

# Master Course High Performance Computing MCS, MSI, MAI, MFT, MSDE

Prof. Olaf Schenk (CI, INF)

# Organization

- Prof. Olaf Schenk, [olaf.schenk@usi.ch](mailto:olaf.schenk@usi.ch)  
Dr. Juraj Kardos, [juraj.kardos@usi.ch](mailto:juraj.kardos@usi.ch)  
Institute of Computing, INF Faculty  
USI, Lugano
- TA PhD Students:  
Tim Holt, [timothy.holt@usi.ch](mailto:timothy.holt@usi.ch)  
Malik Lechekhab, [malik.lechekhab@usi.ch](mailto:malik.lechekhab@usi.ch)
- TA Master Students:  
Panthakkalakath Zenin Easa, [zenin.easa.panthakkalakath@usi.ch](mailto:zenin.easa.panthakkalakath@usi.ch)
- Software Atelier - High Performance Computing  
Tuesday, 2:30pm - 4:15pm, room C1.03  
Wednesday, 10:30am - 12:15pm, MS Teams, room D1.14
- Registration:
  - Please enroll within one week until September 23 on [teaching.inf.usi.ch](https://teaching.inf.usi.ch), and
  - On ICORSI, <https://www.icorsi.ch/course/view.php?id=14652>

# Your Background?

- MSc CS? MSc FinTEC? MSc AI? MSc INF? Other?
- Programming experience & languages?
- Parallel programming languages?
- Operating systems?
- Working at the command line in Unix-like shells (e.g., Linux or a Mac OSX terminal)?
- Scientific libraries or mathematical libraries?
- Latex?
- Version control systems, particularly git, and the use of Github repositories?
- Piz Daint at CSCS?
- Please fill-in the questionnaire form: <https://tinyurl.com/mr3jj2ha>



## About this course (or better this lab)

---

- In depth understanding of:
- When is parallel computing useful?
- Understanding of parallel computing hardware options.
- Overview of programming models (software) and tools, and experience using some of them
- Some important parallel applications and the algorithms
- Performance analysis and tuning
- Ability to implement parallel numerical algorithms efficiently in C/C++ using mathematical libraries on a cluster
- C/C++, MPI, OpenMP, Matlab

# Course Organization

- The course is a **HPC software atelier**
- In-class HPC projects on USI HPC cluster (please always bring your laptop to the class).
- 7 to 8 projects & reading assignments (support and discussion in class)
- Course grading
  - All projects (40% of the grade)
  - no midterm (but much more emphasis on scientific programming)
  - Final oral exam (60% of the grade)
- Late day policy: All assignments are due in class on the assigned due date. ONE free assignment that we will not count for the final grading of the projects.
- Date for the exam (during the official exam period, mid/end of January)

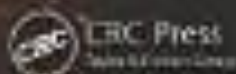


Chapman & Hall/CRC  
Computational Science Series

# Introduction to High Performance Computing for Scientists and Engineers



Georg Hager  
Gerhard Wellein



A CHAPMAN & HALL BOOK

Copyright © 2004

## Books

- *Introduction to High Performance Computing for Scientists and Engineers*

by G. Wellein and G. Hager



# Introduction to High Performance Scientific Computing

Victor Eijkhout

## Books

---

- *Introduction to High-Performance Scientific Computing* and
- *Parallel Computing Book*

by Victor Eijkhout

- Both books are available on <https://bitbucket.org/VictorEijkhout/>

# Applications of Parallel Computers

- Applications of Parallel Computers
  - U.C. Berkeley CS267 Home Page, **Applications of Parallel Computers**, Spring 2018
  - <https://sites.google.com/lbl.gov/cs267-spr2018/>



# Repositories: iCorsi (for Upload & Download)

We will use iCorsi for this <https://www.icorsi.ch/course/view.php?id=14652>

The screenshot shows the iCorsi interface. On the left is a sidebar with a menu for 'INF.M.SA22-23.28' containing links for Participants, Badges, Grades, and several course sections. The main content area displays the course title 'High-Performance Computing SA 2022-2023' and a breadcrumb trail 'Dashboard / My courses / INF.M.SA22-23.28'. Below this is the section '[HPC 2022] High Performance Computing - Course Organization' with an edit icon. The course details include: News (start date and time), Professor (Olaf Schenk), PostDoc (Juraj Kardos), TA (Tim Holt, Malik Lechekhab), When (Fall 2022, Room C1.03 on Tuesday 2:30pm - 4:15pm, Room D.1.14 on Wednesday 10:30am - 12:15pm), Where (Room C1.03 on Tuesday, Room D.1.14 on Wednesday), Slack (https://hpc2022.slack.com), Git Repository (https://github.com/oschenk/hpc2022), and CSCS (Excursion to the Swiss National Supercomputing Center, Wednesday October 12, 2:00pm - 4:30pm). A 'First date' note states the course will start on Tuesday September 20, 20:30pm. The 'Course Description' section explains the course's focus on teaching parallel computing, its organization as an HPC Software Atelier, and the topics to be covered, including GPU architectures, MPI, performance optimization, and machine learning. It also mentions the course's role in the CSCS-USI Summer university and its credit value.

