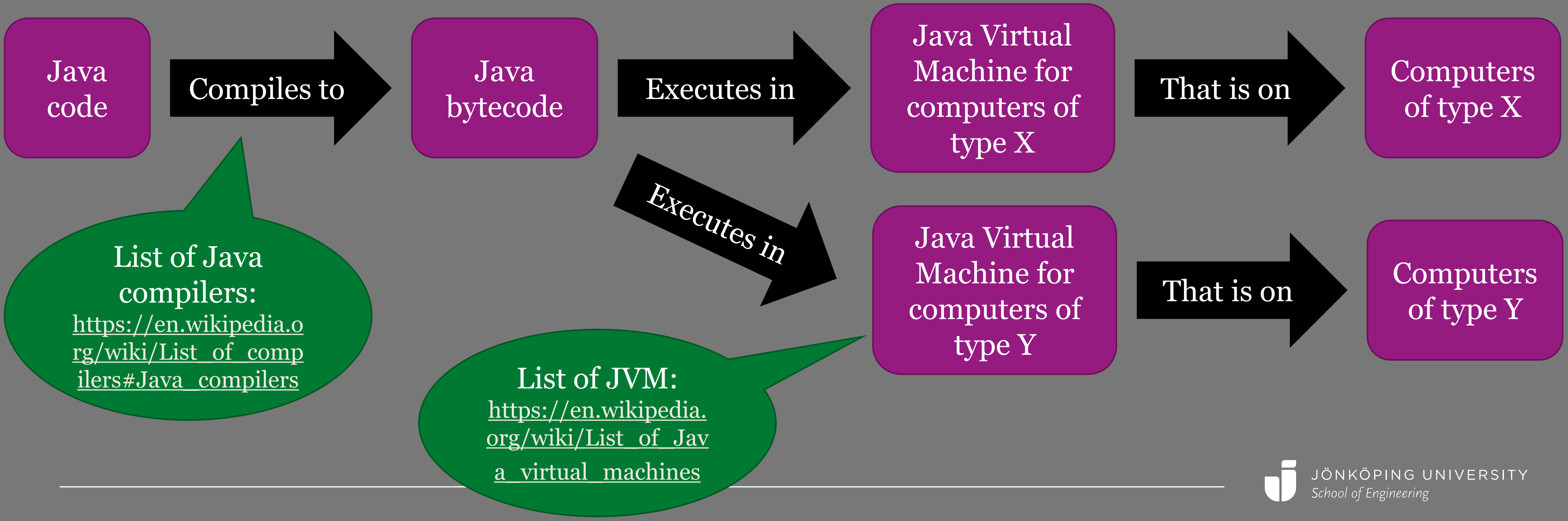
Executes on

Computers of type Y

ARCHITECTURE NEUTRAL

How it works with Java.

Advantage: only compile once ☺
Drawback: Virtual Machines have to be created and installed ☹
Drawback: Virtual Machines are a bit slower ☹



Java code

Compiles to

Java bytecode

Executes in

Java Virtual Machine for computers of type X

That is on

Computers of type X

Executes in

Java Virtual Machine for computers of type Y

That is on

Computers of type Y

List of Java compilers: https://en.wikipedia.org/wiki/List_of_compilers#Java_compilers

