

Advanced Programming [AP-2022]

Detailed Syllabus

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This document lists the topics presented along the course using the PDF slides published on the course web page [<http://pages.di.unipi.it/corradini/Didattica/AP-22/>]. The reading material consists of the slides presented during the course AND of the additional documents listed below for each topic.

[**Note:** The topics marked [Optional] will not asked by the lecturer during the oral exam, unless they are chosen by the student].

1. Languages and Abstract Machines. Compilation and interpretation schemes.

[Chapter 1 [<http://pages.di.unipi.it/corradini/Didattica/AP-22/DOCS/GM-ch1.pdf>] of book *Programming Languages: Principles and Paradigms*, by Maurizio Gabbriellini and Simone Martini.]

2. Runtime Systems and Introduction to the JVM

a. JVM internals

[*JVM Internals*, by J.D. Bloom, <http://blog.jamesdbloom.com/JVMInternals.html>]

b. The JVM Instruction Set

[*Java Code To Byte Code - Part One*, by J.D. Bloom,

http://blog.jamesdbloom.com/JavaCodeToByteCode_PartOne.html]

c. [Optional] See also [Chapter 2 of *The Java Virtual Machine Specification, Java SE 8 Edition* <https://docs.oracle.com/javase/specs/jvms/se8/jvms8.pdf>]

3. Software Components

a. An introduction to Software Components

[Chapters 1, and 4 of [COMP]¹ - *Software Components: Beyond Object-Oriented Programming*. C. Szyperski, D. Gruntz, S. Murer, Addison-Wesley, 2002.]

b. Software Components: the Sun approach, JavaBeans

[Sections 14.1 (p. 261-269), 14.3 (p. 284-293) of [COMP]¹

[Sections 1, 2, 6, 7, 8 of *The JavaBeans API Specification*,

<http://pages.di.unipi.it/corradini/Didattica/AP-22/DOCS/JBS.101.pdf>]

c. Reflection in Java

[*The Java Tutorial on the Reflection API*,

<https://docs.oracle.com/javase/tutorial/reflect/index.html> excluding *Arrays and Enumerated Types*.]

d. Annotations in Java

[*The Java Tutorial on the Reflection API*,

<https://docs.oracle.com/javase/tutorial/java/annotations/index.html>

e. Software Components: the .NET framework by Microsoft

[Sections 15.1, 15.11, and 15.12 of [COMP]¹

f. Frameworks and Inversion of Control: Decoupling components; Dependency Injections; IoC Containers

¹ Selected chapters of book [COMP] can be downloaded from the course web page.

[*Inversion of Control*, by Martin Fowler,
<https://martinfowler.com/bliki/InversionOfControl.html>]

[*Inversion of Control Containers and the Dependency Injection pattern*, by Martin Fowler, <https://martinfowler.com/articles/injection.html>]

g. On designing Software Frameworks

[*Using classic problems to teach Java framework design*, by H.C. Cunningham, Yi Liu and C. Zhang, *Science of Computer Programming* 59 (2006),
<http://pages.di.unipi.it/corradini/Didattica/AP-22/DOCS/FrameworkDesign.pdf>]

4. Polymorphism

a. A classification of Polymorphism

b. Polymorphism in C++: inclusion polymorphism and templates

[Overloads and Templates in C++

<http://www.cplusplus.com/doc/tutorial/functions2/>]

[Inclusion polymorphism in C++,

<http://www.cplusplus.com/doc/tutorial/polymorphism/>]

[Templates in C++, <http://www.cplusplus.com/doc/oldtutorial/templates/>]

c. Java Generics, Type bounds and subtyping, Subtyping and arrays in Java, Wildcards, Type erasure

[Java Generics <https://docs.oracle.com/javase/tutorial/java/generics/index.html>]

d. The Standard Template Library: an overview

[*The Standard Template Library Tutorial*, by Johannes Weidl: Page 4, 12 and parts of Chapter 4 "*Learning STL*",

<http://pages.di.unipi.it/corradini/Didattica/AP-22/DOCS/stl-tutorial-Weidl.pdf>],

e. Generics and inheritance: invariance, covariance and contravariance in Java and other languages

[Covariance and Contravariance in C#,

<https://docs.microsoft.com/en-us/dotnet/csharp/programming-guide/concepts/covariance-contravariance/>
]

[Covariance and Contravariance in Scala,

<http://blog.kamkor.me/Covariance-And-Contravariance-In-Scala>]

5. Functional Programming

a. Introduction to functional programming

[Section 10.1 and 10.2 of Chapter 10 of *Programming Language Pragmatics*, by Michael Scott, 3rd edition.

