

VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI) MATUNGA, MUMBAI 400 019
(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)
For

Multi-Disciplinary Minor
in
Quantum Technology

Implemented for the batch admitted in Academic Year 2026–27



Department of Computer Engineering and Information Technology,
2026

Proposed Scheme Structure of the Minor (Quantum Technology) Program

(OPEN TO ALL BRANCHES)

Table of Courses

Sr.	Semester	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	III	R5IT2209T	Introduction to Quantum Technologies and Applications	2	0	0	2	2	20	30	50
2	IV	R5IT2210T	Foundations of Quantum Technologies	2	0	0	2	2	20	30	50
3	V	R5IT3209T	Programming for Quantum Technologies	2	1	0	3	3	20	30	50
4	VI	R5IT3210T	Quantum Technologies Theory to Experiments	2	1	0	3	3	20	30	50
5	VII	R5IT4205T	Introduction to Quantum Computation	3	1	0	4	4	20	30	50
6	VII	R5IT4206T	Introduction to Quantum Communication	3	1	0	4	4	20	30	50
7	VII	R5IT4207T	Introduction to Quantum Sensing	3	1	0	4	4	20	30	50
8	VII	R5IT4208T	Introduction to Quantum Materials	3	1	0	4	4	20	30	50
9	VIII	R5IT4209T	Engineering Foundations of Quantum Technologies	4	0	0	4	4	20	30	50
10	VIII	R5IT4210T	Solid State Physics for Quantum Technologies	4	0	0	4	4	20	30	50
11	VIII	R5IT4211T	Quantum Optics	4	0	0	4	4	20	30	50
Total								18			

Abbreviations: **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester (Written) Examination, **CO** Course Outcome.

QT 01: Quantum Technologies and Applications 3:0 (Mandatory)

Programme Name	B. Tech. Computer Engineering	Semester: III
Course Code	R5IT2209T	
Course Title	Introduction to Quantum Technologies and Applications	
Course Scheme	(L-T-P: 2-0-0) (TA-MST-ESE : 20-30-50)	
Credits	2	
Course Type	Multi-disciplinary Minor-I (Quantum Technologies)	

COURSE OUTCOMES

This course is meant to give an overview of the field of quantum technologies and make the students familiar with the state-of-the-art in all four verticals. The emphasis is not on depth in this course, but on covering the exciting aspects of the field.

Students of this course learn:

CO	Course Outcome
CO1	The general physical principles of realizing qubits for computation
CO2	The various hardware implementations of qubits for computation
CO3	The basic ideas of quantum sensing
CO4	The applications of quantum sensing
CO5	The implementations of quantum communications protocols in fibre-based and free-space

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Quantum Technologies – four verticals, Motivation for Quantum Technologies	(1 Hour)	CO1–CO5
2	A qualitative overview of salient aspects of quantum physics: Quantum States, Wavefunctions, Probabilistic interpretation, Physical observables, Hermitian operators, expectation values, Heisenberg uncertainty principle, Schrodinger equation, Time evolution, distinction from classical physics, Heuristic description of Superposition, Tunnelling and entanglement, No cloning theorem, Simulating classical systems – Feynman’s idea of a quantum simulator and the birth of the field	(4-5 Hours)	CO1, CO2

Unit	Course Contents	Hrs	CO
3	Quantum Computation : Basics of qubits – what is a qubit?, How is it different from a classical bit? – Review of classical logic gates, Di Vincenzo criteria for realising qubits, Basics of qubit gates and quantum circuits, Physical implementation of qubits (very qualitative description) : • Solid State Qubits : Semiconducting Qubits – quantum dots, spins; Superconducting Qubits – charge, flux and phase; Topological Qubits – proposals and advantages • Atoms and Ions : Trapped ions, Rydberg atoms, Neutral atoms • Photonic Qubits : Conventional linear optical setups, Integrated Photonics • NMR qubits : Conventional NMR qubits- NV centres • Overview of applications and recent achievements :RSA and Shor’s algorithm, Quantum Advantage • Long term goals and strategies being followed : Error correction	(10-12 Hours)	CO1, CO2
4	Quantum Sensing : Basics of quantum sensing, Basics of Photon (single and entangled) generation and detection, Gravimetry, Atomic clock, Magnetometry, State of the art in Quantum Sensing	(8-10 Hours)	CO3, CO4
5	Quantum Communications : Basics of digital communication, Quantifying classical information – Shannon entropy, Basic ideas of quantum communication, security, eavesdropping, Overview of quantum communication achievements, Terrestrial – fibre-based, Free space, Satellite-based	(8-10 Hours)	CO5
6	Topics on Quantum Materials are to be covered in the other portions of the course wherever required and are not listed separately here.	–	–

