

國立中正大學 研究所 課程大綱

Graduate School Course - Course Syllabus

National Chung Cheng University

中文課程名稱 (Chinese Course Name)	無線通訊技術與安全	開課單位 (Offering Department/ Offering Unit)	資訊工程學系暨研究所 (Department of Computer Science and Information Engineering) 工學院前瞻工程全英語碩士學位學程 (Master Program in Advanced Manufacturing Systems) 機械工程學系國際智慧製造碩士專班 (International Master Program in Smart Manufacturing)
英文課程名稱 (English Course Name)	Wireless Communication Technology and Security	課程代碼 (Course Code)	115_1_4105483_01 115_1_4465026_01 115_1_4616049_01
		上課時間 (Time)	週二 第4節、第5節、第6節 (Tuesday AM 10:10 - PM 01:00)
		上課地點 (Location)	EA001教室，資工系館地下一樓 (Basement Floor, Room 001 at College of Engineering (I)) 校園地圖(Campus Map): https://ccu-navigation.ccu.edu.tw/app/index.php
授課教師 (Instructor)	江宗韋 (Tsung-Wei Chiang)	學分數 (Credits)	3
		授課語言 (Language)	全英文授課/無限修人數 EMI Course (Teaching in English)
必/選修 (Required/Selected)	☐ 必修 (Required) ☒ 選修 (Selected)	開課年級 (Level)	研究所，碩博合開，開放大三大四選修 (Graduate Course: open to both Master's and Ph.D. students, also available as an elective for junior and senior undergraduate students)
課程屬性/類別 (Course type)	☐ 人文關懷課程 ☐ 競賽專題課程 ☐ 問題導向課程 ☐ 專題導向課程 ☐ 總整課程 ☐ 實作課程 ☐ 實習 ☒ 其他(Others)		
先修科目或先備能力 (Prerequisites)	1. Fundamental knowledge of probability theory 2. Fundamental knowledge of linear algebra		
課程概述 (Course Descriptions)	This course provides a comprehensive introduction to Low-Density Parity-Check (LDPC) codes for 5G New Radio (NR) mobile communications, the key channel coding technology adopted for the physical layer data channels of 5G NR. The course then introduces the 5G NR radio access technology, covering its standardization, key features, and technology components, including how LDPC coding is applied in 5G NR. The curriculum integrates		

	theoretical concepts and comprehensive math derivations with hands-on coding activities and simulations, bridges academic theories with industrial applications, and provides awareness of emerging research directions about private and secure technology toward 6G mobile communication and AI, preparing students to effectively understand, analyze, and tackle future challenges in advanced wireless communication technology.		
學習目標 (Learning Objectives)	1. Students can understand the key channel coding technology in physical layer signal processing of 5G New Radio (NR) communications, including the parity-check matrix, Tanner graphs, and all major decoding algorithms with their complete mathematical derivations. 2. Students can gain hands-on experience by conducting simulations and practical coding exercises using Python (Google Colab), specifically focusing on LDPC encoding and decoding techniques used in 5G NR. 3. Students can understand the key features and technology components of the 5G NR radio access technology, how LDPC channel coding is adopted in the 5G NR standard, and emerging research directions toward future private and secure 6G systems.		
教科書 (Textbooks and References)	Textbook: 1. Bernard Sklar and Fredric J. Harris, <i>Digital Communications: Fundamentals and Applications</i>. 3rd Edition, Pearson, 2021. 2. S. Parkvall, E. Dahlman, A. Furuskär, and M. Frenne, "NR: The new 5G radio access technology," <i>IEEE Communications Standards Magazine</i>, vol. 1, no. 4, pp. 24 – 30, Dec. 2017. 3. Self-prepared presentation slides and lecture handouts will be provided. References: 1. Erik Dahlman, Stefan Parkvall, Johan Sköld, <i>5G/5G-Advanced: The New Generation Wireless Access Technology</i>. 3rd Edition, Academic Press, 2023. 2. S. Lin and J. Li, <i>Fundamentals of Classical and Modern Error-Correcting Codes</i>. Cambridge, U.K.: Cambridge University Press, 2021. 3. 李大嵩、李明峻、詹士慶、吳昭沁, 第五代行動通訊系統3GPP New Radio (NR): 原理與實務. 全華圖書, 2021. 4. Ali Zaidi, Fredrik Athley, Jonas Medbo, Ulf Gustavsson, Giuseppe Durisi, Xiaoming Chen, <i>5G Physical Layer: Principles, Models and Technology Components</i>. Academic Press, 2018. 5. V.-L. Nguyen, P.-C. Lin, B.-C. Cheng, R.-H. Hwang, and Y.-D. Lin, "Security and privacy for 6G: A survey on prospective technologies and challenges," <i>IEEE Communications Surveys & Tutorials</i>, vol. 23, no. 4, pp. 2384 – 2428, Fourthquarter 2021. 6. 3GPP Specifications.		
課程大綱(Course Syllabus)		概要分配時數 (Number of Approximate Hours)	核心能力 (Core Capabilities)
單元主題(Topic)	內容綱要(Content)	講授(Lecture)	
1. Introduction	• Introduction to the course	1	☒ A1 ☐ A2 ☐ A3 ☐ A4 ☐ A5 ☐ A6

