

# Applied C and C++ in Physics

## 1. Introduction

The goal of this practice project is to bring *computer scientist culture* into the physics curriculum of the students. This line of thinking combines some of the best features of mathematics, engineering and natural science. Similar to mathematicians, computer scientists use formal languages to denote ideas (specifically computations). Like engineers, they design equipment or test-beds, assembling components into systems and evaluating trade-offs among the alternatives. As scientists, they observe the behaviour of complex systems, form hypotheses, and design models to test predictions.

An accomplished computer scientist in today's high tech world needs the engineering / scientific background of modelling and rigorous approach. In this sense the student undertaking this practice project would be best placed for the most rewarding jobs, be they in markets modelling, Industry-4.0, finance, or research.

The most important skill we will train is *interdisciplinary problem-solving* which means the ability to formulate problems, envisage creative solutions and then transpose them into a computer code.

The expert grasp of a *high-level computing language* provides a unique long lasting working tool which will be a faithful companion for all active working life.

Among the various computing paradigms, the object oriented approach developed within the C/C++ language has become almost universally used in the large scale scientific projects. A feature which cannot be overestimated is the revolutionary change of the computer hardware architecture on which the well-established computing packages cease to be efficient. As a consequence, the need of new software developments able to cope with the last generation hardware is a must.

## 2. Project description

The students passing the present project will have a two-fold benefit. The first is an optimistic state of mind and approach in scientific projects. The second is a sizeable accumulation of computer expertise, the cornerstone key of professional success in most employment positions today.

The training skips some of the theoretical parts of C/C++ project design and provides 3 levels of *student-adapted-development-frameworks* with which the students will be able to quickly start coding and learn as they go along.

In this line of approach, the technical details will be provided along the project as the numerical methods – which are the *intelligence part* – will start demanding specific C/C++ constructs.

As a consequence, the project will comprise level-adapted intensive lectures and exercises on:

- ▶ the basics of C and C++,
- ▶ class and more advanced C++ concepts, with emphasis on the new 2011 and 2014 additions,
- ▶ C++ application to physical projects (see list at the end) containing two parts:
  - mathematical part (individually for each group)
  - code implementation (each group individually)

## 3. Description of the work on the project

The unique feature of this project is the *dual-training* numerical-methods / programming.

For logistical reasons, it would be highly desirable to have a laptop, either with a Linux partition, or the `putty` and `ssvnc` utilities (to connect to our Linux servers).

Lectures will alternate with seminars devoted to each project-group, such that the theory, numerical method and coding part be fully understood.

The project will end with an oral presentation of the project, during the last day of practice.

#### 4. Desirable preliminary knowledge

- basics of mathematical analysis, linear algebra and analytic geometry
- basics of physics
- basics of computer knowledge (Linux knowledge useful if existent)

Relaxed, diligent, inquisitive, and challenging students with good sense of humour are welcome!

#### 5. Useful References

##### Introductory

- [1] – M.O. Dima – *C course*, Wuppertal Univ. (2005) – <http://cern.ch/modima/WXX/C/WEB/CCXX.ppt>  
[2] – Allen B. Downey (C-Version by Thomas Scheffler), *How to Think Like a Computer Scientist*, [https://prof.beuth-hochschule.de/fileadmin/prof/scheffler/Lehre/Think-C\\_v1.09.pdf](https://prof.beuth-hochschule.de/fileadmin/prof/scheffler/Lehre/Think-C_v1.09.pdf) (Jan. 2018)  
[3] – Allen B. Downey (C++ Version), *How to Think Like a Computer Scientist*, (Nov. 2012) <http://www.greenteapress.com/thinkcpp/thinkCScpp.pdf>

##### Advanced

- [4] – J. Walker, D. Halliday, R. Resnick – *Fundamentals of Physics*, X<sup>th</sup> edition, Hoboken, NJ: John Wiley & Sons, Inc., 2014.  
[5] – A.L. Garcia – *Numerical Methods for Physics*, CreateSpace Independent Publishing, ISBN 978-1514136683 (2015).  
[6] – S. Prata – *C Primer Plus*, Addison-Wesley Publishing, ISBN 978-0-672-32696-7 (2005).  
[7] – S. Prata – *C++ Primer Plus*, Addison-Wesley Publishing, ISBN 978-0-321-77640-2 (2012).

#### 6. Number of students participating in the project

The projects will need 2-3-4 students each, to jointly contribute to its development. We can approach (function of the C/C++ prior knowledge) *low*, *medium*, and *advanced* projects. For best results, we do not foresee groups exceeding 4 students. All in all, we may coordinate at most 15 students during this practice session.

#### 7. Project leaders on behalf JINR

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## JINR Summer Practice

Applied C and C++ in Physics

**Jul. 2019**

LIT course

Gh. Adam / M. Dima

| <i>PROJECT TOPIC</i>                        | <i>Data set</i>      | <i>code libraries</i> |
|---|----------------------|-----------------------|
| <i>Power factor</i>                         | LED flicker          | CPX, FLX              |
| <i>Bio-<math>\alpha</math> preamplifier</i> | LMH6626              | CPX                   |
| <i>Glow curve fits</i>                      | RefGlow-002, 009     | GEMINI                |
| <i>Circle fits</i>                          | NA-62 RICH           | MXV4                  |
| <i>Track fits (LIN, HLX)</i>                | ATLAS Pixel detector | MXV4                  |
| <i>Baseline detection</i>                   | IBR-2M neutron noise | NXV4, FLX             |
| <i>ECG 50 Hz digital filter</i>             | ECG wave             | FLX                   |