Course References:

Sr. No.	Reference
1	Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
2	Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
3	Quantum Computing & Techniques, Dr. R. Chopra, Khanna Publishing House (2025).
4	Elements of Quantum Computation and Quantum Communication, A. Pathak, Boca Raton, CRC Press (2015)
5	An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, and Michele Mosca, Oxford University Press (2006)

Sr. No.	Reference
6	Quantum computing explained, David McMahon, Wiley (2008)
7	Quantum Computing Mechanics, A. B. Bhattacharya, Khanna Publishing House (2025)

QT 02: Foundations of Quantum Technologies

Programme Name	B. Tech. Computer Engineering	Semester: IV
Course Code	R5IT2210T	
Course Title	Foundations of Quantum Technologies	
Course Scheme	(L-T-P: 2-0-0) (TA-MST-ESE : 20-30-50)	
Credits	2	
Course Type	Multi-disciplinary Minor-II (Quantum Technologies)	

COURSE OUTCOMES

This course is meant for laying down the central theoretical aspects of quantum mechanics in a rigorous manner where students learn the techniques and develop a good intuition for quantum physics.

Students of this course learn

CO	Course Outcome
CO1	The most relevant mathematical techniques
CO2	Basic postulates of quantum mechanics and applications
CO3	Basics of Statistical Physics
CO4	Basics of Information Science
CO5	Basics of computational complexity

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Quantum Mechanics: Brief overview of classical physics (This segment is meant for the student to understand what a Hamiltonian is, which will feature later in quantum mechanics) : Hamiltonian function and Hamilton's equations, Phase-space description of a system, Connection and Equivalence with Newton's laws for simple systems – free particle, particle moving in a conservative potential, examples of Harmonic oscillator, hydrogen atom. • Historical evolution of quantum mechanics : Planck's quantum hypothesis, Photo electric effect, Atomic spectra, Bohr's quantization principle, De Broglie's Wave particle duality. • Postulates of Quantum Mechanics: State vectors and Hilbert Space, Dirac Bra-Ket notation, Measurables and Hermitian Operators, Unitary Transformations, Schrodinger Equation and Time evolution of quantum states, Measurement Postulate, Schrodinger, Heisenberg and Interaction pictures, Eigen values, Expectation values and Matrix elements, Heisenberg's Uncertainty principle. • Density operator formalism of quantum mechanics – pure and mixed states • Superposition and Entanglement in quantum mechanics No cloning theorem • Applications of postulates –Particle in a box, Hydrogen atom, Harmonic Oscillator • Number states, ladder operators and Coherent states of a harmonic oscillator • Spin and Angular momentum – spin half particles • Rabi problem of a spin-half particle in a rotating magnetic field • Bosons and Fermions	(16 - 18 Hours)	CO1, CO2
2	Statistical Physics : Quick review of first and second laws of thermodynamics, Thermal Equilibrium and Gibbs principle, Applying Gibbs principle to Classical and Quantum harmonic oscillators, Bosons and Fermions and Quantum statistics – Fermi-Dirac and Bose- Einstein distributions	(8-10 Hours)	CO3
3	Information Science: Digital communication and information-Quantifying information in terms of Shannon entropy, Basic ideas of quantum information, Decoherence and noise; Introductory ideas of Kraus operators	(3-4 Hours)	CO4
4	Brief overview of Computational Complexity: Qualitative ideas of a Turing machine- Types of Turing machines, Time and Space complexity – P vs NP, PSPACE , Quantum complexity classes – Q, EQP, BQP, BPP, QMA, Post Quantum Cryptography (PQC)	(5-6 Hours)	CO5

