VEERMATA JIAJABAI TECHNOLOGICAL INSTITUTE
MATUNGA, MUMBAI 19

Notice

Multidisciplinary Minor (MDM))

MDM Semester III/ AY 2026-27 Date:- 10th June, 2026

For AY 2026-27, Students of Second Year & Direct Second year of B. Tech (Semester III) are required to fill out a Google form for **MDM** (from 11.06.2026 to 21.06.2026.)

Google Link: https://forms.gle/4oVC1ip87mTau1uY7

Rules:

1. Once selected, the course will not be changed under any circumstances. Therefore, students should be careful while selecting the course
2. In case number of students opting for a particular course is less than 25, the course will be not being offered.
3. It is compulsory to fill the google form to fill the form.

Dr. Arvind Deshpande
Associate Dean Academics

Multidisciplinary Minor (MDM) at Institute Level (B. Tech III Semester AY 2025-26)

Sr. No	Course Title	Eligible for students of following B. tech Programs
1	Robotics	All disciplines
2	Aerospace Technology	All disciplines
3	Sustainable Environment	All disciplines
4	Data Science	All disciplines excluding Computer & Information Technology

5	AI ML	All disciplines excluding Computer & Information Technology
6	Electric Vehicles	All disciplines
7	Entrepreneurship & Startups	All disciplines
8	Managerial Economics and IPR in Manufacturing Sector	All disciplines
9	Internet of Things	All branches **excluding** Electronics and Electronics & Telecommunication
10	Signal Processing and Imaging	All branches excluding Electronics and Electronics & Telecommunication
11	Cyber Security	All disciplines
12	Contract Law, Arbitration, and Valuation	All disciplines
13	Quantum Technology	All disciplines

Veermata Jijabai Technological Institute

Information of Multidisciplinary Minors for Second year students of A.Y 2025-26

1. Title of the Minor: MINOR IN ROBOTICS

Minor will be offered to:- Computer/IT, Electronics/EXTC, Electrical, Mechanical, Production, Civil, Textile

Sr. No.	Name of the Course	Brief Curriculum
1	Introduction to Robotics	**Introduction to robotics** Brief History, Basic Concepts of Robotics such as Definition , Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device etc., Introduction to Principles & Strategies of Automation, Types & Levels of Automations, Need of automation, Industrial applications of robot. **Grippers and Sensors for Robotics** Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper system. Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot. **Drives and Control for Robotics** Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems: Types of Controllers, Introduction to closed loop control **Programming and Languages for Robotics** Robot Programming: Methods of robot programming, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc., Development of languages since WAVE till ROS. **Related Topics in Robotics** Socio-Economic aspect of robotization. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics

2	Mechanics of Robots	**Mathematical Preliminaries of Robotics** Spatial Descriptions: positions, orientations, and frame, mappings: changing description from frame to frame, Operators: translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters. **Robot Kinematics** Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit- Hardenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach. **Velocities & Statics** Cross Product Operator for kinematics, Jacobians - Direct Differentiation, Basic Jacobian, , Jacobian Jv / Jw, Jacobian in a Frame, Jacobian in Frame {0}, Kinematic Singularity, Kinematics redundancy, Force balance equation, Forces, Velocity/Force Duality, Virtual Work, Force ellipsoid, Jacobian, Kinematic Singularity, Kinematics redundancy, Mechanical Design of robot linkages, **Path Planning** Definition-Joint space technique, Use of P-degree polynomial-Cubic, polynomial- Cartesian space technique, parametric descriptions, straight line and circular paths, position and orientation planning **Robot Dynamics** Introduction to Dynamics, Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation.

