

# Scala Quick Ref @ Lund University

<https://github.com/lunduniversity/introprog/tree/master/quickref>

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## Top-level definitions

```
// in file: hello.scala
package x.y.z
object HelloWorld {
  def main(args: Array[String]): Unit = {
    println("Hi " + args.mkString(" "))
  }
}
```

A compilation unit (here hello.scala) consists of a sequence of packagings, import clauses, and class and object definitions, which may be preceded by a package clause, e.g.: **package** x.y.z that places the compiled file HelloWorld.class in directory x/y/z/

**Compile:** scalac hello.scala

**Run:** scala x.y.z.HelloWorld args  
Execution starts in method main.

## Definitions and declarations

A **definition** binds a name to a value/implementation, while a **declaration** just introduces a name (and type) of an abstract member. Below defsAndDecl denotes a list of definitions and/or declarations.

Variable	<b>val</b> x = expr <b>val</b> x: Int = 0 <b>var</b> x = expr <b>val</b> x, y = expr <b>val</b> (x, y) = (e1, e2) <b>val</b> Seq(x, y) = Seq(e1, e2) <b>val</b> x: Int = _	Variable x is assigned to expr. A <b>val</b> can only be <b>assigned once</b> . Explicit type annotation, expr: SomeType allowed after any expr. Variable x is assigned to expr. A <b>var</b> can be <b>re-assigned</b> . Multiple initialisations, x and y is initialised to the same value. Tuple pattern initialisation, x is assigned to e1 and y to e2. Sequence pattern initialisation, x is assigned to e1 and y to e2. Initialized to default value, 0 for number types, null for AnyRef types.
Function	<b>def</b> f(a: Int, b: Int): Int = a + b <b>def</b> f(a: Int = 0, b: Int = 0): Int = a + b f(b = 1, a = 3) <b>def</b> add(a: Int)(b: Int): Int = a + b (a: Int, b: Int) => a + b <b>val</b> g: (Int, Int) => Int = (a, b) => a + b f _ <b>val</b> inc = add(1) _ <b>def</b> addAll(xs: Int*) = xs.sum <b>def</b> twice(block: => Unit) = { block; block }	Function f of type (Int, Int) => Int Default arguments used if args omitted, f(). Named arguments can be used in any order. Multiple parameter lists, apply: add(1)(2) Anonymous function value, "lambda". Types can be omitted in lambda if inferable. Replacing a parameter list with a space and underscore gives the function itself as a value. Partially applied function add(1) of add above, where inc is of type Int => Int Repeated parameters: addAll(1,2,3) or addAll(Seq(1,2,3): _*) Call-by-name argument evaluated later.
Object	<b>object</b> Name { defsAndDecl }	Singleton object auto-allocated when referenced the first time.
Class	<b>class</b> C(parameters) { defsAndDecl } <b>case class</b> C(parameters) { defsAndDecl }	A template for objects, which are allocated with <b>new</b> . Case class parameters become val members, other case class goodies: equals, copy, hashCode, unapply, nice toString, companion object with apply factory.
Trait	<b>trait</b> T { defsAndDecl } <b>class</b> C <b>extends</b> D <b>with</b> T	A trait is an abstract class without parameters. Can be used as an interface. A class can only <b>extend</b> one normal class but mix in many traits using <b>with</b> .
Type	<b>type</b> A = typeDef	Defines an alias A for the type in typeDef. Abstract if no typeDef.
Import	<b>import</b> path.to.module.name <b>import</b> path.to.{a, b => x, c => _}	Makes name directly visible. Underscore imports all. Import several names, b renamed to x, c not imported.

Modifier	applies to	semantics
<b>private</b> [this]	definitions, declarations	Restricts access to this instance only; also private[p] for package p.
<b>private</b>	definitions, declarations	Restricts access to directly enclosing class and its companion.
<b>protected</b>	definitions	Restricts access to subtypes and companion.
<b>override</b>	definitions, declarations	Mandatory if overriding a concrete definition in a parent class.
<b>abstract</b>	class definitions	Abstract classes cannot be instantiated (redundant for traits).
<b>final</b>	definitions	Final members cannot be overridden, final classes cannot be extended.
<b>lazy</b>	val definitions	Delays initialization of val, initialized when first referenced.
<b>sealed</b>	class definitions	Restricts direct inheritance to classes in the same source file.

## Special methods

```
class A(initX: Int = 0) {
  private var _x = initX
  def x: Int = _x
  def x_=(i: Int): Unit = { _x = i }
}

object A {
  def apply(i: Int = 0) = new A(i)
  val a = A(1)._x
}
```

**primary constructor:** new A(1) or using default arg: new A()  
 private member only visible in A and its companion  
**getter** for private field \_x (name chosen to avoid clash with x)  
 special **setter** assignment syntax: val a = new A(1); a.x = 2

**companion object** if same name and in same code file  
**factory method** makes new unnecessary: A.apply(1), A(1), A()  
 private members can be accessed in companion

Getters and setters above are auto-generated by **var** in primary constructor:  
 With **val** in primary constructor only getter, no setter, is generated:

```
class A(var x: Int = 0)
class A(val x: Int = 0)
```

**Private constructor** e.g. to enforce use of factory in companion only: **class A private (var x: Int = 0)**  
 Instead of default arguments, an **auxiliary constructor** can be defined (less common): **def this() = this(0)**

```
class IntVec(private val xs: Array[Int]) {
  def update(i: Int, x: Int): Unit = { xs(i) = x }
  def apply(i: Int): Int = xs(i)
}
```

Special syntax for **update** and **apply**:  
 v(0) = 0 expanded to v.update(0,0)  
 v(0) expanded to v.apply(0)  
 where val v = new IntVec(Array(1,2,3))

## Expressions

literals	0 0L 0.0 "0" '0' true false
block	{ expr1; ...; exprN }
if	if (cond) expr1 else expr2
match	expr match caseClauses
for	for (x <- xs) expr
yield	for (x <- xs) yield expr
while	while (cond) expr
do while	do expr while (cond)
throw	throw new Exception("Bang!")
try	try expr catch pf

