THE CHINESE UNIVERSITY OF HONG KONG
Print Course Catalog Details

Academic Org: Dept of Computer Sci & Engg – Subject: Computer Science

Course: CSCI3350 **Course ID:** 014758 **Eff Date:** 2025-07-01 **Crse Status: Active** **Apprv. Status:** Approved **[**New Course**]**
Introduction to Quantum Computing 量子計算導論

This course offers an introduction to the fascinating world of quantum computing, focusing on its fundamental concepts and algorithms. Additionally, as a unique feature, the instructor will guide students through several interdisciplinary areas where quantum computing intersects with fields such as computational complexity, cryptography, machine learning, networking, and information theory. This unique approach aims to equip students with a broad spectrum of quantum-related skills, preparing them to contribute to the rapidly evolving field of quantum computing, which offers abundant opportunities in both industry and academia.

Topics include:
- Basics of quantum information, the linear-algebra formalism
- Entanglement and nonlocality
- The quantum circuit model
- Basic quantum protocols, such as quantum teleportation and superdense coding
- Basic quantum algorithms, such as Simons' algorithm, the Quantum Fourier Transform, Phase Estimation, Shor's Factoring algorithm, Grover search, amplitude amplification
- Quantum error correction and fault-tolerance
- Selective topics from quantum cryptography, proof of quantumness, quantum information theory, quantum complexity theory, quantum machine learning

No background in quantum physics is required. The only prerequisites are familiarity with undergraduate-level linear algebra and probability theory.

本科介紹量子運算的迷人世界，重點介紹其基本概念和演算法。此外，作為一個獨特的功能，講師將引導學生了解量子計算與計算複雜性、密碼學、機器學習、網路和資訊理論等的幾個跨學科領域。這種獨特的方法旨在為學生提供廣泛的量子相關技能，讓他們為快速發展的量子計算領域做出貢獻，這為工業界和學術界提供了豐富的機會。

主題包括：
- 量子資訊基礎知識、線性代數形式主義
- 糾纏和非定域性
- 量子電路模型
- 基本量子協議，例如量子隱形傳態和超密編碼
- 基本量子演算法，如西蒙斯演算法、量子傅立葉變換、相位估計、肖爾因子分解演算法、格羅弗搜尋、幅度放大
- 量子糾錯與容錯
- 量子密碼學、量子性證明、量子資訊理論、量子複雜性理論、量子機器學習的精選主題

不需要量子物理學背景。唯一的先決條件是熟悉本科程度的線性代數和機率論。

Grade Descriptor: A

EXCELLENT – exceptionally good performance and far exceeding expectation in all or most of the course learning outcomes; demonstration of superior understanding of the subject matter, the ability to analyze problems and apply extensive knowledge, and skillful use of concepts and materials to derive proper solutions.

有關等級說明的資料，請參閱英文版本。

B

GOOD – good performance in all course learning outcomes and exceeding expectation in some of them; demonstration of good understanding of the subject matter and the ability to use proper concepts and materials to solve most of the problems encountered.

有關等級說明的資料，請參閱英文版本。

C

FAIR – adequate performance and meeting expectation in all course learning outcomes; demonstration of adequate understanding of the subject matter and the ability to solve simple problems.

有關等級說明的資料，請參閱英文版本。

D

MARGINAL – performance barely meets the expectation in the essential course learning outcomes; demonstration of partial understanding of the subject matter and the ability to solve simple problems.

有關等級說明的資料，請參閱英文版本。

F

FAILURE – performance does not meet the expectation in the essential course learning outcomes; demonstration of serious deficiencies and the need to retake the course.

有關等級說明的資料，請參閱英文版本。

Equivalent Offering:
Units: 3 (Min) / 3 (Max) / 3 (Acad Progress)
Grading Basis: Graded
Repeat for Credit: N
Multiple Enroll: N
Course Attributes:

Topics:

COURSE OUTCOMES

Learning Outcomes:

At the end of the course of studies, students will be able to:
1. Explain the foundational concepts of quantum computing and how they differ from classical computing paradigms.
2. Apply quantum algorithms to solve specific computational problems, demonstrating the ability to implement these algorithms using quantum circuits.
3. Integrate quantum computing principles with interdisciplinary fields, such as cryptography, machine learning, and information theory, to address complex problems and explore emerging applications.

Course Syllabus:

Week 1: Overview of quantum computing and the class, Basics of quantum information in the linear-algebra formalism, non-cloning, entanglements, quantum teleportation
Week 2: Basics of quantum information in the linear-algebra formalism (continued), Bell inequalities, CHSH game, density operators, mixed states, partial trace
Week 3: Quantum-circuit mode, Solovay-Kitaev theorem, universal gate sets, Deutsch-Jozsa algorithm, Simon's algorithm
Week 4: Quantum Fourier transform, phase estimation, order finding, Shor's algorithm
Week 5: Shor's algorithm (continued), Grover search
Week 6: Quantum error correction, fault tolerance, stabilizer formalism, Gottesman-Knill Theorem
Week 7: Hidden subgroup problem, quantum state complexity, QSampling states, Class QMA, group non-member
Week 8: Quantum complexity classes: BQP, QMA, PostBQP, #P, PP etc. and their relationships, quantum Hamiltonian complexity
Week 9: Proof of quantumness, certifiable randomness, and classical verification of quantum computation
Week 10: Quantum Key Distribution, quantum money, quantum copy-protection
Week 11: Pseudorandom states, pseudorandom unitaries, their implications on computational compelxity and cryptography

Week 12: Overview of selected topics on Quantum Computer Systems I: superconducting quantum computer, quantum noise mitigation, variational quantum algorithms,
Week 13: Overview of selected topics on Quantum Computer Systems II: quantum machine learning, quantum network

Assessment Type:

Examination	: 40%
Homework or assignment	: 30%
Project	: 30%

Feedback for Evaluation:

1. Course evaluation and questionnaire;
2. Results of assignments and examination;
3. Question-and-Answer sessions during class;
4. Student consultation during office hours or online

Required Readings:

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Recommended Readings:

1. Introduction to Quantum Information Science Lecture Notes I & II, by Scott Aaronson
2. The complexity of quantum states and transformations: From quantum money to black holes, by Scott Aaronson
3. Principles of Quantum Communication Theory: A Modern Approach, by Sumeet Khatri, Mark M. Wilde
4. Quantum Computation and Quantum Information, by Michael A. Nielsen and Isaac L. Chuang

OFFERINGS

1. CSCI3350 — Acad Organization=CSD; Acad Career=UG

COMPONENTS

LEC : Size=50; Final Exam=Y; Contact=3
TUT : Size=50; Final Exam=N; Contact=1

ENROLMENT REQUIREMENTS

1. CSCI3350 — **Enrollment Requirement Group:**
Prerequisite: (ENGG1120 or ESTR1005) AND (ENGG2760 or ESTR2018)

New Enrollment Requirement(s):

Pre-requisite = (ENGG1120 or ESTR1005) and (ENGG2760 or ESTR2018)

Additional Information

VTL-Onsite face-to-face hrs 0
VTL-Online synch. hrs 0
VTL-Online asynch. hrs 0
No. of micro-modules 0
Research components (UG) 0%

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