SECOND SEMESTER 2019-2020

COURSE HANDOUT (PART II)

Date: 15.01.2021

In addition to Part I (General Handout for all courses appended to the Time Table), this portion gives further specific details regarding the course.

Course Number: BITS F386

Course Title: Introduction to Quantum Information and Computation

Instructor-in-Charge: RR Mishra

Scope & Objectives: This is an introductory course on the rapidly developing interdisciplinary field of Quantum Information and Computation. The course does not require a thorough knowledge of either Computer Science or Quantum Physics. Relevant concepts of either subject will be developed during the course of instruction.

Course Description: This course is divided into three main parts. (1) *Foundation:* Basic ideas and interpretation of quantum mechanics relevant for understanding quantum information. (2) *Quantum Computation:* Quantum circuit model, quantum gates, and quantum algorithms. (3) *Quantum Information:* Quantum version of Shannon's classical theory of information, quantum cryptography, error correction, etc.

Books:

Textbook : **i)** Quantum Computer Science, An introduction by N. David Mermin, Cambridge University Press (2007)

ii) Quantum Information Theory, Second Edition by Mark M Wilde, Cambridge University Press, 2017

Reference books:

(i) Quantum Computation and Quantum Information, M. A. Nielsen and I. L. Chuang, Cambridge Univ. Press 2002 (**RBI**)

(ii) Quantum Information, Lecture Notes by John Preskill (**RBII**)

Course Plan:

Lec. #	Learning Objectives	Topics to be covered	Reference to Textbook

1	Introduction & Overview	------	----
2-3	Review of Vector Spaces	Basic concepts, Dirac notation, Inner product and orthogonality	TB (i) : Appendices
4 - 8	Foundations of Quantum Concepts (1) : Noiseless Quantum Theory	Quantum Bits, Measurement, Reversible Evolution, Composite Systems, Entanglement	TB (ii): Ch 3
9 - 12	Foundations of Quantum Mechanics (ii) : Noisy Quantum Theory	Noisy (Mixed) Quantum State, Measurement in Noisy Quantum Theory, Evolution of a Noisy Quantum State	TB(ii) : Ch 4
13-22	Quantum computation (General features)	Cbits, Reversible operations on Cbits, Qbits, Reversible operations on Qbits, Circuit diagrams, Measurement gates, The general computational process, Deutsch problem, Bernstein-Vazirani problem, Simon's problem, Constructing Toffoli gates	TB(i) : Chap. 1-2
23-27	Breaking RSA encryption	RSA encryption, Quantum period finding, Calculating the periodic function, Period finding and factoring	TB(i) : Ch.3
28-31	Searching with a quantum computer	The nature of the search, The Grover iteration, Generalization to several special numbers	TB(i) : Ch.4
32-36	Quantum error correction	The physics of error generation, The 5-Qbit error-correcting code, The 7-Qbit error-correcting code, Encoding circuits	TB(i) : Ch.5
37-40	Protocols	Bell states, Quantum Cryptography, Bit commitments, Quantum dense coding, Teleportation, The GHZ puzzle	TB(i) : Ch.6

Evaluation Scheme:

No.	Evaluation Component	Duration	Weightage	Date & Time

1	Tutorial Tests (3 tutorial tests)		10 x 3 = 30%	
2	Assignments (2 No.)		5 x 2 = 10%	
2	Mid-Term (Closed book)	To be announced later	25%	To be announced later
3	Comprehensive Exam. (Open* + Closed book)	To be announced later	35%	To be announced

***Open Book**: Only the books listed in the handout and handwritten notes are allowed.

Chamber Consultation Hours: To be announced in the class.

Notices: Will be put on Nalanda site only.

Make-up Policy: Make-up will be given only in genuine cases, that is, illness leading to hospitalization or emergency situation requiring absence from campus. No make-ups for the tutorials and assignment submissions.

Instructor-in-charge