LAKIREDDY BALI REDDY COLLEGE OF ENGINEERING (AUTONOMOUS)
Mylavaram-521 230, Krishna Dist., Andhra Pradesh

B.Tech-Minor program on Quantum Computing and Quantum Technologies(R23)
(Applicable from the Academic Year 2025-26 onwards)

List of Courses offered

S.No	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1.	23QT01	Survey of Quantum Technologies and Application	3	0	0	3	30	70	100
2.	23QT02	Foundations of Quantum Technologies	3	0	0	3	30	70	100
Practical Course Atleast one of QT 03 and QT 04 is Mandatory									
3.	23QT03	Basic Programming Lab	2	0	2	3	30	70	100
4.	23QT04	Basic Laboratory Course for Quantum Technologies	2	0	2	3	30	70	100
Atleast one of QT 05, QT 06, QT 07, QT 08 is Mandatory									
5.	23QT05	Introduction to Quantum Computation	3	0	0	3	30	70	100
6.	23QT06	Introduction to Quantum Communication	3	0	0	3	30	70	100
7.	23QT07	Introduction to Quantum Sensing	3	0	0	3	30	70	100
8.	23QT08	Introduction to Quantum Materials	3	0	0	3	30	70	100
Optional / Additional Courses									
9.	23QT09	Engineering Foundations of Quantum Technologies	3	0	0	3	30	70	100
10.	23QT10	Solid State Physics for Quantum Technologies	3	0	0	3	30	70	100
11.	23QT11	Quantum Optics	3	0	0	3	30	70	100
12.	23QT12	Quantum Cybersecurity	3	0	0	3	30	70	100
13.	23QT13	Quantum Machine Learning	3	0	0	3	30	70	100
Atleast one of the following MOOC Course(s)									
14.	Quantum Algorithms and Cryptography		12-week 3 Credit - NPTEL MOOC						
15.	Fundamentals of Nano and Quantum Photonics								
16.	Cryogenic Electronics for Quantum Computing								
Any Quantum Computing related 12-week 3 credit NPTEL MOOC upon approval from BOS									

23QT01	Survey of Quantum Technologies and Applications	L	T	P	C
		3	0	0	3

Course Objectives:

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.

Course Outcomes:

Students of this course learn:

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

Course Content and syllabus:

UNIT – 1: Quantum Technologies – four verticals: Motivation for Quantum Technologies
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.

UNIT-II: 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

UNIT-III: 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

UNIT-IV: 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

UNIT-V: Introduction to Quantum Materials: What are quantum materials, Why are they important, Applications (quantum computing, spintronics, etc.) Overview of Key Classes of Quantum Materials: Topological Insulators, Superconductors, Mott Insulators, 2D Materials and Quantum Spin Liquids.

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. Elements of Quantum Computation and Quantum Communication, A. Pathak, Boca Raton, CRC Press (2015)
4. An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, and Michele Mosca, Oxford University Press (2006)
5. Quantum computing explained, David McMahon, Wiley (2008)

23QT02	Foundations of Quantum Technologies	L	T	P	C
		3	0	0	3

Course Objectives:

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.

Course Outcomes:

Students of this course learn

- The most relevant mathematical techniques
- Basic postulates of quantum mechanics and applications
- Basics of Statistical Physics
- Basics of Information Science
- Basics of computational complexity

UNIT-I: 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

UNIT-II 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

UNIT-III: 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

UNIT-IV: 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

UNIT - V: 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 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)

Course References:

1. Introduction to Quantum Mechanics, Griffiths D. J., 3rd Edition, Cambridge University Press (2024)
2. Introduction to Electrodynamics, Griffiths D. J., 4th edition, Cambridge University Press (2020)
3. Principles of Quantum Mechanics, Shankar, R., 2nd edition, Springer (2014)
4. Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
5. Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
6. A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)
7. Information Theory, Robert B. Ash, Dover Publications (2003)
8. Introduction to the Theory of Computation, Michael Sipser, 3rd edition, Cengage India Pvt. Ltd. (2014)
9. Statistical Mechanics, Pathria R. K., Paul D. Beale, 4th edition, Academic Press, (2021)

23QT03	Basic Programming Lab	L	T	P	C
		2	0	2	3

Course outcomes: In this course the students will 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 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
  - 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 References: TBD

23QT04	Basic Laboratory Course for Quantum Technologies	L	T	P	C
		2	0	2	3

Course outcomes: In this course the students will learn

1. .Learn basic experimental techniques in optics
2. Learn Basic experimental techniques in characterizing resonators and RLC circuits
3. Learn basic digital circuits
4. Learn fundamental techniques in RF engineering
5. Learn interfacing instruments with computers and carry out data acquisition