Basic types e.g. Int, Long, Double, String, Char, Boolean  
 The value of a block is the value of its last expression  
 Value is expr1 if cond is true, expr2 if false (else is optional)  
 Matches expr against each case clause, see pattern matching.  
 Loop for each x in xs, x visible in expr, type Unit  
 Yields a sequence with elems of expr for each x in xs  
 Loop expr while cond is true, type Unit  
 Do expr at least once, then loop while cond is true, type Unit  
 Throws an exception that halts execution if not in try catch  
 Evaluate partial function pf if exception in expr, where pf e.g.:  
 {case e: Exception => someBackupValue}

Evaluation order	(1 + 2) * 3	parenthesis control order
Method application	1.+(2)	call method + on object 1
Operator notation	1 + 2	same as 1.+(2)
Conjunction	c1 && c2	true if both c1 and c2 true
Disjunction	c1    c2	true if c1 or c2 true
Negation	!c	logical not, false if c is true
Function application	f(1, 2, 3)	same as f.apply(1,2,3)
Function literal	x => x + 1	anonymous function, "lambda"
Object creation	new C(1,2)	from class C with arguments 1,2
Self reference	this	refers to the object being defined
Supertype reference	super.m	refers to member m of supertype
Non-referable reference	null	refers to null object of type Null
Assignment operator	x += 1	expanded to x = x + 1
	x -= 1	works for any op ending with =
Empty tuple, unit value	()	of type Unit, similar to Java void
	x -= 1	works for any op ending with =
2-tuple value	(1, "hello")	same as new Tuple2(1, "hello")
2-tuple type	(Int, String)	same as Tuple2[Int, String] etc. until Tuple22

**Precedence** of operators beginning with:

all letters **lowest**

|

^

&

= !

< >

:

+ -

\* / %

other special chars **highest**

**Integer division and reminder:**

a / b no decimals if a, b Int, Short, Byte  
 a % b fulfills: (a / b) \* b + (a % b) == a

## Pattern matching, type tests and extractors

expr **match** {     expr is matched against patterns from top until match found, yielding the expression after =>  
   **case** "hello" => expr     **literal pattern** matches any value equal (in terms of ==) to the literal  
   **case** x: C => expr     **typed variable pattern** matches all instances of C, binding variable x to the instance  
   **case** C(x, y, z) => expr     **constructor pattern** matches values of the form C(x, y, z), args bound to x,y,z  
   **case** (x, y, z) => expr     **tuple pattern** matches tuple values, alias for constructor pattern Tuple3(x, y, z)  
   **case** x +: xs => expr     **sequence extractor patterns** matches head and tail, also x +: y +: z +: xs etc.  
   **case** p1 | ... | pN => expr     matches if at least one **pattern alternative** p1, p2 ... or pN matches  
   **case** x@pattern => expr     a **pattern binders** with the @ sign binds a variable to (part of) a pattern  
   **case** x => expr     **untyped variable pattern** matches any value, typical "catch all" at bottom: **case** \_ =>  
 }

Pattern matching on direct subtypes of a **sealed** class is checked if exhaustive by the compiler

Matching with typed variable pattern x **match** { **case** a: Int => a; **case** \_ => 0 } is preferred over explicit `InstanceOf` tests and casts: **if** (x.isInstanceOf[Int]) x.asInstanceOf[Int] **else** 0

The **unapply** method can be used in **extractor** pattern matching (to avoid extra class & instance), e.g.:

```
object Host {
  def unapply(s: String): Option[String] =
    if (!s.startsWith("http://")) None
    else s.stripPrefix("http://").split('/').headOption
}
str match { case Host(name) => ... }
```

**Extractor object**  
 extractor must return **Option**  
**None** gives no match in patterns  
**Some(x)** matches in patterns

**Extractor pattern** leads to a call to Host.unapply(str)

## Generic classes and methods

```
class Box[T](val x: T){
  def pairedWith[U](y: U): (T, U) = (x, y)
}
val b = new Box(0)
val p = b.pairedWith(new Box("zero"))
```

a **generic class** Box with a **type parameter** T, allowing x to be of any type  
 a **generic method** with **type parameter** U  
 T is bound to the type of x, U is free in pairedWith, so y can be of any type  
 same as (with explicit type parameters): val b: Box[Int] = new Box[Int](0)  
 the type of p is (Box[Int], Box[String])

Generic types are erased before JVM runtime except for Array, so a `reflect.ClassTag` is needed when constructing arrays from generic type parameters: **def** mkArray[A: reflect.ClassTag](a: A) = Array[A](a)

## scala.{Option, Some, None}, scala.util.{Try, Success, Failure}

**Option[T]** is like a collection with zero or one element. **Some[T]** and **None** are subtypes of **Option**.

```
val opt: Option[String] = if (math.random > 0.9) Some("bingo") else None
opt.getOrElse(expr)    x: T if opt == Some[T](x) else expr
opt.map(x => ... )     apply x => ... to x if opt is Some(x) else None
opt.get               x: T if Some[T](x) else throws NoSuchElementException
```

```
opt match { case Some(x) => expr1; case None => expr2 }    expr1 if Some(x) else expr2
```

Other collection-like methods on **Option**: `foreach`, `isEmpty`, `filter`, `toVector`, ..., on **Try**: `map`, `foreach`, `toOption`, ...

