$\begin{array}{c} \mathbf{C++\ STL} \\ \mathbf{Standard\ library\ (Functions\ etc.)} \end{array}$

Nathan Warner



Computer Science Northern Illinois University United States

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1 C++ Strings (<string>)

Interlude. Before we begin with the C++ string methods, there are two things to know.

- size_t: an unsigned integral type, and it's designed to be able to represent the size of any object in bytes
- **npos**: (Constant) It's the largest possible value representable by the size_type of std::string

♦ Note:-

 $size_t$ is used as the return value for methods such as "find" to indicate unsuccessful

1.1 Element Access

- at(r:size_t pos):

 char& Returns a reference to the character at the specified position. Store return value in char&
- $str.front():\mapsto char\&$ returns reference to the first character.
- str.back():→ char& returns a reference to the last character.
- $str.c_str():\rightarrow const char^*$ pointing to the null-terminated character array.
- str.data():→ const char* pointing to the underlying character array.

1.2 Capacity

- str.length():→ size_t Returns the number of characters in the string
- str.size():→ size_t Returns the number of characters in the string
- str.empty():→ bool Returns true if the string is empty, false otherwise
- resize(r:size_t n, o:char c):→ void Resizes the string to contain n characters.
- $capacity():\mapsto size_t$ Returns the size of the storage space currently allocated
- reserve(size_t new_cap):
 → void Reserves storage (increases capacity).
- max_size():
 ⇒ size_t Returns the maximum number of characters the string can hold
- shrink_to_fit():→ void Reduces memory usage by freeing unused memory

1.3 Modifiers

- append(string str):→ std::string& mutated_string String to append. (Has other overloads.) (Doesnt need to be saved in T&)
- $push_back(char c):\mapsto void$ Character to append.
- assign(string str, o:start,o:stop):→ std::string& mutated_string used to replace the current content of the string with a new set of characters. (Has other overloads.)
- insert(size_t pos, string str):→ std::string& mutated_str Position and string to insert. (Has other overloads.)
- replace(size_t pos, size_t len, string str):→ mutated_string Position, length, and string for replacement. (Has other overloads.)
- $swap(string str):\mapsto void$ String to swap with.
- pop_back(): → void Removes the last character in the string

1.4 String Operations

- substr(pos, o:len):→ string Generate a substr from a string
- copy(char[] dest, o:len, pos):→ size_t (number of characters that were copied) send contents of string to some character array
- find(substr, o:pos):→ size_t=npos find a substr from within a string
- rfind(substr, o:pos):→ size_t=npos find a substr form withing as string, starting search from the end of the string
- find_first_of(substr (or char), o:pos) → size_t=npos Find character in string (public member function)
- find_last_of(substr (or char), o:pos) → size_t=npos Find character in string from the end (public member function)
- find_first_not_of(substr (or char), o:pos)→ size_t=npos Find absence of character in string (public member function)
- find_last_not_of(substr (or char), o:pos) → size_t=npos Find non-matching character in string from the end (public member function)

1.5 Comparison

- compare(o:pos, o:len, str): \mapsto unsigned integral
 - 0: they compare equal
 - <0: Either the value of the first character that does not match is lower in the compared string, or all compared characters match but the compared string is shorter.
 - >0: Either the value of the first character that does not match is greater in the compared string, or all compared characters match but the compared string is longer.

1.6 Conversions (These are functions)

- stoi(str, o:idx, o:base):→ int (idx is a pointer to a size_t object)
- $stol(str, o:idx, o:base):\mapsto long$
- $stoul(str, o:idx, o:base):\mapsto unsigned long$
- $stoll(str, o:idx, o:base):\mapsto long long$
- $stoull(str, o:idx, o:base):\mapsto unsigned long long$
- $stof(str, o:idx):\mapsto float$
- $stod(str, o:idx):\mapsto double$
- $stold(str, o:idx):\mapsto long double$

2 C-strings (<cstring>)

2.1 Manipulation

- strncpy(char[] dest, char[] src, size_t n):→ const char* Copy up to n characters from the string src to dest.
- strcpy(char[] dest, char[] src) → const char* Copies the C string pointed by source into the array pointed by destination
- strncat(char[] dest, char[] src, size_t n):→ const char* Append up to n characters from the string src onto the end of dest.
- strcat(char[] dest, char[] src) → const char* Appends a copy of the source string to the destination string.

Note: cpy functions return a const char* comprised of the characters from the src array that were used.

2.2 Examination

- strnlen(char[] src, size_t maxlen) \mapsto size_t Return the length of the string (not including the null terminator).
- strlen(char[] src):→ size_t Return the length of the string (not including the null terminator).
- strncmp(char[] src1, char[] src2, size_t n):→ uint (value varies) Compare up to n characters of two strings.
- $strcmp(char[] src1, char[] src2) \mapsto size_t$ (value varires) compare two strings

2.3 Searching

- strchr(char[] src, char c):→ char* get pointer to the first occurrence of character c in the string s, or nullptr if c is not found.
- strrchr(char[] src, char c):→ char* get pointer to the last occurrence of character c in the string s.
- strstr(char[] src, char[] str):→ const char* Return a pointer to the first occurrence of the substring
- strspn(char[] src, char[] charset):→ size_t Returns the length of the initial portion of str1 which consists only of characters that are part of str2.
- strcspn(char[] src, char[] charset):
 ⇒ size_t Get position of first character found from charset
- strpbrk(char[] src, char[] charset):→ const char* Return string consisting of first match form character set in string onward
- $strtok(char[] src, const char* delims):\mapsto char*$

2.4 Error

• **strerror(errno)** → **const** char* — Get pointer to error message string (we are literally passing in the defined variable *errno*)

```
std::ifstream inf("file.txt");
if (inf.fail()) { cout << strerrror(errno); } // No such file in directory
(Because that is what the error string is set to after inf.fail())</pre>
```

we also have control over the error we can pass in, errors that are defined in <cerrno>. Rather than leaving it up to errno. We have:

E2BIG (C++11) Argument list too long (macro constant)

EACCES (C++11) Permission denied (macro constant)

EADDRINUSE (C++11) Address in use (macro constant)

EADDRNOTAVAIL (C++11) Address not available (macro constant)

EAFNOSUPPORT (C++11) Address family not supported (macro constant)

EAGAIN (C++11) Resource unavailable, try again (macro constant)

