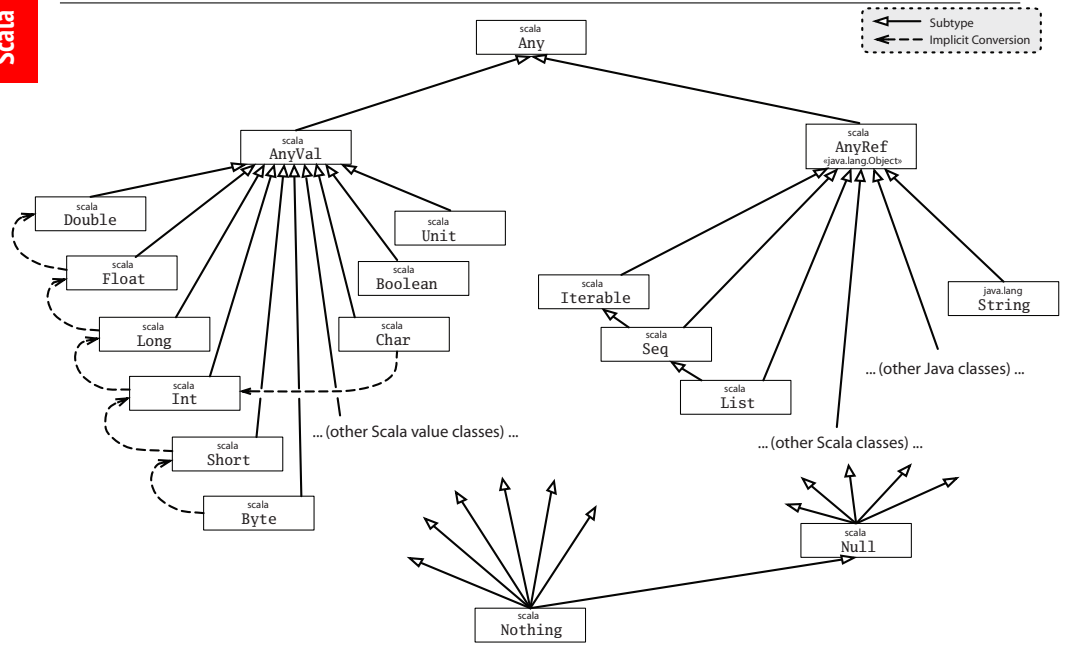
The Scala Type System



Number types

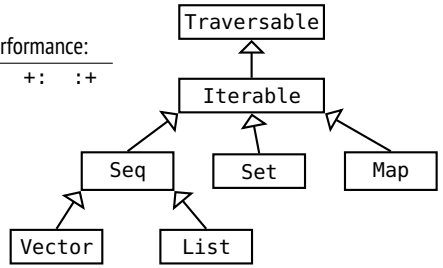
name	# bits	range	litteral
Byte	8	$-2^7 \ldots 2^7-1$	0.toByte
Short	16	$-2^{15} \ldots 2^{15}-1$	0.toShort
Char	16	$0 \ldots 2^{16}-1$	'0' '\u0030'
Int	32	$-2^{31} \ldots 2^{31}-1$	0 0xF
Long	64	$-2^{63} \ldots 2^{63}-1$	0L
Float	32	$\pm 3.4 \cdot 10^{38}$	0F
Double	64	$\pm 1.8 \cdot 10^{308}$	0.0

Methods on numbers

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

The Scala Standard Collection Library

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



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.

Scala Quick Ref @ Lund University

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

Pull requests welcome! Contact: bjorn.regnell@cs.lth.se

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

Modifier	applies to	semantics
private[this]	definitions, declarations	Restricts access to this instance only; also private[p] for package p.
private	definitions, declarations	Restricts access to directly enclosing class and its companion.
protected	definitions	Restricts access to subtypes and companion.
override	definitions, declarations	Mandatory if overriding a concrete definition in a parent class.
abstract	class definitions	Abstract classes cannot be instantiated (redundant for traits).
final	definitions	Final members cannot be overridden, final classes cannot be extended.
lazy	val definitions	Delays initialization of val, initialized when first referenced.
sealed	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: `class A(var x: Int = 0)`
With **val** in primary constructor only getter, no setter, is generated: `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`	Basic types e.g. Int, Long, Double, String, Char, Boolean
block	`{ expr1; ...; exprN }`	The value of a block is the value of its last expression
if	`if (cond) expr1 else expr2`	Value is expr1 if cond is true, expr2 if false (else is optional)
match	`expr match caseClauses`	Matches expr against each case clause, see pattern matching.
for	`for (x <- xs) expr`	Loop for each x in xs, x visible in expr, type Unit
yield	`for (x <- xs) yield expr`	Yeilds a sequence with elems of expr for each x in xs
while	`while (cond) expr`	Loop expr while cond is true, type Unit
do while	`do expr while (cond)`	Do expr at least once, then loop while cond is true, type Unit
throw	`throw new Exception("Bang!")`	Throws an exception that halts execution if not in try catch
try	`try expr catch pf`	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 {
  case "hello" => expr
  case x: C => expr
  case C(x, y, z) => expr
  case (x, y, z) => expr
  case x +: xs => expr
  case p1 | ... | pN => expr
  case x@pattern => expr
  case x => expr
}
```

expr is matched against patterns from top until match found, yielding the expression after =>
literal pattern matches any value equal (in terms of ==) to the literal
typed variable pattern matches all instances of C, binding variable x to the instance
constructor pattern matches values of the form C(x, y, z), args bound to x,y,z
tuple pattern matches tuple values, alias for constructor pattern Tuple3(x, y, z)
sequence extractor patterns matches head and tail, also x +: y +: z +: xs etc.
matches if at least one **pattern alternative** p1, p2 ... or pN matches
a **pattern binders** with the @ sign binds a variable to (part of) a pattern
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 isInstanceOf 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)
opt.map(x => ... }
opt.get
opt match { case Some(x) => expr1;  case None => expr2 }
```