Course References:

Sr. No.	Reference
1	AICTE Prescribed Textbook: Physics (Quantum Mechanics for Engineers), A. B. Bhattacharya & Atanu Nag, Khanna Publishing House (2025)
2	Introduction to Quantum Mechanics, Griffiths D. J., 3rd Edition, Cambridge University Press (2024)
3	Introduction to Electrodynamics, Griffiths D. J., 4th edition, Cambridge University Press (2020)
4	Principles of Quantum Mechanics, Shankar, R., 2nd edition, Springer (2014)
5	Architectures and Cryptographic Universes, A. B. Bhattacharya, Khanna Publishing House (2025).
6	Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
7	Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
8	A Pathak, Elements of Quantum Computation & Quantum Communication, Boca Raton, CRC Press (2015)
9	Information Theory, Robert B. Ash, Dover Publications (2003)
10	Introduction to the Theory of Computation, Michael Sipser, 3rd edition, Cengage India(2014)
11	Statistical Mechanics, Pathria R. K., Paul D. Beale, 4th edition, Academic Press, (2021)

QT 03: Programming for Quantum Technologies (2:1)

Programme Name	B. Tech. Computer Engineering	Semester: V
Course Code	R5IT3209T	
Course Title	Programming for Quantum Technologies	
Course Scheme	(L-T-P: 2-0-1)Th: (TA-MST-ESE : 20-30-50)Lab : (TA-ESE : C-60-40)	
Credits	3	
Course Type	Multi-disciplinary Minor-III (Quantum Technologies)	

COURSE OUTCOMES

This course is meant to provide students a quick hands-on experience in scientific computing and its applications to areas within Quantum Technologies.

Students of this course learn

CO	Course Outcome
CO1	Basics of programming
CO2	To write programs to solve scientific problems
CO3	Techniques for scientific computing
CO4	Applications to quantum mechanics and electromagnetism

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Basics of programming: • Data structures, classes, Object-oriented programming • Data storage and retrieval, Memory allocation • Scientific plotting, documentation of codes	6	CO1
2	Simple algorithms and benchmarking run time • Sorting • Searching • Arithmetic algorithms like GCD, Prime factorisation	6	CO1, CO2
3	Numerical Integration and differential equations • Linear 2nd Order ODEs with constant coefficients • Linear 2nd order ODEs with variable coefficients • Boundary value problems : Poisson equation, Laplace equation, Wave equation, Diffusion Equation	6	CO2, CO3
4	Numerical techniques in linear algebra : Matrix inverse, Eigenvalue problem, Diagonalization of matrices, Singular value decomposition	4	CO3
5	Numerical techniques in Probability and Statistics : (Pseudo) Random number generation, Computing statistical moments for data samples, Least Squares fitting, Error Analysis, Hypothesis Testing, Monte Carlo sampling	4	CO3

Unit	Course Contents	Hrs	CO
6	Applications to Quantum Mechanics (can be done using openly available modules in languages like Python, Julia etc.) : 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.	6	CO4
7	Applications to EM theory (e.g. magnetic field simulation) : Electrostatic charge distributions, Magneto-static current distributions. • Finite Element techniques for electromagnetic simulations	–	CO4

Course References:

Sr. No.	Reference
1	AICTE Prescribed Textbook: Physics (Quantum Mechanics for Engineers), A. B. Bhattacharya & Atanu Nag, Khanna Publishing House (2025).
2	Computational Physics, Nicholas Giordano, Hisao Nakanishi, 2nd edition, Pearson-Addison Wesley (2005)
3	Engineering Physics, A. B. Bhattacharya, Khanna Publishing House (2025).