EALREADY (C++11) Connection already in progress (macro constant)

EBADF (C++11) Bad file descriptor (macro constant)

EBADMSG (C++11) Bad message (macro constant)

EBUSY (C++11) Device or resource busy (macro constant)

ECANCELED (C++11) Operation canceled (macro constant)

ECHILD (C++11) No child processes (macro constant)

ECONNABORTED (C++11) Connection aborted (macro constant)

ECONNREFUSED (C++11) Connection refused (macro constant)

ECONNRESET (C++11) Connection reset (macro constant)

EDEADLK (C++11) Resource deadlock would occur (macro constant)

EDESTADDRREQ (C++11) Destination address required (macro constant)

EDOM Mathematics argument out of domain of function (macro constant)

EEXIST (C++11) File exists (macro constant)

EFAULT (C++11) Bad address (macro constant)

EFBIG (C++11) File too large (macro constant)

EHOSTUNREACH (C++11) Host is unreachable (macro constant)

EIDRM (C++11) Identifier removed (macro constant)

EILSEQ Illegal byte sequence (macro constant)

EINPROGRESS (C++11) Operation in progress (macro constant)

EINTR (C++11) Interrupted function (macro constant)

EINVAL (C++11) Invalid argument (macro constant)

EIO (C++11) I/O error (macro constant)

EISCONN (C++11) Socket is connected (macro constant)

EISDIR (C++11) Is a directory (macro constant)

ELOOP (C++11) Too many levels of symbolic links (macro constant)

```
EMFILE (C++11) File descriptor value too large (macro constant)
EMLINK (C++11) Too many links (macro constant)
EMSGSIZE (C++11) Message too large (macro constant)
ENAMETOOLONG (C++11) Filename too long (macro constant)
ENETDOWN (C++11) Network is down (macro constant)
ENETRESET (C++11) Connection aborted by network (macro constant)
ENETUNREACH (C++11) Network unreachable (macro constant)
ENFILE (C++11) Too many files open in system (macro constant)
ENOBUFS (C++11) No buffer space available (macro constant)
ENODATA (C++11) (deprecated in C++23) No message is available on the
    STREAM head read queue (macro constant)
ENODEV (C++11) No such device (macro constant)
ENOENT (C++11) No such file or directory (macro constant)
ENOEXEC (C++11) Executable file format error (macro constant)
ENOLCK (C++11) No locks available (macro constant)
ENOLINK (C++11) Link has been severed (macro constant)
ENOMEM (C++11) Not enough space (macro constant)
ENOMSG (C++11) No message of the desired type (macro constant)
ENOPROTOOPT (C++11) Protocol not available (macro constant)
ENOSPC (C++11) No space left on device (macro constant)
ENOSR (C++11)(deprecated in C++23) No STREAM resources (macro con-
    stant)
ENOSTR (C++11) (deprecated in C++23) Not a STREAM (macro constant)
ENOSYS (C++11) Function not supported (macro constant)
ENOTCONN (C++11) The socket is not connected (macro constant)
ENOTDIR (C++11) Not a directory (macro constant)
ENOTEMPTY (C++11) Directory not empty (macro constant)
ENOTRECOVERABLE (C++11) State not recoverable (macro constant)
ENOTSOCK (C++11) Not a socket (macro constant)
ENOTSUP (C++11) Not supported (macro constant)
ENOTTY (C++11) Inappropriate I/O control operation (macro constant)
ENXIO (C++11) No such device or address (macro constant)
EOPNOTSUPP (C++11) Operation not supported on socket (macro constant)
EOVERFLOW (C++11) Value too large to be stored in data type (macro con-
    \operatorname{stant})
EOWNERDEAD (C++11) Previous owner died (macro constant)
EPERM (C++11) Operation not permitted (macro constant)
EPIPE (C++11) Broken pipe (macro constant)
EPROTO (C++11) Protocol error (macro constant)
```

ERANGE Result too large (macro constant)

EPROTONOSUPPORT (C++11) Protocol not supported (macro constant)
EPROTOTYPE (C++11) Protocol wrong type for socket (macro constant)

```
EROFS (C++11) Read-only file system (macro constant)
ESPIPE (C++11) Invalid seek (macro constant)
ESRCH (C++11) No such process (macro constant)
ETIME (C++11)(deprecated in C++23) Stream ioctl() timeout (macro constant)
ETIMEDOUT (C++11) Connection timed out (macro constant)
ETXTBSY (C++11) Text file busy (macro constant)
EWOULDBLOCK (C++11) Operation would block (macro constant)
EXDEV (C++11) Cross-device link (macro constant)
```

2.5 Conversion Found in <cstdlib>

- atoi(char[]) Converts a C-string to an int.
- atol(char[]) Converts a C-string to a long.
- atoll(char[]) Converts a C-string to a long long.
- atof(char[]) Converts a C-string to a double.
- strtol(char[], endptr, base) Converts a C-string to a long int, with error checking and more flexibility with base representations.
- strtoul(char[], endptr, base) Converts a C-string to an unsigned long int.
- strtoll(char[], endptr, base) Converts a C-string to a long long int.
- strtoull(char[], endptr, base) Converts a C-string to an unsigned long long int.
- **strtof(char[], endptr)** Converts a C-string to a float.
- strtod(char[], endptr) Converts a C-string to a double.
- strtold(char[], endptr) Converts a C-string to a long double.

```
Note: Consider the codeblock
const char* a = "12.322string";
char* ptr;
double val = strtod(a, &ptr); // ptr will hold the value "string"
```

In this example, you can see that we are making use of the endptr optional parameter, endptr is the address to a char pointer. It allows us to send all the string data that is not able to be converted to the requested data type. It allows us to send all the string data that is not able to be converted to the requested data type to this pointer. Only data AFTER the converted data will be sent.

3 Numeric to string conversions <string>

• to_string(n):→ string — converts numeric type to c++ string

4 Characters (<ctype>)

4.1 Character Classification

- isalpha(char c): Checks if the character is an alphabet (either uppercase or lower-case).
- **isdigit(char c)**: Checks if the character is a digit (0-9).
- isalnum(char c): Checks if the character is either an alphabet or a digit.
- **isspace(char c):** Checks if the character is a whitespace character (like space, tab, newline, etc.).
- isupper(char c): Checks if the character is uppercase.
- islower(char c): Checks if the character is lowercase.
- ispunct(char c): Checks if the character is a punctuation character.
- isprint(char c): Checks if the character is printable.
- iscntrl(char c): Checks if the character is a control character.