<http://pages.di.unipi.it/corradini/Didattica/AP-22/DOCS/Scott-ch10.pdf>]

b. [Optional] A digression on the lambda-calculus [Introduction to Lambda Calculus, <http://www.inf.fu-berlin.de/lehre/WS03/alpi/lambda.pdf>]

6. Haskell

a. Introduction to Haskell, Laziness, Call by need, Basic and compounds types, Patterns and declarations, Function declarations

[Introduction to Haskell, by John C. Mitchell,

<http://pages.di.unipi.it/corradini/Didattica/AP-22/DOCS/Ch5.pdf>]

[An excellent tutorial on Haskell: <http://learnyouahaskell.com>, Sections "Introduction" and "Starting out"]

[Basic Types and Type Classes:

<http://learnyouahaskell.com/types-and-typeclasses>]

[Functions in Haskell: <http://learnyouahaskell.com/syntax-in-functions>]

b. List comprehension, Algebraic Data Types, Higher-order functions, Recursion

[Recursion: <http://learnyouahaskell.com/recursion>]

[Higher-order functions: <http://learnyouahaskell.com/higher-order-functions>]

c. Type classes in Haskell

[Type Classes in Haskell, by John C. Mitchell,

<http://pages.di.unipi.it/corradini/Didattica/AP-22/DOCS/Ch7.pdf>]

d. The Maybe constructor and composition of partial functions.

Monads in Haskell

[A very short tutorial on Monads

<http://www.idryman.org/blog/2014/01/23/yet-another-monad-tutorial/>]

[Monads as Containers, https://wiki.haskell.org/Monads_as_containers]

[Monads as Computations, https://wiki.haskell.org/Monads_as_computation]

e. [Optional] The IO Monad

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/IO

https://wiki.haskell.org/IO_inside

7. Functional programming in Java 8

a. Lambdas in Java 8

[Lambda Expressions in Java

<http://docs.oracle.com/javase/tutorial/java/javaOO/lambdaexpressions.html>]

b. The Stream API in Java 8

[Aggregate Operations in Java

<https://docs.oracle.com/javase/tutorial/collections/streams/index.html>]

8. An overview of the Rust programming language

Reading material: selected sections of <https://doc.rust-lang.org/book/index.html> and slides presented in class

a. Ownership, Borrowing, “Resource Acquisition is Initialization”, and Lifetimes in Rust. Why typical memory-related programming errors cannot happen in Rust.

b. Generic types, traits, smart pointers, unsafe Rust.

9. Scripting Languages and Python

a. Introduction to Python: Basic and Sequence Datatypes, Dictionaries, Control Structures, List Comprehension

[The Python Tutorial: till Section 4.5 and Section 5,

<http://docs.python.org/tutorial/>]

b. Python: Function definition, Positional and keyword arguments of functions, Functional Programming in Python, Iterators and Generators, Using higher order functions: Decorators

[The Python Tutorial: Defining Functions, Sections 4.6 and 4.7,

<https://docs.python.org/3.7/tutorial/controlflow.html#defining-functions>]

[Primer on Python Decorators,

<https://realpython.com/blog/python/primer-on-python-decorators/>]

- c. **[Optional]** Python: Classes and Instances, Single and Multiple Inheritance, Magic Methods for operator overloading, Modules definition and importing
[The Python Tutorial: Sections 6 and 9, <http://docs.python.org/tutorial/>]
- d. **[Optional]** The Global Interpreter Lock (GIL).
[Inside the Python GIL, by David Beazley:
<http://pages.di.unipi.it/corradini/Didattica/AP-22/DOCS/InsideThePythonGIL.pdf>
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