QT 04: Quantum Technologies: Theory to Practice (2:1)

Programme Name	B. Tech. Computer Engineering	Semester: VI
Course Code	R5IT3210T	
Course Title	Quantum Technologies Theory to Practice ¹	
Course Scheme	(L-T-P: 2-0-1) (TA-MST-ESE : 20-30-50)	
Credits	3	
Course Type	Multi-disciplinary Minor-IV (Quantum Technologies)	

COURSE OUTCOMES

² Students of this course learn :

CO	Course Outcome
CO1	Basic experimental techniques in optics
CO2	Basic experimental techniques in characterizing resonators and RLC circuits
CO3	Basic digital circuits
CO4	Fundamental techniques in RF engineering
CO5	Interfacing instruments with computers and carry out data acquisition

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Optics : • Interferometry – wavelength measurements, intensity measurements • Diffraction – single slit, grating • Microscopy – magnification, aberration • Polarization optics – PBS, HWP, QWP	–	CO1
2	RLC circuits • Series and parallel RLC circuits – Verifying the quality factor formulae • Extracting intrinsic losses	–	CO2
3	Digital circuits • Adder, Multiplier • Encoder, Decoder • D flipflop, shift registers • How to use common Integrated Circuit chips	–	CO3

¹The source document's course-information table literally lists the Course Title as *Quantum Technologies Theory to Practice* here, even though the section heading and the unit contents both correspond to *Quantum Technologies: Theory to Practice* (. This appears to be a copy-paste inconsistency in the original source document and is reproduced here as-is.

²The source document's course-information table for this course literally repeated the previous course's Course Outcomes text verbatim. The outcomes shown below are instead taken from the course-specific outcomes list given separately in the source document for this course.

Unit	Course Contents	Hrs	CO
4	Radio Frequency Technology: • Using Oscilloscope • Ring-up and ring-down time measurements of RLC circuits • Measurements of different pulse-shapes generated by a function generator • Using Vector Network Analyser • Transmission and reflection measurements of coaxial cable in open, short and matched termination • Voltage standing wave ratio measurement • Amplitude and Phase quadrature, In-phase and Out-of-phase quadrature plots and Quality factor measurement of RLC circuits • Characterising S-parameters, ABCD and Z matrices of common 2 port networks – coaxial cable, attenuator, low pass high pass bandpass filters etc. • Characterising 3 port networks – directional couplers, circulators, isolators. Using a spectrum analyser : Noise from a resistor at different temperatures	–	CO4
5	Interfacing instruments with a computer	–	CO5
6	Data acquisition: Signal demodulation – heterodyne vs Homodyne, mixing of signals, Sampling, digitisation using ADCs – under-sampling and aliasing, over-sampling and noise, Averaging and interpolation techniques	–	CO5
7	Quantum Simulators: Running quantum protocols in a quantum simulator, implementing simple quantum algorithms on cloud-based quantum computers (depending on availability of time on such machines)	–	CO5
8	Running simple algorithms on cloud-based quantum processors	–	CO5

Course References:

Sr. No.	Reference
1	Optics, Eugene Hecht, A. R. Ganesan, 5th edition, Pearson (2019)
2	Art of Electronics, Paul Horowitz and Winfield Hill, 3rd edition, Cambridge University Press (2015)
3	All-in-One Electronics Simplified, Anil Maini, Khanna Book Publishing Co. (2022).
4	Digital Design, Morris Mano, Michael D. Ciletti, 6th edition, Pearson Education (2018)
5	Microwave Engineering, David Pozar, 4th edition, Wiley (2013)
6	Discrete-time signal processing, Alan V. Oppenheim and Ronald W. Shaffer, 4th edition, Pearson (2009)

Sr. No.	Reference
7	Introduction to Quantum Communication, A. B. Bhattacharya, Khanna Publishing House (2025).
8	Optical quantum information and quantum communication, A. Pathak and A. Banerjee, SPIE Spotlight Series, SPIE Press (2016)