4.2 Character Conversion:

- toupper(char c): Converts the character to uppercase (if it's lowercase).
- tolower(char c): Converts the character to lowercase (if it's uppercase).

5 C++ Arrays <array>

Note: C++ Arrays are defined

std::array<T,N> name;

- at(size_t) → T&: Accesses the element at the specified position with bounds checking.
- front() \mapsto T&: Returns a reference to the first element.
- $back() \mapsto T\&:$ Returns a reference to the last element.
- data()→ T*: Returns a direct pointer to the first element in the array, usefull if we want to use our std::array as if it were a c-style array
- empty() → bool: Checks if the container has no elements.
- size() → size_t: Returns the number of elements in the container.
- max_size() → size_t: Returns the maximum number of elements the container can hold (same as size).
- fill(value) → void: Fills the array with the specified value.
- $swap(other) \mapsto void$: Swaps the contents of the array with those of *other*.
- begin() → Iterator: Returns an iterator pointing to the first element.
- cbegin() → Const_Iterator: Returns a const iterator pointing to the first element.
- end()→ Iterator: Returns an iterator pointing to one-past-the-last element.
- cend()→ Const_Iterator: Returns a const iterator pointing to one-past-the-last element.
- rbegin()→ Reverse_Iterator: Returns a reverse iterator pointing to the last element.
- crbegin()→ Const_Reverse_Iterator: Returns a const reverse iterator pointing to the last element.
- rend()→ Reverse_Iterator: Returns a reverse iterator pointing to one-past-the-first element.
- crend()→ Const_Reverse_Iterator: Returns a const reverse iterator pointing to one-past-the-first element.

6 Algorithms <algorithm>

Prereq: Vocab

- An **InputIterator** is a type of iterator that can be used to read data from a sequence of elements. It supports operations like incrementing (to move to the next element in the sequence), dereferencing (to access the value of the element it currently points to), and comparing with other iterators (to check for the end of the sequence). Input iterators are the least powerful, but most widely applicable kind of iterator, as they only require single-pass, read-only access.
- An **ForwardIterator** is a type of iterator that has all the capabilities of an InputIterator but with some additional properties:
 - It can be incremented multiple times and will always give the same sequence of results (multi-pass guarantee).
 - It supports both it++ and ++it operations with the same effect.
 - Two dereferenced copies of a ForwardIterator are guaranteed to reference the same element (if neither is modified).

ForwardIterator is used in contexts where an algorithm might need to pass over a range of elements multiple times.

- A UnaryPredicate is a function or a function object that takes a single argument and returns a bool. It is used to test whether a certain condition is true for the elements in a sequence. The predicate can be a regular function, a lambda expression, or an object of a class that overloads the function call operator.
- A UnaryOperator refers to a function or a function object that takes a single argument and returns some value.
- An **OutputIterator** is a type of iterator that can be used to write to a sequence of elements. It's a concept from the C++ Standard Library that defines the requirements for an iterator that can be used to output or write data to a container.

Note: A standard iterator can be used in place of a outputiterator, however, here is how we can use a outputiterator to write contents of an array to the output buffer 1br

```
int arr[5] = {1,2,3,4,5};
std::copy(std::begin(arr), std::end(arr),
std::ostream_iterator<int>(cout, " "));
```

std::pair type: std::pair is a class template that provides a way to store two heterogeneous objects as a single unit. The way we access the elements is with .first and .second

6.1 Non-Modifying

- all_of(InputIterator, InputIterator, UnaryPredicate) \mapsto bool: Returns true if the predicate is true for all elements in the given range.
- any_of(InputIterator, InputIterator, UnaryPredicate) → bool: Returns true if the predicate is true for any element in the range.
- none_of(InputIterator, InputIterator, UnaryPredicate) \mapsto bool: Returns true if the predicate is false for all elements in the range.

- for_each(InputIterator, InputIterator, Function) → Function: Applies a function to each element in the range.
- count(InputIterator, InputIterator, const T&) \mapsto size_t: Counts elements equal to the specified value.
- count_if(InputIterator, InputIterator, UnaryPredicate) → size_t: Counts elements for which the predicate is true.
- mismatch(InputIterator1, InputIterator1, InputIterator2) → pair<InputIterator1,
 InputIterator2>: Finds the first position where two ranges differ.
- find(InputIterator, InputIterator, const T&) \mapsto InputIterator: Finds the first element equal to the specified value.
- find_if(InputIterator, InputIterator, UnaryPredicate) → InputIterator: Finds the first element for which the predicate is true.
- find_if_not(InputIterator, InputIterator, UnaryPredicate) \mapsto InputIterator: Finds the first element for which the predicate is false.
- find_end(InputIterator, InputIterator, InputIterator, InputIterator) \mapsto InputIterator: Finds the last occurrence of a subsequence.
- find_first_of(InputIterator, InputIterator, InputIterator, InputIterator)

 → InputIterator: Finds the first element that matches any element in another range.
- adjacent_find(InputIterator, InputIterator, o:UnaryPredicate) \mapsto InputIterator: Finds the first two adjacent items that are equal (or satisfy a given predicate).
- search(InputIterator, InputIterator, InputIterator, InputIterator) \mapsto InputIterator: Searches for the first occurrence of a subsequence.
- search_n(InputIterator, InputIterator, size_t, const T&) \mapsto InputIterator: Searches for a sequence of repeated elements.

Note:

The for each function returns the function that was used to map each element.

- copy(InputIterator, InputIterator, OutputIterator) → OutputIterator: Copies a range of elements to a new location.
- copy_if(InputIterator, InputIterator, OutputIterator, UnaryPredicate) → OutputIterator: Copies elements satisfying a condition to a new location.
- copy_n(InputIterator, Size, OutputIterator) → OutputIterator: Copies a number of elements to a new location.
- copy_backward(BidirectionalIterator1, BidirectionalIterator1, BidirectionalIterator2) → BidirectionalIterator2: Copies elements in reverse order.
- move(InputIterator, InputIterator, OutputIterator) \mapsto OutputIterator: Moves a range of elements to a new location.
- move_backward(BidirectionalIterator1, BidirectionalIterator1, BidirectionalIterator2) → BidirectionalIterator2: Moves elements in reverse order.
- fill(ForwardIterator, ForwardIterator, const T&) \mapsto void: Assigns a value to all elements in a range.

