QUANTUM COMPUTING

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TYPE OF COURSE	: Rerun| Elective | UG
COURSE DURATION	: 12 weeks (29 Jul'19 - 18 Oct'19)
EXAM DATE	: 16 Nov 2019

INDUSTRIES APPLICABLE TO : Intel, Microsoft Research

COURSE OUTLINE

Quantum computing exploits the quantum mechanical nature of matter to simultaneously exist in multiple possible states. Building up on the digital binary logic of bits, quantum computing is built on the basis of interacting two-level quantum systems or 'qubits' that follow the laws of quantum mechanics. Addressability of the quantum system and its fragility to fidelity are the major issues of concern, which if addressed appropriately, will enable this new approach to revolutionize the present form of computing. After developing the basics, this course delves on various implementation aspects of quantum computing and quantum information processing.

ABOUT INSTRUCTOR

Prof. Debabrata Goswami, Department of Chemistry, Indian Institute of Technology, Kanpur works at the forefront of interdisciplinary research that embodies theoretical and experimental developments in the fundamental aspects of femtosecond laser-matter interactions for applications towards quantum computing. After receiving undergraduate degree from IIT Kanpur, Dr. Goswami went to US with multiple scholarships to receive his PhD from Princeton University and completed his one-year postdoctoral Fellowship at Harvard University in 1995. After several research jobs in US, he returned to India in 1998 as a Faculty in TIFR (Mumbai). He moved to IIT Kanpur in 2004, where he continues as the Professor of Chemistry. He is the recipient of several academic and research accolades, including the Wellcome Trust International Senior Research Fellowship (UK), the Swarnajayanti Fellowship and the Thathachary Science Award (India). He is Fellow of the Royal Society of Chemistry, as well as member of several academic and professional societies and councils. He has published well over hundred peer-reviewed research articles, several book chapters, edited conference proceedings and books. His popularizes Science Education and is a popular K12 teacher on Indian television. Over the past decade and half, he has taught several courses both at UG and PG courses at TIFR and IIT Kanpur. The course on Quantum Computing was conceived and developed by Prof. Goswami as an open elective at IIT Kanpur more than a decade back and he has taught it eight times since.

COURSE PLAN

Week 1: Quantum Measurements Density Matrices; • Positive-Operator Valued Measure

Week 2: Fragility of quantum information: Decoherence; • Quantum Superposition and Entanglement

Week 3 : Quantum Gates and Circuits; • No cloning theorem & Quantum Teleportation

Week 4: Bell's inequality and its implications; • Quantum Algorithms & Circuits

Week 5: Deutsch and Deutsch–Jozsa algorithms; • Grover's Search Algorithm

Week 6: Quantum Fourier Transform; • Shore's Factorization Algorithm

Week 7: Quantum Error Correction: Fault tolerance; • Quantum Cryptography

Week 8: Implementing Quantum Computing: issues of fidelity; • Scalability in quantum computing

Week 9: NMR Quantum Computing; • Spintronics and QED approaches

Week10: Linear Optical Approaches; • Nonlinear Optical Approaches;

Week 11: Limits of all the discussed approaches

Week 12: How promising is the future?