Course Content and syllabus:

- Optics
  - Interferometry – wavelength measurements, intensity measurements
  - Diffraction – single slit, grating
  - Microscopy – magnification, aberration
- 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

Course References:

1. Optics – Eugene Hecht
2. Art of Electronics – Horowitz and Hill
3. All in One Electronics Simplified – A.K. Maini
4. Electrical Machines – P.S. Bimbhra
5. Digital Design – Morris Mano
6. Microwave Engineering – David Pozar
7. Discrete-time signal processing – Oppenheim and Shaffer

23QT05	Introduction to Quantum Computation	L	T	P	C
		3	0	0	3

Course outcomes: In this course the students will learn

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

Course Content and syllabus:

- Axiomatic quantum theory
  - Quantum states, observables, measurement
  - Hilbert Space, Unitary Transformations
  - Schrodinger Equation and Unitary evolution
  - No cloning theorem
- 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
- Pure and mixed states
  - Density matrices
  - General quantum evolution and superoperators
  - Positive and Completely Positive Trace-Preserving Maps and Kraus Operators
- Quantum correlations
  - Entanglement and Bell's theorems
- Review of Turing machines and classical computational complexity
- Reversible computation
- Universal quantum logic gates and circuits
- Quantum algorithms
  - Deutsch algorithm
  - Deutsch Josza algorithm
  - Bernstein - Vazirani algorithm
- Database search
  - Grover's algorithm
- Quantum Fourier Transform and prime factorization
  - Shor's Algorithm.
- Introduction to Error correction
  - Fault-tolerance
  - Simple error correcting codes
- Survey of current status
  - NISQ era processors
  - Quantum advantage claims
  - Roadmap for future

Course References:

1. Quantum Mechanics for Engineers – A.B. Bhattacharya & Atanu Nag
2. Quantum Computation and Quantum Information – Nielsen and Chuang
3. Quantum Information Science – Motta and Manenti
4. Quantum error Correction - Frank Gaitan
5. Quantum computing explained- David McMahon.
6. Introduction to Quantum Computing – Hui Yung Wong
7. Quantum Computing and Techniques – Rajiv Chopra

23QT06	Introduction to Quantum Communication	L	T	P	C
		3	0	0	3

Course Outcomes: In this course the students will learn

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

Course Content and syllabus:

- Basics of EM waves and wave equation
    - Maxwell's equations in free space
    - Maxwell's equations in dielectric media
    - Maxwell's equations in lossy media
- 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
- Axiomatic quantum theory
    - Principle of superposition
    - Unitary evolution
    - Pure and mixed states
    - Measurement Postulate
    - No cloning theorem
- Entanglement and Bell Theorems
- Bell Measurements and Tests
- Quantum Teleportation protocol
- Quantum Dense coding
- Quantum Key Distribution protocols
    - BB84
    - E91
    - BBM92.
    - B92
- Survey of Hardware implementations
    - Free space communications
    - Satellite based communications
    - Fibre optics-based communications

Course References:

1. Quantum Computing and Techniques – Rajiv Chopra, Khanna Publishing House, 2024.
2. Quantum computation and quantum information – Nielsen and Chuang Cambridge University Press, Cambridge, 2010
3. A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press, 2015

23QT07	Introduction to Quantum Sensing	L	T	P	C
		3	0	0	3

Course Outcomes: In this course, students will learn how

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 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 quasiprobability 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 References:

1. Quantum Measurement and Control – Wiseman and Milburn
2. Quantum Measurement – Braginsky and Khalili
3. Quantum Information Science – Motta and Manenti
4. Quantum Computing and Techniques – Rajiv Chopra

23QT08	Introduction to Quantum Materials	L	T	P	C
		3	0	0	3

Course Outcomes:

In this course, the students will learn

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

Course Content and syllabus:

- 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)
- Correlated systems
- Magnetism
  - Para, ferro magnetism basics
  - Magnetic measurements, hall effect, magnetoresistance
  - Faraday and Kerr effects
- Superconductivity
  - BCS theory
  - Ginzburg Landau
  - Josephson Effect – AC and DC Josephson effects
  - Survey of superconducting devices for quantum technologies
- 2D materials
  - Graphene and its properties – single and few layers
  - Transition Metal Dichalcogenides – Electronic and Optical Properties
- Topological Phases of matter
  - Basics of Topology
  - Geometric phases - Berry Phase
  - Aharonov Bohm effect
  - Topological phases of matter
- Survey of material growth techniques
  - Molecular beam epitaxy
  - Chemical vapor deposition, MOVPE
  - Pulsed laser deposition, etc.
  - Crystal growth techniques

