# EDAF30 – Programming in C++

## *1. Introduction*

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## Outline

## EDAF30: Programmering i C++, 7.5 hp
### Syfte och mål

*Kursens syfte är att ge kunskaper i objektorienterad programmering i C++.*

Kunskap och förståelse:

- känna till och kunna beskriva skillnaderna mellan C++ och Java
- vara förtrogen med språket C++ och standardbiblioteket STL
- kunna förklara grundläggande begrepp inom objektorienterad C++-programmering
- förstå och kunna förklara de olika typerna av funktionsanrop
- kunna tolka, analysera och förklara befintlig C++-kod.

Färdighet och förmåga:

- kunna utveckla ett fungerande C++-program från en given specifikation
- kunna felsöka metodiskt i C++-kod.

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### Important differences to Java

New or extended concepts in C++
(compared to Java / introductory courses):

- Pointers and memory management
- Functions: call-by-value and call-by-reference
- Polymorphism: both static and dynamic
  (compare *templates* to *generics*)
- Operator overloading

And also

- The tool chain

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### Examination details

The compulsory course items are

- laborations
- project
- written examination

The final grade is based on the result of the written examination.

# EDAF30: programming in C++ , 7.5 hp
## Administration

- Course plan
  - Canvas
  - Zoom
- Registration
- Sign up for labs
  - Work in pairs
  - On the web - link from the course web page
  - Sign up for a group – same time all weeks

## History
## C++ is a descendent of Simula and C.

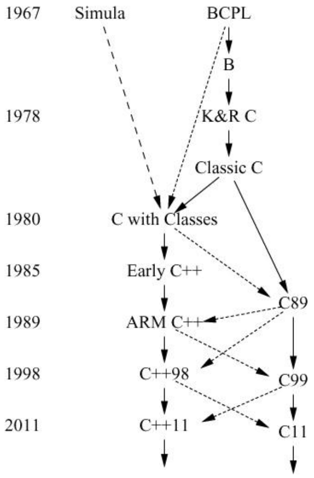
1967: Simula (Dahl & Nygaard)
1972: C (Dennis Ritchie)
1978: K&R C (Kernighan & Ritchie)
1980: C with Classes (Bjarne Stroustrup)
1985: C++ (Bjarne Stroustrup)

- ISO standard 1998

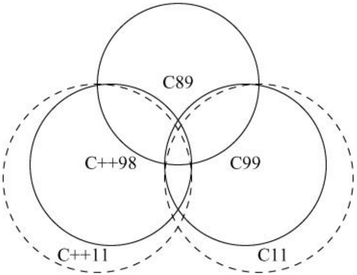
Other relatives:

1995: Java (James Gosling et al.)
2000: C# (Anders Hejlsberg)

- virtual machine
- automatic memory management
- *safe* languages



## C++ is not a pure extension of C



- both ISO C and ISO C++ are descendants of K&R C, and are "siblings"
- some details are incompatible between ISO C och C++
- Areas are not to scale

In general: Don't write C++ as if it were C

## What is C++?

The ISO standard for C++ defines two things

- *Core language features*, e.g.,
  - data types (e.g., **`char`**, **`int`**)
  - control flow mechanisms (e.g., **`if`** and **`while`** statements).
  - rules for declarations
  - templates
  - exceptions
- *Standard-library components*, e.g.,
  - Data structures (e.g., `string`, `vector`, and `map`)
  - Operations for in- and output (e.g., << and `getline()`)
  - Algorithms (e.g., `find()` and `sort()`)

The standard library is written in C++

- Example of what is possible

## A minimal program in C++

empty.cc

```cpp
int main( ) { }
```

- has no parameters
- does nothing
- the return value of `main()` is interpreted by the system as an error code
  - non-zero means error
  - no explicit return value is interpreted as zero (NB! only in `main()`)
  - rarely used in Windows
  - often used on Linux/Mac

## The first C++ program
### Hello, World!

**hello.cc**

```
#include <iostream>
int main( )
{
   std::cout << "Hello, World!" << std::endl;
   return 0;
}
```

**hello.cc**

```
#include <iostream>
using std::cout;
using std::endl;

int main( )
{
   cout << "Hello, World!" << endl;
   return 0;
}
```

## Statements

Mostly the same syntax as in Java:

- **`if`**, **`switch`**
- **`for`**, **`while`**, **`do while`**
- **`break`**, **`continue`**

but **`goto`** *is spelled differently:*

- No **`break`** to a label
- **`goto`** (used in C, rarely used in C++)

## Operators

Operators and expressions quite similar to Java

### The same as in Java

E.g., `+ - * / % ++ -- += -= *= && || & |` etc., and `[] . ?:`

### The trinary operator `?:`(like in Java)

```
z = (x>y) ? x : y;
```

```
if (x>y)
  z=x;
else
  z=y;
```

### Many more, including

Pointer operators: `* & ->`

Input and output: `<< >>` (*overloaded shift operators*)

**`sizeof`**, **`decltype`** (*compile-time*)

## Functions
### Declaration and definition

The main way of getting sonething done in C++:

- call a *function*
  - Declare before use
    A function must have been *declared* before it can be called
  - A function declaration specifices
    - name
    - return type
    - types of the parameters
  - Example: function declarations

```
int random();
void exit(int);
double square(double);
int pow(int x, int exponent);
```

- The compiler ignores parameter names
- Give names if it increases readability

- A function *definition* contains the implementation
  - Must not occur more than once (*One Definition Rule*)

## Difference from Java
### Function and variable declarations

- In Java functions and variables
  can only be declared inside a class.
- In C++, functions and variables
  can exist independently of classes.