- fill_n(OutputIterator, Size, const T&) → OutputIterator: Assigns a value to a number of elements.
- transform(InputIterator, InputIterator, OutputIterator, UnaryOperation)

 → OutputIterator: Applies a function to a range of elements.
- generate(ForwardIterator, ForwardIterator, Generator)

 → void: Fills a range with the results of successive function calls.
- generate_n(OutputIterator, Size, Generator) → OutputIterator: Fills a range with N results of successive function calls.
- remove(InputIterator, InputIterator, const $T\&) \mapsto$ InputIterator: Removes elements equal to a value.
- remove_if(InputIterator, InputIterator, UnaryPredicate) \mapsto InputIterator: Removes elements satisfying a condition.
- remove_copy(InputIterator, InputIterator, OutputIterator, const T&) → OutputIterator: Copies elements not equal to a value.
- remove_copy_if(InputIterator, InputIterator, OutputIterator, UnaryPredicate) → OutputIterator: Copies elements not satisfying a condition.
- replace(InputIterator, InputIterator, const T&, const T&) → void: Replaces all values equal to a specified value.
- replace_if(InputIterator, InputIterator, UnaryPredicate, const T&) → void: Replaces values satisfying a condition.
- replace_copy(InputIterator, InputIterator, OutputIterator, const T&, const T&)

 → OutputIterator: Copies and replaces values.
- replace_copy_if(InputIterator, InputIterator, OutputIterator, UnaryPredicate, const $T\&) \mapsto OutputIterator$: Copies and replaces values based on a condition.
- $swap(T\&, T\&) \mapsto void$: Swaps the values of two objects.
- swap_ranges(ForwardIterator1, ForwardIterator1, ForwardIterator2) \mapsto ForwardIterator2: Swaps two ranges of elements.
- iter_swap(ForwardIterator1, ForwardIterator2)

 → void: Swaps elements pointed to by two iterators.
- reverse(BidirectionalIterator, BidirectionalIterator) → void: Reverses the order of elements in a range.
- reverse_copy(BidirectionalIterator, BidirectionalIterator, OutputIterator)

 → OutputIterator: Creates a reversed copy of a range.
- rotate(ForwardIterator, ForwardIterator, ForwardIterator) \mapsto ForwardIterator: Rotates the order of elements in a range.
- rotate_copy(ForwardIterator, ForwardIterator, ForwardIterator, OutputIterator) → OutputIterator: Copies and rotates a range of elements.
- shift_left(ForwardIterator, ForwardIterator, Size) → ForwardIterator: Shifts elements in a range to the left.
- shift_right(ForwardIterator, ForwardIterator, Size) → ForwardIterator: Shifts elements in a range to the right.

- random_shuffle(RandomAccessIterator, RandomAccessIterator) \mapsto void: Randomly re-orders elements in a range.
- shuffle(RandomAccessIterator, RandomAccessIterator, URNG&) \mapsto void: Randomly re-orders elements in a range using a generator.
- sample(InputIterator, InputIterator, OutputIterator, Size, URNG&) \mapsto OutputIterator: Selects N random elements from a sequence.
- unique(ForwardIterator, ForwardIterator) → ForwardIterator: Removes consecutive duplicate elements in a range.
- unique_copy(InputIterator, InputIterator, OutputIterator) \mapsto OutputIterator: Creates a copy of a range without consecutive duplicates.
- partition(BidirectionalIterator, BidirectionalIterator, UnaryPredicate) \mapsto Iterator: Partition range in two
- partition_copy(BidirectionalIterator, BidirectionalIterator, UutputIterator) → OutputIterator: Partition range in two
- stable_partition(BidirectionalIterator, BidirectionalIterator, UnaryPredicate) → Iterator: Partition range in two stable ordering

6.2 Using lambdas for these functions

```
int arr[] = {1,2,3};
std::for_each(arr, arr+3, [](int& a) -> int { return ++x; });
```

6.3 Getting position of element from returned iterator

Concept 1: If we subtract the iterator (which is the address of the array element) from the beginning of the array, we get the distance between the two pointers (so the index position of the iterator value)

```
idx = it - std::begin(array);
```

6.4 Using shuffle and sample

For these functions we need two components, a seed and a random engine

```
#include <chrono>
#include <random>

unsigned seed

std::chrono::system_clock::now().time_since_epoch().count();

std::default_random_engine engine(seed);
```

We then use the engine variable in place of URNG&

6.5 Sorting operations

- is_sorted(ForwardIterator, ForwardIterator) → bool: Checks whether a range is sorted into ascending order.
- is_sorted_until(ForwardIterator, ForwardIterator) → ForwardIterator: Finds the largest sorted subrange.
- $sort(RandomAccessIterator, RandomAccessIterator) \mapsto void:$ Sorts a range into ascending order.
- partial_sort(RandomAccessIterator, RandomAccessIterator, RandomAccessIterator, comp) → void: Sorts the first N elements of a range.
- partial_sort_copy(InputIterator, InputIterator, RandomAccessIterator, RandomAccessIterator, comp) → RandomAccessIterator: Copies and partially sorts a range of elements.
- stable_sort(RandomAccessIterator, RandomAccessIterator) → void: Sorts a range of elements while preserving order between equal elements.
- nth_element(RandomAccessIterator, RandomAccessIterator, RandomAccessIterator) → void: Partially sorts the given range making sure that it is partitioned by the given element.

6.6 Binary search operations (on sorted ranges)

- lower_bound(ForwardIterator, ForwardIterator, const T&) → ForwardIterator: Returns an iterator to the first element in the range [first, last) that is not less than (i.e., greater or equal to) the given value.
- upper_bound(ForwardIterator, ForwardIterator, const T&) → ForwardIterator: Returns an iterator to the first element in the range [first, last) that is greater than the given value.
- binary_search(ForwardIterator, ForwardIterator, const T&) \mapsto bool: Determines if an element equal to the given value exists within the range [first, last).
- equal_range(ForwardIterator, ForwardIterator, const T&) → pair<ForwardIterator, ForwardIterator, equivalent to the given value in the range [first, last).

