Course Information

Course Title: High Performance Parallel Machine Learning & AI

Course Number: CSYE7105

Credit Hours: 4 SH

Term and Year: Fall 2025

CRN: 17549

Course Format: On ground

Location: Behrakis Health Center 320

Day& Time: Tuesdays and Fridays, 1:35–3:15 p.m.

Instructor Information

Full name: Handan Liu

[You can call me Professor, or Professor Liu, or Dr. Liu]

Email Address: h.liu@northeastern.edu

Office Hour: Every Tuesday 12:30 - 1:30 PM at RY202 in person

Every Thursday 1:30 - 2:30 PM outside the classroom Hurtig 130 in person

Instructor Biography

NEU COE profile: https://coe.northeastern.edu/people/liu-handan/

LinkedIn profile: https://www.linkedin.com/in/handanliu/

Teaching Assistant

The Teaching Assistant is:

- Ramshankar Bhuvaneshwaran bhuvaneshwaran.r@northeastern.edu
- Yang Qu qu.yang1@northeastern.edu

TA Hour: the schedule will be posted in Teams class group.

TA's duty:

- TA hours: 4 hours a week in plan, in-person and/or online (if necessary), scheduled by the TA.
- Monitor and maintain the Teams class group.
- Quickly respond to your questions through Teams class group in addition to TA hours.
- Technique questions should first go to the TA. If the TA can't answer them then the TA will forward the questions to the professor.
- TAs won't answer the questions about results of the assignments before submission. After submission, TAs can answer such questions.
- Review and grade your assignments and quizzes.

Help and Support

- We will use Teams class group as a main tool to help and support you. TA will maintain this group.
- Post/send questions or concerns via Teams class group. TA and I will respond you asap.
- You also can get help and support in TA hours or Professor's office hours.

Course Prerequisites

DAMG 6105 with a minimum grade of B or INFO 6105 with a minimum grade of B

See details in CSYE 7105 at:

https://catalog.northeastern.edu/graduate/engineering/multidisciplinary/#coursestext

The instructor's further advice is as follows:

- Understand machine learning and its applications (refer to INFO6105)
- Understand data processing, data manipulation, and EDA analysis (refer to DAMG6105)
- Understand Python programming (refer to INFO5002)
- Even better if you understand simple C syntax and simple Linux commands.

Course Objective and Description

The objective of this course is to understand the principles of high-performance computing and the practice of the emerging parallelism-based machine learning paradigm. We will learn high-performance parallel architectures and parallel programming models. And we will explore the parallelism of machine learning and deep learning to achieve high-speed and high-performance on heterogeneous cluster architectures, as well as the applications to a variety of domains, including image classification, speech recognition, and natural language processing, etc.

This course is composed of four main parts:

- Understand high-performance parallel architectures and parallel programming models based on the OpenMP and MPI standard libraries.
- Understand HPC supercomputing clusters and their operations.
- Learn and grasp how to parallelize and implement data processing and machine-learning approaches on multiple-CPU architectures.
- Learn and grasp how to use high-performance parallel deep learning approaches to achieve acceleration on multiple-GPU architectures, using PyTorch.

Every student in this course will get an account to access Northeastern high-performance supercomputing cluster and practice many hands-on labs on the cluster CPU and GPU nodes.

Grading/Evaluation Standards

Assignment Grading

This course consists of 4 homework assignments, 1 hands-on operation test, 3 quizzes, a research project, and attendance:

- 4 homework assignments: 20%
  Homework is finished in one week after assigned.
- 1 hands-on operation test: 10%
  Students will operate commands/solutions on Explorer Cluster. TAs will monitor your operations face to face and grade it.
- 3 quizzes: 30%
- Research Project: 35%
    - In this course, the project will be completed by a 2-member team.

    - The final project provides students an opportunity to practice creativity in the application of knowledge gained in this course to real-world scenarios.
    - Proposal 2%, Final Report 10%, Coding 10%, Presentation Slides and Oral Speech 13%.
    - The details will be explained when students start projects.
- Class Attendance: 5%
  Any class lateness more than thirty minutes will be recorded as half attendance for that class.