**Try[T]** is like a collection with **Success[T]** or **Failure[E]**. **import** scala.util.{Try, Success, Failure}  
 Try{ ...; ...; expr1 }.getOrElse(expr2)     evaluates to expr1 if successful or expr2 if exception  
 Try{...; expr1}.recover{ case e: Throwable => expr2 } expr2 if exception else Success(expr1)  
 Try(1/0) match {case Success(x) => x; case Failure(e) => 0}   e here ArithmeticException

## Reading/writing from file, and standard in/out:

**Read** string of lines from **file** (`fromFile` gives `BufferedSource`, `getLines` gives `Iterator[String]`; also from URL):

```
val s = scala.io.Source.fromFile("f.txt", "UTF-8").getLines.mkString("\n")
```

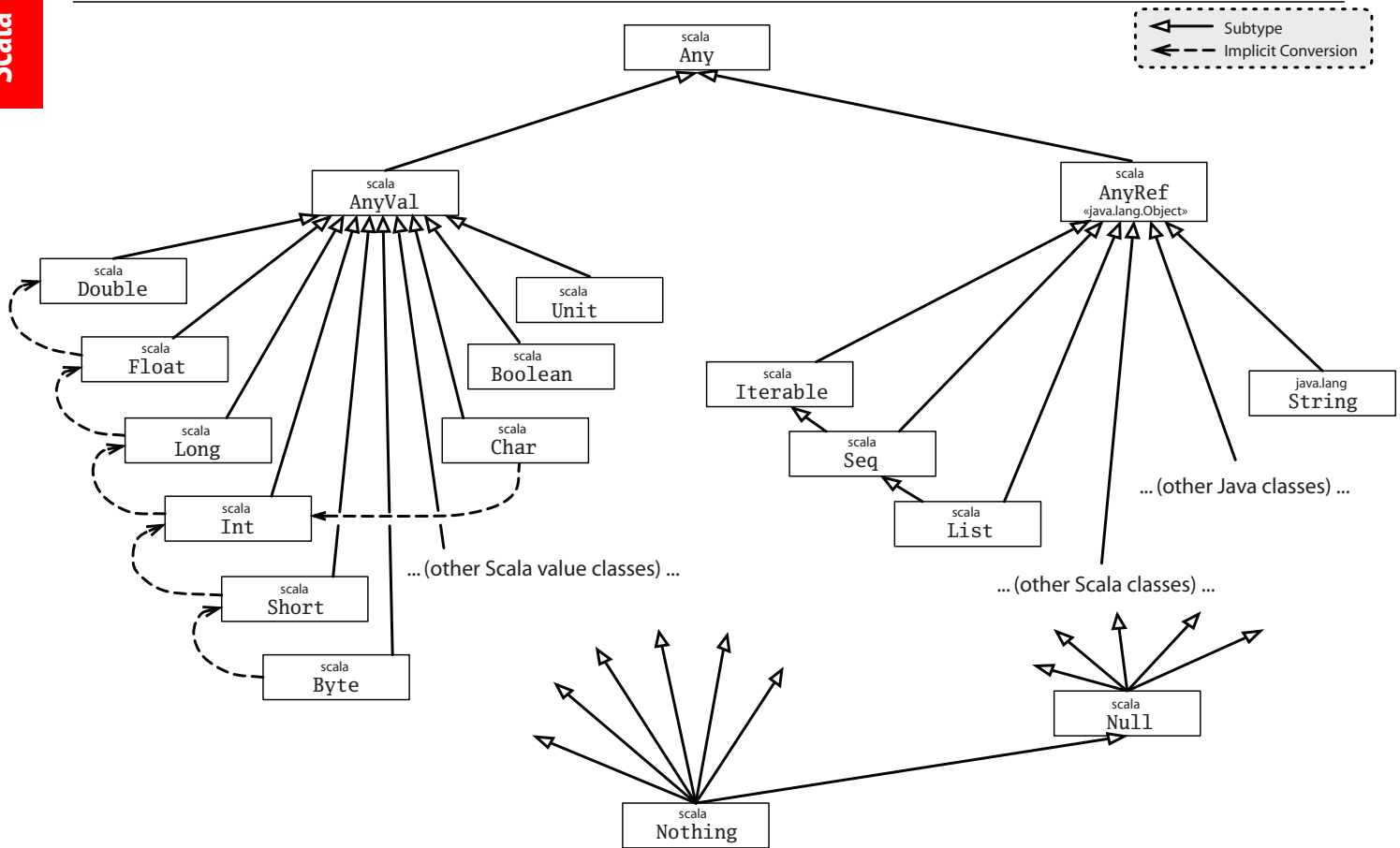
**Read** string from **standard in** (prompt string is optional) using `readLine`; **write** to **standard out** using `println`:

```
val s = scala.io.StdIn.readLine("prompt"); println("you wrote" + s)
```

**Write** string to **file** after **import** java.nio.file.{Path, Paths, Files}; **import** java.nio.charset.StandardCharsets.UTF\_8

```
def save(fileName: String, data: String): Path =
  Files.write(Paths.get(fileName), data.getBytes(UTF_8))
```

# The Scala Type System



## Number types

name	# bits	range	literal
Byte	8	$-2^7 \dots 2^7 - 1$	<code>0.toByte</code>
Short	16	$-2^{15} \dots 2^{15} - 1$	<code>0.toShort</code>
Char	16	$0 \dots 2^{16} - 1$	<code>'0'</code> <code>'\u0030'</code>
Int	32	$-2^{15} \dots 2^{15} - 1$	<code>0</code> <code>0xF</code>
Long	64	$-2^{15} \dots 2^{15} - 1$	<code>0L</code>
Float	32	$\pm 3.4 \cdot 10^{38}$	<code>0F</code>
Double	64	$\pm 1.8 \cdot 10^{308}$	<code>0.0</code>

## Methods on numbers

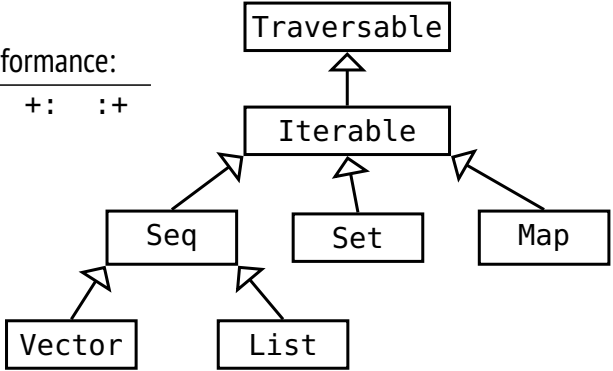
<code>x.abs</code>	<code>math.abs(x)</code> , absolute value
<code>x.round</code>	<code>math.round(x)</code> , to nearest Long
<code>x.floor</code>	<code>math.floor(x)</code> , cut decimals
<code>x.ceil</code>	<code>math.ceil(x)</code> , round up cut decimal
<code>x max y</code>	<code>math.max(x, y)</code> , gives largest, also min
<code>x.toInt</code>	also <code>toByte</code> , <code>toChar</code> , <code>toDouble</code> etc.
<code>1 to 4</code>	<code>Range(1, 2, 3, 4)</code>
<code>0 until 4</code>	<code>Range(0, 1, 2, 3)</code>