6.7 Minimum/maximum operations

- $\max(\text{const } T\&, \text{const } T\&) \mapsto T$: Returns the greater of the two given values.
- max_element(ForwardIterator, ForwardIterator) → ForwardIterator: Returns an iterator to the largest element in the range [first, last).
- min(const T&, const T&) \mapsto T: Returns the smaller of the two given values.
- min_element(ForwardIterator, ForwardIterator) → ForwardIterator: Returns an iterator to the smallest element in the range [first, last).
- minmax(const T&, const T&) \mapsto pair<T, T>: Returns a pair consisting of the smaller and larger of the two elements.

- minmax_element(ForwardIterator, ForwardIterator) → pair<ForwardIterator,
 ForwardIterator>: Returns a pair of iterators to the smallest and the largest elements in the range [first, last).
- clamp(const T&, const T&, const T&) → T: Clamps a value between a pair of boundary values. If the value is less than the lower bound, it returns the lower bound. If it's greater than the upper bound, it returns the upper bound. Otherwise, it returns the value itself.

6.8 Other

- merge(InputIterator1, InputIterator1, InputIterator2, InputIterator2, OutputIterator) → OutputIterator: Merges two sorted ranges [first1, last1) and [first2, last2). The resulting range is also sorted.
- inplace_merge(BidirectionalIterator, BidirectionalIterator, BidirectionalIterator) → void: Merges two consecutive ordered ranges [first, middle) and [middle, last) into a single ordered range [first, last).
- equal(InputIterator1, InputIterator1, InputIterator2) → bool: Determines if the range [InputIterator1, InputIterator1) is equal to the range starting at Inputiterator2.
- is_permutation(ForwardIterator1, ForwardIterator1, ForwardIterator2) → bool (C++11): Determines if the range [first1, last1) is a permutation of the range starting at first2.

6.9 Set Operations

- includes(InputIterator1, InputIterator1, InputIterator2, InputIterator2) → bool: Returns true if the range [first2, last2) is a subsequence of the range [first1, last1).
- set_difference(InputIterator1, InputIterator1, InputIterator2, InputIterator2, OutputIterator) → OutputIterator: Computes the difference of two sets. The result contains elements that are in the first set but not in the second.
- set_intersection(InputIterator1, InputIterator1, InputIterator2, InputIterator2, OutputIterator) → OutputIterator: Computes the intersection of two sets. The result contains elements that are present in both sets.
- set_symmetric_difference(InputIterator1, InputIterator1, InputIterator2, InputIterator2, OutputIterator) → OutputIterator: Computes the symmetric difference between two sets. The result contains elements that are in either of the sets but not in their intersection.
- set_union(InputIterator1, InputIterator1, InputIterator2, InputIterator2, OutputIterator) → OutputIterator: Computes the union of two sets. The result contains all elements that are present in either of the sets, without duplicates.

7 Iterators <iterator>

- advance(Iterator&, Distance) → void: Advances the iterator by the given distance.
- distance(InputIterator, InputIterator) → typename iterator_traits<InputIterator>::difference_t
 Returns the number of steps between two iterators.
- begin(Container&) → Iterator: Returns an iterator pointing to the first element of the container.
- end(Container&) → Iterator: Returns an iterator pointing to the past-the-end element of the container.
- prev(BidirectionalIterator) → BidirectionalIterator: Returns an iterator pointing to the element immediately before the given iterator.
- next(ForwardIterator) → ForwardIterator: Returns an iterator pointing to the element immediately after the given iterator.

7.1 Iterator generators:

- back_inserter(Container&) → BackInsertIterator: Constructs a back-insert iterator that appends new elements to the end of the specified container.
- front_inserter(Container&) \mapsto FrontInsertIterator: Constructs a front-insert iterator that prepends new elements to the beginning of the specified container.
- inserter(Container&, Iterator) → InsertIterator: Constructs an insert iterator for inserting new elements into the container at the position specified by the given iterator.
- make_move_iterator(Iterator) → MoveIterator: Converts a regular iterator into a move iterator, causing the elements to be moved rather than copied.

8 Vectors

8.1 Element Access

- $at(size_type\ n) \mapsto T\&$ Accesses the element at the specified position n in the container, with bounds checking. Throws an out-of-range exception if n is not within the range of the container.

- data() → T*: Provides direct access to the underlying array in the container. Returns
 a pointer to the array.

8.2 Capacity

- empty() → bool: Checks whether the container is empty. Returns true if the container is empty, false otherwise.
- size() → size_type: Returns the number of elements in the container.
- max_size() → size_type: Returns the maximum number of elements that the container can hold.
- capacity() → size_type: Returns the number of elements that can be held in currently allocated storage.
- reserve(size_type n) → void: Reserves storage to make the container capable of holding at least n elements. If n is greater than the current capacity(), new storage is allocated, otherwise the method does nothing.
- **shrink_to_fit()** \mapsto **void**: Reduces memory usage by freeing unused memory. This is a non-binding request to reduce **capacity()** to **size()**. The implementation is allowed to optimize otherwise or ignore the request.

8.3 Modifiers

- push back(const T& value) → void Adds an element to the end of the container.
- pop_back() → void: Removes the last element from the container.
- insert(iterator pos, const T& value) → iterator: Inserts an element at the position given by pos.
- insert(iterator pos, size_t count, tconst T& value) → iterator: Inserts a specified number of element at the position given by pos.
- insert(iterator pos, iteratorFirst, iteratorSecond) → iterator: Inserts a range of elements at the position given by pos.
- clear() → void: Clears the contents of the container. After this call, size() returns zero.

- erase(iterator pos) → iterator: Erases the element at the position given by pos. Returns an iterator following the last removed element.
- emplace(iterator pos, Args... args) → iterator: Constructs an element in-place at the position given by *pos*. The arguments *args* are forwarded to the constructor of the element type.
- emplace_back(Args... args) → T&: Constructs an element in-place at the end of the container. The arguments args are forwarded to the constructor of the element type.
- resize(size_type sz) \mapsto void: Changes the number of elements stored. If sz is smaller than the current size, the container is reduced to its first sz elements.
- swap(Container& other) → void: Swaps the contents with *other* container. The swap operation is generally very fast and never fails.
- assign(InputIterator first, InputIterator last) → void: Assigns new contents to the vector, replacing its current contents, and modifying its size accordingly. The new contents are elements constructed from each of the elements in the range between *first* and *last*, in the same order.
- assign(size_type n, const T& val) → void: Assigns n elements to the vector, each copy of val. If n is larger than the current vector size, additional elements are appended; if n is smaller, the container is reduced to its first n elements.
- assign(std::initializer_list<T> il) → void: Assigns new contents to the vector, replacing its current contents with the elements in the initializer list *il*.