Grading Scale

Percentage Range	**Letter Grade**	**Grade Point Equivalent**
95.0–100.0%	A	4.000
90.0–94.9%	A-	3.667
87.0–89.9%	B+	3.333
84.0–86.9%	B	3.000
80.0–83.9%	B-	2.667
77.0–79.9%	C+	2.333
74.0–76.9%	C	2.000
70.0–73.9%	C-	1.667
69.9% and Below	F	0.000

Students are evaluated based on their performance on assignments, quizzes and both the execution and presentation of the research project.

If a particular grade is required in this course to satisfy any external criteria – including, but not limited to, employment opportunities, visa maintenance, scholarships, and financial aid, it is the student's responsibility to earn that grade by working consistently throughout the semester.

Grades will not be changed based on student needs, nor will extra credit opportunities be provided to an individual student without being made available to the whole class.

Quizzes

Quizzes will be conducted on **Quizzes@Canvas** via **LockDown Browser**.

Quiz1 and Quiz 2 will be conducted **in person** in the classroom. Every student **MUST** take this quiz in the classroom in person.

Quiz3 – Final Exam will be conducted remotely. Students use Lockdown Browser to take this quiz with camera. **The quiz without camera will not be graded.**

Teaching Courseware

- The teaching courseware is that the professor teaches in the class, and includes the slides/notes, code files, recordings if online teaching.
- The courseware will be posted after the class mostly within the same day, no later than the next day. The courseware information can be found in Modules@Canvas.
- If it is an online class, the class will be recorded and uploaded automatically in Zoom Cloud.
- Code files taught in class can be downloaded. Slides can only be viewed online.
- **After a quiz/an exam is completed, it will no longer be displayed.** This is the setting of Canvas. Students should not try to obtain quiz/exam content from the professor or the TA. But TA can show you where you did wrong when you visit the TA hours.

Course Schedule

Note: This schedule **is subject to change** and will be adjusted as needed throughout the semester.

Week	Topics	Assignments
Week 1	Course Introduction	

	High Performance Parallel Computing 1 (Friday) [First Day]	
Week 2	HPC 2 (Tuesday) HPC 3 (Friday)	
Week 3	HPC 4 (Tuesday) HPC 5 (Friday)	HW1
Week 4	Quiz 1 (Tuesday, September 23rd) --> in person Introduction and Use of Explorer Cluster (Friday)	Sponsor students' accounts on Explorer cluster
Week 5	Linux Essentials (Tuesday) Introduction to supercomputing cluster job scheduling system Slurm platform (Friday)	Hands-on Test Assignment
Week 6	Parallel in Python 1 (Tuesday) Parallel in Python 2 and Parallel DA&ML 1 (Friday)	HW2
Week 7	Parallel DA&ML 2 (Tuesday) Quiz 2 (October 17th, Friday) --> in person	
Week 8	Parallel DA&ML 3 (Tuesday) PRJ 1: Team up and Choose topics (Friday)	HW3 PRJ 1
Week 9	GPU and CUDA (Tuesday) Parallel Deep Learning 1 (Friday)	PRJ 2: Proposal Submission
Week 10	PRJ 3: Proposal workday (Tuesday) --> in person Parallel Deep Learning 2 (Friday)	HW4 PRJ 3
Week 11	November 11th, Veterans Day, no class Online workshop (Friday)	

Week 12	Parallel Deep Learning 3 (Tuesday) Parallel Deep Learning 4 (Friday)	PRJ 4: Final-package submission
Week 13	Project Presentation Session 1 (Tuesday) November 26th – 30th, Fall Break, no class	PRJ 5: Presentation
Week 14	Project Presentation Session 2 (Tuesday) Project Presentation Session 3 (Friday)	
Week of Final Exam	Project Presentation Session 4 and Open Office Hours (Tuesday) Quiz 3 (Friday, December 12th) --> online	December 10th is the DDL for all PRJ re-submissions.

Required Tools and Course Textbooks.

Students are expected to read the materials before and after class.