# The Scala Standard Collection Library

scala.collection.immutable.	scala.collection.mutable.	methods with good performance:
<code>Vector</code>	<code>ArrayBuffer</code>	<code>head</code> <code>tail</code> <code>apply</code> <code>+:</code> <code>:+</code>
<code>List</code>	<code>ListBuffer</code>	<code>head</code> <code>+:</code>
<code>Set</code>	<code>Set</code>	<code>contains</code> <code>+</code> <code>-</code>
<code>Map</code>	<code>Map</code>	<code>apply</code> <code>+</code> <code>-</code>

String and Array are implicitly converted to Seq making sequence methods work as for other sequences.

Allocate array of Int of size n: `new Array[Int](n)`



Concrete implementations of **Set** include `HashSet`, `ListSet` and `BitSet`; `collection.SortedSet` is implemented by `TreeSet`. Concrete implementations of **Map** include `HashMap` and `ListMap`; `collection.SortedMap` is implemented by `TreeMap`.

## Methods in trait Traversable[A]

What	Usage	Explanation <i>f</i> is a function, <i>pf</i> is a partial funct., <i>p</i> is a predicate.
Traverse:	<code>xs foreach f</code>	Executes <i>f</i> for every element of <i>xs</i> . Return type Unit.
Add:	<code>xs ++ ys</code>	A collection with <i>xs</i> followed by <i>ys</i> .
Map:	<code>xs map f</code>	A collection formed by applying <i>f</i> to every element in <i>xs</i> .
	<code>xs flatMap f</code>	A collection obtained by applying <i>f</i> (which must return a collection) to all elements in <i>xs</i> and concatenating the results.
	<code>xs collect pf</code>	The collection obtained by applying the <i>pf</i> to every element in <i>xs</i> for which it is defined (undefined ignored).
Convert:	<code>toVector toList toSeq toBuffer toArray</code>	Converts a collection. Unchanged if the run-time type already matches the demanded type.
	<code>toSet</code>	Converts the collection to a set; duplicates removed.
	<code>toMap</code>	Converts a collection of key/value pairs to a map.
Copy:	<code>xs copyToBuffer buf</code>	Copies all elements of <i>xs</i> to buffer <i>buf</i> . Return type Unit.
	<code>xs copyToArray (arr, s, n)</code>	Copies at most <i>n</i> elements of the collection to array <i>arr</i> starting at index <i>s</i> (last two arguments are optional). Return type Unit.
Size info:	<code>xs.isEmpty</code>	Returns true if the collection <i>xs</i> is empty.
	<code>xs.nonEmpty</code>	Returns true if the collection <i>xs</i> has at least one element.
	<code>xs.size</code>	Returns an <code>Int</code> with the number of elements in <i>xs</i> .
Retrieval:	<code>xs.head xs.last</code>	The first/last element of <i>xs</i> (or some elem, if order undefined).
	<code>xs.headOption xs.lastOption</code>	The first/last element of <i>xs</i> (or some element, if no order is defined) in an option value, or <code>None</code> if <i>xs</i> is empty.
	<code>xs find p</code>	An option with the first element satisfying <i>p</i> , or <code>None</code> .
Subparts:	<code>xs.tail xs.init</code>	The rest of the collection except <i>xs.head</i> or <i>xs.last</i> .
	<code>xs slice (from, to)</code>	The elements in from index <i>from</i> until (not including) <i>to</i> .
	<code>xs take n</code>	The first <i>n</i> elements (or some <i>n</i> elements, if order undefined).
	<code>xs drop n</code>	The rest of the collection except <i>xs take n</i> .
	<code>xs takeWhile p</code>	The longest prefix of elements all satisfying <i>p</i> .
	<code>xs dropWhile p</code>	Without the longest prefix of elements that all satisfy <i>p</i> .
	<code>xs filter p</code>	Those elements of <i>xs</i> that satisfy the predicate <i>p</i> .
	<code>xs filterNot p</code>	Those elements of <i>xs</i> that do not satisfy the predicate <i>p</i> .
	<code>xs splitAt n</code>	Split <i>xs</i> at <i>n</i> returning the pair ( <i>xs take n</i> , <i>xs drop n</i> ).
	<code>xs span p</code>	Split <i>xs</i> by <i>p</i> into the pair ( <i>xs takeWhile p</i> , <i>xs.dropWhile p</i> ).
	<code>xs partition p</code>	Split <i>xs</i> by <i>p</i> into the pair ( <i>xs filter p</i> , <i>xs.filterNot p</i> )
	<code>xs groupBy f</code>	Partition <i>xs</i> into a map of collections according to <i>f</i> .
Conditions:	<code>xs forall p</code>	Returns true if <i>p</i> holds for all elements of <i>xs</i> .
	<code>xs exists p</code>	Returns true if <i>p</i> holds for some element of <i>xs</i> .
	<code>xs count p</code>	An <code>Int</code> with the number of elements in <i>xs</i> that satisfy <i>p</i> .
Folds:	<code>xs.foldLeft(z)(op)</code> <code>xs.foldRight(z)(op)</code>	Apply binary operation <i>op</i> between successive elements of <i>xs</i> , going left to right (or right to left) starting with <i>z</i> .
	<code>xs.reduceLeft op</code> <code>xs.reduceRight op</code>	Similar to <code>foldLeft/foldRight</code> , but <i>xs</i> must be non-empty, starting with first element instead of <i>z</i> .
	<code>xs.sum xs.product</code> <code>xs.min xs.max</code>	Calculation of the sum/product/min/max of the elements of <i>xs</i> , which must be numeric.
Make string:	<code>xs mkString (start, sep, end)</code>	A string with all elements of <i>xs</i> between separators <i>sep</i> enclosed in strings <i>start</i> and <i>end</i> ; <i>start</i> , <i>sep</i> , <i>end</i> are all optional.



