

Introduction to this Course

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Computing Methods in Physics

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Anno Accademico 2019/20



SAPIENZA
UNIVERSITÀ DI ROMA

Why C++?

- ▷ I am a particle physicist
- ▷ I am not a
 - ▷ programmer
 - ▷ C++ guru
 - ▷ Python expert
- ▷ Why this course?
 - In past 20 years C++ has become the primary programming language in High Energy Physics
 - Large experiments adopted C++ in 1990s moving away from Fortran
 - Many data analysis tools and numerical libraries rewritten in C++
 - ✧ Detector simulation
 - ✧ Signal extraction from detector and data acquisition
 - ✧ Data analysis
 - ✧ Multidimensional fits and multivariate techniques to determine parameters of the Standard Model from large number of experimental results
 - ✧ Since early 2000 Neural networks and machine-learning techniques have been used in High Energy physics
 - ✧ First easy implementation of these tools in ROOT with C++
 - ✧ Machine Learning has played a key role in discovery of the Higgs boson

Why Python?

- ▷ In past 10 years an explosion of Machine Learning (ML) and Artificial Intelligence (AI) also in commercial areas thanks to smartphones
 - Tagging photos
 - Shazam
 - Playlists on Spotify and Netflix
 - Voice recognition and digital assistants
- ▷ At the same time ML heavily used for data analysis at CERN Large Hadron Collider (LHC) in many areas
 - detector response
 - signal background discrimination
 - physics data analysis such as Higgs discovery
- ▷ Python is a very popular and versatile language for analysis of Big Data in both industry and physics
 - Many many freely available tools and libraries, tutorials, courses, HOW-TOs

About this course

- ▷ working assumption is that
 - you are familiar with the content of courses in Laboratorio di Calcolo and Fisica Nucleare e Subnucleare (Triennale)
 - You know why we write programs and applications to do Physics
 - You know what compilation means and how to use libraries
- ▷ Objectives of this course
 - Understand the advantage of object oriented programming (OOP) and using C++/Python for implementation
 - Being able to write simple applications in C++/Python to solve physics problems, perform data analysis, do numerical simulation
 - Learn to use external libraries and toolkit in your applications
 - For example ROOT in C++
 - Understand the differences between python and C++ and their pros and cons
 - Learn to use popular Machine Learning tools like scikit-learn

C++ in Physics



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Getting Started



Reference Guide



Forum



Gallery

ROOT is ...

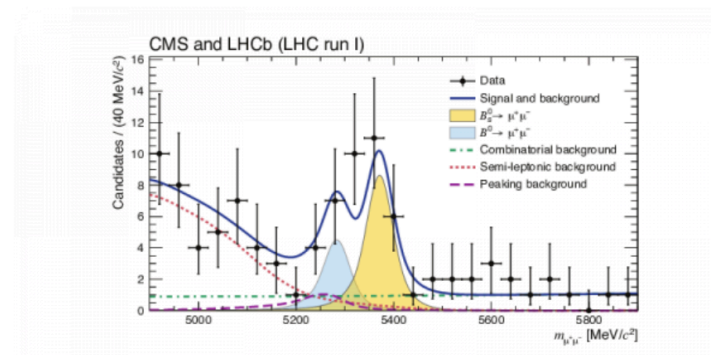
A modular scientific software toolkit. It provides all the functionalities needed to deal with big data processing, statistical analysis, visualisation and storage. It is mainly written in C++ but integrated with other languages such as Python and R.

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Overview

Geant4 is a toolkit for the simulation of the passage of particles through matter. Its areas of application include high energy, nuclear and accelerator physics, as well as studies in medical and space science. The three main reference papers for Geant4 are published in Nuclear Instruments and Methods in Physics Research [A 506 \(2003\) 250-303](#), IEEE Transactions on Nuclear Science [53 No. 1 \(2006\) 270-278](#) and Nuclear Instruments and Methods in Physics Research [A 835 \(2016\) 186-225](#).