    - free functions do not belong to a class
    - member functions in a class

    - global variables
    - member variables

## Function declaration
Example

- Declaration and definition

### Example: Mean value – variant 1

```
double mean(double x1, double x2) // Declaration and definition
{
   return (x1+x2)/2;
}

int main()
{
   double a=2.3;
   double b=3.9;
   cout << mean(a, b) << endl;
}
```

## Function definition
### With previous declaration

- *Forward declaration*
- Fuction definition after `main()`

**Example: mean – variant 2**

```
double mean(double, double);          // declaration (prototype)

int main()
{
   double a=2.3;
   double b=3.9;
   cout << mean(a, b) << endl;        // use
}

double mean(double x1, double x2)     //definition
{
   return (x1+x2)/2;
}
```

# Function declaration and definition in separate files

## Header file with declaration (mean.h)

```
double mean(double, double);          // declaration (prototype)
```

## Main source file

```
#include "mean.h"
int main()
{
   double a=2.3;
   double b=3.9;
   cout << mean(a, b) << endl;        // use
}
```

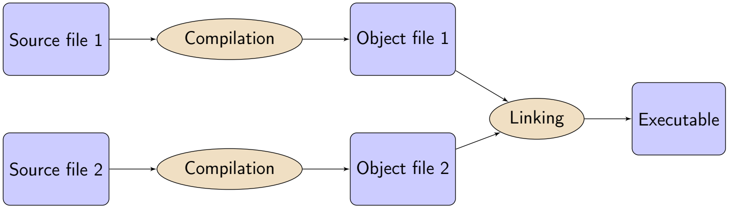
## Library source file (mean.cc)

```
double mean(double x1, double x2)     //definition
{
   return (x1+x2)/2;
}
```

## What is a program?

C++ is a compiled language

- Source code
- Object file(s)
- Executable file



## Data types and variables

- Every name and every expression has a type
- some concepts:
  - a *declaration* introduces a *name* (and gives it a *type*)
  - a *type* defines the set of possible values and operations (for an *object*)
  - an *object* is a place in memory that holds a *value*
  - a *value* is a sequence of bits interpreted according to a *type*.
  - a *variable* is a named *object*

An object has

- a *value* and
- a *representation*

**Unnamed objects**

*Unnamed objects* include

- temporary values
- objects on the heap (allocated with **`new`**)

## Data types
### Primitive types

- Integral types: **`char`**, **`short`**, **`int`**, **`long`**, **`long long`**
  - **`signed`** (as in Java )
  - **`unsigned`** (*modulo* $2^N$ "non-negative" numbers, not in Java)
- Floting point types: **`float`**, **`double`**, **`long double`**
- **`bool`** (`boolean` in Java)
  - integer values are implicitly converted to **`bool`**
  - zero is **`false`**, non-zero is **`true`**
- The type **`char`** is "the natural size to hold a character" on a given machine (often 8 bits). Its size (in C/C++) is called "a byte" regardless of the number of bits.
- **`sizeof`**(**`char`**) $\equiv 1$ (1 byte)
- The sizes of all other data types are multiples of **`sizeof`**(**`char`**).
  - sizes are *implementation defined*
  - **`sizeof`**(**`int`**) is commonly $4$.

## Variables
### Declaration and initialization

#### Declaration without initialization (avoid)

```
int x;          // x has an undefined value (if local)
                // (as local variables in Java)
```

#### Declaration and initialization

```
int x{7};       // C++ style (recommended if unsure)
int y = {7};    // C++ with extra =
int z = 7;      // C style

vector<int> v{1,2,3,4,5};
```

#### C style: Beware of implicit type conversion

```
int x = 7.8;    // x == 7. No warning
int y {7.8};    // Gives a warning (or error with -pedantic-errors)
```

## Suggested reading

References to sections in Lippman

| | |
|---|---|
| Functions | 6.1 (p 201–207) |
| Types, variables | 2.1,2.2,2.5.2 (p 31–37, 41–47, 69) |
| Type aliases | 2.5.1 |
| Arithmetic | 4.1-4.5, 4.11 |
| Constants | 2.4 2.4.4 (p 59–60, 65–66) |
| Pointers and references | 2.3 (p 50–59) |

## Next lecture
### Function calls. Pointers. User-defined types

References to sections in Lippman

| | |
|---|---|
| Literals | 2.1.3 |
| Pointers and references | 2.3 |
| std::string | 3.2 |
| std::vector | 3.3 |
| Arrays and pointers | 3.5 |
| Classes | 2.6, 7.1.4, 7.1.5, 13.1.3 |
| Scope and lifetimes | 2.2.4, 6.1.1 |
| I/O | 1.2, 8.1–8.2, 17.5.2 |