Course Syllabus: Quantum mechanics for engineering and computing.

- Credit hours: 3.0.
- 3000s level undergraduate course, ECE 3502-001.
- Prerequisites:

  APMA 1110 - Single Variable Calculus II, APMA 2120 - Multivariable Calculus, APMA 2130 - Ordinary Differential Equations, PHYS 1425 - General Physics I: Mechanics, Thermodynamics.
- Examinations and Grading: Homework (40%). Mini project using IBM Q quantum computer (60%) or standard exams (midterm exam 30%, final exam 30%).
- Textbook (recommend):

  Introduction to Quantum Mechanics, by David J. Griffiths.
  Quantum Mechanics for Scientists and Engineers, by David A. B. Miller.

- Course description:
  Quantum mechanics is one of the most important discoveries in the 20th century and has reshaped today's science and technology. The rapid development in quantum computation and information is calling for a revolution in engineering and computation. Quantum information and quantum computing is fundamentally different from the classical computers. In order to understand how to build and use a quantum computer, we will review the birth of quantum mechanics and introduce the basic ideas and principles of quantum mechanics. The fundamental concepts in quantum information and computing, such as qubit, entanglement and squeezing, will be discussed. Finally, we will take a quick tour at the physics platform candidates for quantum computing implementation, and the IBM Q quantum computing resources.

- Course objectives:
  1. To expose our students to the basic concepts and principles of quantum mechanics.
  2. To provide students with the tool to solve simple quantum problems using Schrödinger equation.
  3. To introduce the ideas and concepts of quantum computation and quantum information.

- Note: The course will differentiate itself from the Quantum Mechanics course (PHY 3650, 3660) taught in Physics department. We will not explore the contents where nontrivial mathematical formalism, such as complex Hilbert space. Contents that are physics oriented will be avoided as well, such as identical particle statistics, the variational principle, the WKB approximation, scattering and partial wave analysis.

Course outline:

Chapter 1: Introduction to the quantum world

a. A peek: how many quantum knowledges are needed to make your iPhone work?
b. Where it started: the cloud of classical physics - ultraviolet catastrophe.
c. Quanta? Photoelectric Effect.
d. Particle and wave duality for electron in hydrogen atom.

Chapter 2: Quantum 101

a. The birth of Schrödinger equation.
b. The probability wave and Schrödinger's cat.
c. Quantum operators and uncertainty principle.
d. Richard Feynman's vision: quantum computing.

Chapter 3: Physics system with quantum mechanics

a. Harmonic oscillator, photon, and optical telecommunications.
b. Bandgap and Semiconductor.
c. Electron spin and magnetic resonance imaging (MRI).

Chapter 4: Quantum information 101

a. Qubit: why is it better than classical bit?
b. The EPR paradox: do qubits communicate fast than speed of light?
c. Entanglement 1: teleportation.
d. Entanglement 2: quantum cryptography and key distribution- no eavesdropper.

Chapter 5: Quantum computer 101

a. Quantum gate vs. classical gate.
b. Quantum algorithm.
c. How to build a quantum computer?
d. Hands-on time: the IBM Q quantum computer.