**TO:** The Faculty of the College of Engineering

**FROM:** Elmore Family School of Electrical and Computer Engineering

**RE:** New Graduate Course, ECE 50652 Applied Quantum Computing 3 – Algorithm and Software

The faculty of the School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

**ECE 50652 Applied Quantum Computing 3 - Algorithm and Software**
Sem. 2, Lecture 3, Cr. 1, 5 weeks.
Prerequisite: ECE 20875, MA 26500 and MA 26600, or MA 26200, PHYS 17200, ECE AQC 1 (permanent number requested – ECE 50651)

**Description:** This course is part III of the series of Quantum computing courses, which covers aspects from fundamentals to present-day hardware platforms to quantum software and programming. The goal of part III is to discuss some of the key domain-specific algorithms that are developed by exploiting the fundamental quantum phenomena (e.g. entanglement) and computing models discussed in part I. We will begin by discussing classic examples of quantum Fourier transform and search algorithms, along with its application for factorization (the famous Shor's algorithm). Next, we will focus on the more recently developed algorithms focusing on applications to optimization, quantum simulation, quantum chemistry, machine learning, and data science. A particularly exciting recent development has been the emergence of near-intermediate scale quantum (NISQ) computers. We will also discuss how these machines are driving new algorithmic development. A key aspect of the course is to provide hands-on training for running (few qubit instances of) the quantum algorithms on present-day quantum hardware. For this purpose, we will take advantage of the availability of cloud-based access to quantum computers and quantum software. The material will appeal to engineering students, natural sciences students, and professionals whose interests are in using as well as developing quantum technologies.

**Reason:** This is an introductory course in applied quantum computing aimed at students want to enter the field. The course is offered as part of the Quantum MicroMasters program through edX. This course focuses on computing aspects quantum technologies and complements other quantum courses developed in ECE.

**Course Enrollment History:** Spring 2021 – 47, Spring 2022 – 36, Spring 2023 – 39, Spring 2024 - 48

T.S. Mith

Mithuna Thottethodi,
Associate Head for Teaching and Learning
Elmore Family School of Electrical and Computer Engineering

Schedule:

# ECE 50652 Applied Quantum Computing III- Algorithm and Software

Spring 2024

**Instructor:** Pramey Upadhyaya
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**Instructor's personal webpage:**
https://engineering.purdue.edu/ECE/People?resource_id=182798&group_id=2571

**Class Hours:** Online, asynchronous; we will also meet MWF 1:30-2:20 EST for a live recitation session online: https://www.youtube.com/playlist?list=PL9BnFkj_JF9bUuZ-ahuX7TgaQxroD-Uao

**Course Webpage: https://www.edx.org/course/quantum-computing-iii-algorithm-and-software**

**Help and Office Hours:** The most efficient way to have your question answered (one that will help other students also) is to post your questions on the discussion board at Piazza. Either the TA or I will attempt to answer your questions within one business day. Please note that we may not be able to answer your questions over the weekends and when other extraordinary circumstances delay us.

Contact for office hours through internet/audio conferencing web link will be provided at the Piazza discussion board.

**Course Overview:**

*Objective:* Learn domain-specific quantum algorithms and how to run them on present-day quantum hardware.

*Description:* This course is part III of the series of Quantum computing courses, which covers aspects from fundamentals to present-day hardware platforms to quantum software and programming.

Schedule:

The goal of part III is to discuss some of the key domain-specific algorithms that are developed by exploiting the fundamental quantum phenomena (e.g. entanglement) and computing models discussed in part I. We will begin by discussing classic examples of quantum Fourier transform and search algorithms, along with its application for factorization (the famous Shor's algorithm). Next, we will focus on the more recently developed algorithms focusing on applications to optimization, quantum chemistry, and machine learning.

A particularly exciting recent development has been the emergence of near-intermediate scale quantum (NISQ) computers. A key aspect of the course is to provide hands-on training for running (few qubit instances of) the quantum algorithms on present-day quantum hardware. For this purpose, we will take advantage of the availability of cloud-based access to quantum computers and quantum software.

*Outline by Topical Areas:*

- Textbook Quantum Algorithms
- Quantum Fourier transform and search algorithms
- Hybrid quantum-classical algorithms
- Quantum chemistry and optimization algorithms
- Quantum machine-learning algorithms
- Cloud-based quantum programming (QISKIT/ Q#)

**Prerequisites:**

Undergraduate linear algebra, differential equations, python, Quantum Computing 1: Fundamentals

**Textbook:**

None required, lecture videos and handouts will serve as the main material

**References:** Recommended:

1) Nielsen, M., & Chuang, I. (2010). Quantum Computation and Quantum Information: 10th Anniversary Edition. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511976667
2) https://qiskit.org/textbook/preface.html

- The course draws from a wide array of references that will be mentioned throughout the lectures.

**Homeworks:** There will be no graded homework. Instead you are expected to watch "lab videos" and try out running those quantum algorithms/suggested excercises in Qiskit. These self-evaluation videos are meant to help understand concepts and try in a hands-on fashion quantum algorithm.

**Exam:** There will be no final exam but a project presentation that will decide the final grade.

Schedule:

**Evaluation Criteria:** Programming Assignment-50 %, Final project -50%

**Late Work Policy:** Late work will be accepted, however, a penalty of 10% will be assessed for each day the assignment is late. This late penalty will not be assessed if you have a special situation such as illness.

**Computer Requirements:** We will primarily use Python and access to IBM's quantum machines in cloud to finish the lab part of the course. Follow the instructions here to install QISKIT: https://qiskit.org/documentation/install.html. You are also expected to open a free account at IBM to access IBM's machines: https://quantum-computing.ibm.com/