

# National Cheng Kung University

## Modular Course 2021 Summer Program

馬克斯威爾方程之數值解及其在現代光電的應用

Solving Maxwell's Equations by Numerical Methods and its Applications in Modern Photonics

Instructor	Affiliation	Graduation (Ph.d.)
張世慧	NCKU Department of Photonics	Northwestern University, USA
Course Type	Course Credit	Student Size (Maximum)
Lecture + Recitation	1.5	35

若因 COVID-19 疫情導致無法實體授課，本課程改以線上授課。修習過光電所「光電數值模擬」課程者，此門課不予承認。選修本課程同學請自備筆電。

### Student Background

College of Science、College of Engineering、College of Bioscience and Biotechnology、College of Electrical Engineering & Computer Science、College of Medicine

### Difficulty

Challenging  Medium Well  Medium  Entry Level ( Basic)

### Format of The Course

Lecture 60% , Practice 40%

#### Note:

上午講授以投影片為主(或遠距教學時，直播並錄影提供同步與非同步線上學習)，並輔以程式示範與講解

下午實作在電腦教室(或遠距教學時，利用自己的電腦，並運用網路會議提供個別指導)上機演練，並加以改寫

The morning lecture is based on power point slides with the aid of demonstrating the sample Matlab programing codes. (For distance teaching during pandemic, real time broadcasting and video recording will be provided for synchronous and asynchronous online learning.)

The afternoon workshop is to practice the Matlab codes in the computer classroom.

(For distance teaching during pandemic, use your computer to practice Matlab codes provided on moodle website, and online group meeting for advising and personal guidance.)

### Grading Policy

Practice 50% , Homeworks 50%

#### Note:

將課程所教之模擬計算應用在科學相關問題

實驗操作為課堂演習示範程式操作及改寫共五個主題

作業為每堂課內容的程式 一共 5 個作業

Apply the computational programing techniques learned in the lecture to scientific /engineering problems related to your research interest. We will cover five topics with useful techniques to solve Maxwell's equations in various interdisciplinary areas.

Workshop is to practice the sample programing code provided in the lecture and rewrite them. There are five programing homework based on the lecture and workshop.

(For distance teaching during pandemic, workshop results and homework are all submitted online.)

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### Code of Conduct for The Course

透過演習課上機練習將課程講述內容理解並應用

### Course Description

Introduce Maxwell's equations, and its numerical solution by finite-difference time-domain method, acquiring techniques in a short time to solve related electrodynamics, photonics problems in your research area.

在短時間內從開始認識馬克斯威爾方程，到學會如何利用有限差分時域法的電腦數值模擬，來解決在相關領域所遇到的各式各樣電磁學、光學的問題。

### Timetable and Syllabus

Peroid	Timetable	Syllabus
8/23(一)	9:00-12:00 13:00-15:30	<b>Lecture: Maxwell's Equations and Finite Difference Method</b> <b>Workshop: Scalar wave equation and Yee Algorithm for 1/2/3D,</b> numerical dispersion relation/stability condition 講義:馬克斯威爾方程與有限差分法 演習:純量波方程有限差分法, Yee 演算法在 1/2/3 維度,數值誤差/色散/穩定條件
8/24(二)	9:00-12:00 13:00-15:30	<b>Lecture: Wave Excitation and Fourier Spectrum Analysis</b> <b>Workshop: Gaussian pulse, TF/SF compact plane wave excitation,</b> Transmission/Reflection/Absorption/Scattering Spectrum, steady state pattern 講義:波源激發與傅立葉頻譜分析 演習:高斯波源,全場散設廠簡潔平面波激發,穿透/反射/吸收/散射頻譜,穩態場
8/25(三)	9:00-12:00 13:00-15:30	<b>Lecture: Absorbing Boundary Conditions and Periodic Structures</b> <b>Workshop: Analytical/Perfect Matching Layer/CPML absorption</b> boundary. Periodic boundary conditions 講義:吸收邊界層與週期結構 演習:解析/完美匹配層/捲積匹配層 吸收邊界,週期性邊界
8/26(四)	9:00-12:00 13:00-15:30	<b>Lecture: Material Dispersion and Nonlinearity</b> <b>Workshop: Drude/Lorentz model, gain material, 2nd and 3rd nonlinear</b> material. 講義:材料色散與非線性 演習:金屬/吸收介電質模型,雷射增益材料,二/三階非線性物質
8/27(五)	9:00-12:00 13:00-15:30	<b>Lecture: Application in Photonics, Physics, Chemistry, Geophysics,</b> Biomedicines <b>Workshop: Photonic crystals, Photonic topological insulators, LSPR,</b> SERS, radar design. 講義:此方法在光電物理化學地科生物醫學方面的應用

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		演習:光子晶體，光學拓譜絕緣體，表面電漿共振，表面增益拉曼，雷達設計
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### Goal of the Course

1. 認識馬克斯威爾方程與學習電腦數值模擬方法與原理

Understand Maxwell's equations and solve it by computational numerical method

2. 讓學生瞭解使用基本 Matlab 相關功能，修改與執行事先編寫好之有限差分時域法範例程式碼來解馬克斯威爾方程

Understand basic and related Matlab functions, learn how to run and modify the pre-design sample code with various techniques

3. 應用所教的程式解決相關領域的電磁學、光學的問題

Apply the modified codes to solve related EM and photonics problems in your research area.

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

光電在現代科學發展上例如物理、化學、生醫、工程領域扮演了十分重要的角色，而馬克斯威爾方程正是光電領域的主要核心，如何利用現代電腦演算法來輕鬆解看起來很難的馬克斯威爾方程，進而設計出相關光電元件或解決相關跨領域光電問題，都可在這堂找到所需要的工具幫助快速入門並掌握其技巧。

Photonics play a key role in the modern science development such as areas of physics, chemistry, bio-medicine, and engineering. Maxwell's equations are at the core center of all the photonics developments. This course provides the necessary tools and techniques that enable students to quickly learn how to solve Maxwell's equations by modern computational algorithms and technology, as well as to design photonics devices and resolve interdisciplinary problems with related photonics concepts.

### Remarks

#### References :

Computational Electrodynamics: The Finite-Difference Time-Domain Method 3rd ed, A. Taflove and S. C. Hagness, Artech House, June 2005