

Programming with Scala: Language Exploration

Bhim Upadhyaya ©2017

Contents

Contents	i
1 Introduction to Computing	3
1.1 Introduction to Computers	5
1.1.1 Basic Components	5
1.1.2 Operation	5
1.2 Operating Systems	5
1.3 Programming Languages	5
1.4 Introduction to Scala	6
1.5 Program Attributes	6
1.6 Conclusion	6
1.7 Review Questions	6
1.8 Problems	6
1.9 Answers to Review Questions	6
1.10 Solutions to Problems	6
2 Scala Fundamentals	7
2.1 Literals	7
2.2 Identifiers and Keywords	7
2.3 Types	7
2.4 Declarations and Definitions	7
2.5 Expressions	8
2.6 Conclusion	8

2.7	Review Questions	8
2.8	Problems	8
2.9	Answers to Review Questions	8
2.10	Solutions to Problems	8
3	Classes and Objects	9
3.1	Class Members	9
3.2	Class Definition	9
3.3	Object Definitions	9
3.4	Conclusion	9
3.5	Review Questions	10
3.6	Problems	10
3.7	Answers to Review Questions	10
3.8	Solutions to Problems	10
4	Control Structures	11
4.1	For Expressions	11
4.2	While Loops	11
4.3	If Expressions	11
4.4	Exception Handling	11
4.5	Conclusion	12
4.6	Review Questions	12
4.7	Problems	12
4.8	Answers to Review Questions	12
4.9	Solutions to Problems	12
5	Operators	13
5.1	Operators as Methods	13
5.2	Arithmetic Operators	13
5.3	Relational and Logical Operators	13
5.4	Bitwise Operators	13

5.5	Operator Precedence and Associativity	14
5.6	Conclusion	14
5.7	Review Questions	14
5.8	Problems	14
5.9	Answers to Review Questions	14
5.10	Solutions to Problems	14
6	Data Input and Output	15
6.1	Single Character Input	15
6.2	Single Character Output	15
6.3	Reading From a File	15
6.4	Writing to a File	15
6.5	Navigating Directories	16
6.6	Conclusion	16
6.7	Review Questions	16
6.8	Problems	16
6.9	Answers to Review Questions	16
6.10	Solutions to Problems	16
7	Traits	17
7.1	Traits as Interfaces	17
7.2	Construction Order	17
7.3	Trait Members	17
7.4	Multiple Inheritance	17
7.5	Traits with Implementations	18
7.6	Conclusion	18
7.7	Review Questions	18
7.8	Problems	18
7.9	Answers to Review Questions	18
7.10	Solutions to Problems	18

8	Functions	19
8.1	Functions as Methods	19
8.2	Anonymous Functions	19
8.3	Functions as Values	19
8.4	Higher-Order Functions	19
8.5	Closures	20
8.6	Currying	20
8.7	Conclusion	20
8.8	Review Questions	20
8.9	Problems	20
8.10	Answers to Review Questions	20
8.11	Solutions to Problems	20
9	Pattern Matching	21
9.1	Case Classes	21
9.2	Variable Patterns	21
9.3	Typed Patterns	21
9.4	Pattern Binders	21
9.5	Literal Patterns	22
9.6	Stable Identifier Patterns	22
9.7	Constructor Patterns	22
9.8	Tuple Patterns	22
9.9	Extractor Patterns	22
9.10	Sequence Patterns	22
9.11	Infix Operation Patterns	22
9.12	XML Patterns	22
9.13	Regular Expression Patterns	23
9.14	Irrefutable Patterns	23
9.15	Type Patterns	23
9.16	Conclusion	23