INF.M.SA22-23.28

Participants

Badges

Grades

[HPC 2022] High Performance Computing - Course Organization

[HPC 2022] - General Course Material

[HPC 2022] Project 0 - HPC Primer in C++

[HPC 2022] Project 1 - Memory Hierarchies and Matrix-Matrix Multiplications

[HPC 2022] Project 3

[HPC 2022] Project 4

[HPC 2022] Project 5

[HPC 2022] Project 6

[HPC 2022] Project 7

[HPC 2022] Project 8

Dashboard

Calendar

High-Performance Computing SA 2022-2023

Dashboard / My courses / INF.M.SA22-23.28

[HPC 2022] High Performance Computing - Course Organization

**News:** The course starts on Tuesday, September 20, 2:30pm - 4:15pm

**Professor:** Olaf Schenk

**PostDoc:** Juraj Kardos

**TA:** Tim Holt, Malik Lechekhab

**When:** Fall 2022, Room C1.03 on Tuesday 2:30pm - 4:15pm, Room D.1.14 on Wednesday 10:30am - 12:15pm

**Where:** Room C1.03 on Tuesday, Room D.1.14 on Wednesday

**Slack:** Please sign up on <https://hpc2022.slack.com>

**Git Repository:** <https://github.com/oschenk/hpc2022>

**CSCS:** Excursion to the [Swiss National Supercomputing Center](#), Wednesday October 12, 2:00pm - 4:30pm

**First date:** The HPC course will start on Tuesday September 20, 2:30pm (General remarks, Cluster Accounts, Installation of Intel MKL Software, MPI, etc) in lecture room C1.03 .

**Course Description**

The course is designed to teach students how to program parallel computers to efficiently solve challenging problems in science and engineering, where very fast computers are required either to perform complex simulations or to analyze enormous datasets. This HPC course is a graduate-level introduction to high performance computing. It refers to two things: efficient as the problem size grows, and efficient as the system size measured in numbers of cores grows. The course is organized as an HPC Software Atelier. The practical aspect of this course is implementing the techniques you'll learn to run on real parallel systems, so you can check whether what appears to work well in theory also translates into practice. Programming models you will use include OpenMP, and MPI, and possibly others. Therefore, this computing lab consists of hand-on projects on HPC. Students will also be offered a number of projects on performance analysis, parallelism detection and efficient development for modern manycore processors using OpenMP and MPI. This experience will be very useful for individual semester projects in other classes, where students might develop & deploy components of massively parallel numerical simulation software. GPU computing will not be covered in this course. It will be fully discussed in the annual CSCS-USI Summer university on [Effective High-Performance Computing & Data Analytics](#) where we will focus on the effective exploitation of state-of-the-art hybrid High-Performance Computing (HPC) systems with a special focus on Data Analytics. The content of the summer university course is tailored for intermediate graduate students interested in both learning parallel programming models, and having hands-on experience using HPC systems. Starting from an introductory explanation of the available systems at CSCS, the course will progress to more applied topics such as parallel programming on accelerators, scientific libraries, and deep learning software frameworks. The following topics will be covered: GPU architectures, GPU programming, Message passing programming model (MPI), Performance optimization and scientific libraries, interactive supercomputing, Python libraries, Introduction to Machine Learning, and GPU optimized framework. The Summer School will be held mid of July 2023, most probably as an hybrid summer school. More information is available at this [Link](#). Students will be able to earn six ECT credit points for this [Effective High-Performance Computing & Data Analytics](#) course (subject to exam).

# Projects & Icorsi

## Icorsi

- The mini-projects sheets will be uploaded on the iCorsi webpage
- The exercise should be solved until the deadline which is given on the project summary
- Please upload your code and a clear summary solution in electronic form on the iCorsi page
- We only accept submissions using our Latex template including Julia and C/C++ code.