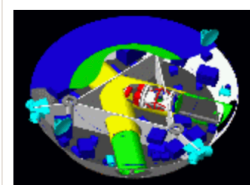
Applications



A sampling of applications, technology transfer and other uses of Geant4

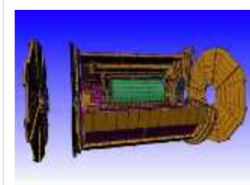
[printer-friendly version](#)

User Support



Getting started, guides and information for users and developers

Publications



Validation of Geant4, results from experiments and publications

Collaboration



Who we are: collaborating institutions, members, organization and legal information

News

- 29 Jun 2018
Release 10.5-BETA is available from the [BETA Download](#) area.
- 25 May 2018
Patch-02 to **release 10.4** is available from the [Download](#) area.
- 12 Mar 2018
[2018 planned developments](#)
- 20 Oct 2017
Patch-03 to release 10.3 is available from the [source archive](#) area.

About lectures

- ▷ I will not go into details of all possible operators, functions, commands, and syntax of C++ and Python
 - excellent online resources and web pages with examples and tutorials
 - lectures will focus on use case and examples, and application is problems to solve
- ▷ Will discuss aspects of OOP with C++ that make it better and more versatile than C
- ▷ Many specific examples to exercise with OOP in C++
- ▷ Feel free to try free online tutorial for more technical aspects of the language

Learning a Language

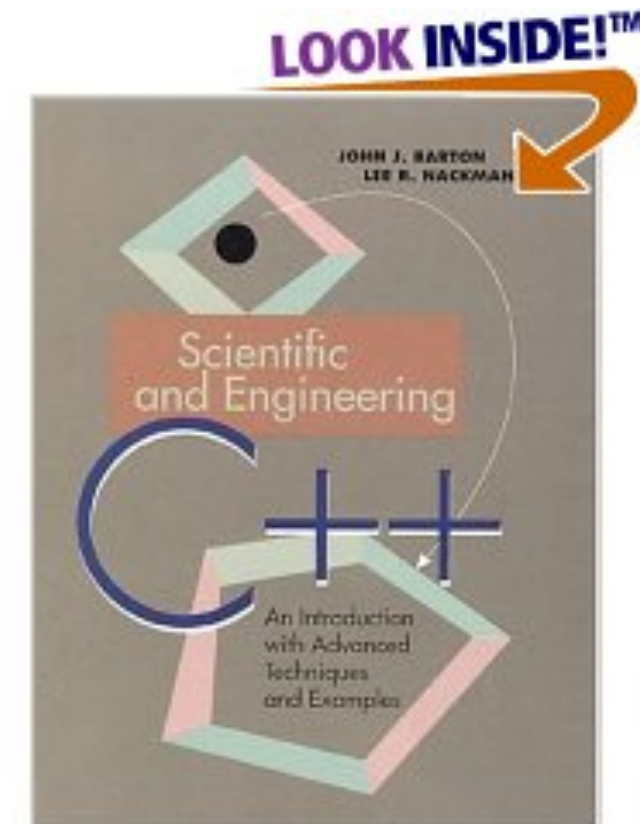
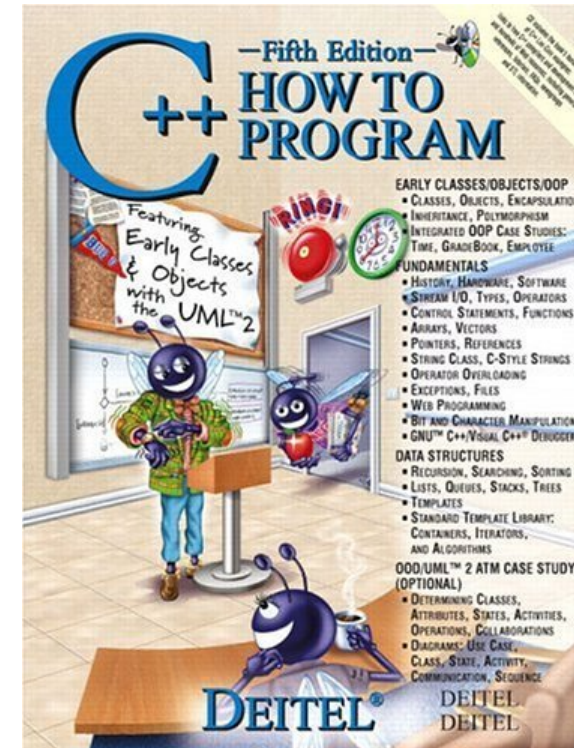
- ▷ Learning a programming language similar to learning a new spoken language
 - Learn by trying and making mistakes
 - Theory is useless if
 - your code does not compile
 - compiles but does not run
 - runs but you do not understand its output
- ▷ Writing trivial and simple applications is vital to understand features of OOP and C++/Python
 - You learn to understand and fix compilations errors
 - Extremely important when you will have to use application with $O(10^6)$ of code and not written by you!
 - By repeating the same steps and basic operations in C++ trivial errors will go away and you will focus more on advanced features of the language