9.17 Review Questions	23
9.18 Problems	23
9.19 Answers to Review Questions	23
9.20 Solutions to Problems	23
10 Inheritance and Composition	25
10.1 Extending Classes	25
10.2 Overriding Methods and Fields	25
10.3 Abstract Classes	25
10.4 Invoking Superclass Constructors	25
10.5 Polymorphism and Dynamic Binding	26
10.6 Composition	26
10.7 Conclusion	26
10.8 Review Questions	26
10.9 Problems	26
10.10 Answers to Review Questions	26
10.11 Solutions to Problems	26
11 List Processing	27
11.1 List Construction	27
11.2 Operations	27
11.3 Patterns	27
11.4 List Class	27
11.5 List Object	28
11.6 Conclusion	28
11.7 Review Questions	28
11.8 Problems	28
11.9 Answers to Review Questions	28
11.10 Solutions to Problems	28
12 The Scala Collections Framework	29

12.1 Mutable versus Immutable Collections	29
12.2 Sets	29
12.3 Maps	29
12.4 Sequences	29
12.5 Tuples	30
12.6 Conclusion	30
12.7 Review Questions	30
12.8 Problems	30
12.9 Answers to Review Questions	30
12.10 Solutions to Problems	30
13 Actors	31
13.1 The Components of Actors	31
13.2 Creating Actors	31
13.3 Sending and Receiving Messages	31
13.4 Life Cycle	31
13.5 Channels	32
13.6 Linking	32
13.7 Conclusion	32
13.8 Review Questions	32
13.9 Problems	32
13.10 Answers to Review Questions	32
13.11 Solutions to Problems	32
14 XML Processing	33
14.1 XML Literals	33
14.2 Serialization and Deserializing	33
14.3 Data Extraction	33
14.4 Pattern Matching	33
14.5 Loading and Saving	34

14.6 Conclusion	34
14.7 Review Questions	34
14.8 Problems	34
14.9 Answers to Review Questions	34
14.10 Solutions to Problems	34
15 Parsing	35
15.1 Lexical Analysis and Parsing	35
15.2 Running Parser	35
15.3 Regular Expression Parser	35
15.4 JSON Parser	35
15.5 Error Handling	36
15.6 Conclusion	36
15.7 Review Questions	36
15.8 Problems	36
15.9 Answers to Review Questions	36
15.10 Solutions to Problems	36
16 GUI Programming	37
16.1 Simple Application	37
16.2 Events	37
16.3 Panels	37
16.4 Layouts	37
16.5 Example Application	38
16.6 Conclusion	38
16.7 Review Questions	38
16.8 Problems	38
16.9 Answers to Review Questions	38
16.10 Solutions to Problems	38
17 Unit Testing	39

17.1 Unit Testing in Scala	39
17.2 ScalaTest	39
17.3 ScalaCheck	39
17.4 JUnit	39
17.5 TestNG	40
17.6 Tests as Specifications	40
17.7 Conclusion	40
17.8 Review Questions	40
17.9 Problems	40
17.10Answers to Review Questions	40
17.11Solutions to Problems	40
Index	41

List of Figures

Draft not for circulation

Draft not for circulation

List of Tables

1.1 Sample Biological Taxonomy Data	4
---	---

Draft not for circulation

Draft not for circulation

Chapter 1

Introduction to Computing

The Oxford English Dictionary (OED) defines computing as “the use of operation of computers”; similarly, computation is defined as “the action of mathematical calculation.” In daily life, we often find these words being used interchangeably even though scientific community makes distinction. Let’s first analyze computation as it came first in the human civilization, formally with the invention of numbers. But it is quite self-evident that humans performed computation before inventing numbers as there should be a thought process before finding suitable symbols for that thought process. This kind of thought process is likely to be available in other *Mammalia*s as well as in some other *Classes*, categorized using traditional biological taxonomy.

Let’s take two examples to illustrate computation: $1 + 1 = 2$ and $13 + 29 = 42$. Now, let’s ask ourselves these questions: *What percentage of world population can perform first addition? What percentage of the world population can perform second addition without using a calculating machine? What percentage of world population can perform second addition using a calculating machine?* We should not be surprised if the answer to our first question is not 100%. The United Nations’ data show that answers to our second and third questions are not 100% [UNL].