3	Microprocessor & Embedded Systems	**Introduction to Embedded Systems and microcomputers** Introduction to Embedded Systems, Embedded System Applications, Block diagram of embedded systems, Trends in Embedded Industry, Basic Embedded System Models, Embedded System development cycle, Challenges for Embedded System Design, Evolution of computing systems and applications. Basic Computer architecture: Von-Neumann and Harvard Architecture. Basics on Computer organizations. Computing performance, Throughput and Latency, Basic high performance CPU architectures, Microcomputer applications to Embedded systems and Mechatronics. **Microprocessor** 8086 Microprocessor and its Internal Architecture, Pin Configuration and their functions, Mode of Operation, Introduction to I/O and Memory, Timing Diagrams, Introduction to Interrupts. Introduction to C language, Instruction format, C language programming format, Addressing mode, Instruction Sets, Programming 8086 microprocessor. **Microprocessor Interfacing** Introduction to interfacing, Memory Interfacing, Programmable Peripheral Interfacing, Programmable I/O, Programmable Interrupt Controller, Programmable Timers, Programmable DMA Controller, Programmable Key Board Controller, Data acquisition Interfacing: ADC, DAC, Serial and parallel data Communication interfacing. Microcontroller: Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, programming model, addressing modes, Instruction sets, Assembly and C programming for Microcontroller, I/O programming using assembly and C language, Interrupt Controller, I/O interfacing, Timers, Real Time Clock, Serial and parallel Communication protocols, SPI Controllers. LCD Controller. **Microcontroller Interfacing** Introduction to Microcontroller Interfacing and applications: case studies: Display Devices, controllers and Drivers for DC, Servo and Stepper Motor. **Introduction to Advanced Embedded Processor and Software** ARM Processor, Unified Model Language (UML), Embedded OS, Real Time Operating System (RTOS), Embedded C. **Microprocessor and Embedded System Laboratories** Basic C language programming implementation on Microprocessor and Microcontroller. Interfacing Displays, Key boards and sensors with Microprocessors and Microcontrollers, Data Acquisition using Microprocessor and Microcontroller, Implementation of Controlling schemes for DC, Servo, Stepper motor using C programming in microprocessors and Microcontrollers.
4	Control of Robotic Systems	**Basics of Control** Differential Equation, Transfer function, Frequency response, Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design, Bode, polar, Nyquist plot. **Linear Control** Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, P, PI & PID Controller, control law partitioning, modelling and control of a single joint. **Non-Linear Control System** Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, stability analysis by describing function method, Lyapunov's stability criterion, the control problems for manipulators.

		Motion Control Point to Point Control, trajectory generation, Continuous Path Control, Joint based control, Cartesian Control, Force Control, hybrid position/force control system.
5	Wheeled Mobile Robots	

2. Title of the Minor: MINOR IN AEROSPACE TECHNOLOGY

Minor will be offered to:- Computer/IT, Electronics/EXTC, Electrical, Mechanical, Production, Civil, Textile

Sr. No.	Name of the Course	Brief Curriculum
1	An Introduction to Aerospace Engineering	**Atmosphere** Properties and characteristics of the atmosphere **Basic Components of Fixed-Wings Airborne Systems** The fixed wings, control surfaces – ailerons and rudders, their functionality and basic working principles **Introductory Fluid Mechanics & Aerodynamics** Concept of Pressure; A primer on Conservation Laws – Mass, Momentum and Energy. Bernoulli's Principle; A primer on viscous flows and concept of skin-friction; Basic Principle of Lift generation, airfoils – symmetric and cambered; Irrotational flows: Sink, source, doublet & irrotational vortex **Introduction to Propulsion Systems** Primer on the thermodynamic cycles of aircraft engines – ideal and real cycles; Axial Compressors and Turbines; Turbofan, turboprop, turbojet engines; An historical perspective of engines; Rocket engines – the principle of thrust generation with converging-diverging nozzles **Aircraft Performance** Mechanics of flight; Flight stability - considerations of stability in commercial and fighter aircrafts; Glide, climb, ceiling, turn and pull-up; V-n diagram; Range and Endurance **Navigation, Guidance & Control** Brief introduction to radar; Guided missiles, simplified missile guidance laws **Futuristic Aerospace Technologies** Electric propulsion; Hydrogen combustion engines; Supersonic & hypersonic Ramjet/Scramjet