## Methods in trait Iterable[A]

What	Usage	Explanation
Iterators:	<code>val it = xs.iterator</code>	An iterator <code>it</code> of type <code>Iterator</code> that yields each element one by one: <code>while (it.hasNext) f(it.next)</code>
	<code>xs grouped size</code>	An iterator yielding fixed-sized chunks of this collection.
	<code>xs sliding size</code>	An iterator yielding a sliding fixed-sized window of elements.
Subparts:	<code>xs takeRight n</code> <code>xs dropRight n</code>	Similar to <code>take</code> and <code>drop</code> in <code>Traversable</code> but takes/drops the last <code>n</code> elements (or any <code>n</code> elements if the order is undefined).
	<code>xs zip ys</code> <code>xs zipAll (ys, x, y)</code>	An iterable of pairs of corresponding elements from <code>xs</code> and <code>ys</code> . Similar to <code>zip</code> , but the shorter sequence is extended to match the longer one by appending elements <code>x</code> or <code>y</code> .
Zipper:	<code>xs.zipWithIndex</code>	An iterable of pairs of elements from <code>xs</code> with their indices.
	<code>xs sameElements ys</code>	True if <code>xs</code> and <code>ys</code> contain the same elements in the same order.

## Methods in trait Seq[A]

Indexing and size:	<code>xs(i)</code> <code>xs apply i</code>	The element of <code>xs</code> at index <code>i</code> .
	<code>xs.length</code>	Length of sequence. Same as <code>size</code> in <code>Traversable</code> .
	<code>xs.indices</code>	Returns a <code>Range</code> extending from 0 to <code>xs.length - 1</code> .
	<code>xs.isDefinedAt i</code>	True if <code>i</code> is contained in <code>xs.indices</code> .
	<code>xs lengthCompare n</code>	Returns -1 if <code>xs</code> is shorter than <code>n</code> , +1 if it is longer, else 0.
Index search:	<code>xs indexOf x</code>	The index of the first element in <code>xs</code> equal to <code>x</code> .
	<code>xs lastIndexOf x</code>	The index of the last element in <code>xs</code> equal to <code>x</code> .
	<code>xs indexOfSlice ys</code> <code>xs lastIndexOfSlice ys</code>	The (last) index of <code>xs</code> such that successive elements starting from that index form the sequence <code>ys</code> .
	<code>xs indexWhere p</code>	The index of the first element in <code>xs</code> that satisfies <code>p</code> .
	<code>xs segmentLength (p, i)</code>	The length of the longest uninterrupted segment of elements in <code>xs</code> , starting with <code>xs(i)</code> , that all satisfy the predicate <code>p</code> .
	<code>xs prefixLength p</code>	Same as <code>xs.segmentLength(p, 0)</code>
Add:	<code>x +: xs</code> <code>xs :+ x</code>	Prepend/Append <code>x</code> to <code>xs</code> . Colon on the collection side.
	<code>xs padTo (len, x)</code>	Append the value <code>x</code> to <code>xs</code> until length <code>len</code> is reached.
Update:	<code>xs patch (i, ys, r)</code>	A copy of <code>xs</code> with <code>r</code> elements of <code>xs</code> replaced by <code>ys</code> starting at <code>i</code> .
	<code>xs updated (i, x)</code>	A copy of <code>xs</code> with the element at index <code>i</code> replaced by <code>x</code> .
	<code>xs(i) = x</code> <code>xs.update(i, x)</code>	Only available for mutable sequences. Changes the element of <code>xs</code> at index <code>i</code> to <code>x</code> . Return type <code>Unit</code> .
	<code>xs.sorted</code> <code>xs sortWith lt</code>	A new <code>Seq[A]</code> sorted using implicitly available ordering of <code>A</code> . A new <code>Seq[A]</code> sorted using less than <code>lt</code> : <code>(A, A) =&gt; Boolean</code> .
By:	<code>xs sortBy f</code> <code>xs maxBy f</code> <code>xs minBy f</code>	A new <code>Seq[A]</code> sorted/minimized/maximized by implicitly available ordering of <code>B</code> after applying <code>f</code> : <code>A =&gt; B</code> to each element.
Reverse:	<code>xs.reverse</code>	A new sequence with the elements of <code>xs</code> in reverse order.
	<code>xs.reverseIterator</code>	An iterator yielding all the elements of <code>xs</code> in reverse order.
	<code>xs reverseMap f</code>	Similar to <code>map</code> in <code>Traversable</code> , but in reverse order.
Tests:	<code>xs startsWith ys</code>	True if <code>xs</code> starts with sequence <code>ys</code> .
	<code>xs endsWith ys</code>	True if <code>xs</code> ends with sequence <code>ys</code> .
	<code>xs contains x</code>	True if <code>xs</code> has an element equal to <code>x</code> .
	<code>xs containsSlice ys</code>	True if <code>xs</code> has a contiguous subsequence equal to <code>ys</code>
	<code>(xs corresponds ys)(p)</code>	True if corresponding elements satisfy the binary predicate <code>p</code> .
Subparts:	<code>xs intersect ys</code>	The intersection of <code>xs</code> and <code>ys</code> , preserving element order.
	<code>xs diff ys</code>	The difference of <code>xs</code> and <code>ys</code> , preserving element order.
	<code>xs union ys</code>	Same as <code>xs ++ ys</code> in <code>Traversable</code> .
	<code>xs.distinct</code>	A subsequence of <code>xs</code> that contains no duplicated element.