Analyzing further in the same direction, there are many more questions to be asked including: *How long it took us to recognize real world objects? How long it took us to take instructions (both in the form of signs and spoken language) from elders and perform the addition task for the first time in our lives? How long it took us to recognize written alphabets and numerals? How long it took us to perform written addition? How long it took human kind to be in this state of mind, which allows one to instruct and another to follow instructions and perform actions?* These questions might look a bit overwhelming and unnecessary at first, but these and many other similar questions govern our learning life cycles.

Now, let’s take slightly different example to set stage for our Scala lessons.

SN	Hierarchy	Human	Dog	Domestic Pigeon	Cat
1	<i>Kingdom</i>	Animalia	Animalia	Animalia	Animalia
2	<i>Phylum</i>	Chordata	Chordata	Chordata	Chordata
3	<i>Class</i>	Mammalia	Mammalia	Aves	Mammalia
4	<i>Order</i>	Primates	Carnivora	Columbiformes	Carnivora
5	<i>Family</i>	Hominidae	Canidae	Columbidae	Felidae
6	<i>Genus</i>	Homo	Canis	Columba	Felis
7	<i>Species</i>	H. Sapiens	C. lupus	C. livia	F. catus

Table 1.1: Sample Biological Taxonomy Data

This too might look counter intuitive initially but we will write a Scala program for this later in this chapter. Table 1 shows sample biological categorization of human, dog, domestic pigeon, and cat. Here are some of the questions. *Is it a computational problem? Do we have sufficient information to decide whether it is a computational problem?*

Let's say, we are asked to build a dictionary or an information base that can be referred to get information. Now, it is fairly convenient to decide whether it is a computational problem if we have computing background. But this might be still confusing if we do not have any idea about computing, because computation cannot be seen on the surface. Even Google search may not look like a computational problem on the surface as we can't see regular calculations. In fact, Google search is a complex computation.

Assuming we don't have any knowledge of computing as defined by OED. Probably it is fair to say that all the human beings search at least one item in their life. When we are searching something, our mind performs computation. We might need to locate, count, or categorize items. Locating something might involve counting. For example, if we have to locate a book in another room, then we have to cross at least one door, assuming these are regular rooms in a regular house. Since we have enormous practice going from one room to another room in our lives, we might be performing the computation even without realizing it. Now, let's think about what it takes to train an infant as he/she grows to perform the same task. Does the infant need to learn how to count in order to perform this task? Probably the answer is yes. And it might take years to train the infant. Learning computing is not much different from this infant's training. The major difference is age. And of course, infants too can start learning computing these days.

We know how hard it is to live our lives without using any tool. Even in stone age, our ancestors used some sort of tools: a stone, a stick, or a little more

sophisticate tool. Now, all of us, we know why we need tools. Also we know that it is not the same tool that can be utilized to solve every problem in our lives. This is true in the case of computational tools as well. Since this book deals with a particular programming language, Scala, in details, let's be concrete and say that this is true for programming languages as well. Programming languages are parts of computational tools.

Now we have some ideas about computation. Let's ask another question: *can every computational problem be computed?* Well, there are several university level courses dedicated to answer this question. For now, we focus on our two problems—addition and tiny information base for biological taxonomy. The first one can certainly be computed. We limited the scope of second and made it viable for computing. Please note that we did not go for genomics, which requires enormous computing power.

In the following section, we discuss the basics of computing tools, called computers.

