# **Concept reference**

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## Concepts

- Assignable
- InputIterator
- OutputIterator
- ForwardIterator
- BidirectionalIterator
- RandomAccessIterator
- DefaultConstructible
- CopyConstructible
- EqualityComparable
- LessThanComparable
- SignedInteger

## **Concept Assignable**

Assignable

## Description

Assignable types must have copy constructors, operator= for assignment, and the swap() function defined.





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#### **Refinement of**

CopyConstructible

#### Notation

X A type playing the role of assignable-type in the Assignable concept.

x, y Objects of type X

#### Valid expressions

Name	Expression	Туре	Semantics
Assignment	$\mathbf{x} = \mathbf{y}$	X &	Require operator=
Swap	swap(x, y)	void	Require swap() function

#### Models

• int

### See also

CopyConstructible

# **Concept InputIterator**

InputIterator

### Description

An input iterator is an iterator that can read through a sequence of values. It is single-pass (old values of the iterator cannot be reused), and read-only.

An input iterator represents a position in a sequence. Therefore, the iterator can point into the sequence (returning a value when dereferenced and being incrementable), or be off-the-end (and not dereferenceable or incrementable).

## **Refinement of**

- Assignable
- DefaultConstructible
- EqualityComparable

## Associated types

value\_type

std::iterator\_traits<Iter>::value\_type

The value type of the iterator (not necessarily what \*i returns)

• difference\_type



std::iterator\_traits<Iter>::difference\_type

The difference type of the iterator

#### • category

```
std::iterator_traits<Iter>::iterator_category
```

The category of the iterator

#### Notation

	Iter	A type playing the role of iterator-type in th	e InputIterator concep
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- i, j Objects of type Iter
- x Object of type value\_type

#### **Type expressions**

Category tag	category must be derived from std::input_iterator_tag, a model of DefaultConstructible, and a model of CopyConstructible.
Value type copy constructibility	value_type must be a model of CopyConstructible.
Difference type properties	difference_type must be a model of SignedInteger.

#### Valid expressions

Name	Expression	Туре	Precondition	Semantics	Postcondition
Dereference	*i	Convertible to value_type	i is incrementable (not off-the-end)		
Preincrement	++i	Iter &	i is incrementable (not off-the-end)		
Postincrement	i++		i is incrementable (not off-the-end)	Equivalent to (void)(++i)	i is dereference- able or off-the-end
Postincrement and dereference	*i++	Convertible to value_type	i is incrementable (not off-the-end)	<pre>Equivalent to {value_type t = *i; ++i; re- turn t;}</pre>	i is dereference- able or off-the-end

### Complexity

All iterator operations must take amortized constant time.

#### Models

• std::istream\_iterator

#### See also

DefaultConstructible



- EqualityComparable
- ForwardIterator
- OutputIterator

# **Concept OutputIterator**

OutputIterator

#### Description

An output iterator is an iterator that can write a sequence of values. It is single-pass (old values of the iterator cannot be re-used), and write-only.

An output iterator represents a position in a (possibly infinite) sequence. Therefore, the iterator can point into the sequence (returning a value when dereferenced and being incrementable), or be off-the-end (and not dereferenceable or incrementable).

### **Associated types**

• value\_type

std::iterator\_traits<Iter>::value\_type

The stated value type of the iterator (should be void for an output iterator that does not model some other iterator concept).

• difference\_type

```
std::iterator_traits<Iter>::difference_type
```

The difference type of the iterator

category

```
std::iterator_traits<Iter>::iterator_category
```

The category of the iterator

#### Notation

Iter A type playing the role of iterator-type in the OutputIterator concept.

ValueType A type playing the role of value-type in the OutputIterator concept.

- i, j Objects of type Iter
- x Object of type ValueType

#### Type expressions

The type Iter must be a model of Assignable.

The type ValueType must be a model of Assignable.

The type Iter must be a model of DefaultConstructible.

The type Iter must be a model of EqualityComparable.



Category tag

category must be derived from std::output\_iterator\_tag, a model of DefaultConstructible, and a model of CopyConstructible.

Difference type properties

difference\_type must be a model of SignedInteger.

### Valid expressions

Name	Expression	Туре	Precondition	Semantics	Postcondition
Dereference	*i		i is incrementable (not off-the-end)		
Dereference and assign	*i = x		i is incrementable (not off-the-end)		*i may not be written to again un- til it has been incre- mented.
Preincrement	++i	Iter &	i is incrementable (not off-the-end)		
Postincrement	i++		i is incrementable (not off-the-end)	Equivalent to (void)(++i)	i is dereference- able or off-the-end
Postincrement, dereference, and assign	*i++ = x		i is incrementable (not off-the-end)	<pre>Equivalent to {*i = t; ++i;}</pre>	i is dereference- able or off-the-end

## Complexity

All iterator operations must take amortized constant time.

### Models

- std::ostream\_iterator, ...
- std::insert\_iterator, ...
- std::front\_insert\_iterator, ...
- std::back\_insert\_iterator, ...

