B.Tech. Minor Programme in Quantum Technology

Semester 2:

PH1094M: Mathematical Foundations of Quantum Computing [3-0-0-6]

Probability and Statistics: Introduction to Statistics, Data Representation, Random Variables and Probability Distributions [8]; **Mathematical Tools for Quantum Computing**: Function Spaces and Basic Operators, Fourier Transform [6]; vectors and vector spaces, inner products, norms and orthogonality, matrices and linear transformations [8]; **Introduction to Computational Models**: Classical Bits vs Information Representation, Introduction to Algorithms and Computational thinking, Basics of Boolean Algebra, Logic Gates and Circuits, Limitations of Classical Computation [18].

Text Books :
1. Larson, R. (2026). Elementary Statistics: Picturing the World (9th ed.). Pearson
2. Mano, M. M. (1993). Computer System Architecture (3rd ed.). Prentice Hall
Reference Books :
1. Floyd, T. L. (2015). Digital Fundamentals (11th ed.). Pearson
2. Mano, M. M. (1979). Digital Logic and Computer Design. Pearson
3. Nielsen, M. A. & Chuang, I. L. (2010). Quantum Computation and Quantum Information (10th Anniversary ed.). Cambridge University Press

Semester 3:

PH xxxxM Foundation of Quantum Technologies [3-0-0-6]

Quantum Computation: Basics of qubits, Basics of qubit gates and quantum circuits, Physical implementation of qubits, Overview of applications and recent achievements [12]; **Quantum Sensing**: Basics of quantum sensing, Basics of Photon, State of the art in Quantum Sensing [6]; **Quantum Communications**: Basics of digital communication [3], Quantifying classical information – Shannon entropy, Basic ideas of quantum communication [10], security, eavesdropping, Overview of quantum communication achievements [9].

Text Books :
1. Manenti, R. & Motta, M. (2023). Quantum Information Science (1st ed.). Oxford University Press
2. Nielsen, M. A. & Chuang, I. L. (2010). Quantum Computation and Quantum Information (10th Anniversary ed.). Cambridge University Press
Reference Books :
1. Kaye, P., La!amme, R. & Mosca, M. (2006). An Introduction to Quantum Computing. Oxford University Press
2. McMahon, D. (2007). Quantum Computing Explained. Wiley

Semester 4:

PH xxxxM Quantum Technologies and Applications

Quantum Mechanics: Postulates of Quantum Mechanics [4],Density operator formalism of quantum mechanics – pure and mixed states [3],Superposition and Entanglement in quantum mechanics [3],No cloning theorem, Applications of postulates [2], Number states, ladder operators [4] and Coherent states of a harmonic oscillator [2],Spin and Angular momentum – spin half particles [3],Rabi problem of a spin-half particle in a rotating magnetic field [3]; Statistical Physics:Quick review of first and second laws of thermodynamics [1], Thermal Equilibrium and Gibbs principle,Applying Gibbs principle [2] to Classical and Quantum harmonic oscillators [3],Bosons and Fermions and Quantum statistics [2];Information Science: Digital communication and information [1],Basic ideas of quantum

information [3],Decoherence and noise [3],Introductory ideas of Kraus operator [2];Brief overview of Computational Complexity [1]

Text Books :
1. Gri!ths, D. J. (2024). Introduction to Quantum Mechanics (3rd ed.). Cambridge University Press
2. Nielsen, M. A. & Chuang, I. L. (2010). Quantum Computation and Quantum Information (10th Anniversary ed.). Cambridge University Press

Semester 5:

PH xxxxM Quantum Computation

Computer Architecture Basics: Principles of Computer Design [2], Basic Computer organization and Microprocessor [3], Memory Hierarchy [1] Review of Turing Machines and Classical Computational Complexity [2]; Qubits versus classical bits [3]; Quantum correlations [3];Introduction to Quantum computational models [2];Universal quantum logic gates [3] and circuits [3], Gate Universality and examples[2]; Quantum algorithms [2]; Quantum Fourier Transform and prime factorization [6]; Database search [3];Quantum complexity classes [2];Additional Topics in Quantum Algorithms [2];Introduction to Error correction[3]

Text Books :
1. Manenti, R. & Motta, M. (2023). Quantum Information Science (1st ed.). Oxford University Press
2. Frank Gaitan (2008). Quantum error correction and Fault tolerant computing (1st ed.). CRC Press
Reference Books :
1. Nielsen, M. A. & Chuang, I. L. (2010). Quantum computation and quantum information (10th Anniversary ed.). Cambridge University Press
2. Hui Yung Wong (2022). Introduction to Quantum Computing: From a lay person to a programmer in 30 steps (1st ed.). Springer Nature Switzerland AG

Semester 6:

PH xxxxM Basic Laboratory Course for Quantum Technologies*

Experiments based on advanced RF and microwave electronics, quantum optics, quantum noise and quantum computing. Hands on skill development towards laboratory equipment interfacing and automation.

Reference Books :
1. E. Hecht (2019). Optics (5th ed.). Pearson Education
2. B. E. A. Saleh & M. C. Teich (2019). Fundamentals of Photonics (3rd ed.). John Wiley \& Sons
3. P. Horowitz & W. Hill (2015). The Art of Electronics (3rd ed.). Cambridge University Press
4. D. M. Pozar (2011). Microwave Engineering (4th ed.). John Wiley \& Sons
5. J. Essick (2019). Hands-On Introduction to LabVIEW for Scientists and Engineers (4th ed.). Oxford University Press
6. R. A. Witte (2014). Spectrum and Network Measurements (2nd ed.). SciTech Publishing
7. B. Razavi (2011). RF Microelectronics (2nd ed.). Prentice Hall

*The below-mentioned course is alternative to the above 6th Semester course (Huge funding is sought to set up a QT Laboratory. It is under consideration by Govt. Funding agency.in case of no funding to set-up a QT-Laboratory the below mentioned course will run)

OR

PH xxxxM Quantum Technology Numerical Laboratory

Basic Numerical Methods: Overview of Programming using Python; Matrix inverse, Eigenvalue problem, Diagonalization of matrices, Singular value decomposition; Numerical integration and differential equations; Random number generation, computing statistical moments for data samples, Monte Carlo sampling.
Applications to Quantum Technology: Eigen energies of coupled two level systems, Eigen energies of two-level system coupled to oscillator (Jaynes-Cummings Model), Driven two-level system – Rabi Problem, driven damped oscillator — coherent states; Simulating single-qubit and multi-qubit systems, gate operations, and state-vector evolution; Simulating decoherence, dephasing, and amplitude damping using master equations; Simulating spin systems (like Nitrogen-Vacancy centers in diamond) or superconducting qubit Hamiltonians.

Text Books and References:

1. Computational Physics: Problem solving with Python, Rubin H. Landau et al. 4th Ed. Wiley (2024).
2. Programming Quantum Computers: Essential Algorithms and Code Samples, Eric R. Johnston, Nic Harrigan and Maercedes Gimeno-Segovia
3. QuTiP 5: The Quantum Toolbox in Python, by Neill Lambert, Eric Giguère, Paul Menczel, et al. , Physics Reports,1153,1-62 (2026)
4. Quantum Computing with Qiskit [Open source]