2	Flight and Space Mechanics	**Atmosphere** Properties and characteristics of the atmosphere **Lift and drag on 3D Geometries** 3D Wings; Starting, Bound & Wingtip vortices; Induced Drag; Different kinds of Drag, Center of pressure, Center of Moments. **Performance of Aircrafts** Performance: Level flight, cruise and climb, optimal cruise trajectories, Vn-diagrams; Performance comparison of jet and propeller driven engines. **Stability of Aircrafts** Static longitudinal, directional and lateral stability and control, Stick-fixed and Stick-free stability, Hinge moments, Trim-tabs, Aerodynamic balancing **Manoeuvrability and Control** Longitudinal, lateral Control, Control Surface configurations for control, Stall Recovery, Airplane Spin **Space Mechanics** Conic Sections and Central force motion; Orbital Mechanics & Kepler's Laws; Lambert's Problem; Non-Keplerian motion; Orbit Manoeuvres – Hohmann transfer, inclination change bi-elliptic manoeuvres; Lunar/Interplanetary trajectories- sphere of influence.
3	Aircraft Structures	**Introduction to Aircraft Structures** Overview of aircraft structural components: fuselage, wings, empennage, landing gear, etc; types of aircraft structures: semi-monocoque, monocoque, and truss structures; Loads acting on aircraft structures: aerodynamic, inertial, ground, and pressure loads; Material selection for aircraft structures: aluminum alloys, composites, titanium, and steel. **Stress and Strain Analysis** Review of stress and strain concepts; Bending, shear, and torsion in beams; Stress-strain relationships for isotropic and anisotropic materials; Mohr's circle for stress and strain transformation. **Structural Load Analysis** Airworthiness requirements and design criteria; V-n diagram (flight envelope); Load factors and limit loads; Shear force and bending moment diagrams for aircraft wings and fuselage. **Analysis of Thin-Walled Structures** Thin-walled pressure vessels; Shear flow in thin-walled beams; Torsion of thin-walled closed and open sections; Bending and shear stress distribution in thin-walled beams. **Structural Stability and Buckling** Euler's buckling theory; Buckling of columns and plates; Local and global buckling in aircraft structures; Post-buckling behavior and design considerations. **Fatigue and Fracture Mechanics** Fatigue loading and S-N curves; Crack initiation and propagation; Stress concentration factors; Damage tolerance and fail-safe design principles. **Composite Materials in Aircraft Structures** Introduction to composite materials: fibers, matrices, and laminates; Mechanical properties of

4	Aerodynamics	**Introduction to Aerodynamics** Basic fluid properties: density, viscosity, compressibility, and thermal conductivity; Flow characteristics: laminar and turbulent flow, steady and unsteady flow; Continuity, momentum, and energy equations; Dimensional analysis and Buckingham Pi theorem. **Incompressible Flow Over Airfoils** Airfoil nomenclature and geometry; Pressure distribution over airfoils; Lift, drag, and moment coefficients; Thin airfoil theory; Kutta condition and circulation. **Finite Wing Theory** Vortex filament and Biot-Savart law; Downwash and induced drag; Prandtl's lifting line theory; Elliptical lift distribution and wing efficiency. **Compressible Flow** Thermodynamics of compressible flow; Speed of sound and Mach number; Isentropic flow relations; Normal and oblique shock waves; Expansion waves (Prandtl-Meyer flow). **High-Speed Aerodynamics** Subsonic, transonic, supersonic, and hypersonic flow regimes; Critical Mach number and drag divergence; Wave drag and area rule; Shock-expansion theory for supersonic airfoils.
		Boundary Layer Theory Boundary layer concept and characteristics; Laminar and turbulent boundary layers; Boundary layer separation and control; Drag due to skin friction and pressure drag. **Wind Tunnel Testing** Wind tunnel types and their applications; Similarity parameters: Reynolds number, Mach number, and Strouhal number; Measurement techniques for lift, drag, and pressure distribution; Flow visualization techniques.
5	Aerospace Propulsion	

3. Title of the Minor: Sustainable Environment

Minor will be offered to: - Computer/IT, Electronics/EXTC, Electrical, Mechanical, Production, Civil, Textile

Sr. No.	Name of the Course	Brief Curriculum
1	Principles of Sustainability	**Concept of sustainability:** Definition of sustainability, three pillars of sustainable development, environmental, social, and economic aspects of development, interconnectivity of people, planet, and prosperity aspects. **Sustainable Development Goals:** Millenium development goals, formulation of sustainable development goals, indicators for various sustainability goals, sustainability index and associated targets. **Ecosystem services:** Understanding various ecosystem services, effect of industrialization on ecosystem services, impact of climate change. **Sustainability in supply chain:** Understanding sustainable supply chain management, sustainability reporting and associated standards, national and global legislations associated to sustainable reporting. **Principles of green chemistry:** Definition of green chemistry, 12 principles of green chemistry, resource recovery, environmentally sound reject management practices. **Engineering applications of sustainability principles:** Applications of sustainability principles to engineering projects, sustainable product design, innovative thinking and optimum resource management.
2	Water and Wastewater Management	Characteristics of water and wastewater: Physical, chemical, and biological characteristics of water and wastewater, drinking water standards in India (IS10500-2012), treated wastewater discharge standards, water quality index. Water treatment processes: Design of unit processes used for water treatment such as aeration, sedimentation, filtration, and chlorination, developing water treatment scheme for ground water and surface water. Wastewater treatment processes: Design of unit processes used for wastewater treatment such as screening, coagulation and flocculation, biological treatment, filtration, and adsorption, developing wastewater treatment scheme for domestic wastewater. Resource recovery: Understanding efficient water and wastewater management, resource recovery from waste streams, concepts of reuse and recycle. Industrial effluent treatment: Effluent characteristics for ‘red category’ industries, treatment units used for industrial effluent treatment, effluent management for major polluting industries. Zero Liquid Discharge: Definition of Zero Liquid Discharge (ZLD) systems, tertiary treatment units and reject management systems, advantages and disadvantages of ZLDs, case studies on sectors implementing ZLD regulations.