List of JVM: https://en.wikipedia.org/wiki/List_of_Java_virtual_machines

GARBAGE COLLECTION

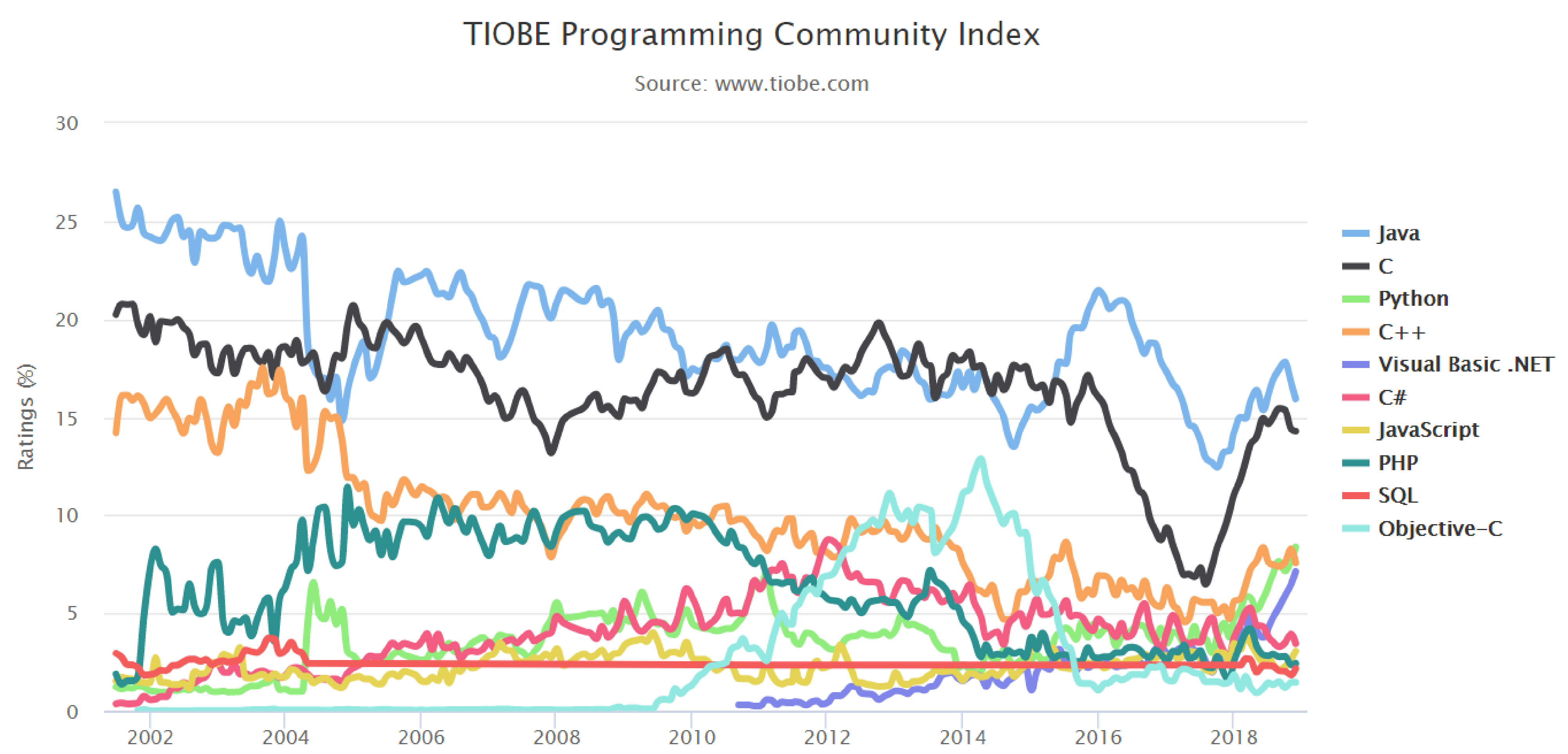
C++

```
for(int i=0; i<100; i++){
  // Create a new object.
  Circle* c = new Circle(5);

  double r = c->getRadius();

  // Free memory.
  delete c;
}
```