Course organisation

- ▷ In classe lectures on Tuesday and Friday
- ▷ Lectures in PDF format with many examples discussed
 - Material presented and files of all examples available on the course website after the lecture
- ▷ Exercise is necessary to learn
- ▷ This year introducing assisted lab sessions of 2 hours on Monday
 - suggested by students last year
 - you work in groups of two on problems or examples discussed in class
- ▷ Exams
 - Dates already available on infostud
 - a PDF file with 2 problems (usually 1 in C++ and 1 in python) available on course web site the day of the exam
 - You are given 48 hours to submit your project online
 - Oral discussion of the code and your choices to determine the grade
 - Grades range from 18 to 30 depending on number of mistakes
 - Depending on number of students attending the course we might have a midterm exam

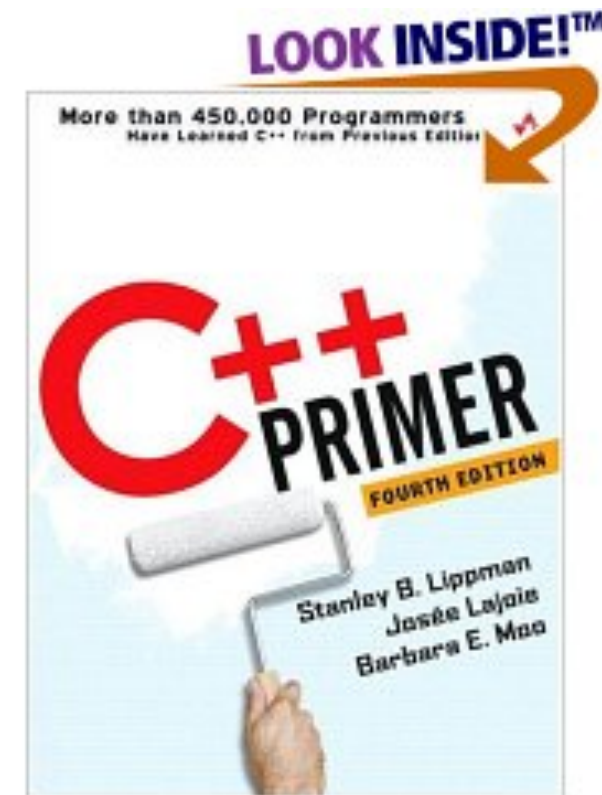
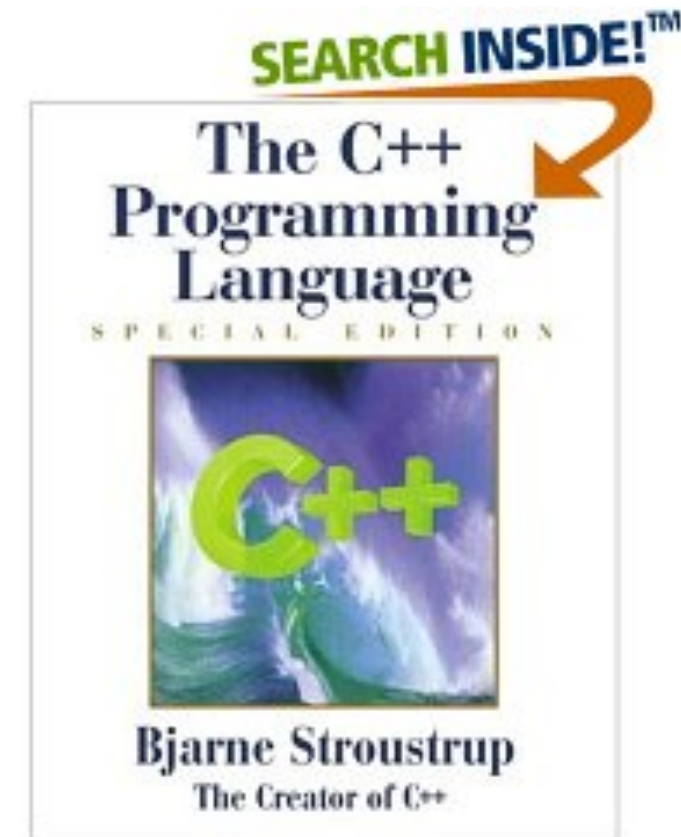
Simple reference books