8.4 Iterators

- begin() → Iterator: Returns an iterator pointing to the first element.
- cbegin() \rightarrow Const_Iterator: Returns a const iterator pointing to the first element.
- end() → Iterator: Returns an iterator pointing to one-past-the-last element.
- cend() → Const_Iterator: Returns a const iterator pointing to one-past-the-last element.
- rbegin()→ Reverse_Iterator: Returns a reverse iterator pointing to the last element.
- crbegin()→ Const_Reverse_Iterator: Returns a const reverse iterator pointing to the last element.
- rend()→ Reverse_Iterator: Returns a reverse iterator pointing to one-past-the-first element.
- crend()→ Const_Reverse_Iterator: Returns a const reverse iterator pointing to one-past-the-first element.

8.5 Emplace example <vector>

```
class MyClass {
   public:
       MyClass(int x, double y) : x(x), y(y) {}
       void print() const { std::cout << "MyClass(" << x << ", " <</pre>
    \rightarrow y << ")\n"; }
   private:
       int x;
       double y;
   };
   int main() {
11
       std::vector<MyClass> vec;
       // Construct MyClass objects directly at the end of the
       vec.emplace_back(10, 3.14);
14
       vec.emplace_back(20, 6.28); return 0; }
```

9 List < list>

9.1 Element Access

- front() \mapsto T&: Accesses the first element.
- back() \mapsto T&: Accesses the last element.

9.2 Capacity

- $empty() \mapsto bool$: Checks whether the container is empty.
- size() → size_type: Returns the number of elements.
- max_size() → size_type: Returns the maximum possible number of elements.

9.3 Modifiers

- $resize(size_type\ sz) \mapsto void$: Changes the number of elements stored.
- $push_back(const T\& value) \mapsto void$: Adds an element to the end.
- $push_front(const\ T\&\ value) \mapsto void$: Inserts an element to the beginning.
- $pop_back() \mapsto void$: Removes the last element.
- $pop_front() \mapsto void$: Removes the first element.
- assign(InputIterator first, InputIterator last) \mapsto void: Assigns values to the container.
- assign(size_type n, const T& val) \mapsto void: Assigns n elements to the vector, each copy of val. If n is larger than the current vector size, additional elements are appended; if n is smaller, the container is reduced to its first n elements.
- assign(std::initializer_list<T> il) → void: Assigns new contents to the vector, replacing its current contents with the elements in the initializer list *il*.
- insert(Iterator pos, const T& value) \mapsto Iterator: Inserts elements.
- remove(const T& value) \mapsto size_T: Removes elements satisfying specific criteria.
- remove_if(UnaryPredicate pred) → size_T: Removes elements satisfying specific criteria.
- reverse() \mapsto void: Reverses the order of the elements.
- $clear() \mapsto void$: Clears the contents.
- erase(Iterator pos) \mapsto Iterator: Erases elements.
- emplace(Iterator pos, Args&&... args) → Iterator: Constructs element inplace.
- emplace_back(Args&&... args) → T&: Constructs an element in-place at the end.

- emplace_front(Args&&... args) \mapsto T&: Constructs an element in-place at the beginning.
- $merge(List\& other) \mapsto void$: Merges two sorted lists.
- splice(Iterator pos, List& other) \mapsto void: Moves elements from another list.
- unique() → size_t: Removes consecutive duplicate elements.
- $swap(Container\& other) \mapsto void$: Swaps the contents.
- $sort() \mapsto void$: Sorts the elements.

9.4 Iterators

- begin() → Iterator: Returns an iterator pointing to the first element.
- **cbegin()** → **Const_Iterator**: Returns a const iterator pointing to the first element.
- end()→ Iterator: Returns an iterator pointing to one-past-the-last element.
- cend()→ Const_Iterator: Returns a const iterator pointing to one-past-the-last element.
- rbegin()→ Reverse_Iterator: Returns a reverse iterator pointing to the last element.
- crbegin() → Const_Reverse_Iterator: Returns a const reverse iterator pointing to the last element.
- rend() → Reverse_Iterator: Returns a reverse iterator pointing to one-past-the-first element.
- crend()→ Const_Reverse_Iterator: Returns a const reverse iterator pointing to one-past-the-first element.

10 Set <set>

11 Map <map>

12 cstdarg (For variadic functions)

12.1 Types

 \bullet $\mbox{\bf va_list}$ Type to hold information about variable arguments

12.2 Functions

- va_start Initialize a variable argument list

- va_copy Copy variable argument list

13 Functional

Memory stuff from Cstdlib and <cstring>

- calloc(size_t num, size_t size) → void*: Allocate and zero-initialize an array. Returns a pointer to the allocated memory, or NULL if the allocation fails.
- free(void* ptr) → void: Deallocate memory block. Frees the memory space pointed to by ptr, which must have been returned by a previous call to malloc, calloc, or realloc. Otherwise, or if free(ptr) is called more than once, undefined behavior occurs.
- malloc(size_t size) → void*: Allocate a memory block. Returns a pointer to the allocated memory, or NULL if the allocation fails.
- realloc(void* ptr, size_t new_size) → void*: Reallocate a memory block. Changes the size of the memory block pointed to by ptr to new_size. The function may move the memory block to a new location, in which case the new location is returned. Returns NULL if the allocation fails.
- memchr(const void* str, int c, size_t n) → void*: Searches for the first occurrence of the character c (an unsigned char) in the first n bytes of the string pointed to by str. Returns a pointer to the matching byte or NULL if the character does not occur in the given memory area.
- memcmp(const void* str1, const void* str2, size_t n) → int: Compares the first n bytes of the memory areas str1 and str2. Returns an integer less than, equal to, or greater than zero if str1 is found, respectively, to be less than, to match, or be greater than str2.
- memset(void* str, int c, size_t n) → void*: Fills the first n bytes of the memory
 area pointed to by str with the constant byte c. Returns a pointer to the memory
 area str.
- memcpy(void* dest, const void* src, size_t n) → void*: Copies n bytes from memory area src to memory area dest. The memory areas must not overlap. Returns a pointer to dest.
- memmove(void* dest, const void* src, size_t n) → void*: Moves n bytes from memory area src to memory area dest. The memory areas may overlap. Returns a pointer to dest.