Java

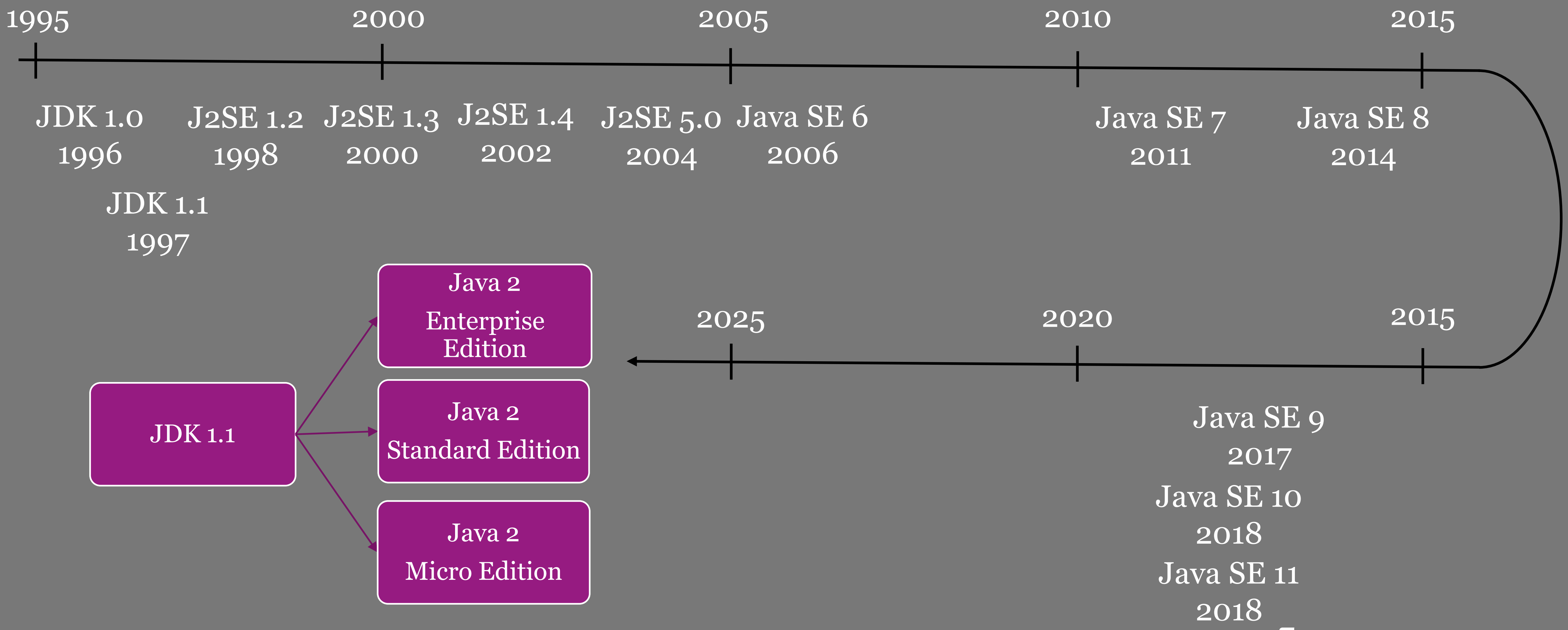
```
for(int i=0; i<100; i++){
  // Create a new object.
  Circle c = new Circle(5);

  double r = c.getRadius();

  // No need to delete it.
  // Handled by the GC.
}
```

THE MOST "POPULAR" LANGUAGES



Source: http://www.tiobe.com/index.php/content/paperinfo/tpci/index.html

TIMELINE



1995 2000 2005 2010 2015

JDK 1.0
1996

JDK 1.1
1997

J2SE 1.2
1998

J2SE 1.3
2000

J2SE 1.4
2002

J2SE 5.0
2004

Java SE 6
2006

Java SE 7
2011

Java SE 8
2014

2015 2020 2025

Java SE 9
2017

Java SE 10
2018

Java SE 11
2018

JDK 1.1

Java 2
Enterprise Edition

Java 2
Standard Edition

Java 2
Micro Edition

LET'S GET STARTED WITH JAVA

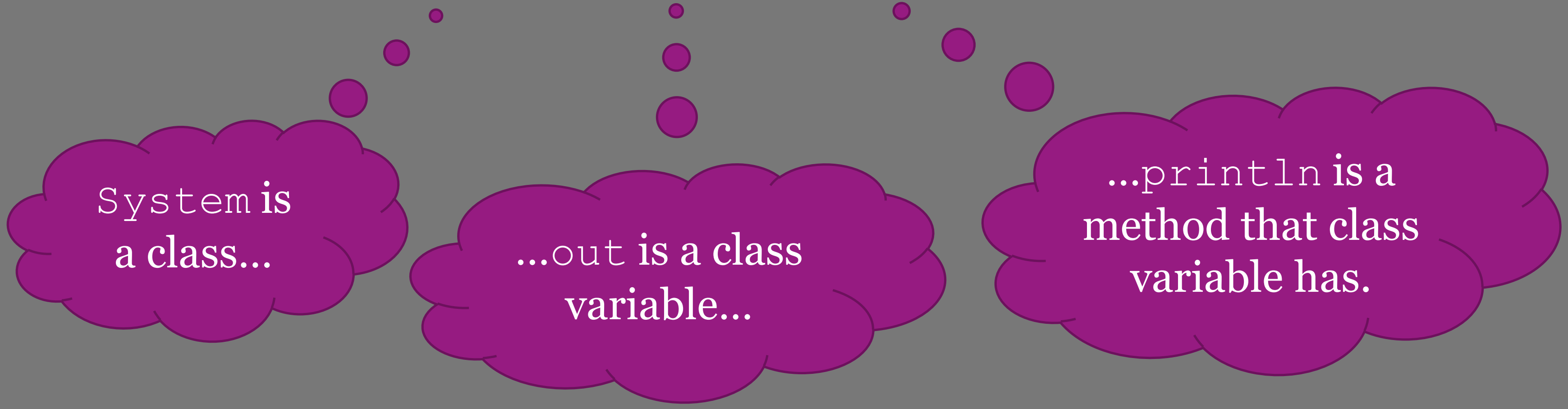
- Files containing Java code should be saved with the `.java` extension.
- Each `.java` file should contain one of the following types: class, interface, enumeration or annotation.
  - The name of the type must match the name of the file.
  - `NamesAreWrittenLikeThis` (CamelCase, first letter capitalized).
- The types are organized in packages.
  - Write the package statement at the top of the file:

    ```
    package se.svensson.sven.package.name;
    ```
- Any class can act as the file containing the main program.
  - The entry point is a class method with the following signature:

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

LET'S GET STARTED WITH JAVA (2)

- Use the *import* statement to import things from a package.
  - `import the.package.Name;` imports `Name` from `the.package`.
  - `import the.package.*;` imports everything from `the.package`.
- Everything in the package `java.lang` is imported by default.
- Use `System.out.println(...)` to write to the console.



`System` is a class...

...`out` is a class variable...

...`println` is a method that class variable has.

HELLO WORLD

```java
package se.ju.larpet.testprogram;

public class MyProgram{
  public static void main(String[] args){
    // Here we put our main program code.
    System.out.println("Hello World!");
  }
}
```

MyProgram.java

HOW TO RUN THE CODE

- Compile `.java` files to `.class` files (`MyClass.java` → `MyClass.class`).
  - The `javac` command is used for this.
- Run the `.class` file with the `main` method in a JVM.
  - The `java` command is used for this.
- Multiple classes are better packaged into a *jar* (Java ARchive) file.
  - Jar files are ZIP files with `.jar` extension.
  - The `jar` command is used for this.
  - Libraries/Programs are distributed as jar files.
    - To run a jar file: `java -jar the-jar-file.jar`

EXAMPLE

LOCAL VARIABLES

Can be used inside constructors and methods.

```
<datatype> variableName = <expression>;
```

- Naming convention: `likeThis` (camelCase, first letter lowercase).
- Can later be assigned a new value.

```
variableName = <expression>
```

PRIMITIVE DATATYPES

Datatype	Size	Min value	Max value	Default value (for fields)
byte	8 bits	`-128`	`127`	`0`
short	16 bits	`-32 768`	`32 767`	`0`
int	32 bits	`-2 147 483 648`	`2 147 483 647`	`0`
long	64 bits	-2^{63}	$2^{63}-1$	`0L`
float	32 bits			`0.0f`
double	64 bits			`0.0`
char	16 bits			`'\u0000'`
boolean				`false`

NUMERICAL BINARY OPERATORS

Operator	Symbol
Addition	+
Subtraction	-
Multiplication	*
Division	/
Modulus	%

- If one operand is `double`
  → convert the other to `double`.
- Otherwise, if one operand is `float`
  → convert the other to `float`.
- Otherwise, if one operand is `long`
  → convert the other to `long`.
- Otherwise, convert both to `int`s.

The outcome has the same datatype as the (possibly converted) operands.

- int / int → int
- int / 0 → throws `ArithmeticException`
- decimal number / 0.0 → `Double.POSITIVE_INFINITY` or `Double.NEGATIVE_INFINITY`
- short + short → int

RELATIONAL OPERATORS

Operation	Symbol
Less than	<
Greater than	>
Equal to	==
Not equal to	!=
Less than or equal to	<=
Greater than or equal to	>=

- If one operand is `double`
  → convert the other to `double`.
- Otherwise, if one operand is `float`
  → convert the other to `float`.
- Otherwise, if one operand is `long`
  → convert the other to `long`.
- Otherwise, convert both to `ints`.

LOGICAL OPERATORS

- Only works on Booleans!
- Most common logical operators:
  - Not:
    ```
    !<expression>
    ```
  - Or:
    ```
    <expression> || <expression>
    ```
  - And:
    ```
    <expression> && <expression>
    ```

Are lazy!

