M.D. UNIVERSITY, ROHTAK

SCHEME OF STUDIES AND EXAMINATION

B. TECH. Minor in Quantum Technology

(For all branches)

Scheme effective from 2026-27

B. TECH Minor in Quantum Technology
(For all branches)
Scheme effective from 2026-27

Sr. No	Semester	Course No.	Subject	Teaching Schedule			Examination Schedule (Marks)				Duration of Exam (Hours)	No of hours/week
				L	P	Total Credits	Marks of Class works	Theory	Practical	Total		
1	3	26CSEQTM-201-G	Survey of Quantum technologies and Applications	3	-	3	25	50	-	75	3	3
2	3	26CSEQTM-202-G	Basic of Programming Lab	0	2	1	5	-	20	25	3	2
3	4	26CSEQTM-203-G	Foundation of Quantum Technologies	3	-	3	25	50	-	75	3	3
4	4	26CSEQTM-204-G	Basic programing for Quantum Technologies	0	2	1	5	-	20	25	3	2
5	5	26CSEQTM-301-G	Quantum Computation	3	-	3	25	50	-	75	3	3
6	5	26CSEQTM-302-G	Seminar on Engineering Foundations of Quantum Technologies	0	2	1	5	-	20	25	3	2
7	6	26CSEQTM-303-G	Quantum Communication	3	-	3	25	50	-	75	3	3
8	7	26CSEQTM-304-G	Seminar on Tool & Simulators for Quantum Technology	0	2	1	5	-	20	25	3	2
9	8	26CSEQTM-401-G	Quantum Sensing	3	-	3	25	50	-	75	3	3
10	9	26CSEQTM-402-G	Seminar on Quantum Materials, Quantum optics, of Solid State Physics for Quantum Technology	0	2	1	5	-	20	25	3	2
			TOTAL			20						

Survey of Quantum Technologies and Applications

Course code	26CSEQTM-201-G				
Category	Minor Degree Course				
Course title	Quantum Computing				
Scheme and Credits	L	T	P	Credits	Semester 3
	3	0	0	3	
Internal Assessment	25 Marks				
Exam (Semester Exam)	75 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Objective:

1. To understand the fundamentals of single-qubit quantum systems, operators, and methods.
2. To Understand the functionality and applications of for quantum computing.
3. To develop an understanding of multi-qubit systems, quantum gates, quantum circuits, and quantum entanglement.
4. To design and analyse quantum algorithms for solving computational problems.

Course Contents:

i. Quantum Technologies – four verticals
   a) Motivation for Quantum Technologies

ii. A qualitative overview of salient aspects of quantum physics
   a) Quantum States, Wave functions, Probabilistic interpretation
   b) Physical observables, Hermitian operators, expectation values
   c) Heisenberg uncertainty principle
   d) Schrodinger equation, Time evolution
   e) distinction from classical physics
   f) Heuristic description of Superposition, Tunnelling and entanglement
   g) No cloning theorem
   h) Simulating classical systems – Feynman's idea of a quantum simulator and the birth of the field

iii. Quantum Computation
   a) Basics of qubits -- what is a qubit?
   b) How is it different from a classical bit? – Review of classical logic gates
   c) Di Vincenzo criteria for realising qubits
   d) Basics of qubit gates and quantum circuits
   e) Physical implementation of qubits (very qualitative description)
      1) Solid State Qubits
         a) Semiconducting Qubits – quantum dots, spins
         b) Superconducting Qubits – charge, flux and phase

            c) Topological Qubits – proposals and advantages
        2) Atoms and Ions
            a) Trapped ions
            b) Rydberg atoms
            c) Neutral atoms
        3) Photonic Qubits
            a) Conventional linear optical setups
            b) Integrated Photonics
        4) NMR qubits
            a) Conventional NMR qubits
            b) NV centres
    f) Overview of applications and recent achievements
        1) RSA and Shor's algorithm
        2) Quantum Advantage
    g) Long term goals and strategies being followed
        1) Error correction

iv. Quantum Sensing
    a) Basics of quantum sensing
    b) Basics of Photon (single and entangled) generation and detection
    c) Gravimetry
    d) Atomic clock
    e) Magnetometry
    f) State of the art in Quantum Sensing

v. Quantum Communications
    a) Basics of digital communication
    b) Quantifying classical information – Shannon entropy
    c) Basic ideas of quantum communication, security, eavesdropping
    d) Overview of quantum communication achievements
        1) Terrestrial – fibre-based
        2) Free space, Satellite-based