List of Reference Books (Optional)

Introduction to High Performance Computing for Scientists and Engineers (Chapman & Hall/CRC Computational Science) 1st Edition

by Georg Hager (Author), Gerhard Wellein (Author)

ISBN-13: 978-1439811924

2010

An Introduction to Parallel Programming 1st Edition

by Peter Pacheco (Author)

ISBN-13: 978-0123742605

2011

Parallel Programming: Concepts and Practice 1st Edition

by Bertil Schmidt Ph.D. (Author), Jorge Gonzalez-Dominguez Ph.D. (Author), Christian Hundt (Author), Moritz Schlarb (Author)

ISBN-13: 978-0128498903

2017

Advanced Python Programming: Build high performance, concurrent, and multi-threaded apps with Python using proven design patterns Paperback – February 28, 2019

by Dr. Gabriele Lanaro (Author), Quan Nguyen (Author), Sakis Kasampalis (Author)

ISBN-13 : 978-1838551216

2019

The OpenMP Common Core: Making OpenMP Simple Again (Scientific and Engineering Computation) Paperback – November 19, 2019

by Timothy G. Mattson (Author), Yun (Helen) He (Author), Alice E. Koniges (Author)

ISBN-13 : 978-0262538862

2019

Parallel Scientific Computing in C++ and MPI (A Seamless Approach to Parallel Algorithms and their Implementation) PAP/CDR Edition

by George Em Karniadakis (Author)

ISBN-13: 978-0521520805

2003

Hands-On GPU Programming with Python and CUDA: Explore high-performance parallel computing with CUDA 1st Edition

by Dr. Brian Tuomanen (Author)

ISBN-13: 978-1788993913

2018

List of Reference Websites (Necessary):

- OpenMP https://www.openmp.org/Links to an external site.
- MPI
    - https://www.open-mpi.org
    - https://www.mpich.org
    - https://www.mpi-forum.org
- NVidia: High Performance Supercomputing and CUDA
    - https://developer.nvidia.com/cuda-zone
    - https://www.nvidia.com/en-us/data-center
- Multiprocessing
    - https://docs.python.org/3.4/library/multiprocessing.html?highlight=process
- Joblib
    - https://joblib.readthedocs.io/en/latest/parallel.htmlLinks to an external site.
- Dask:
    - https://www.dask.org/Links to an external site.
    - https://docs.dask.org/en/stable
- Scikit-Learn
    - https://scikit-learn.org/stable
- NVidia Deep Learning:
    - https://developer.nvidia.com/deep-learning
    - https://www.nvidia.com/en-us/deep-learning-ai/education/
    - https://developer.nvidia.com/nccl

    - https://docs.nvidia.com/deeplearning/sdk/nccl-developer-guide/docs/overview.html
- PyTorch https://pytorch.org/tutorials/
- TensorFlow https://www.tensorflow.org/

Northeastern and MGEN Policies

Please refer to the MGEN FAQ page.

Incomplete Grades

An incomplete grade may be reported by the instructor when a student has failed to complete a major component of a required course, such as homework, a quiz or final examination, a term paper, or a laboratory project. Students may make up an incomplete grade by satisfying the requirements of the instructor. Be aware that instructors' policies on the granting of incomplete grades may vary and that the final decision on an incomplete grade is up to the instructor. Instructors may deny requests for an incomplete grade. If the missing assignment(s) have not been submitted to the instructor within 30 days from the end of the term in which the course was offered, or the agreed upon due date, the grade entered will reflect the student's grade in the course for the work completed and the missing assignments receiving no credit toward the final grade.

Attendance/Late Work Policy

Attendance Policy

In each term, students enrolled in on-ground sections are expected to be on campus and attending class beginning with the first day of classes. Students in online sections are expected to log in and participate in class beginning with the first day of classes.

Students who join a class after the first day of class during the university add period, or who are approved for late registration by the instructor and the Graduate School of Engineering, are responsible for all coursework missed prior to enrolling. In the interest of students' success, the college does not support the arrival of students to class after the university add deadline. **Enrolled students who do not attend class during the first week of a semester risk being dropped from the course.**

In cases where an enrolled student cannot arrive to campus by the first day of class due to circumstances beyond their control, it is the student's responsibility to contact the instructor for approval and notify the Graduate School of Engineering.