## Methods in trait Set [A]

<code>xs(x)</code>	<code>xs apply x</code>	True if x is a member of xs. Also: xs contains x
<code>xs subsetOf ys</code>		True if ys is a subset of xs.
<code>xs + x</code>	<code>xs - x</code>	Returns a new set including/excluding elements.
<code>xs + (x, y, z)</code>	<code>xs - (x, y, z)</code>	Addition/subtraction can be applied to many arguments.
<code>xs intersect ys</code>		A new set with elements in both xs and ys. Also: &
<code>xs union ys</code>		A new set with elements in either xs or ys or both. Also:
<code>xs diff ys</code>		A new set with elements in xs that are not in ys. Also: &~

## Additional mutation methods in trait mutable.Set [A]

<code>xs += x</code>	<code>xs -= x</code>	Returns the same set with included/excluded elements.
<code>xs += (x, y, z)</code>	<code>xs -= (x, y, z)</code>	Addition/subtraction can be applied to many arguments.
<code>xs ++= ys</code>		Adds all elements in ys to set xs and returns xs itself.
<code>xs add x</code>		Adds element x to xs and returns true if x was in xs, else false.
<code>xs remove x</code>		Removes x from xs and returns true if x was in xs, else false.
<code>xs retain p</code>		Keeps only those elements in xs that satisfy predicate p.
<code>xs.clear</code>		Removes all elements from xs. Return type Unit.
<code>xs(x) = b</code>	<code>xs.update(x, b)</code>	If b is true, adds x to xs, else removes x. Return type Unit.
<code>xs.clone</code>		Returns a new mutable set with the same elements as xs.

## Methods in trait Map [K, V]

<code>ms get k</code>		The value associated with key k an option, None if not found.
<code>ms(k)</code>	<code>xs apply k</code>	The value associated with key k, or exception if not found.
<code>ms getOrElse (k, d)</code>		The value associated with key k in map ms, or d if not found.
<code>ms isDefinedAt k</code>		True if ms contains a mapping for key k. Also: ms.contains(k)
<code>ms + (k -&gt; v)</code>	<code>ms + ((k, v))</code>	The map containing all mappings of ms as well as the mapping k -> v from key k to value v. Also: ms + (k -> v, l -> w)
<code>ms - k</code>		Excluding any mapping of key k. Also: ms - (k, l, m)
<code>ms ++ ks</code>	<code>ms -- ks</code>	The mappings of ms with the mappings of ks added/removed.
<code>ms.keys</code>	<code>ms.values</code>	An iterable containing each key/value in ms.

## Additional mutation methods in trait mutable.Map [K, V]

<code>ms(k) = v</code>	<code>ms.update(k, v)</code>	Adds mapping k to v, overwriting any previous mapping of k.
<code>ms += (k -&gt; v)</code>	<code>ms -= k</code>	Adds/Removes mappings. Also vid several arguments.
<code>ms put (k, v)</code>	<code>ms remove k</code>	Adds/removes mapping; returns previous value of k as an option.
<code>ms retain p</code>		Keeps only mappings that have a key satisfying predicate p.
<code>ms.clear</code>		Removes all mappings from ms.
<code>ms transform f</code>		Transforms all associated values in map ms with function f.
<code>ms.clone</code>		Returns a new mutable map with the same mappings as ms.

## Factory examples:

```
Vector(0, 0, 0) same as Vector.fill(3)(0)
collection.mutable.Set.empty[Int] same as collection.mutable.Set[Int]()
Map("se" -> "Sweden", "nk" -> "Norway") same as Map(("se", "Sweden"), ("nk", "Norway"))
Array.ofDim[Int](3,2) gives Array(Array(0, 0), Array(0, 0), Array(0, 0)) same as
Array.fill(3,2)(0); Vector.iterate(1.2, 3)(_ + 0.5) gives Vector(1.2, 1.7, 2.2)
Vector.tabulate(3)("s" + _) gives Vector("s0", "s1", "s2")
```

## Strings

Some methods below are from `java.lang.String` and some methods are implicitly added from `StringOps`, etc. Strings are implicitly treated as `Seq[Char]` so all `Seq` methods also works.

<code>s(i)</code>	apply <code>i</code>	<code>s.charAt(i)</code>	Returns the character at index <code>i</code> .
<code>s.capitalize</code>			Returns this string with first character converted to upper case.
<code>s.compareTo(t)</code>			Returns <code>x</code> where <code>x &lt; 0</code> if <code>s &lt; t</code> , <code>x &gt; 0</code> if <code>s &gt; t</code> , <code>x</code> is 0 if <code>s == t</code>
<code>s.compareToIgnoreCase(t)</code>			Similar to <code>compareTo</code> but not sensitive to case.
<code>s.endsWith(t)</code>			True if string <code>s</code> ends with string <code>t</code> .
<code>s.replaceAllLiterally(s1, s2)</code>			Replace all occurrences of <code>s1</code> with <code>s2</code> in <code>s</code> .
<code>s.split(c)</code>			Returns an array of strings split at every occurrence of character <code>c</code> .
<code>s.startsWith(t)</code>			True if string <code>s</code> begins with string <code>t</code> .
<code>s.stripMargin</code>			Strips leading white space followed by <code> </code> from each line in string.
<code>s.substring(i)</code>			Returns a substring of <code>s</code> with all characters from index <code>i</code> .
<code>s.substring(i, j)</code>			Returns a substring of <code>s</code> from index <code>i</code> to index <code>j-1</code> .
<code>s.toInt</code> <code>s.toDouble</code> <code>s.toFloat</code>			Parses <code>s</code> as an <code>Int</code> or <code>Double</code> etc. May throw an exception.
<code>42.toString</code> <code>42.0.toString</code>			Converts a number to a <code>String</code> .
<code>s.toLowerCase</code>			Converts all characters to lower case.
<code>s.toUpperCase</code>			Converts all characters to upper case.
<code>s.trim</code>			Removes leading and trailing white space.