Course Outcomes:

Students of this course learn:

1. The general physical principles of realising qubits for computation
2. The various hardware implementations of qubits for computation
3. The basic ideas of quantum sensing
4. The applications of quantum sensing
5. The implementations of quantum communications protocols in fibre-based and free-space

Course References:

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)
6. Quantum computing explained, David McMahon, Wiley (2008)
7. Quantum Computing Mechanics, A. B. Bhattacharya, Khanna Publishing House (2025)

Basic of Programming Lab

Course code	26CSEQTM-202-G				
Category	Minor Degree Course				
Course title	Quantum Computing				
Scheme and Credits	L	T	P	Credits	Semester 3
	3	0	0	3	
Internal Assessment	25 Marks				
Exam (Semester Exam)	75 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

- Basics of programming
    - Data structures, classes, Object-oriented programming
    - Data storage and retrieval, Memory allocation
    - Scientific plotting, documentation of codes
- Simple algorithms and benchmarking run time
    - Sorting
    - Searching
    - Arithmetic algorithms like GCD, Prime factorisation
- 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
- Numerical techniques in linear algebra
    - Matrix inverse
    - Eigenvalue problem
    - Diagonalisation of matrices
    - Singular value decomposition
- 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
- 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
- Applications to EM theory (e.g. magnetic field simulation)
    - Electrostatic charge distributions
    - Magnetostatic current distributions
    - Finite Element techniques for electromagnetic simulations

Course outcomes:

Students of this course learn

1. Basics of programming
2. To write programs to solve scientific problems
3. Techniques for scientific computing
4. Applications to quantum mechanics and electromagnetism

Course References:

- AICTE Prescribed Textbook: Physics (Quantum Mechanics for Engineers), A. B. Bhattachraya & Atanu Nag, Khanna Publishing House (2025).
- Computational Physics, Nicholas Giordano, Hisao Nakanishi, 2nd edition, Pearson-Addison Wesley (2005)
- Engineering Physics, A. B. Bhattachraya, Khanna Publishing House (2025).

Foundation of Quantum Technologies

<table>
<tr><td>Course code</td><td colspan="5">26CSEQTM-203-G</td></tr>
<tr><td>Category</td><td colspan="5">Minor Degree Course</td></tr>
<tr><td>Course title</td><td colspan="5">Quantum Computing</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester 4</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Internal Assessment</td><td colspan="5">25 Marks</td></tr>
<tr><td>Exam (Semester Exam)</td><td colspan="5">75 Marks</td></tr>
<tr><td>Total</td><td colspan="5">100 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
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Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

- 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 quantisation 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
- Statistical Physics (8-10 lectures)
    - 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
- Information Science (3-4 lectures)
    - Digital communication and information
        - Quantifying information in terms of Shannon entropy
    - Basic ideas of quantum information
    - Decoherence and noise
    - Introductory ideas of Kraus operators
- Brief overview of Computational Complexity (5-6 lectures)
    - 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)

Course Outcomes:

Students of this course learn

1. The most relevant mathematical techniques
2. Basic postulates of quantum mechanics and applications
3. Basics of Statistical Physics
4. Basics of Information Science
5. Basics of computational complexity

Course References:

1. AICTE Prescribed Textbook: Physics (Quantum Mechanics for Engineers), A. B. Bhattachraya & 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)