Students registered in MGEN courses (INFO, CSYE, and DAMG) are allowed **a maximum of 2 absences per course,** with 3 or more absences resulting in an **'F'** for that course. Course instructors are not expected to make accommodations and students are expected to inform their instructors of any absences in advance of the class. Should a student anticipate being unable to attend 3 or more classes, they should discuss their situation with their Academic Advisor to explore other types of leave and accommodations in accordance with the University's academic and global entry expectations. Students may be asked to share communications about class absences with their Academic Advisor. If a student is sick long-term or experiences a medical issue that prevents class attendance, it is strongly encouraged that they speak with their Academic Advisor (coe-gradadvising@northeastern.edu) to learn more about the Medical Leave of Absence. International students should review the Office of Global Services webpage to understand their visa compliance requirements.

Teaching Assistants (TAs) or Instructional Assistants (IAs) will be present at each class to collect student attendance.

Late Work Policy

Students must submit assignments by the deadline in the time zone noted in the syllabus. Students must communicate with the faculty prior to the deadline if they anticipate work will be submitted late. Work submitted late without prior communication with faculty will not be graded.

Course Evaluations

Student feedback on their learning experience is valuable and helps improve future courses. We encourage all students to complete the course evaluation surveys when they become available.

Surveys are distributed at both the midterm mark and the end of the term via email and are completely anonymous and confidential. Any questions about the surveys can be directed to mgen-programs@coe.northeastern.edu

MGEN Student Feedback

Students who would like to provide the MGEN unit with anonymous feedback on this particular course, Teaching Assistants, Instructional Assistants, professors, or to provide general feedback

regarding their program, may do so using this survey: https://neu.co1.qualtrics.com/jfe/form/SV_cTIAbH7ZRaaw0Ki

Academic Integrity

A commitment to the principles of academic integrity is essential to the mission of Northeastern University. The promotion of independent and original scholarship ensures that students derive the most from their educational experience and their pursuit of knowledge. Academic dishonesty violates the most fundamental values of an intellectual community and undermines the achievements of the entire University.

As members of the academic community, students must become familiar with their rights and responsibilities. In each course, they are responsible for knowing the requirements and restrictions regarding research and writing, examinations of whatever kind, collaborative work, the use of study aids, the appropriateness of assistance, and other issues. Students are responsible for learning the conventions of documentation and acknowledgment of sources in their fields. Northeastern University expects students to complete all examinations, tests, papers, creative projects, and assignments of any kind according to the highest ethical standards, as set forth either explicitly or implicitly in this Code or by the direction of instructors.

The following is a broad overview, but not an all-encompassing definition, of what constitutes a violation of academic integrity:

Cheating: The University defines cheating as using or attempting to use unauthorized materials, information, or study aids in any academic exercise. When completing any academic assignment, a student shall rely on their own mastery of the subject.

Fabrication: The University defines fabrication as falsification, misrepresentation, or invention of any information, data, or citation in an academic exercise.

Plagiarism: The University defines plagiarism as using as one's own the words, ideas, data, code, or other original academic material of another without providing proper citation or attribution. Plagiarism can apply to any assignment, either final or drafted copies, and it can occur either accidentally or deliberately. Claiming that one has "forgotten" to document ideas or material taken from another source does not exempt one from plagiarizing.

Unauthorized Collaboration: The University defines unauthorized collaboration as instances when students submit individual academic works that are substantially similar to one another. While several students may have the same source material, any analysis, interpretation, or

reporting of data required by an assignment must be each individual's independent work unless the instructor has explicitly granted permission for group work.

Participation in Academically Dishonest Activities: The University defines participation in academically dishonest activities as any action taken by a student with the intention of gaining an unfair advantage over other students.

Facilitating Academic Dishonesty: The University defines facilitating academic dishonesty as intentionally or knowingly helping or contributing to the violation of any provision of this policy.

Please visit https://osccr.sites.northeastern.edu/academic-integrity-policy/ to access the full academic integrity policy.

University Health and Counseling Services

As a student enrolled in this course, you are fully responsible for assignments, work, and course materials as outlined in this syllabus and in the classroom. Over the course of the semester if you experience any health issues, please contact UHCS.