Exception Classes <std::except>

15.1 Objects

- logic_error: exception class to indicate violations of logical preconditions or class invariants
- invalid_argument: exception class to report invalid arguments
- domain_error: exception class to report domain errors
- length_error: exception class to report attempts to exceed maximum allowed size
- out_of_range: exception class to report arguments outside of expected range
- runtime_error: exception class to indicate conditions only detectable at run time
- range_error: exception class to report range errors in internal computations
- overflow_error: exception class to report arithmetic overflows
- underflow_error: exception class to report arithmetic underflows

Note:-

All of these constructors have four overloads

- 1. std::string
- 2. C-String
- 3. Other of same type
- 4. Other of same type (noexcept version)

15.2 Methods

• what()

c-style IO operations < cstdio >

16.1 Operations on files

- remove(const char* filename) → int: Removes the file specified by filename. Returns zero on success, or nonzero if an error occurs.
- rename(const char* oldname, const char* newname) → int: Renames the file or directory specified by oldname to newname. Returns zero on success, or nonzero if an error occurs.
- tmpfile(void) → FILE*: Creates a temporary file in binary update mode (wb+) that is automatically deleted when it is closed or the program terminates. Returns a pointer to the FILE object that represents the temporary file.
- tmpnam(char* str) → char*: Generates and returns a unique temporary filename. If str is a null pointer, the temporary filename is stored in a static internal array and returned. If str is not a null pointer, the temporary filename is stored in str. Returns a pointer to the temporary filename.

16.2 File Access

- fclose(FILE* stream) → int: Closes the file associated with the stream. Returns zero on success, or EOF if an error occurs.
- fflush(FILE* stream) → int: Flushes the output buffer of a stream. If stream is NULL, flushes all output buffers. Returns zero on success, or EOF if an error occurs.
- fopen(const char* filename, const char* mode) → FILE*: Opens the file specified by filename using the mode specified by mode. Returns a pointer to the FILE object associated with the opened file, or NULL if the file cannot be opened.
- freopen(const char* filename, const char* mode, FILE* stream) → FILE*: Frees the stream and reopens the file specified by filename using the mode specified by mode. Returns a pointer to the FILE object associated with the reopened file, or NULL if the file cannot be opened.
- setbuf(FILE* stream, char* buf) → void: Sets the buffer to be used by the stream for I/O operations to buf. If buf is NULL, buffering is disabled for the stream.
- setvbuf(FILE* stream, char* buf, int mode, size_t size) → int: Sets the buffer to be used by the stream for I/O operations to buf and specifies the mode of buffering. The size parameter specifies the size of the buffer. Returns zero on success, or nonzero if an error occurs.

16.3 Formatted input/output

- fprintf(FILE* stream, const char* format, ...) → int: Writes formatted data to the given output stream. Returns the number of characters written, or a negative value if an error occurs.
- fscanf(FILE* stream, const char* format, ...) → int: Reads formatted input from a stream. Returns the number of input items successfully matched and assigned, which can be fewer than provided for, or even zero in the event of an early matching failure.

- printf(const char* format, ...) \mapsto int: Prints formatted data to stdout. Returns the number of characters transmitted, or a negative value if an error occurs.
- scanf(const char* format, ...) → int: Reads formatted input from stdin. Returns the number of items successfully read and assigned, which may be less than the number of format specifiers.
- snprintf(char* str, size_t size, const char* format, ...) → int: Writes formatted output to a string of up to size 1 characters, including a terminating null byte. Returns the number of characters that would have been written if size had been sufficiently large, not counting the terminating null byte.
- sprintf(char* str, const char* format, ...) → int: Writes formatted data to a string. Returns the number of characters written, excluding the terminating null byte.
- sscanf(const char* str, const char* format, ...) → int: Reads formatted input from a string. Returns the number of fields successfully converted and assigned; the return value does not include fields that were read but not assigned.
- vfprintf(FILE* stream, const char* format, va_list arg) → int: Writes formatted data from a variable argument list to the given output stream. Returns the number of characters written, or a negative value if an error occurs.
- vfscanf(FILE* stream, const char* format, va_list arg) → int: Reads formatted data from a stream into a variable argument list. Returns the number of input items successfully matched and assigned.
- vprintf(const char* format, va_list arg) → int: Prints formatted data from a variable argument list to stdout. Returns the number of characters transmitted, or a negative value if an error occurs.
- vscanf(const char* format, va_list arg) → int: Reads formatted data into a variable argument list from stdin. Returns the number of items successfully read and assigned.
- vsnprintf(char* str, size_t size, const char* format, va_list arg) → int: Writes formatted data from a variable argument list to a sized buffer. Returns the number of characters that would have been written if size had been sufficiently large, not counting the terminating null byte.
- vsprintf(char* str, const char* format, va_list arg) → int: Writes formatted data from a variable argument list to a string. Returns the number of characters written, excluding the terminating null byte.
- vsscanf(const char* str, const char* format, va_list arg) → int: Reads formatted data from a string into a variable argument list. Returns the number of fields successfully converted and assigned.

16.4 Character input/output

- fgetc(FILE* stream) → int: Gets the next character (an unsigned char) from the specified stream and advances the position indicator for the stream. Returns the character read as an unsigned char cast to an int or EOF on end of file or error.
- fgets(char* str, int n, FILE* stream) → char*: Reads in at most one less than n characters from stream and stores them into the buffer pointed to by str. Reading stops after an EOF or a newline. If a newline is read, it is stored into the buffer. A

