INTRODUCTION TO QUANTUM COMPUTING: QUANTUM ALGORITHMS AND QISKIT

MULTI-FACULTY

PRE-REQUISITES : Basic Linear algebra is a pre-requisite. (You can brush-up from any crash course, ex: https://www.khanacademy.org/math/linear-algebra) Week 0 will have a Linear Algebra Brushup Assignment that can help set expectations on pre-requisite for the course.

INTENDED AUDIENCE : Open to students, researchers and faculty from Computer Science and Physics, Mathematics and Chemistry departments.

INDUSTRIES APPLICABLE TO : IBM, Microsoft, Intel, TCS, Infosys, CQC, Honeywell, Google, Riggetti, D-Wave and several others would be interested and value this course as IBM has been the pioneer in Quantum technologies both in hardware and software and have several Quantum computers available as well as the entire software stack is available.

COURSE OUTLINE :
Quantum computing is fast emerging as one the key disruptive technologies of our times. It is a fundamentally new computing paradigm that has the potential to efficiently solve certain challenging problems which cannot be solved efficiently in a classical setting. IBM has made significant investment in this technology and is recognized as a leader in this space. This course will provide introduction to Quantum Computation, starting with basic concepts such as superposition and entanglement, to discussing the quantum circuit model of computation and basic Quantum algorithms that demonstrate the power of computing with quantum bits. We will also introduce the idea of quantum error correction to mitigate the effects of noise in today's quantum devices. We will have full hands-on sessions for each concept taught using Qiskit, a pythonic way of programming and the IBM Circuit Composer.

ABOUT INSTRUCTOR :
Prof. Prabha Mandayam, Associate Professor, IIT Madras – PhD in Quantum Computing, Caltech.Bio - Prabha Mandayam graduated with a Masters in Physics from IIT Madras and obtained her PhD from the Institute for Quantum Computing at Caltech. After working as a post-doctoral fellow at the Institute for Mathematical Sciences and INSPIRE faculty fellow at the Chennai Mathematical institute, she rejoined her alma mater as faculty in 2014,. Her research interests include quantum error correction and quantum cryptography.

Prof. Anupama Ray, Advisory Research Scientist, IBM Quantum Ambassador and Qiskit Advocate, IBM Research – PhD in Deep Learning, IIT Delhi. Bio- Anupama Ray is an Advisory Research Scientist at IBM Research, India. She is an IBM Quantum Ambassador and a Qiskit Advocate. She completed her Ph.D from Indian Institute of Technology Delhi. With her doctoral research focusing on developing and applying multi-dimensional deep recurrent neural networks for document analysis and computer vision applications. At IBM Research she has been predominantly working in the area of natural language processing: building NLP systems for low-resource languages, domain independent information extraction systems and natural language generation. She has interests in Quantum ML, Quantum NLP, and AI for societal applications. She has published several papers in top tier conferences and journals and has received several Best paper awards. She has been the recipient of the IEEE Best Woman Professional (Early Career) and several awards at IBM Research such as Research Division Award, Eminence and Excellence Award and Outstanding Technical Achievement Award to name a few. She was nominated and selected as a Young Scientist in Global Young Scientist Summit and is an active member of IEEE, AAAI, and Society of Women Engineers (SWE) India.

Prof. Sheshashayee Raghunathan, Senior Engineer IBM Quantum Ambassador and Qiskit Advocate – PhD in Quantum Computing, University of Southern California Bio- Shesha Raghunathan joined IBM in 2011 as part of Electronic Design Automation (EDA) Timing analysis development team. He has worked on various aspect of analysis including noise, timing abstraction and reporting. Currently he has been focusing primarily on EDA 3.0 (analytics in EDA) and is leading timing triage efforts. Since 2018 he has additional responsibility of being an IBM Quantum Ambassador, now a Distinguished Ambassador, and is the team lead for India/SA region. As IBM Quantum Distinguished Ambassador Shesha is amongst few who can officially talk about and for IBM Quantum technology. Shesha got his PhD in Electrical Engineering (Quantum Computing) from University of Southern California, LA in 2010. He has over 10 publications spanning reconfigurable computing, static timing analysis and quantum computing, and has 4 patents to his name.

COURSE PLAN :

Week 1: Introduction and IBM Quantum Perspective, Q Mission in India – Invited talk, Quantum Computing Applications, Quantum Computing Basics

Week 2: IBM Quantum Composer and Quantum Lab using Qiskit

Week 3: Quantum Algorithms-I (Oracles, Deustch Jozsa), Quantum Algorithms-II (Grover's Algorithm with Hands-on)

Week 4: Quantum Error Correction – Invited Talk, NISQ era Quantum Algorithms (VQE/QAOA and industrial applications)