1.1 Introduction to Computers

(content here)

1.1.1 Basic Components

(content here)

1.1.2 Operation

(content here)

1.2 Operating Systems

(content here)

1.3 Programming Languages

(content here)

1.4 Introduction to Scala

(content here)

1.5 Program Attributes

(content here)

1.6 Conclusion

(content here)

1.7 Review Questions

(content here)

1.8 Problems

(content here)

1.9 Answers to Review Questions

(content here)

1.10 Solutions to Problems

(content here)

Chapter 2

Scala Fundamentals

(content here)

2.1 Literals

(content here)

2.2 Identifiers and Keywords

(content here)

2.3 Types

(content here)

2.4 Declarations and Definitions

(content here)

2.5 Expressions

(content here)

2.6 Conclusion

(content here)

2.7 Review Questions

(content here)

2.8 Problems

(content here)

2.9 Answers to Review Questions

(content here)

2.10 Solutions to Problems

(content here)

Chapter 3

Classes and Objects

(content here)

3.1 Class Members

(content here)

3.2 Class Definition

(content here)

3.3 Object Definitions

(content here)

3.4 Conclusion

(content here)

3.5 Review Questions

(content here)

3.6 Problems

(content here)

3.7 Answers to Review Questions

(content here)

3.8 Solutions to Problems

Draft not for circulation

Chapter 4

Control Structures

(content here)

4.1 For Expressions

(content here)

4.2 While Loops

(content here)

4.3 If Expressions

(content here)

4.4 Exception Handling

(content here)

4.5 Conclusion

(content here)

4.6 Review Questions

(content here)

4.7 Problems

(content here)

4.8 Answers to Review Questions

(content here)

4.9 Solutions to Problems

Draft not for circulation

Chapter 5

Operators

(content here)

5.1 Operators as Methods

(content here)

5.2 Arithmetic Operators

(content here)

5.3 Relational and Logical Operators

(content here)

5.4 Bitwise Operators

(content here)

5.5 Operator Precedence and Associativity

(content here)

5.6 Conclusion

(content here)

5.7 Review Questions

(content here)

5.8 Problems

(content here)

5.9 Answers to Review Questions

(content here)

5.10 Solutions to Problems

Chapter 6

Data Input and Output

(content here)

6.1 Single Character Input

(content here)

6.2 Single Character Output

(content here)

6.3 Reading From a File

(content here)

6.4 Writing to a File

(content here)

6.5 Navigating Directories

(content here)

6.6 Conclusion

(content here)

6.7 Review Questions

(content here)

6.8 Problems

(content here)

6.9 Answers to Review Questions

(content here)

6.10 Solutions to Problems

Chapter 7

Traits

(content here)

7.1 Traits as Interfaces

(content here)

7.2 Construction Order

(content here)

7.3 Trait Members

(content here)

7.4 Multiple Inheritance

(content here)

7.5 Traits with Implementations

(content here)

7.6 Conclusion

(content here)

7.7 Review Questions

(content here)

7.8 Problems

(content here)

7.9 Answers to Review Questions

(content here)

7.10 Solutions to Problems

Chapter 8

Functions

(content here)

8.1 Functions as Methods

(content here)

8.2 Anonymous Functions

(content here)

8.3 Functions as Values

(content here) sectionFunction Parameters (content here)

8.4 Higher-Order Functions

(content here)

8.5 Closures

(content here)

8.6 Currying

(content here)

8.7 Conclusion

(content here)

8.8 Review Questions

(content here)

8.9 Problems

(content here)

8.10 Answers to Review Questions

(content here)

8.11 Solutions to Problems

Chapter 9

Pattern Matching

(content here)

9.1 Case Classes

(content here)

9.2 Variable Patterns

(content here)

9.3 Typed Patterns

(content here)

9.4 Pattern Binders

(content here)

9.5 Literal Patterns

(content here)

9.6 Stable Identifier Patterns

(content here)

9.7 Constructor Patterns

(content here)

9.8 Tuple Patterns

(content here)

9.9 Extractor Patterns

(content here)

9.10 Sequence Patterns

(content here)

9.11 Infix Operation Patterns

(content here)

9.12 XML Patterns

(content here)

9.13 Regular Expression Patterns

(content here)

9.14 Irrefutable Patterns

(content here)

9.15 Type Patterns

(content here)

9.16 Conclusion

(content here)

9.17 Review Questions

(content here)

9.18 Problems

(content here)

