SECOND SEMESTER 2017-2018

COURSE HANDOUT (PART II)

Date: 6th January 2018

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: Jayendra N. Bandyopadhyay

1. **Course Description:**

This course is divided into three parts. (1) *Foundation:* This part is divided into two sub-parts. (a) *Mathematical foundation*: Basic mathematical tools will be discussed. (b) *Quantum Mechanical foundation*: Basic ideas and interpretation of quantum mechanics relevant for understanding quantum information will be discussed. (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.

2. **Scope & Objectives:**

- This is an introductory course on a rapidly developing interdisciplinary field.
- Students from different disciplines will get opportunity to exchange ideas. This will help them to develop base for advanced studies in many other interdisciplinary fields.
- Understand the difference between the macroscopic classical world, and the microscopic world governs by the rules of quantum mechanics.
- Understand the application of quantum mechanics:
    - To develop different quantum algorithms.
    - To develop quantum communication protocols
    - To develop quantum informational protocols.

Books:

(I) Textbook: Quantum Computation and Quantum Information, M. A. Nielsen and I. L. Chuang, Cambridge Univ. Press 2002 (**TB**).

(II) Class notes: Most of the available books on this subject are very exhaustive, including our prescribed Textbook. So my sincere suggestion will be to prepare proper class notes and use it for all things including your Open Book part of examination

(III) Reference books:

(a) Principles of Quantum Computation and Information, Vols. 1 & 2, G. Benenti, G. Casati, and G. Strini, World Scientific, 2007.

(b) Quantum Theory: Concepts and Methods, A. Peres, Kluwer Academic Publishers, 1999.

Course Plan:

Module Number	Lecture Sessions	Reference	Learning Outcome
1. Mathematical foundation	L1.1. Basics of vectors L1.2. (Real) Linear vector space 1 L1.3. (Real) Linear vector space 2 L1.4. Complex vector space 1 L1.5. Complex vector space 2 L1.6. Hilbert space	TB Chap 1-2 Class notes	Understanding of basic mathematical tools required for the development of all quantum computational and informational protocols
2. Foundation of Quantum Mechanics (QM)	L2.1. Counterintuitive experiments of QM L2.2. More experiments L2.3. Postulates of QM L2.4. Discussion on the interpretation of the	TB Chap. 2 Class notes	Understanding of quantum mechanics and how it explains different so called counter intuitive phenomenon of (microscopic) quantum world.

	postulates L2.5. Introduction of qubit(s) L2.6. Bloch sphere representation of qubit L2.7. Composite system: Entanglement L2.8. EPR pairs and its so called paradox L2.9 Bell's inequality L2.10. No cloning principle		
3. Quantum Computation	L3.1. Quantum circuit model 1 L3.2. Quantum circuit model 2 L3.3. Quantum circuit model 3 L3.4. Logic gates L3.5. Quantum gates 1 L3.6. Quantum gates 2 L3.7. Universal gates L3.8. Quantum teleportation L3.9. Super-dense coding L3.10. Deutsch/Deutsch-Jozsa algorithm L3.11. Grover's search	TB Chap. 4-6 Class notes	1. Basic model of quantum computer. 2. Quantum computational protocols. 3. Quantum algorithms.

	algorithm 1 L3.12. Grover's search algorithm 2 L3.13. Shor's algorithm 1 L3.13. Shor's algorithm 2 L3.14. Shor's algorithm 3		
4. Quantum Information	L4.1. Shannon's coding theorem 1 L4.2. Shannon's coding theorem 2 L4.3. Quantum coding theorem 1 L4.4. Quantum coding theorem 2 L4.5. Mathematical properties of entropy: von Neumann entropy L4.6. Relative entropy L4.7. Quantum cryptography 1 L4.8. Quantum cryptography 2 *L4.9. Quantum error correction 1 *L4.10. Quantum error correction 2 *If time permits	TB Chap. 10-12	1. Glimpses of classical information theory 2. Quantum informational protocols

Evaluation Scheme:

No.	Evaluation Component	Duration	Weightage	Date & Time
1	Tutorials	--------	30%	
2	Mid-Term (Close book)	90 Mins	30%	7/3 9:00 - 10:30 AM
3	Comprehensive Exam. (Open*+Close book)	3 Hrs	40%	5/5 FN

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

Chamber Consultation Hours: To be announced in the class.

Notices: Will be uploaded on Intrabits site only.

Make-up Policy: Make-up will be given only in genuine cases, that is, illness leading to hospitalization or going out of station with prior permission. No make-ups for the tutorials.

Instructor-in-charge