PHYS1007 Quantum Information for Everyone

Course Syllabus - Spring 2025

- **Instructor**

  Name: HUANG, Shilin 黃施霖

  Contact Details: huangsl@ust.hk

  Office Hours:

  Date/Time: Monday 14:00-15:00pm, or by appointment.

  Office: 4479 (4417 before Feb 10).

- **Teaching Assistant(s)**

  Name: WU, Jiahui 吳嘉輝

  Contact Details: jwudp@connect.ust.hk

  Office Hours: by appointment

  Name: LO, Yuk Ho 勞昱豪

  Contact Details: xzhube@connect.ust.hk

  Office Hours: by appointment

- **Meeting Time and Venue**

  Lectures:

  Date/Time: Monday 13:30pm - 14:50pm, Friday 9:00pm - 10:20pm

  Venue: LTK

  Lab:

  Lab session will be arranged in **April** to help with hands-on experiements.

  Location: Modern Physics Teaching Lab 4117A.

- **Course Description**

  Credit Points: 3

  Pre-requisite: Level 3 or above in HKDSE Mathematics Extended Module M2

  Exclusion: PHYS4812

  Brief Information/synopsis:

  Information cannot exist without a physical system to represent it. Quantum physics enables some fundamental new ways of information processing. In recent years, quantum information processing (QIP) has emerged as one of the "most fiercely competitive in today's world of technology". This course offers an introduction to the past, present and future of QIP. The theme is to explain the major ideas and issues in QIP, and how this new technology will change our understanding of information processing. The course starts from a gentle introduction to quantum theory without assuming any physics background, then moves to the key applications of QIP including quantum computing, quantum cryptography, and quantum communication. Besides theory, demonstrations and hands-on experiences with quantum hardware will also be given. Students will benefit from

learning quantum information technology in an interdisciplinary environment, with knowledge and skills for comprehending the fast-paced developments in today's technological world.

- **Intended Learning Outcomes**

  Upon successful completion of this course, students should be able to:

No.	ILOs
1	Explain the basic concepts of quantum information science
2	Apply the basic concepts to information processing tasks
3	Explain the current stage of global research and development for quantum software and hardware
4	Exercise effective communication of quantum information science concepts to interdisciplinary audiences

- **Assessment Scheme**

  a. Examination duration: TBA

  b. Percentage of coursework, examination, etc.:

Assessment	Assessing Course ILOs
10% by homework There are 5 homework assignments.	1, 2, 3, 4
15% by lab report For quantum computer experiments.	1, 2, 3, 4
30% by midterm exam (March 24 in-class)	1, 2
45% by final exam	1, 2

  c. The grading is assigned based on students' performance in assessment tasks/activities.

- **Student Learning Resources**

  Recommended Reading:

  Text(s):

  Mermin, "Quantum computer science", https://www.lassp.cornell.edu/mermin/qcomp/CS483.html

  Yanofsky and Mannucci, "Quantum Computing for Computer Scientists", Cambridge University Press, 2008

  Nielsen and Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 2000

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- **Teaching and Learning Activities**

  Scheduled activities: 3 hrs lecture

- **Course Schedule**

  Weekly schedule**:**

  - **Week 1 (Lec1-2)**: A brief history of computers
  - **Week 2 (Lec3-4)**: A brief introduction to quantum computers
  - **Week 3 (Lec5-6)**: Matrix representation of quantum gates

- **Week 4 (Lec7-8)**: Quantum circuits, search algorithm
- **Week 5 (Lec9-10)**: Complex numbers, single qubit gates
- **Week 6 (Lec11-12)**: Universal circuits, quantum Fourier transform
- **Week 7 (Lec13-14)**: Quantum mechanics, quantum entanglement
- **Week 8 (Lec15-16)**: A brief introduction to building quantum computers
- **Week 9 (Lec17-18)**: Breaking RSA encryption
- **Week 10 (Lec19-20):** A brief introduction to quantum cryptography
- **Week 11 (Lec21-22):** A brief introduction to quantum communication
- **Week 12 (Lec23-24):** A brief introduction to quantum error correction