- More operators exist, e.g.:
  - Bitwise or: `<expression> | <expression>`
  - Bitwise and: `<expression> & <expression>`

THE IF STATEMENT

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

THE (DO) WHILE LOOP

```
while(<expression>){
   <statements>
}
```

```
do{
   <statements>
}while(<expression>);
```

THE FOR LOOP

```
for(<initialization>; <condition>; <change>){
   <statements>
}
```

Typically use the variable `i`, storing an `int`.

ARRAYS

```
<datatype>[] variableName = new <datatype>[<expression>];
```

- All elements must be of `<datatype>`.
- The first index is `0`.
- Retrieve element at position `<index>`:

  `variableName[<index>]`
- Assign `<newValue>` to element at position `<index>`:

  `variableName[<index>] = <newValue>`
- Number of elements in the array:

  `variableName.length`

ARRAYS EXAMPLE

```
public class NumbersProgram{
  public static void main(String[] args){
    int[] numbers = new int[3];
    numbers[0] = 3;
    numbers[1] = 1;
    numbers[2] = 4;
    int sum = numbers[0] + numbers[1] + numbers[2];




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

ARRAYS EXAMPLE

```java
public class NumbersProgram{
  public static void main(String[] args){
    int[] numbers = new int[3];
    numbers[0] = 3;
    numbers[1] = 1;
    numbers[2] = 4;
    int sum = 0;
    for(int i=0; i<numbers.length; i++){
      sum += numbers[i];
    }
    System.out.println(sum);
  }
}
```

INITIALIZING ARRAYS

```
int[] numbers = new int[3];
numbers[0] = 3;
numbers[1] = 1;
numbers[2] = 4;
```

```
int[] numbers = {3, 1, 4};
```

THE ENHANCED FOR LOOP

- Iterates through arrays and collections.
  - Collection = class implementing the interface `Iterable<T>`.
- No index.

```
for(<datatype> variableName : collection){
   <statements>
}
```

ARRAYS EXAMPLE

```java
public class NumbersProgram{
  public static void main(String[] args){
    int[] numbers = new int[3];
    numbers[0] = 3;
    numbers[1] = 1;
    numbers[2] = 4;
    int sum = 0;
    for(int i=0; i<numbers.length; i++){
      sum += numbers[i];
    }
    System.out.println(sum);
  }
}
```

```java
public class NumbersProgram{
  public static void main(String[] args){
    int[] numbers = {3, 1, 4};



    int sum = 0;
    for(int number : numbers){
      sum += number;
    }
    System.out.println(sum);
  }
}
```

CLASS VISIBILITY

Sets restriction on who may use the class.

```
package sample.package;


<visibility> class MyClassName{
   // Code for the class...
}
```

<visibility>	Accessible
public	Everywhere.
(default)	Same package.

MEMBER VISIBILITY

Used for fields, constructors, methods and nested types.

```
package sample.package;

public class ClassName{
  <visibility> <datatype> fieldName;
  <visibility> ClassName(){}
  <visibility> <datatype> methodName(){}
  <visibility> class NestedClassName{
  }
}
```

`<visibility>`	**Accessible**
`public`	Everywhere.
`protected`	The package + subclasses in other packages.
(default)	The package.
`private`	The class itself only.

A COUNTER EXAMPLE

```
public class Counter{
  private int value;
  public Counter(int startValue){
    value = startValue;
  }
  public void increment(int amount){
    value += amount;
  }
  public int getValue(){
    return value;
  }
}
```

```
public class TestCounterProgram{
  public static void main(String[] args){
    Counter c = new Counter(5);
    c.increment(3);
    System.out.println(c.getValue());
  }
}
```

WHERE'S `THIS`?

- In constructors, `this` refers to the object being created.
- In methods, `this` refers to the object calling the method.
- In most cases it's not needed.
  - If a name can't refer to anything else but a member on `this`, Java will use that member.

A COUNTER EXAMPLE

```java
public class Counter{
  private int value;
  public Counter(int startValue){
    value = startValue;
  }
  public void increment(int amount){
    value += amount;
  }
  public int getValue(){
    return value;
  }
}
```

```java
public class Counter{
  private int value;
  public Counter(int value){
    this.value = value;
  }
  public void increment(int amount){
    value += amount;
  }
  public int getValue(){
    return value;
  }
}
```

METHOD OVERLOADING

Methods can have the same name.

- Their parameters must be different.

The same goes for constructors.

- `this(<arguments>)` calls other constructors (must be first statement).