## **Concept ForwardIterator**

ForwardIterator

## Description

A forward iterator is an iterator that can read through a sequence of values. It is multi-pass (old values of the iterator can be re-used), and can be either mutable (data pointed to by it can be changed) or not mutable.

An iterator represents a position in a sequence. Therefore, the iterator can point into the sequence (returning a value when dereferenced and being incrementable), or be off-the-end (and not dereferenceable or incrementable).

## **Refinement of**

• InputIterator



• OutputIterator

#### Associated types

value\_type

```
std::iterator_traits<Iter>::value_type
```

The value type of the iterator

category

std::iterator\_traits<Iter>::iterator\_category

The category of the iterator

#### Notation

Iter A type playing the role of iterator-type in the ForwardIterator concept.

- i, j Objects of type Iter
- x Object of type value\_type

#### **Type expressions**

Category tag category must be derived from std::forward\_iterator\_tag.

#### Valid expressions

Name	Expression	Туре	Precondition	Semantics	Postcondition
Dereference	*i	const-if-not-mut- able value_type &	i is incrementable (not off-the-end)		
Member access	i->{member-name} (return type is pointer-to-object type)	const-if-not-mut- able value_type *	i is incrementable (not off-the-end)		
Preincrement	++i	Iter &	i is incrementable (not off-the-end)		
Postincrement	i++	Iter	i is incrementable (not off-the-end)	Equivalent to {Iter j = i; ++i; return j;}	i is dereference- able or off-the-end

## Complexity

All iterator operations must take amortized constant time.

### Invariants

Predecrement must return object &i = &(++i)



Unique path through sequence i == j implies ++i == ++j

#### Models

- T \*
- std::hash\_set<T>::iterator

#### See also

• BidirectionalIterator

# **Concept Bidirectionallterator**

BidirectionalIterator

### Description

A bidirectional iterator is an iterator that can read through a sequence of values. It can move in either direction through the sequence, and can be either mutable (data pointed to by it can be changed) or not mutable.

An iterator represents a position in a sequence. Therefore, the iterator can point into the sequence (returning a value when dereferenced and being incrementable), or be off-the-end (and not dereferenceable or incrementable).

## **Refinement of**

• ForwardIterator

#### **Associated types**

value\_type

```
std::iterator_traits<Iter>::value_type
```

The value type of the iterator

category

std::iterator\_traits<Iter>::iterator\_category

The category of the iterator

#### Notation

- Iter A type playing the role of iterator-type in the BidirectionalIterator concept.
- i, j Objects of type Iter
- x Object of type value\_type

#### **Type expressions**

Category tag category must be derived from std::bidirectional\_iterator\_tag.



Name	Expression	Туре	Precondition	Semantics	Postcondition
Predecrement	i	Iter &	<pre>i is incrementable (not off-the-end) and some derefer- enceable iterator j exists such that i == ++j</pre>		
Postdecrement	i	Iter	Same as for pre- decrement	Equivalent to {Iter j = i; - -i; return j;}	i is dereference- able or off-the-end

### Complexity

All iterator operations must take amortized constant time.

### Invariants

Predecrement must return object	&i = &(i)
Unique path through sequence	i == j impliesi ==j
Increment and decrement are inverses	++i;i; andi; ++i; must end up with the value of i unmodified, if i both of the operations in the pair are valid.

## Models

- T \*
- std::list<T>::iterator

## See also

RandomAccessIterator

# **Concept RandomAccessIterator**

RandomAccessIterator

## Description

A random access iterator is an iterator that can read through a sequence of values. It can move in either direction through the sequence (by any amount in constant time), and can be either mutable (data pointed to by it can be changed) or not mutable.

An iterator represents a position in a sequence. Therefore, the iterator can point into the sequence (returning a value when dereferenced and being incrementable), or be off-the-end (and not dereferenceable or incrementable).

## **Refinement of**

- BidirectionalIterator
- LessThanComparable



### Associated types

• value\_type

std::iterator\_traits<Iter>::value\_type

The value type of the iterator

category

std::iterator\_traits<Iter>::iterator\_category

The category of the iterator

• difference\_type

```
std::iterator_traits<Iter>::difference_type
```

The difference type of the iterator (measure of the number of steps between two iterators)

#### Notation

Iter	A type playing the role of iterator-type in the RandomAccessIterator concept.

- i, j Objects of type Iter
- x Object of type value\_type
- n Object of type difference\_type
- int\_off Object of type int

#### **Type expressions**

Category tag category must be derived from std::random\_access\_iterator\_tag.