- ▷ Deitel & Deitel, **C++ How To Program 5th Edition**, editore Pearson - Prentice Hall
 - ▷ Very good for beginners with many examples and step by step instructions. Useful tips for both basic and advanced users
 - ▷ Italian version probably available in the library
 - ▷ Recently released 6th edition
- ▷ J. Barton & L. Nackman, **Scientific and Engineering C++**, editore Addison-Wesley
 - ▷ Simple and a bit minimal
 - ▷ Covers all important features but very little text and difficult to use as a text book



More advances textbooks

- ▷ B. Stroustrup, C++ Programming Language
 - Bible of C++ written by the original author of C++
 - Very dense and very complete covering everything!
 - Not a teaching text book but a very good reference for detailed aspects of the language
 - Similar to Landau & Lifshits for Mechanics!
- ▷ Lippman, C++ Primer
 - Another very complete reference book lightly easier than the previous one



C++ topics covered in this course

- ▷ Elements of C++
 - Common features and differences with C
- ▷ Introduction to object oriented programming (OOP)
- ▷ Class and objects
- ▷ Polymorphism and Inheritance
- ▷ Abstraction: virtual class and interfaces
- ▷ elements of generic programming with *templates*
- ▷ error management with *exceptions*
- ▷ If we have enough time
 - makefiles and file organisation
 - Libraries and dependencies between objects

Many resources online

The screenshot shows the homepage of cplusplus.com. At the top, there is a search bar with the text "Search:" and a "Go" button. To the right of the search bar, it says "Not logged in" with links for "register" and "log in". The main header features the "cplusplus.com" logo and a "home" link. A left sidebar contains a "C++" section with links to "Information", "Tutorials", "Reference", "Articles", and "Forum". The main content area is divided into six sections: "Information", "Tutorials", "Reference", "Articles", "Forum", and "C++ Search". Each section provides a brief description and a list of links to specific resources. The "Information" section includes links to a description of the C++ language, its history, and a frequently asked questions page. The "Tutorials" section offers a collection of tutorials covering various C++ features. The "Reference" section provides descriptions of important classes, functions, and objects from the Standard Language Library. The "Articles" section lists user-contributed articles categorized by topics like algorithms, standard library, C++11, and Windows API. The "Forum" section describes message boards for exchanging knowledge and comments. The "C++ Search" section includes a search bar and links to other search tools available on the website.

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C++

- [Information](#)
- [Tutorials](#)
- [Reference](#)
- [Articles](#)
- [Forum](#)

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Information

General information about the C++ programming language, including non-technical documents and descriptions:

- [Description of the C++ language](#)
- [History of the C++ language](#)
- [F.A.Q., Frequently Asked Questions](#)

Tutorials

Learn the C++ language from its basics up to its most advanced features.

- [C++ Language](#): Collection of tutorials covering all the features of this versatile and powerful language. Including detailed explanations of [pointers](#), [functions](#), [classes](#) and [templates](#), among others...
- [more...](#)

Reference

Description of the most important classes, functions and objects of the Standard Language Library, with descriptive fully-functional short programs as examples:

- [C library](#): The popular C library, is also part of the of C++ language library.
- [IOStream library](#). The standard C++ library for Input/Output operations.
- [String library](#). Library defining the string class.
- [Standard containers](#). Vectors, lists, maps, sets...
- [more...](#)

Articles

User-contributed articles, organized into different categories:

- [Algorithms](#)
- [Standard library](#)
- [C++11](#)
- [Windows API](#)
- [Other...](#)

You can contribute your own articles!

Forum

Message boards where members can exchange knowledge and comments. Ordered by topics:

- [General C++ Programming](#)
- [Beginners](#)
- [Windows](#)
- [UNIX/Linux](#)

This section is open to user participation! Registered users who wish to post messages and comments can do so in this section.

C++ Search

Search this website:

Other tools are also available to search results within this website:

- [more search options](#)

Some useful sites

- ▷ www.cplusplus.com
 - Tutorial, lezioni, manuali di riferimento, FAQ
- ▷ <http://www.cppreference.com/>
 - Un vero e proprio manuale online