PH413, Computational Physics (Spring 2026)

- Instructor: Yongsoo Yang (yongsoo.yang@kaist.ac.kr)

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- Class Hours: Monday and Wednesday 10:30 AM – 11:45 AM (3 credits / semester)

- Classroom: 1322 Natural Science (E6)
  * The lectures will be given in an in-person setup at the designated classroom. The students are expected to attend the lectures in person.

- Office Hour: By appointment

- Main Textbook: M. Newman, Computational Physics (CreateSpace Independent Publishing Platform, 2012)
- Reference: M. Nielsen, Neural Networks and Deep Learning (http://neuralnetworksanddeeplearning.com/)

- Evaluation (tentative)
  - Attendance&Participation:50%, Homework 25%, Final Project & Presentation 25%
  - Final grades will be given in ABCDF form.

- Course Design
  - This course adopts a "**flipped learning**" approach. Brief lectures covering each topic will be made available on KLMS prior to class, along with assigned homework. During lab sessions, students will engage with TAs to discuss the homework problems and relevant technical tools. Homework must be submitted before the faculty-led lecture session, and the session will mainly be open discussions on the given topic. Active participation is a key component of this course, as the instructor will evaluate student engagement during discussions. The course is designed to foster peer-to-peer learning through collaborative and active discussions. If you prefer a quiet, self-study learning style without engaging in group discussions, this course may not be the best fit for you. Participation accounts for 50% of the final grade, so students who do not actively contribute may struggle to succeed. In such cases, self-studying the recommended textbook and reference materials may be a more suitable option, rather than taking this class and coming to the discussion-based classroom.

- Course Prerequisites
  - **Python Programming**: Students are expected to have prior knowledge of Python programming. The instructors will assume familiarity with the material covered in Chapters 1–3 of the main textbook. If you are not comfortable with these topics, please review them before the semester begins.
  - **Physics Background**: While prior knowledge of classical mechanics, thermodynamics and statistical physics, electromagnetism, and quantum mechanics is not mandatory, it will greatly enhance your ability to grasp the physical concepts discussed in the course.

- Course Description
  - This course provides an introductory exploration of neural-network-based computational physics. While it will quickly cover some basic concepts of neural networks, the focus will not be on in-depth or comprehensive study of neural network theory. For those seeking advanced knowledge in neural networks, we recommend exploring courses offered by the mathematics or computer science departments. The primary emphasis of this course is on comparing **conventional computational methods** and **neural-network-based approaches** to solving physics problems. We will examine the strengths and limitations of each technique, equipping students with the skills to selectively and effectively apply both traditional and AI-based tools in physics research.

- Lecture Schedule (tentative)

Week	Topic
1	Mar 2 (Mon): No Class (3.1. day observed) Mar 4 (Wed): Introduction to PH413 Class Software Installation, Basic Python Programming (TA Practice session), Introduction to Neural Networks I (TA Practice Session) Reading (optional): M. Newman, Computational Physics **Chap. 1-4** Reading (optional): M. Nielsen, Neural Networks and Deep Learning **Chap. 1-3**
2	** Mar 8 (Sun): Homework #1 Due* Mar 9 (Mon): Introduction to Neural Networks I (Discussion Session) Mar 11 (Wed): Introduction to Neural Networks II (TA Practice Session) Reading (optional): M. Nielsen, Neural Networks and Deep Learning **Chap. 4-6**
3	** Mar 15 (Sun): Homework #2 Due* Mar 16 (Mon): Introduction to Neural Networks II (Discussion Session) Mar 18 (Wed): Numerical Integration / Differentiation (TA Practice Session) Reading: M. Newman, Computational Physics **Chap. 5**
4	** Mar 22 (Sun): Homework #3 Due* Mar 23 (Mon): Numerical Integration / Differentiation (Discussion Session) Mar 25 (Wed): Linear / Nonlinear Equations (TA Practice Session) Reading: M. Newman, Computational Physics **Chap. 6**
5	** Mar 29 (Sun): Homework #4 Due* Mar 30 (Mon): Linear / Nonlinear Equations (Discussion Session) Apr 1 (Wed): Ordinary Differential Equations (TA Practice Session) Reading: M. Newman, Computational Physics **Chap. 8**
6	** Apr 5 (Sun): Homework #5 Due* Apr 6 (Mon): Ordinary Differential Equations (Discussion Session) Apr 8 (Wed): Partial Differential Equations (TA Practice Session) Reading: M. Newman, Computational Physics **Chap. 9**
7	** Apr 6 (Sun): Homework #6 Due* Apr 13 (Mon): Partial Differential Equations (Discussion Session) Apr 15 (Wed): Random Numbers (TA Practice Session) Reading: M. Newman, Computational Physics **Chap. 10.1 – 10.2**
8	Midterm Week, **Final Project Plan Submission Due**
9	** Apr 26 (Sun): Homework #7 Due* Apr 27 (Mon): Random Numbers (TA-Led Discussion Session) Apr 29 (Wed): Monte Carlo Integration (TA Practice Session) Reading: M. Newman, Computational Physics **Chap. 10.3 – 10.4**
10	** May 3 (Sun): Homework #8 Due* May 4 (Mon): Monte Carlo Integration (Discussion Session) May 6(Wed): Noise Reduction and Crystal Structure (TA Practice Session)
11	** May 10 (Sun): Homework #9 Due* May 11 (Mon): Noise Reduction and Crystal Structure (Discussion Session) May 13(Wed): Tomography and Data Augmentation (TA Practice Session)
12	** May 17 (Sun): Homework #10 Due* May 18 (Mon): Tomography and Data Augmentation (Discussion Session) May 20 (Wed): Conservation Laws and Interaction Modeling (TA Practice Session)
13	** May 26 (Tue): Homework #11 Due* May 25 (Mon): No Class (Budda's birthday observed) May 27 (Wed): Conservation Laws and Interaction Modeling (Discussion Session)
14	Jun 1 (Mon): Summary, optional selective topic discussion Jun 3 (Wed): No Class (Local government election day)
15	Final Presentation
16	Final Presentation