			☐ A7 ☒ A8
2. LDPC Codes: Background and Overview	- Shannon's noisy channel coding theorem and the origin of LDPC codes (Gallager, MacKay) - LDPC codes in modern standards - Python code demo	2	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8
3. LDPC Codes: The Parity-Check and Matrices	- Parity-check matrix, parity checks, regular/irregular LDPC codes, syndrome testing - Python code demo	3	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8
4. LDPC Codes: Finding the Best-Performing Codes	- A good starting point: the (6,3) code - The Tanner graph, cycles, and girth of a graph - Python code demo	3	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8
5. LDPC Codes: Hard-Decision Decoding	- Decoding overview - Majority-logic, bit-flipping, and weighted bit-flipping decoding; belief propagation preview - Python code demo	6	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8
6. LDPC Codes: Mathematical Foundations	- Soft-decision versus hard-decision decoding - A posteriori probability and likelihood; Gallager's major development; check-node and bit-node message computations - Python code demo	6	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8
7. LDPC Codes: Decoding in the Probability Domain	- Sum-product algorithm (SPA) message-passing steps with worked iterations - Python code demo	6	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8
8. LDPC Codes: Decoding in the Logarithmic Domain	- Log-likelihood functions and the $\varphi(x)$ function - Log-domain decoding steps with worked iterations - Python code demo	6	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8
9. LDPC Codes: Reduced-Complexity Decoding and Performance	- Min-sum and normalized min-sum algorithms - Performance comparisons of LDPC and turbo codes; LDPC codes near the Shannon limit - Complete mathematical derivations - Python code demo	8	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8
10. 5G NR: The New Radio Access Technology & QC-LDPC	- NR standardization and key features; transmission scheme, numerology, and frame structure - Duplex schemes, low-latency support, QC-LDPC channel coding,	8	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8

	beam-centric design and multi-antenna transmission, initial access, LTE coexistence, and performance evaluation • Python code demo		
11. Private and Secure Technology for 6G and AI	• Introduction to research topics in privacy-preserving and secure wireless technologies for 6G and AI • Physical-layer security; privacy-preserving federated learning; security and privacy for 6G • Python code demo	6	☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8

備註(Notes)：
 本課程大綱為目前之規劃內容，可能因國定假日、不可預期之停課、演習或其他特殊情況而調整；相關異動將另行公告，並以實際上課公告為準。授課教師將視情況提供適切之課程安排與教學內容。(This syllabus reflects the current course plan and may be adjusted due to national holidays, unforeseen class suspensions, drills, or other special circumstances. Any changes will be announced through official course channels. The instructor will make appropriate adjustments to course arrangements and instructional content as needed.)

教學要點概述
 (Teaching Key Points Overview)

教材編選 (Teaching Materials)	☒ 自製簡報(Self-prepared presentation slides) ☒ 課程講義(Lecture handouts) ☒ 教學程式(Teaching scripts/programs)
教學方法 (Teaching Methods)	☒ 投影片講述(Slide-based instruction) ☒ 板書講述(Blackboard-based instruction)
評量工具 (Evaluation Tools)	☒ 上課點名(Attendance) 15% ☒ 隨堂作業(In-class assignments) 30% ☒ 程式實作(Programming projects) 25% ☒ 期末報告(Final report) 30%
教學資源 (Teaching Resources)	☒ 課程網站(Course website) ☒ 教材電子檔供下載(Digital materials for download) ☐ 實習網站(Lab website)
教師相關訊息 (Instructor's Information)	全英文授課。 (This course will be taught in English.) 請學生尊重智慧財產權及使用正版教科書。 (Students should respect intellectual property rights and use authorized textbooks.)
教學相關配合事項 (Course relative information)	所有作業與報告（含程式碼與書面內容）均嚴禁抄襲。凡經查證屬實者，本課程一律以不及格論處。(Plagiarism is strictly prohibited in all homework and assignments, including both code and written reports. Any student found to have engaged in plagiarism will automatically fail the course.) 若作業或報告中使用 AI 工具（如 ChatGPT、Gemini、Claude 等），須於文件中明確標註使用情形，並說明哪些部分為 AI 生成或輔助完成。未依規定揭露者，在此課程可能視同抄襲處理。(If AI tools (e.g., ChatGPT, Gemini, Claude) are used in an assignment or report, students