# Repositories: Github (for Download)

We will use Github for this  
course  
<https://github.com/oschenk/hpc2022>

The screenshot shows the GitHub repository page for 'High-Performance Computing 2022 (Master USI)' by user 'oschenk'. The repository is on the 'main' branch and has 5 commits. The file list includes 'Lecture/01-Introduction-cluster', 'Projects/Project0', '.gitignore', and 'README.md'. The 'README.md' file is open, showing the course details.

**High-Performance Computing 2022 (Master USI)**

**General information**

**Lecturer :** Olaf Schenk, **PostDoc :** Juraj Kardos **Assistants :** Malik Lechekhab, Timothy Holt, and Zenin Easa Panthakkalakath

**Slack list :** <https://hpc2022.slack.com>

**When :** Tuesday 4:30pm-6:15pm, Wednesday 10:30am - 12:15am. The course starts on Tuesday, September 20, 2:30pm - 4:15pm

**Where :** Room D.1.14 on Tuesday 2:30pm - 4:15pm,, Room D.1.15 on Wednesday 10:30am - 12:15am

**Git:** <https://github.com/oschenk/hpc2022>

**Course Description**

The course is designed to teach students how to program parallel computers to efficiently solve challenging problems in science and engineering, where very fast computers are required either to perform complex simulations or to analyze enormous datasets. This HPC course is a graduate-level introduction to high performance computing. It refers to two things: efficient as the problem size grows, and efficient as the system size measured in numbers of cores grows. The course is organized as an HPC Software Atelier. The practical aspect of this course is implementing the techniques you'll learn to run on real parallel systems, so you can check whether what appears to work well in theory also translates into practice. Programming models you will use include OpenMP, and MPI, and possibly others. Therefore, this computing lab consists of hand-on projects on HPC. Students will also be offered a number of projects on performance analysis, parallelism detection and efficient development for modern manycore processors using OpenMP and MPI. This experience will be very useful for individual semester projects in other classes, where students might develop & deploy components of massively parallel numerical simulation software. GPU computing will not be covered in this course. It will be fully discussed in the annual CSCS-USI Summer university on Effective High-Performance Computing & Data Analytics where we will focus on the effective exploitation of state-of-the-art hybrid HPC systems with a special focus on Data Analytics. The content of the summer university course is tailored for intermediate graduate students interested in both learning parallel programming models, and having hands-on experience using HPC systems. Starting from an introductory explanation of the available systems at CSCS, the course will progress to more applied topics such as parallel programming on accelerators, scientific libraries, and deep learning software frameworks. The following topics will be covered:

- GPU architectures
- GPU programming

**Releases**

No releases published  
[Create a new release](#)

**Packages**

No packages published  
[Publish your first package](#)