Course References:

1. Engineering Physics – A.B. Bhattacharya & Atanu Nag
2. Condensed Matter Physics – Marder
3. Introduction to Superconductivity – Michael TInkham

23QT09	Engineering Foundations of Quantum Technologies	L	T	P	C
		3	0	0	3

Course Outcomes: Students of this course will 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 Content and syllabus:

- Electrical Networks (4 hours)
    - Analog RLC circuits – resonances, impedances, quality factors
    - Transmission line basics (2 hours)
        - Telegrapher equations, wave impedance, impedance matching, transmission line resonators
- Computer Science (15 hours)
    - Basics of computer architecture (1 hour)
        - Arithmetic Logic Unit
        - Memory
    - Abstract models of computation (12 hours)
        - 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
- Electrical Communications (1 hour)
    - Analog Communications (1 hour)
        - Quadrature amplitude modulation
        - Heterodyne and Homodyne demodulation
- Noise and Signals (6 hours)
    - 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
- Digital Communications (4 hours)
    - Information entropy
    - Noiseless channel encoding

- Noisy channel encoding
- Basics of cryptography (6 hours)
  - Basics of Number Theory
  - One time pad, Private key, public key, symmetric and asymmetric cryptography protocols
  - RSA

Course References:

1. Design of Analog Circuits – A.V.N. Tilak
2. Electrical Machinery – P.S. Bimbhra
3. Electrical Power System – Tanmoy Deb
4. Electronic Principles – Malvino
5. Electrical Circuit Analysis – William Hayt
6. Digital Systems – Morris Mano
7. Theory of Computation – Michael Sipser
8. Theory of Computation – Prem Nath
9. Information Theory – Robert B Ash
10. Protecting Information – From Classical error correction to quantum cryptography – Loepp and Wootters
11. Microwave Engineering – David Pozar

23QT10	Solid State Physics for Quantum Technologies	L	T	P	C
		3	0	0	3

Course Outcomes: The students of this course will learn the

1. Basics of solid states physics
2. Various approximations for electronic states in matter
3. The theory of phonons in solids
4. The theory of magnetism
5. The theory of superconductivity

Course Content and syllabus:

- 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.
- Bonding in solids –
  - van der Waals and Repulsive interactions,
  - Lennard Jones potential,
  - Madelung constant
- 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
- Beyond the Free electron model
  - Kronig-Penney Model
  - Periodic potential – Bloch Theorem
  - Band theory
  - Tight binding model
- 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.
- Magnetism
  - Dia-, Para-, and Ferromagnetism
  - Langevin's theory of paramagnetism
  - Weiss Molecular theory
- 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 Tc superconductivity

Course References:

1. Engineering Physics – A.B. Bhattacharya & Atanu Nag
2. Solid State Physics – Charles Kittel
3. Solid State Physics – Ashcroft and Mermin
4. Condensed Matter Physics – Marder
5. Introduction to Superconductivity – Michael Tinkham

23QT11	Quantum Optics	L	T	P	C
		3	0	0	3

Course Outcomes: In this course, students will

1. Learn to quantise the electromagnetic field
2. Learn about the various experimental techniques in photonics
3. Learn about the various representations of states of light
4. Learn about classical, semi-classical and fully quantum models of light-matter interaction
5. Learn to Model decoherence through Master equation

Course Content and syllabus:

- Quantization of the electromagnetic field
  - Number states, coherent states, squeezed states
  - Hanbury-Brown and Twiss experiments – Photon bunching, Photon anti bunching
  - Hong-Ou-Mandel interference
- Theory of Optical coherence
  - Young's double slit experiment and first order coherence
  - Coherence functions of arbitrary order
  - Normal ordering, symmetric ordering and ani-normal ordering of operators
  - Interferometry
- Phase-space representations of states of light
  - Wigner distribution
  - P-distribution
  - Husimi Q function
- Light-matter interaction
  - Classical model of light-matter interaction
  - Semi-classical model of light-matter interaction
  - Quantum light-matter interaction
  - Rabi Model
  - Jayne's-cummings model
- Open quantum systems
  - Fermi golden rule
  - Born-Markov Lindblad Master Equation

Course References:

1. Engineering Physics – A.B. Bhattacharya & Atanu Nag
2. Introductory Quantum Optics – Gerry and Knight
3. Quantum optics – Walls and Milburn
4. Quantum Optics – Girish Agrawal
5. Quantum Measurement and Control – Wiseman and Milburn