```
public class MyClass{
  public MyClass(int aNumber){
    // Constructor with one int parameter.
  }
  public MyClass(){
    this(64);
  }
  public static void main(String[] args){
    MyClass object1 = new MyClass(1);
    MyClass object2 = new MyClass();
  }
}
```

CONSTRUCTORS

- All classes must have at least one.
- If you write none, Java will add one for you.
  - Called the default constructor.
  - Got no parameters.

INHERITANCE

A class always inherit members from *one* other class.

- Default super class: `Object`
- You specify the super class:
  ```
  public class MyClass extends TheSuperClass{ ... }
  ```
- The keyword `super` refers to the super class.
  - In constructors, call a constructor in the super class:
    ```
    super(<arguments>)
    ```
  - In methods, call a method in the super class:
    ```
    super.methodName(<arguments>)
    ```
- Constructors are not explicitly inherited.
- One constructor in the super class must be called.
  - If you don't call it, Java will do it for you (the default constructor).

INHERITANCE EXAMPLE

```java
public class ClassA{
  private int theNumber;
  public ClassA(int aNumber){
    theNumber = aNumber;
  }
  public int getNumber(int factor){
    return theNumber*factor;
  }
}
```

```java
public class ClassB extends ClassA{
  public ClassB(){
    super(42);
  }
  @Override
  public int getNumber(int term){
    return super.getNumber(2)+term;
  }
}
```

Dear compiler,
We are overriding this
method on purpose.

ABSTRACT METHODS & CLASSES

The keyword `abstract` makes classes and methods abstract.

- Example abstract method:
  ```
  public abstract void methodName();
  ```
- Example abstract class:
  ```
  public abstract class ClassName{ ... }
  ```
  - Can't be instantiated.
  - Must be abstract if it has at least one abstract method.

INTERFACES

- Java doesn't support multiple inheritance.
  - Instead, Java has interfaces.
- An interface is a collection of public abstract methods.
  - And static methods, and default methods, ...
- A class can implement multiple different interfaces:

```
public class MyClass implements InterfaceA, InterfaceB{ ... }
```

INTERFACE EXAMPLE

```java
public interface SimpleCalculator{
  void add(double number);
}
```

```java
public interface ComplexCalculator{
  void multiply(double number);
}
```

```java
public class Calculator implements
SimpleCalculator, ComplexCalculator{
  private double memory;
  public Calculator(){
    memory = 0.0;
  }
  @Override
  public void add(double number){
    memory += number;
  }
  @Override
  public void multiply(double number){
    memory *= number;
  }
}
```

EXCEPTIONS

- Use the throw statement to throw exceptions:

  ```
  throw <theException>;
  ```

- Any instance of a class subclassing `Throwable` can be thrown.
  - Typically extend the class `Exception` for your own exceptions.
- Methods throwing exceptions:

  ```
  public void methodName() throws TheException{ }
  ```

  - `RunnableException`s don't need this.
- Handle thrown exceptions with the `try`, `catch` and `finally` statements.

EXCEPTIONS EXAMPLE

```
class MyException extends Exception{
  public MyException(String msg){
    super(msg);
  }
}
```

```
try{
  mightThrowException();
}catch(MyException e){
  // Handle the exception.
  System.out.println(e.getMessage());
}catch(ExceptionName e){
  e.printStackTrace();
}finally{
  // Clean up!
}
```

GENERIC CLASSES

- A generic class has type parameters:

```
class ClassName<T>{ ... }
```

- The one using the class specifies which type to use:

```
ClassName<AClass> o = new ClassName<>()
```

- Typically used for collections:

```
ArrayList<MyClass> list = new ArrayList<>();
list.add(new MyClass());
list.add(new MyClass());
```

LIST EXAMPLE

```
public class Human{
  public int age;
  public Human(int age){
    this.age = age;
  }
}
```

```
public class TestClass{
  public static void main(String[] args){
    ArrayList<Human> humans = new ArrayList<>();
    humans.add(new Human(23));
    humans.add(new Human(24));
    Human human = humans.get(1);
    humans.remove(0);
    humans.remove(human);
  }
}
```

EXAMPLE