**Contributors** 3

- oschenk Olaf Schenk
- tabholt Timothy Holt

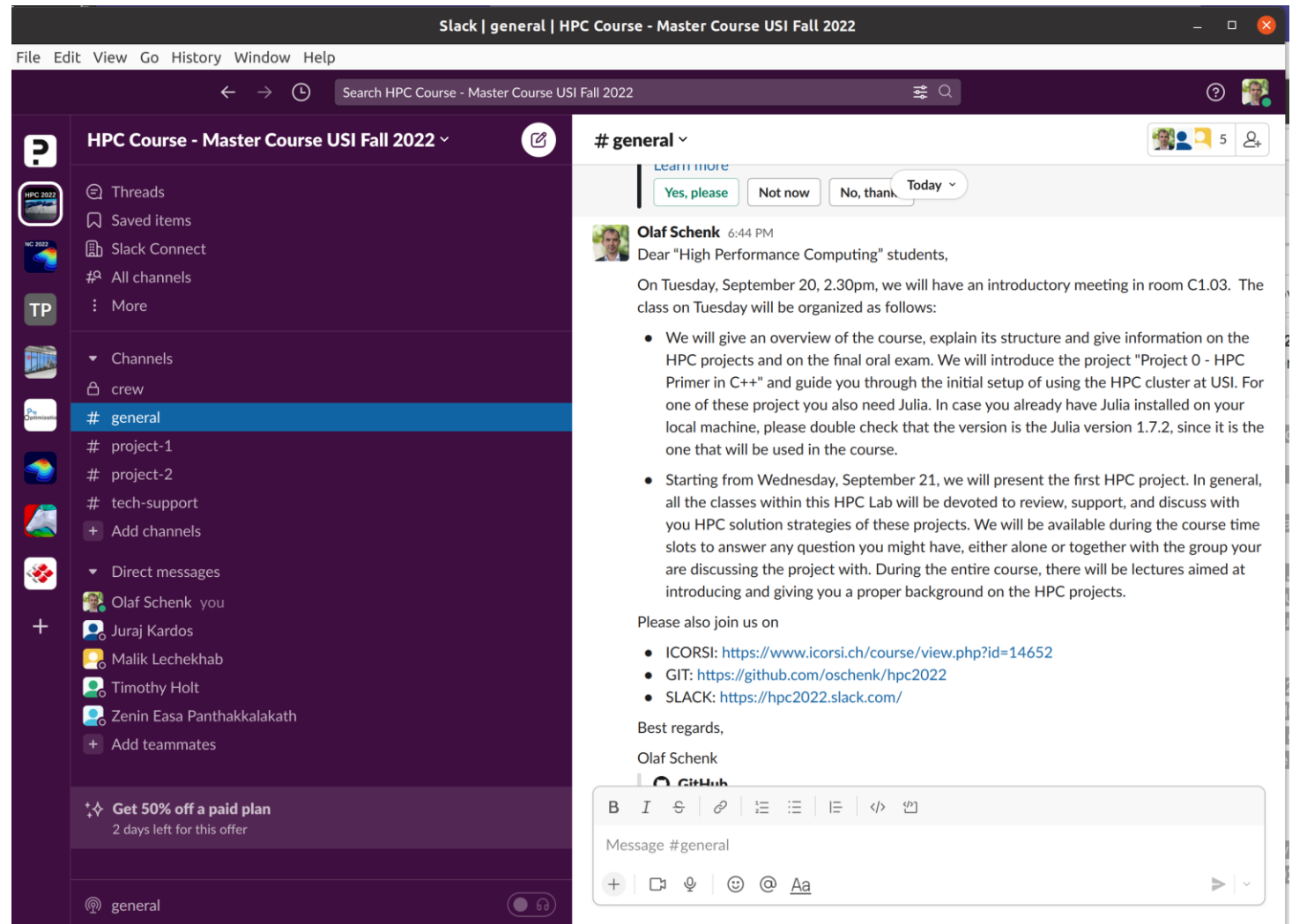
**Languages**

C++ 84.2%    Makefile 10.6%  
Shell 3.5%    C 1.7%

# Slack (for General Support and Discussion)

SLACK -

<https://hpc2022.slack.com>





# Assignments collaboration policy

- You are allowed to discuss such questions with anyone you like; however:
- Your submission **must list anyone** you discussed problems with.
- You must write up your submission **independently**.
- Late day policy: All assignments are due in class on the assigned due date, but you/we have ONE free mini-project that we will not count for the final grade.
- We only accept submissions using our Latex template and C/C++ code. Each project will have 100 points (out of 15 point will be given to the general written quality of the report).

Where do we meet in  
this Software Atelier  
(Lab) on High  
Performance  
Computing?

Room C1.03  
Tuesday

2:30pm - 4:15pm

Room D.1.14

Wednesday

10:30am - 12:15pm



# CSCS - Swiss National Supercomputing Centre

- CSCS  
Swiss National Supercomputing Centre  
Via Trevano 131  
6900 Lugano
- CSCS Visit:  
Wednesday  
October 12, 2:00pm - 4:30pm  
(Please attend in person)
- The agenda will be  
  
Overview CSCS (30 min)  
Research Talk (30 min)  
Guided Tour CSCS Server Room (60 min)







## CSCS-USI Course: Effective HPC & Data Analytics with GPUs (July 2023, 10 days)

This summer school will focus on the effective exploitation of state-of-the-art hybrid High-Performance Computing (HPC) systems with a special focus on Data Analytics.

### First week

- GPU architectures
- GPU programming (CUDA and OpenACC)
- Message passing programming model (MPI)
- Performance optimization and scientific libraries
- Interactive Supercomputing with JupyterLab

### Second week

- Interactive supercomputing Python HPC libraries
- Introduction to Machine Learning frameworks (Rapids)
- Deep Learning on HPC platforms (TensorFlow)

**6 ECTS for MSC students in AI, CS, FINTECH**



# Next Schedule

- Questions?
- Release of HPC project 0: September 20.
- Release of HPC project 1: September 21.
- Deadline for HPC project 0: Wednesday, 5 October 2022, 11:59 PM
- Deadline for HPC project 1: Wednesday, 12 October 2022, 11:59 PM

## Today

- Support with Cluster installation/accounts – Dr. Juraj Kardos
- Presentation of project P0 - Tim Holt