QT 05: Introduction to Quantum Computation 3:0

Programme Name	B. Tech. Computer Engineering	Semester: VII
Course Code	R5IT4205T	
Course Title	Introduction to Quantum Computation	
Course Scheme	(L-T-P: 3-0-1) (TA-MST-ESE : 20-30-50)	
Credits	4	
Course Type	Elective-I (Quantum Technologies)	

COURSE OUTCOMES

Students of this course learn

CO	Course Outcome
CO1	To review the basic postulates of quantum mechanics.
CO2	The theoretical basics of qubits and their physical realizations.
CO3	To work with density operators and time evolution for mixed states.
CO4	The basic ideas of quantum gates.
CO5	The working of important quantum algorithms.
CO6	The basics of quantum error correction.

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Qubits versus classical bits : Spin-half systems and photon polarizations, Trapped atoms and ions, Artificial atoms using circuits, Semiconducting quantum dots, Single and Two qubit gates – Solovay - Kitaev Theorem	–	CO2
2	Quantum correlations : Entanglement and Bell's theorems	–	CO2, CO3
3	Review of Turing machines and classical computational complexity : Time and space complexity (P, NP, PSPACE)	–	CO5
4	Reversible computation	–	CO4
5	Universal quantum logic gates and circuits	–	CO4
6	Quantum algorithms : Deutsch algorithm, Deutsch Josza algorithm, Bernstein - Vazirani algorithm, Simon's algorithm	–	CO5
7	Database search :Grover's algorithm	–	CO5
8	Quantum Fourier Transform and prime factorization: Shor's Algorithm.	–	CO5
9	Quantum complexity classes – Q, EQP, BQP, BPP, QMA	–	CO5
8	Additional Topics in Quantum Algorithms : Variational Quantum Eigen solver (VQE), HHL, QAOA	–	CO5

Unit	Course Contents	Hrs	CO
9	Introduction to Error correction : Fault-tolerance, Simple error correcting codes	–	CO6
10	Survey of current status : NISQ era processors, Quantum advantage claims, Roadmap for future	–	CO6

Course References:

Sr. No.	Reference
1	Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
2	Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
3	A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)
4	Quantum Computing & Techniques, Dr. R. Chopra, Khanna Publishing House (2025).
5	Quantum error correction and Fault tolerant computing, Frank Gaitan, 1st edition, CRC Press (2008)
6	Quantum computing explained, David McMahon, Wiley (2008)
7	Architectures and Cryptographic Universes (The Mechanics of Quantum Computing), A. B. Bhattacharya, Khanna Publishing House (2025).
8	Introduction to Quantum Computing: From a lay person to a programmer in 30 steps, Hui Yung Wong, 1st edition, Springer-Nature Switzerland AG (2022)

QT 06: Introduction to Quantum Communication

Programme Name	B. Tech. Computer Engineering	Semester: VII
Course Code	R5IT4206T	
Course Title	Introduction to Quantum Communication	
Course Scheme	(L-T-P: 3-0-1) (TA-MST-ESE : 20-30-50)	
Credits	4	
Course Type	Elective-I (Quantum Technologies)	

COURSE OUTCOMES

Students of this course learn

CO	Course Outcome
CO1	The basics of EM theory
CO2	The basics of photodetection
CO3	The basics of information theory
CO4	The central ideas in quantum communications.

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Basics of Polarization optics : Quarter and half-wave plates, Polarizing beam splitters	–	CO1
2	Basics of linear and square-law detectors, Quadrature amplitude modulation : Heterodyne and Homodyne demodulation and linear detectors, Intensity measurements and square law detectors, Photomultipliers, Avalanche Photo diodes	–	CO2
3	Digital communication – information theory (basics) : Information entropy, Noiseless channel encoding , Noisy channel encoding	–	CO3
4	No cloning theorem, Quantum Memories, Quantum repeaters, Entanglement and Bell Theorems, Bell Measurements and Tests, Quantum Teleportation protocol, Quantum Dense coding	–	CO4
5	Quantum Key Distribution protocols: BB84, E91, BBM92, B92 , COW,DPS	–	CO4
6	Quantum Networks and Quantum Internet, Survey of Hardware implementations : Free space communications, Satellite based communications, Fibre optics-based communications	–	CO4

Course References:

Sr. No.	Reference
1	Quantum computation and quantum information – Nielsen and Chuang Cambridge University Press, Cambridge (2010)
2	A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)
3	Introduction to Quantum Communication, A. B. Bhattacharya, Khanna Publishing House (2025).