	must clearly disclose where such tools were used and specify which portions were generated or assisted by AI. Undisclosed use of AI may be treated as plagiarism in this course.)
課程目標與教育核心能力相關性 (Relationship between Course Objectives and Core Educational Competencies)	
請勾選： ☒ A1 ☒ A2 ☒ A3 ☒ A4 ☐ A5 ☐ A6 ☐ A7 ☒ A8	
A1	具有資訊工程與科學領域之專業知識(Competence in computer science and computer engineering.) 為何有關(Why Relevant)： The course content covers the fundamental physical-layer coding knowledge applied for 5G NR mobile communications and related privacy and security introductions, aiming to cultivate students' professional knowledge from a systematic perspective in the field of information and communication. 達成指標(Achievement Indicators)： Grades are determined by assignments, practical programming tasks, and the final (project) report. Graduate students must achieve a score of over 70, and undergraduates must exceed 60 to pass. 評量方法(Assessment Methods)： Assessment Criteria for Assignments, Programming Projects, and the Final (Project) Report: • Level 5: Submission of 80% of assignments and an anticipated semester grade of 80 points or above, or a report grade of 80 points or above. • Level 4: Submission of 60% of assignments and an anticipated semester grade of 70 points or above, or a report grade of 70 points or above. • Level 3: Submission of 40% of assignments and an anticipated semester grade of 60 points or above, or a report grade of 60 points or above. • Level 2: Submission of 20% of assignments and an anticipated semester grade of 50 points or above, or a report grade of 50 points or above. • Level 1: No assignment submissions or an anticipated semester grade of less than 50 points, or a report grade of less than 50 points.
A2	具有創新思考、問題解決、獨立研究之能力(Be creative and be able to solve problems and to perform independent research.) 為何有關(Why Relevant)： Assignments integrate practical experience; students are required to write programming implementations to enhance their ability to independently solve practical and interesting problems. Assignments will also include reading academic literature and providing concrete summaries. 達成指標(Achievement Indicators)： Students are encouraged to participate in discussions and bravely attempt solutions, but must complete their assignments independently. Flaws or errors in assignments are entirely acceptable, as there may not always be an absolute correct answer. Plagiarism is strictly prohibited for all homework and assignments. 評量方法(Assessment Methods)： Same as the Assessment Criteria outlined in A1.
A3	具有撰寫中英文專業論文及簡報之能力(Demonstrate good written, oral, and communication skills, in both Chinese and English.) 為何有關(Why Relevant)： Students are required to complete the final project report in English, clearly articulating the

	motivation, logical reasoning, methodology, and outcomes.
	達成指標(Achievement Indicators) : The final project report should be clear, easy to follow, logically sound, and systematically organized.
	評量方法(Assessment Methods) : Same as the Assessment Criteria outlined in A1.
A4	具策劃及執行專題研究之能力(Be able to plan and execute projects.)
	為何有關(Why Relevant) : Students will base their work on programming assignments to complete a final project report. The report should clearly present the motivation, methodology, results, and possible innovations.
	達成指標(Achievement Indicators) : The final project report should be clear, easy to follow, logically sound, and systematically organized.
	評量方法(Assessment Methods) : Same as the Assessment Criteria outlined in A1.
A8	具國際觀及科技前瞻視野(Have international view and vision of future technology.)
	為何有關(Why Relevant) : Assignments will include tasks for students to read the latest academic articles and produce summaries. Students are required to learn about current knowledge of one of the key coding technology in 5G physical-layer mobile communications as well as the potential developments in the future 6G system.
	達成指標(Achievement Indicators) : Students can study international journals and conference papers, and are able to accurately summarize and analyze their contents.
	評量方法(Assessment Methods) : Same as the Assessment Criteria outlined in A1.
教育目標 (Educational Objectives)	
1.具獨立從事學術研究或產品創新研發之人才(To cultivate talent with the ability to conduct independent academic research or drive product innovation and development.)	
2.具團隊合作精神及科技整合能力，並在團隊中扮演領導、規劃、管理之角色(To develop teamwork spirit and technological integration skills, enabling individuals to assume leadership, planning, and management roles within a team.)	
3.具創新研發、自我挑戰與終身學習能力之人才(To nurture talent with innovative research capabilities, a drive for self-challenge, and a commitment to lifelong learning.)	
4.具有學術倫理、工程倫理、國際觀之人才(To foster individuals with academic integrity, engineering ethics, and a global perspective.)	
核心能力 (Core Competencies)	
A1.具有資訊工程與科學領域之專業知識(Competence in computer science and computer engineering.)	
A2.具有創新思考、問題解決、獨立研究之能力(Be creative and be able to solve problems and to perform independent research.)	

A3.具有撰寫中英文專業論文及簡報之能力(Demonstrate good written, oral, and communication skills, in both Chinese and English.)

A4.具策劃及執行專題研究之能力(Be able to plan and execute projects.)

A5.具有溝通、協調、整合及進行跨領域團隊合作之能力(Have communication, coordination, integration skills and teamwork in multi-disciplinary settings.)

A6.具有終身學習與因應資訊科技快速變遷之能力(Recognize the need for, and have the ability to engage in independent and life-long learning.)

A7.認識並遵循學術與工程倫理(Understand and commit to academic and professional ethics.)

A8.具國際觀及科技前瞻視野(Have international view and vision of future technology.)

請尊重智慧財產權，不得非法影印教師指定之教科書籍

(Please respect the intellectual property rights; do not photocopy the textbooks assigned by professors.)