Basic programming for Quantum Technologies

<table>
<tr><td>Course code</td><td colspan="5">26CSEQTM-204-G</td></tr>
<tr><td>Category</td><td colspan="5">Minor Degree Course</td></tr>
<tr><td>Course title</td><td colspan="5">Quantum Computing</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester 4</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Internal Assessment</td><td colspan="5">25 Marks</td></tr>
<tr><td>Exam (Semester Exam)</td><td colspan="5">75 Marks</td></tr>
<tr><td>Total</td><td colspan="5">100 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
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Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

- Optics
  - Interferometry – wavelength measurements, intensity measurements
  - Diffraction – single slit, grating
  - Microscopy – magnification, aberration
  - Polarization optics – PBS, HWP, QWP
- RLC circuits
  - Series and parallel RLC circuits – Verifying the quality factor formulae
  - Extracting intrinsic losses
- Digital circuits
  - Adder, Multiplier
  - Encoder, Decoder
  - D flipflop, shift registers
  - How to use common Integrated Circuit chips
- 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

- Interfacing instruments with a computer

- Data acquisition
  - Signal demodulation – heterodyne vs Homodyne, Mixing of signals
  - Sampling, digitisation using ADCs – under-sampling and aliasing, oversampling and noise
  - Averaging and interpolation techniques
- 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)
- Running simple algorithms on cloud-based quantum processors (optional)

Course outcomes:

Students of this course learn

1. Basic experimental techniques in optics
2. Basic experimental techniques in characterising resonators and RLC circuits
3. Basic digital circuits
4. Fundamental techniques in RF engineering
5. Interfacing instruments with computers and carry out data acquisition

Course References:

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. Cilletti, 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)
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)

Quantum Computation

Course code	26CSEQTM-301-G				
Category	Minor Degree Course				
Course title	Quantum Computing				
Scheme and Credits	L	T	P	Credits	Semester 5
	3	0	0	3	
Internal Assessment	25 Marks				
Exam (Semester Exam)	75 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

- 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
- Quantum correlations
  - Entanglement and Bell's theorems
- Review of Turing machines and classical computational complexity
  - Time and space complexity (P, NP, PSPACE)
- Reversible computation
- Universal quantum logic gates and circuits
- Quantum algorithms
  - Deutsch algorithm
  - Deutsch Josza algorithm
  - Bernstein - Vazirani algorithm
  - Simon's algorithm
- Database search
  - Grover's algorithm
- Quantum Fourier Transform and prime factorization
  - Shor's Algorithm.
- Quantum complexity classes – Q, EQP, BQP, BPP, QMA
- Additional Topics in Quantum Algorithms
  - Variational Quantum Eigensolver (VQE)
  - HHL
  - QAOA
- Introduction to Error correction
  - Fault-tolerance
  - Simple error correcting codes
- Survey of current status
  - NISQ era processors
  - Quantum advantage claims
  - Roadmap for future

Course outcomes:

Students of this course learn

1. To review the basic postulates of quantum mechanics
2. The theoretical basics of qubits and their physical realisations To work with density operators and time evolution for mixed states
3. The basic ideas of quantum gates
4. The working of important quantum algorithms
5. The basics of quantum error correction

Course References:

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).
   - B. Introduction to Quantum Computing: From a lay person to a programmer in 30 steps, Hui Yung Wong, 1st edition, Springer-Nature Switzerland AG (2022)

Seminar on Engineering Foundations of Quantum Technologies

<table>
<tr><td>Course code</td><td colspan="5">26CSEQTM-302-G</td></tr>
<tr><td>Category</td><td colspan="5">Minor Degree Course</td></tr>
<tr><td>Course title</td><td colspan="5">Quantum Computing</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester 5</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Internal Assessment</td><td colspan="5">25 Marks</td></tr>
<tr><td>Exam (Semester Exam)</td><td colspan="5">75 Marks</td></tr>
<tr><td>Total</td><td colspan="5">100 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
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Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