Name	Expression	Туре	Semantics
Motion	i += n	Iter &	Equivalent to applying $i++n$ times if n is positive, applying $in$ times if n is negative, and to a null operation if n is zero.
Motion (with integer offset)	i += int_off	Iter &	Equivalent to applying $i++n$ times if n is positive, applying $in$ times if n is negative, and to a null operation if n is zero.
Subtractive motion	i -= n	Iter &	Equivalent to i+=(-n)
Subtractive motion (with in- teger offset)	i -= int_off	Iter &	Equivalent to i+=(-n)
Addition	i + n	Iter	<pre>Equivalent to {Iter j = i; j += n; return j;}</pre>
Addition with integer	i + int_off	Iter	<pre>Equivalent to {Iter j = i; j += n; return j;}</pre>
Addition (count first)	n + i	Iter	Equivalent to i + n
Addition with integer (count first)	int_off + i	Iter	Equivalent to i + n
Subtraction	i - n	Iter	Equivalent to i + (-n)
Subtraction with integer	i - int_off	Iter	Equivalent to i + (-n)
Distance	i-j	difference_type	The number of times i must be incremented (or decremen- ted if the result is negative) to reach j. Not defined if j is not reachable from i.
Element access	i[n]	const-if-not-mutable value_type &	Equivalent to *(i + n)
Element access with integer index	i[int_off]	const-if-not-mutable value_type &	Equivalent to *(i + n)

## Complexity

All iterator operations must take amortized constant time.

## Models

- T \*
- std::vector<T>::iterator



- std::vector<T>::const\_iterator
- std::deque<T>::iterator
- std::deque<T>::const\_iterator

### See also

• LessThanComparable

# **Concept DefaultConstructible**

DefaultConstructible

## Description

DefaultConstructible objects only need to have a default constructor.

## Notation

X A type playing the role of default-constructible-type in the DefaultConstructible concept.

#### Valid expressions

Name	Expression	Туре	Semantics
Construction	X()	Х	Construct an instance of the type with default parameters.

#### Models

- int
- std::vector<double>

# Concept CopyConstructible

CopyConstructible

### Description

Copy constructible types must be able to be constructed from another member of the type.

### Notation

X A type playing the role of copy-constructible-type in the CopyConstructible concept.

x, y Objects of type X

#### Valid expressions

Name	Expression	Туре	Semantics
Copy construction	X(x)	X	Require copy constructor.



## Models

• int

# Concept EqualityComparable

EqualityComparable

## Description

Equality Comparable types must have == and != operators.

### Notation

X A type playing the role of comparable-type in the EqualityComparable concept.

x, y Objects of type X

### Valid expressions

Name	Expression	Туре
Equality test	x === y	Convertible to bool
Inequality test	x != y	Convertible to bool

#### Models

- int
- std::vector<int>

# Concept LessThanComparable

LessThanComparable

## Description

LessThanComparable types must have <, >, <=, and >= operators.

## Notation

X A type playing the role of comparable-type in the LessThanComparable concept.

x, y Objects of type X



Name	Expression	Туре	Semantics
Less than	x < y	Convertible to bool	Determine if one value is less than another.
Less than or equal	x <= y	Convertible to bool	Determine if one value is less than or equal to another.
Greater than	x > y	Convertible to bool	Determine if one value is greater than another.
Greater than or equal to	x >= y	Convertible to bool	Determine if one value is greater than or equal to another.

### Models

• int

# **Concept SignedInteger**

SignedInteger

## **Refinement of**

- CopyConstructible
- Assignable
- DefaultConstructible
- EqualityComparable
- LessThanComparable

### Notation

T A type playing the role of integral-type in the SignedInteger concept.

```
x, y, Objects of type T
```

z

a, b Objects of type int

## Type expressions

Conversion to int T must be convertible to int.





Name	Expression	Туре
Conversion from int	T(a)	Т
Preincrement	++x	Τ &
Predecrement	X	Τ &
Postincrement	x++	Т
Postdecrement	X	Т
Sum	x + y	Т
Sum with int	x + a	Т
Sum-assignment	x += y	Τ &
Sum-assignment with int	x += a	Τ &
Difference	x - y	Т
Difference with int	x - a	Т
Product	x * y	Т
Product with int	x * a	Т
Product-assignment with int	x *= a	Τ &
Product with int on left	a * x	Т
Quotient	x / y	Т
Quotient with int	x / a	Т
Right-shift	x >> y	Т
Right-shift with int	x >> a	Т
Right-shift-assignment with int	x >>= a	Τ &
Less-than comparison	x < y	Convertible to bool
Less-than comparison with int	x < a	Convertible to bool
Less-than comparison with size_t	<pre>x &lt; boost::sample_value &lt; std::size_t &gt;()</pre>	Convertible to bool
Greater-than comparison	x > y	Convertible to bool
Greater-than comparison with int	x > a	Convertible to bool
Less-than-or-equal comparison	x <= y	Convertible to bool
Less-than-or-equal comparison with int	x <= a	Convertible to bool
Greater-than-or-equal comparison	x >= y	Convertible to bool



Name	Expression	Туре
Greater-than-or-equal comparison with int	x >= a	Convertible to bool
Greater-than-or-equal comparison with int on left	a >= x	Convertible to bool
Equality comparison	x == y	Convertible to bool
Equality comparison with int	x == a	Convertible to bool