Escape	char	Special strings	
<code>\n</code>	line break	<code>"hello\nworld\t!"</code>	string including escape char for line break and tab
<code>\t</code>	horizontal tab	<code>"""a "raw" string"""</code>	can include quotes and span multiple lines
<code>\"</code>	double quote	<code>s"x is \$x"</code>	<b>s interpolator</b> inserts values of existing names
<code>\'</code>	single quote	<code>s"x+1 is \${x+1}"</code>	<b>s interpolator</b> evaluates expressions within <code>\${}</code>
<code>\\</code>	backslash	<code>f"\$x%5.2f"</code>	format <code>Double x</code> to 2 decimals at least 5 chars wide
<code>\u0041</code>	unicode for A	<code>f"\$y%5d"</code>	format <code>Int y</code> right justified at least five chars wide

## scala.collection.JavaConverters

Enable `.asJava` and `.asScala` conversions: **import** `scala.collection.JavaConverters._`

<code>xs.asJava</code> on a <b>Scala</b> collection of type:		<code>xs.asScala</code> on a <b>Java</b> collection of type:
<code>Iterator</code>	↔	<code>java.util.Iterator</code>
<code>Iterable</code>	↔	<code>java.lang.Iterable</code>
<code>Iterable</code>	←	<code>java.util.Collection</code>
<code>mutable.Buffer</code>	↔	<code>java.util.List</code>
<code>mutable.Set</code>	↔	<code>java.util.Set</code>
<code>mutable.Map</code>	↔	<code>java.util.Map</code>
<code>mutable.ConcurrentMap</code>	↔	<code>java.util.concurrent.ConcurrentMap</code>

## Reserved words

These 40 words and 10 symbols have special meaning and cannot be used as identifiers in Scala.

**abstract case catch class def do else extends false final finally for  
forSome if implicit import lazy macro match new null object override  
package private protected return sealed super this throw trait try true  
type val var while with yield \_ : = => <- <: <% >: # @**



# Java snabbreferens @ LTH

Vertikalstreck | används mellan olika alternativ. Parenteser ( ) används för att gruppera en mängd alternativ. Hakparenteser [ ] markerar valfria delar. En sats betecknas stmt medan x, i, s, ch är variabler, expr är ett uttryck, cond är ett logiskt uttryck. Med ... avses valfri, extra kod.

## Satser

Block	{stmt1; stmt2; ...}	fungerar "utifrån" som <b>en</b> sats
Tilldelning	x = expr;	variabeln och uttrycket av kompatibel typ
Förkortade	x += expr; x++;	x = x + expr; även -=, *=, /= x = x + 1; även x --
if-sats	if (cond) {stmt; ...} [else { stmt; ...} ]	utförs om cond är true utförs om false
switch-sats	switch (expr) { case A: stmt1; break; ... default: stmtN; break; }	expr är ett heltalsuttryck utförs om expr == A (A konstant) "faller igenom" om break saknas sats efter default: utförs om inget case passar
for-sats	for (int i = a; i < b; i++) { stmt; ... }	satserna görs för i = a, a+1, ..., b-1 Görs ingen gång om a >= b i++ kan ersättas med i = i + step
for-each-sats	for (int x: xs) { stmt; ... }	xs är en samling, här med heltal x blir ett element i taget ur xs fungerar även med array
while-sats	while (cond) {stmt; ...}	utförs så länge cond är true
do-while-sats	do { stmt; ... } while (cond);	utförs minst en gång, så länge cond är true
return-sats	return expr;	returnerar funktionsresultat

## Uttryck

Aritmetiskt uttryck	(x + 2) * i / 2 + i % 2	för heltal är / heltalsdivision, % "rest"
Objektuttryck	new Classname(...)   ref-var   null   function-call   this   super	
Logiskt uttryck	! cond   cond && cond   cond    cond   relationsuttryck   true   false	
Relationsuttryck	expr ( <   <=   ==   >=   >   != ) expr	för objektuttryck bara == och !=, också typtest med expr instanceof Classname
Funktionsanrop	obj-expr.method(...) Classname.method(...)	anropa "vanlig metod" (utför operation) anropa statisk metod
Array	new int[size] vname[i] vname.length	skapar int-array med size element elementet med index i, 0..length-1 antalet element
Matris	new int[r][c] m.length m[i].length	//Skapar matris med r rader och c kolonner //Ger matrisens längd (d.v.s. antalet rader) //Ger antalet element (längden) på raden i
Typkonvertering	(newtype) expr (int) real-expr (Square) aShape	konverterar expr till typen newtype - avkortar genom att stryka decimaler - ger ClassCastException om aShape inte är ett Square-objekt

## Deklarationer

Allmänt	<code>[ &lt;protection&gt; ] [ static ] [ final ] &lt;type&gt; name1, name2, ...;</code>	
<type>	byte   short   int   long   float   double   boolean   char   Classname	
<protection>	public   private   protected	för attribut och metoder i klasser (paketskydd om inget anges)
Startvärde	int x = 5;	startvärde bör alltid anges
Konstant	final int N = 20;	konstantnamn med stora bokstäver
Array	<type>[] vname = new <type>[10];	deklarerar och skapar array
Matris	<type>[][] m = new <type>[4][5];	// deklarerar och skapar 4x5 matrisen m

## Klasser

Deklaration	<pre>[ public ] [ abstract ] class Classname     [ extends Classname1 ] [ implements Interface1, Interface2, ... ] {         &lt;deklaration av attribut&gt;         &lt;deklaration av konstruktörer&gt;         &lt;deklaration av metoder&gt;     }</pre>	
Attribut	Som vanliga deklARATIONER. Attribut får implicita startvärden, 0, 0.0, false, null.	
Konstruktör	<pre>&lt;prot&gt; Classname(param, ...) {     stmt; ... }</pre>	Parametrarna är de parametrar som ges vid new Classname(...). Satserna ska ge attributen startvärden
Metod	<pre>&lt;prot&gt; &lt;type&gt; name(param, ...) {     stmt; ... }</pre>	om typen inte är void måste en return-sats exekveras i metoden
Huvudprogram	public static void main(String[] args) { ... }	
Abstrakt metod	Som vanlig metod, men abstract före typnamnet och { . . . } ersätts med semikolon. Metoden måste implementeras i subclasserna.	

