



HOGESCHOOL ROTTERDAM / CMI

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# Functional Programming

INFADP01-D/INFADP21-D  
2021-2022

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Number of study points: 4 ects

Course owners: Francesco Di Giacomo, Mohamed Abbadi



## Module description

<b>Module name:</b>	Functional Programming
<b>Module code:</b>	INFADP01-D/INFADP21-D
<b>Study points and hours of effort:</b>	<p>This module gives 4 ects, in correspondence with 112 hours:</p> <ul style="list-style-type: none"> <li>• 2 X 7 hours of theory.</li> <li>• 2 X 7 hours of practice.</li> <li>• the rest is self-study</li> </ul>
<b>Examination:</b>	Written Exam and Practical assessment
<b>Course structure:</b>	Lectures, self-study, and practical exercises
<b>Prerequisite knowledge:</b>	all INFDEV courses.
<b>Learning materials:</b>	<ul style="list-style-type: none"> <li>• Book: Don Syme - Expert F#</li> <li>• exercises and assignments, to be done at home and during the practical part of the lectures (pdf): <u>uploaded to microsoft teams.</u></li> </ul>
<b>Connected to competences:</b>	realiseren en ontwerpen
<b>Learning objectives:</b>	<p>At the end of the course, the student:</p> <ul style="list-style-type: none"> <li>• <b>understands</b> the fundamental semantic difference between functional and imperative programming. (FP VS IMP)</li> <li>• <b>understands</b> reduction strategies such as <math>\rightarrow_{\beta}</math>. (RED)</li> <li>• <b>understands</b> the basics of a functional type system. (TYP)</li> <li>• <b>can program</b> with the typical constructs of a modern functional language. The language of focus is F#. (FP EXT)</li> </ul>
<b>Course owners:</b>	Francesco Di Giacomo, Mohamed Abbadi
<b>Date:</b>	May 30, 2022



# 1 General description

Functional programming and functional programming languages are increasing in popularity for multiple reasons and in multiple ways, to the point that even mainstream languages such as Python, C++, C#, and Java are being extended with more and more functional programming features such as tuples, lambda's, higher order functions, and even monads such as LINQ and async/await. Whole architectures such as the popular map/reduce are strongly inspired by functional programming.

“Java™ developers should learn functional paradigms now, even if they have no immediate plans to move to a functional language such as Scala or Clojure. Over time, all mainstream languages will become more functional” [IBM].

“LISP is worth learning for a different reason — the profound enlightenment experience you will have when you finally get it. That experience will make you a better programmer for the rest of your days, even if you never actually use LISP itself a lot.” – Eric S. Raymond

“SQL, Lisp, and Haskell are the only programming languages that I’ve seen where one spends more time thinking than typing.” – Philip Greenspun

“I do not know if learning Haskell will get you a job. I know it will make you a better software developer.” – Larry O’ Brien

The reason for this growth is to be found in the safe and deep expressive power of functional languages, which are capable of recombining simpler elements into powerful, complex other elements with less space for mistakes and more control in the hands of the programmer. This comes at a fundamental cost: functional languages are structurally different from imperative and object oriented languages, and thus a new mindset is required of the programmer that wishes to enter this new world. Moreover, functional languages often require more thought and planning, and are thus experienced, especially by beginners, as somewhat less flexible and supporting of experimentation.

## 1.1 Relationship with other didactic units and required knowledge

This module completes and perfects the understanding and knowledge of programming that was set up in the Development courses of the first year. The preliminary knowledge necessary to fully understand this course covers the following topics:

- Semantics of programming languages and its evaluation.
- The memory model of *Stack* and *Heap*.
- *Type systems* and type checking.
- Dynamic vs Static typing.



## 2 Course program

The course topics are divided in 5 conceptual units, not necessarily in a one-to-one correspondance with the course weeks, which are seven.

### Unit 1

#### Topics

- Stateful vs stateless computation
- Lambda calculus semantics.
  - Variables
  - Lambda-abstractions/functions
  - Function application
- Introduction to F#

### Unit 2

#### Topics

- Typed lambda calculus. Typing variables, lambda abstractions, function applications.
- Basic data structures in F#
- Structural equality.

### Unit 3

#### Topics

- Polymorphism in functional programming
- Discriminated unions.
- Pattern matching.

### Unit 4

#### Topics

- Higher-order functions.
- Function composition.
- HOF design patterns.

### Unit 5

#### Topics

- Hierarchical advanced data structures.
- Immutable trees.
- Immutable binary search trees.
- Decision trees.
- Graphs.



### 3 Assessment

The course is tested with two exams: a written exam and a practical exam. The theory part happens on paper while you can use your laptop in the practical one. Both parts result in a single grade. This means that partial grades on each part are not kept.

#### 3.1 Theoretical examination INFADP01-D/INFADP21-D

The general shape of an exam for INFADP01-D/INFADP21-D is made up of a short series of highly structured open questions. In each exam the content of the questions will change, but the structure of the questions will remain the same. Questions might include (but not limited to): apply the semantics of lambda calculus on a small function, determine the type of a functional program, determine the result of the execution of a functional program. A sample exam will be provided during the course. The theoretical examination mainly covers the lambda calculus topics from unit 1 and 2.

#### 3.2 Practical examination INFADP01-D/INFADP21-D

The practical exam requires to implement a series of functions (described in the exam text) in the language F#. The practical examination contains a question on each learning unit (simple recursion, recursion with basic data structures, polymorphism, higher-order design patterns, and advanced data structures). During the practical examination you are allowed to use your laptop.

##### 3.2.1 Important

For the practical part, you will be provided with a solution template that contains an automatic checker as a pre-compiled library. This checker will tell you in any moment which exercises are correct and your score. In order to compile and run this template, you need .NET 6.0, so be sure that everything is set up correctly on your machine before the exam. You can test if everything works in advance by compiling and running one of the sample exams.

#### 3.3 Note for retakers

The retakers of the old INFDEV02-8 (Development 8) and functional programming (INFFPR01-D/21-D) must repeat the whole exam because now the system records just a single grade. This means that if you passed partially the theory or practice of either Development 8 or INFFPR01-D/21-D you need to repeat the whole exam.



## Appendix 1: Assessment matrix

Learning objective	Dublin descriptors
FP VS IMP	1, 4, 5
RED	1, 2, 4, 5
TYP	1, 4, 5
FP EXT	1, 2

Dublin-descriptors:

1. Knowledge and understanding
2. Applying knowledge and understanding
3. Making judgments
4. Communication
5. Learning skills