APS1081 Course Description:

Quantum computation offers a novel substrate on which machine learning and other adaptive systems may be profitably realized. The course provides the student with the foundations of quantum computation (QC), machine learning algorithms, and how machine learning systems — both classical and novel ones — can benefit from QC.

The foundations of classical analog and digital computation will be first covered, including relevant aspects of the theory of operation of classical computers, how such computers are realized in hardware, and how algorithmic performance is achieved. Quantum computation (QC) will be discussed from an operational (engineering) perspective, with an emphasis on how quantum and classical computation differ, and the implications of these differences on (a) theoretical algorithmic performance, (b) novel algorithmic schemes, and (c) other pragmatic facets. As a vehicle towards understanding QC, we will cover general QC algorithms, classical algorithms on QC, as well as adaptive machine learning systems. A brief survey of supervised, unsupervised and reinforcement learning will be provided, with an emphasis on those foundational aspects that stand to benefit from QC. How such schemes may be implemented on QC and the implementation and performance perspectives will be discussed, as well as how such schemes may be modified to exploit QC-specific advantages will be presented.

Being a course on the engineering facets of QC, ML and their intersection, the course has a significant practical component to provide students with relevant practical skills, and demonstration of the underlying theory.