Descriptions of Courses

▣Graduate Program

QU501 Introductory Quantum Mechanics
This is an introductory course on quantum mechanics focusing on the aspects related to quantum information/technology. Concepts such as Hilbert(vector) space, superposition, entanglement, density matrix, two level systems, quantum harmonic oscillator, hydrogen atom, 2nd quantization, etc. will be taught in this course.

QU511 Quantum Computing
In this course, we aim to understand the fundamental theory and key technologies of quantum computing systems implemented in various architectures. We learn about the characteristics of different architectures such as neutral atoms, trapped ions, and superconducting qubits. Additionally, we study the fundamentals of qubit control and the hardware and software for microwave-based measurements.

QU512 Quantum Software
The course aims to deliver the fundamentals of quantum software. It contains examples of known quantum software centered around the circuit theory, entanglement, and quantum noise, towards practical applications in computing and communication.

QU513 Quantum Communications and Networks
In this course, students will learn the fundamental principles of quantum communications by carrying out studies on key application areas. Towards the end of the semesters, students will give presentations on milestone researches in the relevant fields.

QU514 Quantum Metrology and Sensing
Quantum systems are highly sensitive to their environments, allowing us to detect nanoscale signals such as electromagnetic fields and temperatures. The intended learning outcomes of the class are to understand the principles of quantum systems and their control for applications of quantum metrology and sensing.

QU811 Neutral Atom Quantum Simulator Development
In this laboratory course of neutral-atom quantum simulator, we introduce the concepts of quantum simulation, the laser-cooling and trapping of atoms, the principles of entangled atom dynamics, the technology of laser cooling and trapping of atoms, entangled atom dynamics, numerical emulation of quantum many-body dynamics, and Rydberg-atom quantum simulator experience.

QU812 Measurement of Superconducting Qubits
n this course, we aim to understand and practice the key technologies for measuring and controlling superconducting qubit-based quantum computing. We learn the fundamentals of superconducting qubit control and the hardware and software for microwave-based measurements.

QU813 Applications of Superconductor Based Quantum Devices
In this course, we develop control systems for the implementation of superconducting quantum devices. We learn the fundamentals of superconductivity theory and the essential elements required for the design and fabrication of superconducting quantum devices, as well as the necessary hardware and software for their fabrication.

QU814 Quantum Algorithms and Quantum Software
The course aims to investigate the state of the art quantum algorithms and quantum software, in

particular the topics around quantum circuit, quantum algorithm, quantum certification, and network information theory.

QU815 Quantum Machine Learning and Quantum Neural Network Lab

This course provides understandings of the basics of quantum software on artificial intelligence systems using quantum computers and the corresponding practices on coding. Students will learn the theory and model of quantum machine learning and quantum neural network, and learn the major skills on quantum AI implementation through coding practice based on qiskit and pennylane.

QU816 Quantum Error and Noise Correction

For the realization of quantum information processing, it is crucial to address the issues of quantum errors and noises. This lecture aims to deliver theories on quantum error corrections and quantum entanglement distillation, which are essential for quantum computing and communication. Furthermore, entanglement distillation protocols will be implemented experimentally.

QU817 Applications of Quantum Metrology and Sensing

Intended learning outcomes of the course is to understand the principle of quantum metrology and sensing and their practice. By developing methods and systems to control Hamiltonians of the quantum systems, students will learn how to control the physical quantum systems.

QU818 Quantum Integrated Nanophotonics

This course focuses on quantum optics research with an integrated nanophotonics platform and provides students with fundamentals in this area. Students will learn advanced integrated nanophotonic devices, including waveguides, resonators, couplers, and modulators, with an emphasis on their quantum optical applications. By analyzing the limitations and challenges of current nanophotonic devices, students will work towards the development of next-generation quantum integrated nanophotonics.

QU819 Fundamentals on Nanophotonic Hybrid Quantum System

As each platform for producing, manipulating, and transmitting quantum information offers unique benefits, it is anticipated that future quantum information systems will be created by integrating these distinct platforms. This course will introduce nanophotonic hybrid systems capable of integrating multiple platforms by providing quantum transduction. The curriculum will cover the principles, design, and fabrication methods of nanophotonic hybrid systems, with an emphasis on the latest research.