QT 07: Introduction to Quantum Sensing 3:0

Programme Name	B. Tech. Computer Engineering	Semester: VII
Course Code	R5IT4207T	
Course Title	Introduction to Quantum Sensing	
Course Scheme	(L-T-P: 3-0-1) (TA-MST-ESE : 20-30-50)	
Credits	4	
Course Type	Elective-I (Quantum Technologies)	

COURSE OUTCOMES

Students of this course learn

CO	Course Outcome
CO1	The basics of classical sensing
CO2	Aspects of quantum measurement
CO3	Ways to quantify quantum sensing
CO4	About measurements of quantum states of light
CO5	About the applications of quantum sensing

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Classical sensing: Photo detection	–	CO1
2	Classical noise: Johnson Noise, Telegraph noise, flicker or 1/f noise	–	CO1
3	Sensitivity of classical measurements: Classical Fisher information, Cramer - Rao bounds (information theory basics may be required here).	–	CO3
4	Quantum measurements : projective/orthogonal measurements, Approximate/non-orthogonal measurements, Weak continuous measurements, Error-disturbance relations, Standard quantum limits, Quantum non-demolition measurements	–	CO2
5	States of light : Fock states, Coherent states, Squeezed states, Tomography, Wigner quasi-probability distribution, P-distribution, Husimi Q function	–	CO4
6	Quantum photo detection : Square-law detectors, Intensity measurements and Photo-detection, Linear Detectors and Quadrature Measurements	–	CO4
7	Quantum Cramer-Rao bounds, Single photon-based sensing applications, Entanglement based sensing applications , Atomic state-based sensing, solid-state spin-based sensing applications (gravimetry, magnetometry)	–	CO3, CO5

Course References:

Sr. No.	Reference
1	AICTE Prescribed Textbook: Physics (Quantum Mechanics for Engineers), Khanna Publishing House (2025).
2	Quantum Measurement and Control, Howard Wiseman and David Milburn, Cambridge University Press (2014)
3	Quantum Measurement, Vladimir Braginsky and Farid Ya Khalili, Cambridge University Press (1995)
4	Quantum Information Science, Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
5	Quantum Computing Mechanics, A. B. Bhattacharya, Khanna Publishing House (2025).

QT 08: Introduction to Quantum Materials 3:0

Programme Name	B. Tech. Computer Engineering	Semester: VII
Course Code	R5IT4208T	
Course Title	Introduction to Quantum Materials	
Course Scheme	(L-T-P: 3-0-1) (TA-MST-ESE : 20-30-50)	
Credits	4	
Course Type	Elective-I (Quantum Technologies)	

COURSE OUTCOMES

Students of this course learn

CO	Course Outcome
CO1	The basic idea of quantum materials
CO2	The basics of band theory of solids
CO3	The basics of magnetism
CO4	The basics of superconductivity
CO5	About new 2D materials like graphene, TMDCs
CO6	About topology and topological phases of matter

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Band theory basics : Metals, Semiconductors and Insulators, Band structure of solids, Survey of semiconducting devices for quantum technologies (electronic, quantum optical devices and principle of operation)	–	CO2
2	Correlated systems, Magnetism : Para, ferro magnetism basics, Magnetic measurements, hall effect, magnetoresistance, Faraday and Kerr effects	–	CO3
–	Superconductivity: BCS theory, Ginzburg Landau, Josephson Effect – AC and DC Josephson effects, Survey of superconducting devices for quantum technologies	–	CO4
4	2D materials : Graphene and its properties – single and few layers, Transition Metal Dichalcogenides – Electronic and Optical Properties	–	CO5
5	Topological Phases of matter : Basics of Topology, Geometric phases - Berry Phase, Aharonov Bohm effect, Topological phases of matter	–	CO6
6	Survey of material growth techniques : Molecular beam epitaxy, Chemical vapor deposition, MOVPE, Pulsed laser deposition, etc. , Crystal growth techniques	–	CO1