Seminar covering major topics as under:

- Electrical Networks
  (Analog RLC circuits, Transmission line basics
- Computer Science
  (Basics of computer architecture , Abstract models of computation, Complexity Theory)
- Electrical Communications
  (Analog Communications)
  - Noise and Signals
  - Characterising Noise
  - Types of Noise, Signal conditioning and noise mitigation, Amplification and Added Noise
- Digital Communications
  - Information entropy, Noiseless channel encoding, Noisy channel encoding
  - Basics of cryptography

Basics of Number Theory, Random Number Generation, Onetime pad, Private key, public key, symmetric and asymmetric cryptography protocols, RSA and DH, Post Quantum Cryptography (PQC) advance and other related/topics

Course Outcomes:

Students of this course learn

1. Relevant topics from Electrical Networks to design and analyse analog circuits
2. Relevant topics from RF and Microwave Engineering to design systems
3. Relevant topics in Theory of computation to benchmark algorithms
4. Relevant topics in analog and digital communications
5. Basics of cryptography

Course References:

1. Art of Electronics, Paul Horowitz and Winfield Hill, 3rd edition, Cambridge University Press (2015)
2. All-in-One Electronics Simplified, A.K. Maini, Khanna Book Publishing Co. (2022).
3. Digital Design, Morris Mano, Michael D. Cilletti, 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), A. 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 P

Quantum Communication

Course code	26CSEQTM-303-G				
Category	Minor Degree Course				
Course title	Quantum Computing				
Scheme and Credits	L	T	P	Credits	Semester 6
	3	0	0	3	
Internal Assessment	25 Marks				
Exam (Semester Exam)	75 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

- Basics of Polarization optics
  - Quarter and half-wave plates
  - Polarizing beam splitters
- 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
- Digital communication – information theory (basics)
  - Information entropy
  - Noiseless channel encoding
  - Noisy channel encoding
- No cloning theorem
- Quantum Memories
- Quantum repeaters
- Entanglement and Bell Theorems
- Bell Measurements and Tests
- Quantum Teleportation protocol
- Quantum Dense coding
- Quantum Key Distribution protocols
  - BB84
  - E91
  - BBM92.
  - B92
  - COW
  - DPS
- Quantum Networks and Quantum Internet
- Survey of Hardware implementations
  - Free space communications
  - Satellite based communications
  - Fibre optics-based communications

Course Outcomes:

Students of this course learn

1. The basics of EM theory
2. The basics of photodetection
3. The basics of information theory
4. The central ideas in quantum communications

Course References:

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).

Seminar on Tool & Simulators for Quantum Technology

Course code	26CSEQTM-304-G				
Category	Minor Degree Course				
Course title	Quantum Computing				
Scheme and Credits	L	T	P	Credits	Semester 3
	3	0	0	3	
Internal Assessment	25 Marks				
Exam (Semester Exam)	75 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

Seminar covering major topics as under:

- Band theory basics
- Correlated systems
- Magnetism
- Superconductivity
- 2D materials
- Topological Phases of matter
- Survey of material growth techniques.
- Advance and other related topics.

Course Outcomes:

Students of this course learn

1. The basic idea of quantum materials
2. The basics of band theory of solids
3. The basics of magnetism
4. The basics of superconductivity
5. About new 2D materials like graphene, TMDCs
6. About topology and topological phases of matter

Course References:

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)

Quantum Sensing

<table>
<tr><td>Course code</td><td colspan="5">26CSEQTM-401-G</td></tr>
<tr><td>Category</td><td colspan="5">Minor Degree Course</td></tr>
<tr><td>Course title</td><td colspan="5">Quantum Computing</td></tr>
<tr><td rowspan="2">Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Credits</td><td rowspan="2">Semester 7</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Internal Assessment</td><td colspan="5">25 Marks</td></tr>
<tr><td>Exam (Semester Exam)</td><td colspan="5">75 Marks</td></tr>
<tr><td>Total</td><td colspan="5">100 Marks</td></tr>
<tr><td>Duration of Exam</td><td colspan="5">03 Hours</td></tr>
</table>