## Standardklasser, java.lang, behöver inte importeras

Object	Superklass till alla klasser.	
	boolean equals(Object other);	ger true om objektet är lika med other
	int hashCode();	ger objektets hashkod
	String toString();	ger en läsbar representation av objektet
Math	Statiska konstanter Math.PI och Math.E. Metoderna är statiska (anropas med t ex Math.round(x)):	
	long round(double x);	avrundning, även float → int
	int abs(int x);	x , även double, ...
	double hypot(double x, double y);	$\sqrt{x^2 + y^2}$
	double sin(double x);	sin x, liknande: cos, tan, asin, acos, atan
	double exp(double x);	$e^x$
	double pow(double x, double y);	$x^y$
	double log(double x);	ln x
	double sqrt(double x);	$\sqrt{x}$
	double toRadians(double deg);	$deg \cdot \pi / 180$
System	void System.out.print(String s);	skriv ut strängen s
	void System.out.println(String s);	som print men avsluta med ny rad
	void System.exit(int status);	avsluta exekveringen, status != 0 om fel
	Parametern till print och println kan vara av godtycklig typ: int, double, ...	

Wrapperklasser	För varje datatyp finns en wrapperklass: char → Character, int → Integer, double → Double, ... Statiska konstanter MIN_VALUE och MAX_VALUE ger minsta respektive största värde. Exempel med klassen Integer:	
	Integer(int value); int intValue();	skapar ett objekt som innehåller value tar reda på värdet
String	Teckensträngar där tecknen inte kan ändras. "asdf" är ett String-objekt. s1 + s2 för att konkatenera två strängar. StringIndexOutOfBoundsException om någon position är fel.	
	int length(); char charAt(int i); boolean equals(String s); int compareTo(String s); int indexOf(char ch); int indexOf(char ch, int from); String substring(int first, int last); String[] split(String delim);	antalet tecken tecknet på plats i, 0..length()—1 jämför innehållet (s1 == s2 fungerar inte) < 0 om mindre, = 0 om lika, > 0 om större index för ch, —1 om inte finns som indexOf men börjar leta på plats from kopia av tecknen first..last—1 ger array med "ord" (ord är följder av tecken åtskilda med tecknen i delim)
	Konvertering mellan standardtyp och String (exempel med int, liknande för andra typer):	
	String.valueOf(int x); Integer.parseInt(String s);	x = 1234 → "1234" s = "1234" → 1234, NumberFormatException om s innehåller felaktiga tecken
StringBuilder	Modifierbara teckensträngar. length och charAt som String, plus:	
	StringBuilder(String s); void setCharAt(int i, char ch); StringBuilder append(String s); StringBuilder insert(int i, String s); StringBuilder deleteCharAt(int i); String toString();	StringBuilder med samma innehåll som s ändrar tecknet på plats i till ch lägger till s, även andra typer: int, char, ... lägger in s med början på plats i tar bort tecknet på plats i skapar kopia som String-objekt

## Standardklasser, import java.util.Classname

List	List<E> är ett gränssnitt som beskriver listor med objekt av parameterklassen E. Man kan lägga in värden av standardtyperna genom att kapsla in dem, till exempel int i Integer-objekt. Gränssnittet implementeras av klasserna ArrayList<E> och LinkedList<E>, som har samma operationer. Man ska inte använda operationerna som har en position som parameter på en LinkedList (i stället en iterator). IndexOutOfBoundsException om någon position är fel.	
	För att operationerna contains, indexOf och remove(Object) ska fungera måste klassen E över-skugga funktionen equals(Object). Integer och de andra wrapperklasserna gör det.	
ArrayList	ArrayList<E>();	skapar tom lista
LinkedList	LinkedList<E>();	skapar tom lista
	int size();	antalet element
	boolean isEmpty();	ger true om listan är tom
	E get(int i);	tar reda på elementet på plats i
	int indexOf(Object obj);	index för obj, —1 om inte finns
	boolean contains(Object obj);	ger true om obj finns i listan
	void add(E obj);	lägger in obj sist, efter existerande element
	void add(int i, E obj);	lägger in obj på plats i (efterföljande element flyttas)
	E set(int i, E obj);	ersätter elementet på plats i med obj
	E remove(int i);	tar bort elementet på plats i (efter-följande element flyttas)
	boolean remove(Object obj);	tar bort objektet obj, om det finns
	void clear();	tar bort alla element i listan

Random	Random(); Random(long seed); int nextInt(int n); double nextDouble();	skapar "slumpmässig" slumpvalsgenerator – med bestämt slumpvalsfrö heltal i intervallet [0, n) double-tal i intervallet [0.0, 1.0)
Scanner	Scanner(File f); Scanner(String s); String next(); boolean hasNext(); int nextInt(); boolean hasNextInt(); String nextLine();	läser från filen f, ofta System.in läser från strängen s läser nästa sträng fram till whitespace ger true om det finns mer att läsa nästa heltal; också nextDouble(), ... också hasNextDouble(), ... läser resten av raden

## Filer, import java.io.File/FileNotFoundException/PrintWriter

Läsa från fil	Skapa en Scanner med new Scanner(new File(filename)). Ger FileNotFoundException om filen inte finns. Sedan läser man "som vanligt" från scannern (nextInt och liknande).
Skriva till fil	Skapa en PrintWriter med new PrintWriter(new File(filename)). Ger FileNotFoundException om filen inte kan skapas. Sedan skriver man "som vanligt" på PrintWriter-objektet (println och liknande).
Fånga undantag	Så här gör man för att fånga FileNotFoundException: <pre> Scanner scan = null; try {     scan = new Scanner(new File("indata.txt")); } catch (FileNotFoundException e) {     ... ta hand om felet } </pre>

## Specialtecken

Några tecken måste skrivas på ett speciellt sätt när de används i teckenkonstanter:

\n	ny rad, radframmatningstecken
\t	ny kolumn, tabulatortecken (eng. tab)
\\	bakåtsnedstreck: \ (eng. backslash)
\"	citationstecken: "
\'	apostrof: '

## Reserverade ord

Nedan 50 ord kan ej användas som identifierare i Java. Orden **goto** och **const** är reserverade men används ej.

**abstract assert boolean break byte case catch char class const  
continue default do double else enum extends final finally float for  
goto if implements import instanceof int interface long native new  
package private protected public return short static strictfp super  
switch synchronized this throw throws transient try void volatile while**