```
public class Pair<T1, T2>{
  private T1 field1;
  private T2 field2;
  public Pair(T1 field1, T2 field2){
    this.field1 = field1;
    this.field2 = field2;
  }
  public T1 get1(){ return field1; }
  public T2 get2(){ return field2; }
}
```

```
public class TestClass{
 public void Test(){
  Pair<ClassA, ClassB> p = new Pair<>(
   new ClassA(),
   new ClassB()
  );
  ClassA a = p.get1();
  ClassB b = p.get2();
 }
}
```

GENERIC CLASSES

- Primitive datatypes can't be used as generic type parameters.
- But each primitive datatype have a corresponding class:
  - `int` has the class `Integer`.
  - `double` has the class `Double`.
  - …

EXAMPLE

```
public class TestClass{
  public void Test(){
    Pair<Integer, Double> p = new Pair<>(
      new Integer(20),
      new Double(2.32)
    );
    int a = p.get1().intValue();
    double b = p.get2().doubleValue();
  }
}
```

GENERIC CLASSES

Java 5.0 added:

- Autoboxing:
  - Convert a primitive type to corresponding class automatically.
- Unboxing:
  - Convert a class to the corresponding primitive type automatically.

EXAMPLE

```
public class TestClass{
  public void Test(){
    Pair<Integer, Double> p = new Pair<>(
      20,
      2.32
    );
    int a = p.get1();
    double b = p.get2();
  }
}
```

DOWNCASTING

```java
public abstract class ClassA{}
```

```java
public class ClassB1 extends ClassA{
  public int b1 = 1;
}
```

```java
public class ClassB2 extends ClassA{
  public int b2 = 23;
}
```

```java
public class Test{
  public int sum(List<ClassA> things){
    int sum = 0;
    for(ClassA thing : things){
      if(thing instanceof ClassB1){
         ClassB1 t = (ClassB1) thing;
         sum += t.b1;
      }else{
         ClassB2 t = (ClassB2) thing;
         sum += t.b2
      }
    }
    return sum;
  }
}
```

DOWNCASTING

Avoid it if possible.

- E.g. by using polymorphism.

```
public class Test{
  public int sum(List<ClassA> things){
    int sum = 0;
    for(ClassA thing : things){
      sum += thing.getInt();
    }
    return sum;
  }
}
```

```
public abstract class ClassA{
  public abstract int getInt();
}
```

```
public class ClassB1 extends ClassA{
  public int b1 = 1;
  @Override
  public int getInt(){ return b1; }
}
```

```
public class ClassB2 extends ClassA{
  public int b2 = 23;
  @Override
  public int getInt(){ return b2; }
}
```

STRINGS

- Handled through the class `String` from the package `java.lang`.
  - Can be created with double quotes:
    `"This is a string!"`
- Are immutable.
- Concatenate strings with the + operator.
  - `"This is "+"a string!"` → `"This is a string!"`
  - Any value can be used with the concatenation operator.
    - The `toString()` method is called on the object.
- The == operator compares references, use the `equals` method instead.

THE STATIC KEYWORD

```
public class Counter{
  private static int value = 0;
  public static void inc(int amount){
    value += amount;
  }
  public static int getValue(){
    return value;
  }
}
```

```
public class TestProgram{
  public static void main(String[] args){
    Counter.inc(12);
    System.out.println(Counter.getValue());
  }
}
```

THE STATIC KEYWORD

```java
public class MyClass{
  private int age = 23;
  public class MyInnerClass2{
    // I can access instance variables from MyClass!
  }
  public static class MyInnerClass{
    // I can't do that ☹
  }
}
```

THE STATIC KEYWORD

```
public class MyClass{
  public static ArrayList<Integer> ints = new ArrayList<>();
  static{
    ints.add(1);
    ints.add(2);
    ints.add(3);
  }
}
```

ENUMS

```java
public class MyClass{
  public enum Day{ MONDAY, TUESDAY, WEDNESDAY, THURSDAY,
                   FRIDAY, SATURDAY, SUNDAY }
  public static void main(String[] args){
    Day today = Day.SATURDAY;
    if(today == Day.MONDAY){
      System.out.println("Time to work!");
    }
  }
}
```