Course Information	
Course title	Quantum Information and Computation
Semester	109-2
Designated for	COLLEGE OF SCIENCE DEPARTMENT OF MATHEMATICS
Instructor	HAO-CHUNG CHENG
Curriculum Number	CommE5061
Curriculum Identity Number	942 U0750
Credits	3.0
Course Syllabus	
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Course Description	This course is scheduled as three parts: the mathematical formalism of quantum information, its application in computing tasks, and its application in communication-related and more advanced topics. 1. Foundations of Quantum Theory I: Postulates and Quantum States. 2. Foundations of Quantum Theory II: Measurements and Operations. 3. Basic Quantum Protocols. 4. Quantum Computation I: Quantum Circuit Model and Algorithms. 5. Quantum Computation II: Algorithms Based on Amplitude Amplification. 6. Quantum Computation II: Algorithms Based on Phase Estimation. 7. State Discrimination and Semidefinite Programming. 8. Quantum Entanglement and Its Usage. 9. Quantum Shannon Theory I: Entropy and Quantum Hypothesis Testing. 10. Quantum Shannon Theory II: Quantum Compression. 11. Quantum Shannon Theory III: Quantum Communication. 12. Quantum Cryptography: Quantum Key Distribution. 13. Advanced Topics: Quantum Error Correction (as time permits).
Course Objective	This course presents the subject of quantum information processing, which lies at the intersection of mathematics, physics, computer science, and engineering. We explore the mathematical foundation of quantum information, and how to measure, compress, communicate, and compute it. Those quantum information-processing tasks are fundamental to a broad range

	of studies including quantum computing, quantum communications, and quantum cryptography. Most of these studies have demonstrated striking and transformative features, which hence facilitate the rapid developments of current quantum information technologies. 1. Introduce fundamental concepts and mathematical framework of quantum information (the so-called quantum bits) — how to model it, process it, compress it, and communicate it. 2. Present core quantum computing topics including quantum circuit models and basic quantum algorithms, and how to harness quantum computing power to speed-up classical computational tasks. 3. Learn various quantum information-processing protocols including compressing quantum information and communicating classical/quantum information through a quantum channel. 4. Develop necessary abilities for students to independently study advanced topics in quantum information sciences and to innovate applications in quantum information technology. 5. Perform a term project on studying advanced topics of the latest research, experiment development, technologies of quantum information processing.
Course Requirement	The course is intended for graduate students (undergraduate students are also welcome) who have previously taken courses of linear algebra and basic probability theory. No previous background in quantum mechanics is required. The grading criterion is based on homework (40%), mid-term exam (30%), and final project (30%).
References	[1] Benjamin Schumacher and Michael Westmoreland. Quantum Processes systems, and Information, Cambridge Press, 2010. [2] P. Kaye, R. Laflamme, M. Mosca. An Introduction to Quantum Computing, Oxford University Press, 2007. [3] Mark M. Wilde. Quantum Information Theory, Cambridge University Press, 2018. [4] John Watrous. The Theory of Quantum Information, Cambridge University Press, 2018. [5] Mario Ziman and Teiko Heinosaari. The Mathematical Language of Quantum Theory: From Uncertainty to Entanglement, Cambridge University Press, 2011.
Designated reading	Textbook: Michael Nielsen and Issac Chuang. Quantum Computation and Quantum Information, Cambridge University Press, 2009.