

Course Syllabus for EC526 – Parallel HPC Algorithms

This is an over complete list. **Time constraints and interest of students** will select and deselect topics that are included in coding exercises.

1. First Part Weeks 1-4 : **Algebra**

- Intro to HPC and Engineering impact
- Language type: Symbolic, Interpreted and Compiled
- The ubiquitous Linear Algebra: HPC/ML/BigD/QC
- Numerical algebra for calculus and Floating Point Errors.
- Differentiation & Integration (Gauss and Monte Carlo)
- Newtons method for root finding & Non-linear optimization
- Data Analysis, Curve fitting & Error analysis
- FFT and related examples of recursion for divide and conquer
- Simple ODEs (oscillation vs relaxation)

2. Second Part: Weeks 5-9: **Parallelization Tools**

- PDE in Electrostatics and Image Processing,
- Select Projects & Parallelization Method
- OpenMP and OpenACC (for CUDA) threads.
- Message passing with MPI and Network Performance
- Scripts for submitting to HPC systems.
- Use of Numerical Libraries

3. Third Part Weeks 10-14 (5 weeks): **Special Topics/Projects**

- Dynamical PDEs for Heat Flow vs Wave propagation.
- Conjugate Gradient and iterative solvers
- Multi-grid Linear Solvers
- MD short range (neighborhood tables) vs long range Coulomb
- MonteCarlo for Magnetism: Cluster and Graphs
- Finite Element Method in 2D
- Digital Quantum Computing Programs

There is no Text – Unfortunately it hasn't been written in spite of the centrality of these fundamental algorithms and software tool in current trends in HPC, Big Data and Machine Learning. The course lecture notes, selected links to on line documents materials and exercises will be posted on [github](#).

Course Outcomes: Students will be able to

- Develop efficient mathematical kernels, controlling round off and convergence.
- Develop data structures for basic linear operator on regular and semi-regular grids.
- Analyzed complexity and accuracy of linear solvers with FFT and Multi-scale methods.
- Implement parallel software with openACC (for CUDA) threads and MPI message protocols.
- Work in a team project on integrated software using Makefiles and github repositories.