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

- Classical sensing
  - Photo detection
- Classical noise
  - Johnson Noise, Telegraph noise, flicker or 1/f noise
- Sensitivity of classical measurements
  - Classical Fisher information
  - Cramer - Rao bounds (information theory basics may be required here).
- Quantum measurements
  - projective/orthogonal measurements
  - Approximate/non-orthogonal measurements
  - Weak continuous measurements
  - Error-disturbance relations
  - Standard quantum limits
  - Quantum non-demolition measurements
- States of light
  - Fock states
  - Coherent states
  - Squeezed states
  - Tomography
  - Wigner quasi-probability distribution
  - P-distribution
  - Husimi Q function
- Quantum photo detection
  - Square-law detectors, Intensity measurements and Photo-detection
  - Linear Detectors and Quadrature Measurements
- 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)

Course Outcomes:

Students of this course learn

1. The basics of classical sensing
2. Aspects of quantum measurement
3. Ways to quantify quantum sensing
4. About measurements of quantum states of light
5. About the applications of quantum sensing

Course References:

2. AICTE Prescribed Textbook: Physics (Quantum Mechanics for Engineers), Khanna Publishing House (2025).
3. Quantum Measurement and Control, Howard Wiseman and David Milburn, Cambridge University Press (2014)
4. Quantum Measurement, Vladimir Braginsky and Farid Ya Khalili, Cambridge University Press (1995)
5. Quantum Information Science, Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
6. Quantum Computing Mechanics, A. B. Bhattacharya, Khanna Publishing House (2025).

Seminar on Quantum Materials, Quantum Optics, Solid State Physics for Quantum Technology

Course code	26CSEQTM-402-G				
Category	Minor Degree Course				
Course title	Quantum Computing				
Scheme and Credits	L	T	P	Credits	Semester 7
	3	0	0	3	
Internal Assessment	25 Marks				
Exam (Semester Exam)	75 Marks				
Total	100 Marks				
Duration of Exam	03 Hours				

Note: The examiner will set nine questions in total. Question one will be compulsory. Question one will have parts all units and remaining eight questions of 15 marks each to be set by taking two questions from each unit. The students have to attempt five questions in total, first being compulsory and selecting one from each unit.

Course Content and syllabus:

Seminar covering major topics as under:

- Structure of solids –
- Characterisation of crystal structures – XRD etc.
- Bonding in solids –
- The Drude theory of metals –
- Beyond the Free electron model
- Phonons in Solids
- Magnetism
- Superconductivity
- Quantization of the electromagnetic field
- Theory of Optical coherence
- Phase-space representations of states of light
- Light-matter interaction
- Open quantum systems
- Structure of solids
- Bonding in solids
- The Drude theory of metals –
- Beyond the Free electron model
- Phonons in Solids
- Magnetism
- Superconductivity
- Advance and other related topics.

Course References:

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).
6. AICTE Prescribed Textbook: Physics (Oscillations, Waves and Optics), A. B. Bhattacharya & Atanu Nag, Khanna Publishing House (2025)
7. Introductory Quantum Optics, Christopher Gerry and Peter Knight, Cambridge

University Press (2004)
8. Quantum Optics, D. F. Walls, Gerard J. Milburn, 2nd Edition, Springer (2008)
9. Quantum Optics: An introduction, Mark Fox, Oxford University Publishers (2006)
10. Quantum Optics for Beginners, Z. Ficek and M. R. Wahiddin, 1st edition, Jenny Stanford Publishing (2014)
11. Condensed Matter Physics, M P Marder, 2nd Edition, John Wiley and Sons, 2010
12. Engineering Physics, A. B. Bhattachraya, Khanna Publishing House (2024).
13. Introduction to Superconductivity, Michael Tinkham, standard ed., Medtech (2017)