x: T if opt == Some[T](x) else expr
apply x => ... to x if opt is Some(x) else None
x: T if Some[T](x) else throws NoSuchElementException
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)
Try{...; expr1}.recover{ case e: Throwable => expr2 }
Try(1/0) match {case Success(x) => x; case Failure(e) => 0}
```

evaluates to expr1 if successful or expr2 if exception
expr2 if exception else Success(expr1)
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 fromURL):

```
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))
```

Strings

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

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

Escape	char
`\n`	line break
`\t`	horisontal tab
`\"`	double quote "
`\'`	single quote '
`\\`	backslash \
`\u0041`	unicode for A

Special strings

`"hello\nworld\t!"`	string including escape char for line break and tab
`"""a "raw" string"""`	can include quotes and span multiple lines
`s"x is $x"`	**s interpolator** inserts values of existing names
`s"x+1 is ${x+1}"`	s interpolator evaluates expressions within `${}`
`f"$x%5.2f"`	format Double x to 2 decimals at least 5 chars wide
`f"$y%5d"`	format Int y right justified at least five chars wide

scala.collection.JavaConverters

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

`xs.asJava` on a **Scala** collection of type:		`xs.asScala` on a **Java** collection of type:
`Iterator`	⟷	`java.util.Iterator`
`Iterable`	⟷	`java.lang.Iterable`
`Iterable`	←	`java.util.Collection`
`mutable.Buffer`	⟷	`java.util.List`
`mutable.Set`	⟷	`java.util.Set`
`mutable.Map`	⟷	`java.util.Map`
`mutable.ConcurrentMap`	⟷	`java.util.concurrent.ConcurrentMap`

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  _  :  =  =>  <-  <:  <%  >:  #  @
```


Methods in trait `Traversable[A]`

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

Methods in trait `Iterable[A]`

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

Methods in trait `Seq[A]`

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

Methods in trait `Set[A]`

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

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

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

Methods in trait `Map[K, V]`

`ms get k`	The value associated with key k an option, None if not found.
`ms(k)  xs apply k`	The value associated with key k, or exception if not found.
`ms getOrElse (k, d)`	The value associated with key k in map ms, or d if not found.
`ms isDefinedAt k`	True if ms contains a mapping for key k. Also: ms.contains(k)
`ms + (k -> v)  ms + ((k, v))` `ms updated (k, v)`	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)
`ms - k`	Excluding any mapping of key k. Also: ms - (k, l, m)
`ms ++ ks  ms -- ks`	The mappings of ms with the mappings of ks added/removed.
`ms.keys  ms.values  ms.keySet`	An Iterable/Set containing each key/value in ms.
`ms.mapValues`	A new Map obtained by applying f to values.

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

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

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

```
Scanner scan = null;
try {
    scan = new Scanner(new File("indata.txt"));
} catch (FileNotFoundException e) {
    … ta hand om felet
}
```

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
```


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 **en** 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	[<protection>] [static] [final] <type> name1, name2, … ;	
<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

```
[ public ] [ abstract ] class Classname
    [ extends Classname1 ] [ implements Interface1, Interface2, … ] {
    <deklaration av attribut>
    <deklaration av konstruktorer>
    <deklaration av metoder>
}
```

Attribut Som vanliga deklarationer. Attribut får implicita startvärden, 0, 0.0, false, null.

Konstruktor

```
<prot> Classname(param, …) {
    stmt; …
}
```

Parametrarna är de parametrar som ges vid new Classname(…). Satserna ska ge attributen startvärden

Metod

```
<prot> <type> name(param, …) {
    stmt; …
}
```

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 subklasserna.

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);	skapar ett objekt som innehåller value
int intValue();	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();	antalet tecken
char charAt(int i);	tecknet på plats i, 0..length()−1
boolean equals(String s);	jämför innehållet (s1 == s2 fungerar inte)
int compareTo(String s);	< 0 om mindre, = 0 om lika, > 0 om större
int indexOf(char ch);	index för ch, −1 om inte finns
int indexOf(char ch, int from);	som indexOf men börjar leta på plats from
String substring(int first, int last);	kopia av tecknen first..last−1
String[ ] split(String delim);	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);	x = 1234 → ”1234”
Integer.parseInt(String s);	s = ”1234” → 1234, NumberFormat-Exception om s innehåller felaktiga tecken

StringBuilder Modifierbara teckensträngar. length och charAt som String, plus:

StringBuilder(String s);	StringBuilder med samma innehåll som s
void setCharAt(int i, char ch);	ändrar tecknet på plats i till ch
StringBuilder append(String s);	lägger till s, även andra typer: int, char, …
StringBuilder insert(int i, String s);	lägger in s med början på plats i
StringBuilder deleteCharAt(int i);	tar bort tecknet på plats i
String toString();	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 överskugga funktionen equals(Object). Integer och de andra wrapperklasserna gör det.

ArrayList
LinkedList

ArrayList<E>();	skapar tom lista
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 (efterföljande element flyttas)
boolean remove(Object obj);	tar bort objektet obj, om det finns
void clear();	tar bort alla element i listan