9.19 Answers to Review Questions

(content here)

9.20 Solutions to Problems

Draft not for circulation

Chapter 10

Inheritance and Composition

(content here)

10.1 Extending Classes

(content here)

10.2 Overriding Methods and Fields

(content here)

10.3 Abstract Classes

(content here)

10.4 Invoking Superclass Constructors

(content here)

10.5 Polymorphism and Dynamic Binding

(content here)

10.6 Composition

(content here)

10.7 Conclusion

(content here)

10.8 Review Questions

(content here)

10.9 Problems

(content here)

10.10 Answers to Review Questions

(content here)

10.11 Solutions to Problems

Chapter 11

List Processing

(content here)

11.1 List Construction

(contenthere)

11.2 Operations

(content here)

11.3 Patterns

(content here)

11.4 List Class

(content here)

11.5 List Object

(content here)

11.6 Conclusion

(content here)

11.7 Review Questions

(content here)

11.8 Problems

(content here)

11.9 Answers to Review Questions

(content here)

11.10 Solutions to Problems

Chapter 12

The Scala Collections Framework

(content here)

12.1 Mutable versus Immutable Collections

(content here)

12.2 Sets

(content here)

12.3 Maps

(content here)

12.4 Sequences

(content here)

12.5 Tuples

(content here)

12.6 Conclusion

(content here)

12.7 Review Questions

(content here)

12.8 Problems

(content here)

12.9 Answers to Review Questions

(content here)

12.10 Solutions to Problems

Chapter 13

Actors

(content here)

13.1 The Components of Actors

(content here)

13.2 Creating Actors

(content here)

13.3 Sending and Receiving Messages

(content here)

13.4 Life Cycle

(content here)

13.5 Channels

(content here)

13.6 Linking

(content here)

13.7 Conclusion

(content here)

13.8 Review Questions

(content here)

13.9 Problems

(content here)

13.10 Answers to Review Questions

(content here)

13.11 Solutions to Problems

Chapter 14

XML Processing

(content here)

14.1 XML Literals

(content here)

14.2 Serialization and Deserializing

(content here)

14.3 Data Extraction

(content here)

14.4 Pattern Matching

(content here)

14.5 Loading and Saving

(content here)

14.6 Conclusion

(content here)

14.7 Review Questions

(content here)

14.8 Problems

(content here)

14.9 Answers to Review Questions

(content here)

14.10 Solutions to Problems

Draft not for circulation

Chapter 15

Parsing

(content here)

15.1 Lexical Analysis and Parsing

(content here)

15.2 Running Parser

(content here)

15.3 Regular Expression Parser

(content here)

15.4 JSON Parser

(content here)

15.5 Error Handling

(content here)

15.6 Conclusion

(content here)

15.7 Review Questions

(content here)

15.8 Problems

(content here)

15.9 Answers to Review Questions

(content here)

15.10 Solutions to Problems

Chapter 16

GUI Programming

(content here)

16.1 Simple Application

(content here)

16.2 Events

(content here)

16.3 Panels

(content here)

16.4 Layouts

(content here)

16.5 Example Application

(content here)

16.6 Conclusion

(content here)

16.7 Review Questions

(content here)

16.8 Problems

(content here)

16.9 Answers to Review Questions

(content here)

16.10 Solutions to Problems

Chapter 17

Unit Testing

(content here)

17.1 Unit Testing in Scala

(content here)

17.2 ScalaTest

(content here)

17.3 ScalaCheck

(content here)

17.4 JUnit

(content here)

17.5 TestNG

(content here)

17.6 Tests as Specifications

(content here)

17.7 Conclusion

(content here)

17.8 Review Questions

(content here)

17.9 Problems

(content here)

17.10 Answers to Review Questions

(content here)

17.11 Solutions to Problems

Bibliography

[UNL] United nations adult literacy rate. <http://data.un.org/Data.aspx?d=SOWC&f=inID>

Draft not for circulation