Course References:

Sr. No.	Reference
1	Condensed Matter Physics, M P Marder, 2nd Edition, John Wiley and Sons, 2010
2	Engineering Physics, A. B. Bhattachraya, Khanna Publishing House (2024).
3	Introduction to Superconductivity, Michael Tinkham, standard ed., Medtech (2017)

QT 09: Engineering Foundations of Quantum Technologies 3:0

Programme Name	B. Tech. Computer Engineering	Semester: VIII ³
Course Code	R5IT4209T	
Course Title	Engineering Foundations of Quantum Technologies	
Course Scheme	(L-T-P: 3-1-0) (TA-MST-ESE: 20-30-50)	
Credits	4	
Course Type	(optional / additional)	

COURSE OUTCOMES

Students of this course learn

CO	Course Outcome
CO1	Relevant topics from Electrical Networks to design and analyse analog circuits The basics of band theory of solids
CO2	Relevant topics from RF and Microwave Engineering to design systems The basics of superconductivity
CO3	Relevant topics in Theory of computation to benchmark algorithms About topology and topological phases of matter
CO4	Relevant topics in analog and digital communications
CO5	Basics of cryptography

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Electrical Networks - Analog RLC circuits – resonances, impedances, quality factors - Transmission line basics. - Telegrapher equations, wave impedance, impedance matching, - transmission line resonators	4 hrs	CO1

³The source document's course-information table for this course literally lists the Semester as VII, even though the Table of Courses lists this course code (R5IT4209T) under the Semester VIII, Electives-II row. This appears to be a copy-paste inconsistency in the original source document; the semester is corrected here to match the Table of Courses.

Unit	Course Contents	Hrs	CO
2	Computer Science • Basics of computer architecture . • Arithmetic Logic Unit • Memory • Abstract models of computation. • Finite State Machine • Turing Machines • Overview of Hierarchy of languages – Regular, Context-Free, Turing Decidable and Turing Recognisable • Complexity Theory (2 hours) • Time and Space complexity • P vs NP, NP-completeness	15 hrs	CO3
3	Electrical Communications • Analog Communications (1 hour) • Quadrature amplitude modulation • Heterodyne and Homodyne demodulation	1 hr	CO4
4	Noise and Signals • Characterising Noise • Types of Noise • Shot Noise • Johnson-Nyquist Noise • Telegraphic noise or flicker or 1/f noise • Signal conditioning and noise mitigation • Amplification and Added Noise • Linear Amplifier theory • Signal-Noise Ratio, Added Noise, Noise Figure of amplification • Dynamic Range • Noise temperature • Quantum limits on noise in linear amplifiers	6 hrs	CO2
5	Digital Communications • Information entropy • Noiseless channel encoding • Noisy channel encoding	4 hrs	CO4
6	Basics of cryptography • Basics of Number Theory • Random Number Generation • One time pad, Private key, public key, symmetric and asymmetric cryptography protocols • RSA and DH • Post Quantum Cryptography (PQC)	6 hrs	CO5

Course References:

Sr. No.	Reference
1	Art of Electronics, Paul Horowitz and Winfield Hill, 3rd edition, Cambridge University Press (2015)

Sr. No.	Reference
2	All-in-One Electronics Simplified, A.K. Maini, Khanna Book Publishing Co. (2022).
3	Digital Design, Morris Mano, Michael D. Ciletti, 6th edition, Pearson Education (2018)
4	Microwave Engineering, David Pozar, 4th edition, Wiley (2013)
5	Information Theory, Robert B. Ash, Dover Publications (2003)
6	Architectures and Cryptographic Universes (The Mechanics of Quantum Computing), B. Bhattacharya, Khanna Publishing House (2025).
7	Introduction to the Theory of Computation, Michael Sipser, 3rd edition, Cengage India Pvt. Ltd. (2014)
8	Foundations of Quantum Technologies, A. B. Bhattacharya, Khanna Publishing House (2025).
9	Quantum Computing & Techniques, Dr. R. Chopra, Khanna Publishing House (2025).
10	Protecting Information – From Classical error correction to quantum cryptography, Susan Loepp and William K. Wootters, Cambridge University Press (2006)

