National Cheng Kung University
Modular Courses 2026 Winter Program

Academic Year：114, Semester：2 Category：Natural and Engineering Sciences

Python應用計算物理 - 連續動力學
Computational Physics via Python – Dynamics of continuum

Instructor	Affiliation	Graduation (Ph.D.)
Yasutaro Nishimura nishimura@pssc.ncku.edu.tw	Institute of Space and Plasma Sciences National Cheng Kung University	University of Wisconsin–Madison

Category	Course Credit	Student Size(Maximum)
Natural and Engineering Sciences	1.5	15

Student Background

None

Difficulty

Challenging ■ Moderately Difficult Medium Entry Level (Basic)

Format of The Course

Lecture 60%, Hands-on Practice 30%, Discussion 10%
Individual students ↔ instructor direct discussions to concretize the contents of the lecture into numerical codes (> 30 minutes).

Grading Policy

問題考試 30%：Short Quiz on the very basic of numerical algorithm and PDE solutions (~ 60 min on Friday).

報告 70%：One final report on using computers, due on Monday after the class week.

Code of Conduct for The Course

Sophomore level (2nd year college level) math and general physics.

Course Description

Theoretical and computational modeling of continua (described by Eulerian variables: fluids and field quantities) is a central scientific tool in physical sciences and engineering (aerodynamics, nonlinear optics, charge particle dynamics and space technology to name a few examples). Despite the fact that the world in reality is made out of a system of discrete points, the idea of "continua" has been successful in describing various phenomena due to the interaction at the molecular level. In this course, through an assistance of numerical computations, we study diffusion (equivalently heat conduction), convection, and wave (linear and nonlinear) dynamics. With an expanding feasibility of the programming language Python, the course will cover succinct and paradigmatic examples.

Keywords: Numerical simulation, Partial Differential Equations (PDE), Linear and nonlinear waves, Schroedinger equation, Soliton, Python.

National Cheng Kung University
Modular Courses 2026 Winter Program

Academic Year：114, Semester：2　　Category：Natural and Engineering Sciences

Timetable and Syllabus

Period	Timetable	Syllabus
2026/1/12(一)	9:00-12:00	Lectures : Introduction to modeling dynamics of continua by partial differential equations.
	12:00-13:00	Lunch time
	13:00-15:30	Introduction to programming (1) Add one to ten (2) Numerical integration. Laptop PCs with compilers will be provided to all the students. Individual students↔ instructor direct“Discussions” to concretize the contents of the lecture into numerical codes (>30 minutes).
2026/1/13(二)	9:00-12:00	Lectures : Quick review of Fluid and Electrodynamics (Continuum or Eulerian variables). Poisson/Helmholtz equations and analytical solutions.
	12:00-13:00	Lunch time
	13:00-15:30	Practice : Iterative (Gauss-Seidel) and Direct (Gaussian-elimination) solvers. Discussions > 30 minutes.
2026/1/14(三)	9:00-12:00	Lectures : Diffusion equation and analytical solutions.
	12:00-13:00	Lunch time
	13:00-15:30	Practice : Implicit (Cranck-Nicholson, Thomas algorithm) versus explicit solver. Courant–Friedrichs–Lewy (CFL) conditions. Discussions > 30 minutes.
2026/1/15(四)	9:00-12:00	Lectures : Linear wave, Burgers’, and KdV equations.
	12:00-13:00	Lunch time
	13:00-15:30	Practice : Explicit solver by Leap-frog and Upwind schemes. Discussions > 30 minutes.
2026/1/16(五)	9:00-10:00	Quiz
	10:00-12:00	Lectures : Schroedinger equation in quantum mechanics, nonlinear Schroedinger equation (NLS) in optical fibers, and Zakharov equation describing nonlinear phase of Lanngmuir waves. Inverse scattering methods in KdV and NLS.
	12:00-13:00	Lunch time
	13:00-15:30	Practice : Numerical solutions of nonlinear Schroedinger equation by Leap-Frog and Split-Step-Fourier methods. Discussions > 30 minutes.

Goal of the Course

1. Learn how numerical simulation can discover new physical phenomena.
2. Learn scientific programming by solving simple PDEs (Poisson, Diffusion, and Wave).
3. Learn dynamics of nonlinear waves, by examining solutions of Burgers’, KdV (Korteweg-De Vries),

National Cheng Kung University
Modular Courses 2026 Winter Program

Academic Year：114, Semester：2 Category：Natural and Engineering Sciences

and non-linear Schroedinger equations.

The Importance, Cross-Over Disciplinary and Contemporary of The Curriculum

Theoretical and computational modeling of continua (described by Eulerian variables: fluids and field quantities) is a central scientific tool in physical sciences and engineering. Mechanical engineering, aerodynamics, aeronautics, nonlinear optics, charge particle dynamics, space technology to name a few.

Remarks

None

本課程若因天災等不可抗力之因素或中央、地方政府公告停課，授課教師需依情況依建議補課方式調整課程進度與補課；若需使用假日、國定假日補課，則需與所有修課學生達成共識方能用例假日補課。

建議補課方式：

1. 線上授課方式補課；
2. 當預期可能會因天災(颱風、超大豪雨…等)宣佈停課時，建議老師先行調整加快課程進度或預先增加可能天氣預警之前幾次課程時數；
3. 停課後隔天起延後下課，補足停課延誤的進度；若停課超過 1 天，則在開始上課後延後下課補課，或當週星期六、日補課；

更改課程授課方式，例如：DEMO 改以考試、報告、作業取代。