COURSE: QIC750/ECE676/PHYS768

NOTE: Everything in this course outline is contingent on the continuing state of the ongoing global pandemic. This includes how exams will be administered and the marking scheme for assessment. Everything is subject to change in response to emergency guidance and restrictions from the government and the university. Best efforts will be made to give you as much time as possible to adjust to changes.

COURSE TITLE: **Implementations of Quantum Information Processing**
INSTRUCTORS: Prof. Na Young Kim
Office: [redacted]
Email: nayoung.kim@uwaterloo.ca
Office Hours: by appointment (via email)
LECTURE HOURS: [redacted] (Webex when needed.)
TA: TBD

DESCRIPTION:
This course gives an introduction to physical implementations of quantum computers with an emphasis on common and connecting themes.

PREREQUISITE: Quantum mechanics, linear algebra

SYLLABUS:

1. ***Review of Important Quantum Models***
   Time-evolution and the Hamiltonian; The quantum harmonic oscillator; The 2-level system (spin 1/2); Density matrices. The Bloch Sphere

2. ***Spin-based Quantum Computing***
   Nuclear magnetic resonance; The Rabi problem and RWA

3. ***Superconducting Qubits***
   Quantized circuits. Charge and Flux qubits. Circuit Quantum Electrodynamics. Jaynes-Cummings Hamiltonian: Coupling between a harmonic oscillator and two-level system.

4. ***Photonic Quantum Information***
   Optical elements. Polarization, time-bin and dual-rail encoding; quantum key distribution

5. ***Ion Traps***
   Trapping ions. Optical and Microwave qubits. Raman transitions. Cirac-Zoller gate.

6. ***Special Topics***
   Students will give presentations on topics of interest to themselves drawn from the literature

COURSE MATERIAL: Lecture notes will be provided on **Learn**, as well as a draft textbook based on the notes. When in-person lectures are not allowed, online lectures will be offered through the MS Teams interface of Learn.

OTHER REFERENCE: Modern Quantum Mechanics, J.J. Sakurai. Addison-Wesley Publishing, (1994).

OTHER RESOURCES:
- We will use the **CrowdMark** platform for submitting and grading homework assignments
- We will use the **Piazza** platform for online discussions and questions

MARKING SCHEME:
- Homework: 30%
- Presentations: 20%
- Final Exam: 50%

The intention is to have a closed-book, in-person final exam. If this is not possible due to the pandemic, we will have an online exam administered through CrowdMark. If this becomes necessary, more details will be provided as soon as is practical.

Plagiarism detection software (Turnitin) will be used to screen assignments in this course, to verify that use of all materials and sources is documented. If you object to your work being screened by Turnitin, contact Prof. Kim with your concerns within the first 2 weeks of class.