QT 10: Solid State Physics for Quantum Technologies 3:0

Programme Name	B. Tech. Computer Engineering	Semester: VIII ⁴
Course Code	R5IT4210T	
Course Title	Engineering Foundations of Quantum Technologies ⁵	
Course Scheme	(L-T-P: 3-1-0) (TA-MST-ESE : 20-30-50)	
Credits	4	
Course Type	(optional / additional)	

COURSE OUTCOMES

Students of this course learn

CO	Course Outcome
CO1	Basics of solid states physics
CO2	Various approximations for electronic states in matter
CO3	The theory of phonons in solids
CO4	The theory of magnetism
CO5	The theory of superconductivity

COURSE CONTENTS

Unit	Course Contents	Hrs	CO
1	Structure of solids • Symmetry, Bravais lattices • Laue equations and Bragg's law • Brillouin Zones • Atomic scattering and structure factors. • Characterisation of crystal structures – XRD etc.	7 hrs	CO1
2	Bonding in solids • van der Waals and Repulsive interactions, • Lennard Jones potential, • Madelung constant	4 hrs	CO1
3	The Drude theory of metals • DC & AC electrical conductivity of a metal; • Hall effect & magnetoresistance • Density of states, Fermi-Dirac distribution, Specific heat of degenerate electron gases • Free electron model	8 hrs	CO2

⁴The source document's course-information table for this course literally lists the Semester as VII, even though the Table of Courses lists this course code (R5IT4210T) under the Semester VIII, Electives-II row. This appears to be a copy-paste inconsistency in the original source document; the semester is corrected here to match the Table of Courses.

⁵The source document's course-information table literally lists the Course Title as *Engineering Foundations of Quantum Technologies* here, even though the section heading and the unit contents both correspond to *Solid State Physics for Quantum Technologies*. This appears to be a copy-paste inconsistency in the original source document and is reproduced here as-is.

Unit	Course Contents	Hrs	CO
4	Beyond the Free electron model • Kronig-Penney Model • Periodic potential – Bloch Theorem • Band theory • Tight binding model	8 hrs	CO2
5	Phonons in Solids • One dimensional monoatomic and diatomic chains • Normal modes and Phonons • Phonon spectrum • Long wavelength acoustic phonons and elastic constants • Vibrational Properties- normal modes, acoustic and optical phonons.	7 hrs	CO3
6	Magnetism • Dia-, Para-, and Ferromagnetism • Langevin's theory of paramagnetism • Weiss Molecular theory	4 hrs	CO4
7	Superconductivity: • Phenomenological description – Zero resistance, Meissner effect • London Theory • BCS theory • Ginzburg-Landau Theory • Type-I and type-II superconductors • Flux quantization • Josephson effect. • High T_c superconductivity	7 hrs	CO5

Course References:

Sr. No.	Reference
1	Introduction to Solid State Physics, Charles Kittel, Wiley India Edition (2019)
2	Foundations of Quantum Technologies, A. B. Bhattacharya, Khanna Publishing House (2025).
3	Condensed Matter Physics, M P Marder, 2nd Edition, John Wiley and Sons (2010)
4	Introduction to Superconductivity, Michael Tinkham, standard edition, Medtech (2017)
5	Engineering Physics, A. B. Bhattacharya, Khanna Publishing House (2024).

Note

The elective **R5IT4211T – Quantum Optics** appears in the Table of Courses (Semester VIII, Electives-II) but the source syllabus document does not contain a corresponding detailed course-content section (QT 11); it is therefore not reproduced here beyond the summary table entry.