- terminating null byte ('\0') is stored after the last character in the buffer. Returns str on success, and NULL on error or when end of file occurs while no characters have been read.
- fputc(int char, FILE* stream) → int: Writes the character char (an unsigned char) to the specified stream and advances the position indicator for the stream. Returns the character written as an unsigned char cast to an int or EOF on error.
- fputs(const char* str, FILE* stream) → int: Writes a string to the specified stream up to but not including the null character. Returns a nonnegative number on success, or EOF on error.
- **getc(FILE* stream)** → **int**: Gets the next character (an unsigned char) from the specified stream and advances the position indicator for the stream. This function may be implemented as a macro. Returns the character read as an unsigned char cast to an int or EOF on end of file or error.
- **getchar(void)** → **int**: Gets the next character (an unsigned char) from stdin and advances the position indicator for the stream. Returns the character read as an unsigned char cast to an int or EOF on end of file or error.
- **gets(char* str)** → **char*** (**Deprecated and dangerous**): Reads a line from stdin into the buffer pointed to by **str** until either a terminating newline or EOF, which it replaces with a null byte ('\0'). No check for buffer overrun is performed (please use **fgets** instead). Returns **str** on success, and NULL on error or when end of file occurs while no characters have been read.
- putc(int char, FILE* stream) → int: Writes the character char (an unsigned char) to the specified stream and advances the position indicator for the stream. This function may be implemented as a macro. Returns the character written as an unsigned char cast to an int or EOF on error.
- putchar(int char) → int: Writes the character char (an unsigned char) to stdout and advances the position indicator for the stream. Returns the character written as an unsigned char cast to an int or EOF on error.
- puts(const char* str) → int: Writes the string str and a trailing newline to stdout. Returns a nonnegative number on success, or EOF on error.
- ungetc(int char, FILE* stream) → int: Pushes the character char (an unsigned char) back onto the input buffer of the specified stream. The character will be returned by the next read on that stream. Returns the character pushed back after cast to unsigned char and then to int, or EOF on error.

16.5 Direct input/output

- fread(void* ptr, size_t size, size_t nmemb, FILE* stream) \mapsto size_t: Reads nmemb items of data, each size bytes long, from the stream pointed to by stream, storing them at the location given by ptr. Returns the number of items (not bytes) successfully read which may be less than nmemb if an error occurs or if the end of file is reached before reaching nmemb.
- fwrite(const void* ptr, size_t size, size_t nmemb, FILE* stream) \(\to \) size_t: Writes nmemb items of data, each size bytes long, to the stream pointed to by stream, obtaining them from the location given by ptr. Returns the number of items successfully written, which may be less than nmemb if an error occurs.

16.6 File positioning

- fgetpos(FILE* stream, fpos_t* pos) → int: Gets the current file position of the stream and stores it in the object pointed to by pos. Returns zero on success, or nonzero on error.
- fseek(FILE* stream, long int offset, int whence) → int: Sets the file position of the stream to the given offset. The new position, measured in bytes, is obtained by adding offset bytes to the position specified by whence. If whence is set to SEEK_SET, SEEK_CUR, or SEEK_END, the offset is relative to the start of the file, the current file position, or the end of the file, respectively. Returns zero on success, or nonzero on error.
- fsetpos(FILE* stream, const fpos_t* pos) → int: Sets the file position of the stream to the position specified by pos, which is a position given by a previous call to fgetpos. Returns zero on success, or nonzero on error.
- ftell(FILE* stream) → long int: Returns the current file position of the stream, or -1 on an error.
- rewind(FILE* stream) → void: Sets the file position to the beginning of the file of the given stream. Also clears the error and the end-of-file indicators for the stream.

16.7 Error-handling

- clearerr(FILE* stream) → void: Clears both the end-of-file and the error indicators for the stream. This function does not return a value.
- feof(FILE* stream) → int: Checks the end-of-file indicator for the given stream. Returns a nonzero value if the end-of-file indicator is set for stream, otherwise zero.
- ferror(FILE* stream) → int: Checks the error indicator for the given stream. Returns a nonzero value if the error indicator is set for stream, otherwise zero.
- **perror**(**const char* s**) → **void**: Prints a descriptive error message to stderr. First, if the string **s** is not NULL and does not point to an empty string, this string is printed followed by a colon and a space. Then an error message corresponding to the current value of the global variable **errno** is printed, followed by a newline. This function does not return a value.

16.8 Macros

- **BUFSIZ**: This macro constant expands to an integral expression with the size of the buffer used by the setbuf function.
- **EOF**: It is a macro definition of type int that expands into a negative integral constant expression (generally, -1).
- **FILENAME_MAX**: This macro constant expands to an integral expression corresponding to the size needed for an array of char elements to hold the longest file name string allowed by the library.
- FOPEN_MAX: This macro constant expands to an integral expression that represents the maximum number of files that can be opened simultaneously.

- **L_tmpna**: This macro constant expands to an integral expression corresponding to the size needed for an array of char elements to hold the longest file name string possibly generated by tmpnam.
- NULL: This macro expands to a null pointer constant.
- TMP_MAX: This macro expands to the minimum number of unique temporary file names that are guaranteed to be possible to generate using tmpnam.

16.9 Types

- FILE Object containing information to control a stream (type)
- fpos_t Object containing information to specify a position within a file (type)
- size_t Unsigned integral type (type)

Miscellaneous utilities: <cstdlib

17.1 Process control

- abort(void) → void: Causes abnormal program termination without cleaning up. The program terminates as if by calling 'std::terminate', and the termination status is implementation-defined. This function does not return.
- exit(int status) → void: Causes normal program termination with cleaning up. Performs standard cleanup for program termination (like flushing buffers) and calls the functions registered by 'std::atexit', then terminates the program with the given status. This function does not return.
- quick_exit(int status) → void (C++11): Causes quick program termination without completely cleaning up. Calls the functions registered by 'std::at_quick_exit' and terminates the program with the given status, without calling destructors for objects of automatic, thread, or static storage duration. This function does not return.
- _Exit(int status) → void (C++11): Causes normal program termination without cleaning up, similar to 'abort'. It terminates the program without calling destructors or any functions registered with 'std::atexit' or 'std::at_quick_exit'. This function does not return.
- atexit(void (*func)(void)) → int: Registers a function to be called on 'std::exit()' invocation. The specified function is called when the program terminates normally. Returns zero on success, non-zero if the registration fails.
- at_quick_exit(void (*func)(void)) → int (C++11): Registers a function to be called on 'std::quick_exit' invocation. The specified function is called when the program terminates via 'std::quick_exit'. Returns zero on success, non-zero if the registration fails.
- system(const char* command) → int: Calls the host environment's command processor ('/bin/sh' on Unix, 'CMD.EXE' on Windows) with the specified command. Returns an implementation-defined value if successful, and a negative value if an error occurs or if the command processor is not available.
- getenv(const char* name) → char*: Provides access to the list of environment variables. Returns a pointer to the value associated with the environment variable 'name', or 'NULL' if the variable is not found. The returned pointer points to static data whose content should not be modified.