QU820 Development of Quantum Material-based Devices

This course is designed for students interested in learning many particle concept and understanding quantum materials in terms of superconducting, magnetic, dielectric and defect properties. Students will experience epitaxial film synthesis with atomic precision, device fabrication and characterizations for quantum materials-based device applications.

PH475 Quantum Information I

This lecture covers the basic principle of quantum technology, which includes quantum coherence, quantum entanglement, quantum measurement, quantum devices, quantum communications, and quantum computing.

PH476 Quantum Information II

This lecture covers the basic principle of quantum technology, which includes quantum coherence, quantum entanglement, quantum measurement, quantum devices, quantum communications, and quantum computing.

PH503 Quantum Mechanics I
This course introduces the mathematical foundation of quantum mechanics to the first year physics graduate students. Topics include: Hilbert space, Measurement theory, Theory of rotation and Angular momentum, Group theory and application to quantum mechanics, Wigner Eckart theorem, Clebsch Gordon coefficients, Stationary perturbation, Time dependent perturbation, Applications to atoms, molecules and solids.
Topical Prerequisites: One year of undergraduate Quantum Mechanics, Mathematical Physics, Mechanics, Electromagnetism.

PH504 Quantum Mechanics II
This course is designed to help the first year physics graduate students understand complicated phenomena of scattering and to give an introduction to the second quantization and Dirac equation for future use in solid state physics and particle physics. Topics include: Scattering, Nonrelativistic Second Quantization, Fermion Systems and Boson Systems, Dirac Equation.
Prerequisites: PH503 Quantum Mechanics I.

PH624 Quantum Optics
Laser resonator, Laser rate equations, Q-switching, Mode-locking, and Laser amplifiers are covered. Various electro-optic modulators, Laser optic components, Laser applications are also discussed. Introductory quantum optics is treated.
Recommended Topical Prerequisites: Electromagnetic theory, Optics, and Quantum mechanics.

PH611 Advanced Solid State Physics I
This course is intended to provide graduate students in physics, chemistry, electrical engineering, and materials science with a graduate-level understanding of topics in solid state physics. Topics include: Brillouin zone, Crystal symmetry, Phonons, Electron energy band theory, Electron-electron and electron-phonon interactions, Electron dynamics, and Transport properties.
Prerequisites: PH503 and PH504

PH613 Semiconductor Physics
This course is designed to provide graduate students in physics, chemistry, electrical engineering, and materials science with an ability to understand the scientific and technological backgrounds of semiconductors and related devices. Topics include: electronic structure and optical properties of semiconducting materials, defects and impurities, electron transport, electron/optical devices and device structures.
Topical Prerequisites: Schrödinger equation and Hamiltonian, crystal structure and lattices, Boltzman and Fermi-Dirac distributions, Bloch theorem.
Prerequisites: PH611 and PH612

PH711 Physics of Magnetism
This course introduces from the physics of macroscopic magnetic properties of magnetic materials to the spintronics that handles individual spins quantum mechanically. Topics include the Origin of magnetism, Magnetic domain, Magnetic anisotropy, Magnetoresistance and spin tunneling.

PH713 Physics of Superconductivity
Lectures will be given on the physical theories and applications of superconducting phenomena. The BCS theory, Ginsberg-Landau theory, Vortex theory in type II semiconductors, and the Theory of Josephson tunneling will be discussed. The physical principles and fabrication methods of superconducting electronic devices will also be discussed. Recent developments in the field of high-Tc superconductors and their technological applications will also be included.

EE547 Introduction to Quantum Information Processing
Quantum Computing is a newly emerging technique to manipulate information to solve

mathematically complex problems. This course teaches the fundamental understandings of the quantum information theory and its application with quantum computing algorithms at an entry level. The class will be concluded with discussions on quantum bit system technologies.

EE661 Solid State Physics
The course will cover basic physics and applications of various solid state materials such as metals, semiconductors, dielectrics, thermoelectric materials, and magnetic materials. Also are included the various physics of nanostructures such as quantum well, quantum wire, quantum dots.

QU960 M.S. Thesis

QU965 Independent Study in M.S.

QU980 Ph.D. Thesis

QU966 M.S. Seminar

QU986 Ph.D. Seminar