For more information, visit https://www.northeastern.edu/uhcs.

Student Accommodations/Disability Access Services (DAS)

Northeastern University and the Disability Access Services (DAS) are committed to providing disability services that enable students who qualify under Section 504 of the Rehabilitation Act and the Americans with Disabilities Act Amendments Act (ADAAA) to participate fully in the activities of the university. To receive accommodations, students must provide appropriate documentation as provided by the DAS office.

If the course is conducted in an on-ground (in-person) format, students are expected to attend class physically as scheduled. Professors are not required to provide virtual attendance links unless a student has documented accommodation approved by the Disability Access Services (DAS) office and their Academic Advisor. If a student requires accommodation for remote participation, they must submit a formal request through the Disability Office and coordinate with their Academic Advisor prior to the course start date.

For more information, visit https://disabilityaccessservices.sites.northeastern.edu/

Office of Global Services

As an F-1, J-1, or Study Permit student, you must meet certain obligations in order to maintain lawful nonimmigrant status. Maintaining status is necessary in order to retain eligibility for the benefits of F-1 or J-1 status, such as employment authorization and program extension, and can be crucial to a successful application for a change or adjustment of nonimmigrant status in the future. Failure to maintain your nonimmigrant status can result in serious problems with immigration and could lead to deportation from the U.S. or Canada.

Students must maintain on-ground presence throughout the academic term. At Northeastern, there are four different defined instructional methods: Traditional, Hybrid, Live Cast, and Online. Traditional, Hybrid, and Live Cast courses meet the Visas' on-ground presence requirements. Online courses do not meet the Visas' on-ground presence requirements.

Students enrolled in Summer courses should adhere to OGS guidelines on maintaining status during the Summer term.

For more information please visit, https://international.northeastern.edu/ogs/current-students/understanding-visa-requirements/guidelines-on-maintaining-status/

Library Services

The Northeastern University Library is at the hub of campus intellectual life. Resources include over 900,000 print volumes, 206,500 e-books, and 70,225 electronic journals.

For more information and for education specific resources, visit https://library.northeastern.edu

Network Campus Library Services: Northeastern University Library Global Campus Portals

24/7 Canvas Technical Help

For immediate technical support for Canvas, call 617-373-4357 or email help@northeastern.edu

Canvas Student Resources: https://canvas.northeastern.edu/student-resources/

For assistance with my Northeastern e-mail, and basic technical support:

Visit ITS at https://its.northeastern.edu

Email: help@northeastern.edu

ITS Customer Service Desk: 617-373-4357

Outreach, Engagement, Belonging

Northeastern University is committed to fostering a community of belonging, which is essential to the advancement of Northeastern University's mission of teaching and research. Our university is stronger as a result of the varied backgrounds, experiences, and perspectives that all members of our global community bring to the pursuit of knowledge. Embracing this pluralism is not the work of one office, department, or academic unit. It is a shared responsibility that spans disciplines and boundaries. By harnessing the power of our differences, we will continue to light the path to bold new ideas and life-changing discoveries.

It is my intention that students from all backgrounds and perspectives will be well served by this course, and that the diverse experiences that students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, socioeconomic background, family education level, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and belonging environment for every other member of the class. Your suggestions are encouraged and appreciated.

Please visit Belonging at Northeastern – Northeastern Provost for complete information.

Title IX

Title IX of the Education Amendments of 1972 protects individuals from sex or gender-based discrimination, including discrimination based on gender-identity, in educational programs and activities that receive federal financial assistance. Northeastern's Title IX Policy prohibits Prohibited Offenses, which are defined as sexual harassment, sexual assault, relationship or domestic violence, and stalking. The Title IX Policy applies to the entire community, including male, female, transgender students, faculty and staff. In case of an emergency, please call 911.

The Office for University Equity and Compliance (OUEC) leads Northeastern University's efforts in maintaining compliance with all federal, state, and provincial civil rights laws and prohibits discrimination within any of its programs, activities, and services. Please visit https://ouec.northeastern.edu/ for more information and for the link to file a report.