3	Environmental Economics	Introduction to Environmental Economics: Meaning, Definition, and Relevance of Environmental Economics; Basic Concepts and Tools from Microeconomics and Welfare Economics; Comparison with Other Sub-disciplines like Ecological, Economics, and Natural Resource Economics; Major Problems and Key Concerns of Environmental Economics. Commons and Collective Actions Problem: Seminal Theories; Mancur Olson's Theory of Collective Action; Collective Action and Prisoner's Dilemma Game. Environment and Economic Growth: Poverty, Environment and Economic Growth Linkages-Environmental Kuznets Curve, Environmental Sustainability; Environmental Performance Index; Benefit-cost Analysis. Consumer Demand for Environmental Goods: Consumer Demand for Environmental Goods and Welfare Effects of Price Change; Values, Environmental Values, and Non-market Valuations: Revealed Preference Methods, Stated Preference Methods. Market-efficiency, Optimality, Consumers and Producers Surplus. Public Market and Environment: Optimal Provision of Public Goods and Bads; Externality and Market Failure; Pigouvian Fee, Property Rights and Coase Theorem. Environmental Acts and Regulations: Environmental Regulations and Basic Regulatory Instruments-Market-based Instruments/ Approaches; Environmental Regulation and Basic Regulatory Instruments-Market Trading Systems.
4	Air and Noise pollution control engineering	Fundamentals of Air Pollution and Noise Pollution Composition of dry ambient air, properties of air, Definition of air pollution, Classification of air pollutants, Units for classification of air pollutants, History of air pollution- global and national, Scope of problem-general, urban, rural, and specific. Noise: Basic concept, measurement, various control methods. Sources of Air Pollution and Its Effects Sources of air pollution: Natural and man-made, Major pollutants from different sources in Greater Mumbai area and other Indian cities, Emission factors. 3. Effect of air and noise pollution on human health, plants, animals, properties, and visibility, CoH, CoHb Meteorology and Air Pollution Dispersion Meteorological aspects of air pollution, large-scale wind circulation including geostrophic wind and gradient wind, influence of cyclones, anticyclones, planetary boundary layers, lapse rate, and stability conditions, wind velocity profile and maximum mixing depth, topographic effects and their role in pollutant dispersion, types of plume patterns and their significance in air quality assessment Air Quality Monitoring and Standards Methods and instruments for stack and ambient air monitoring, sampling and analysis techniques for gaseous and particulate pollutants, principles of isokinetic sampling and continuous monitoring, particle size analysis and mass analysis, Government of India’s air pollution acts and laws, Indian emission and air quality standards, noise standards, amendments in air pollution laws, IS standards for ambient air quality and industrial emissions. Air Pollution Control Devices – Principles and Design Design and operation of air pollution control devices, hoods and ducts including hood specifications and design considerations, duct design and ventilation by dilution, settling chambers for dust removal in laminar and turbulent flow, economic sizing and efficiency considerations, inertial devices such as cyclones for particulate collection, factors affecting efficiency, pressure drop and power requirements, economic sizing of cyclones. Advanced Control Technologies and Filtration Systems Electrostatic precipitators (ESP) including collection efficiency, electric field principles, particle charging mechanisms, effects of temperature and dust resistivity on collection efficiency, pressure drop, power requirement, sizing, and costing, particulate scrubbers

		including interception, impaction, collection efficiencies, design criteria for cyclone and Venturi scrubbers, filtration systems such as bag filters and baghouses, fabric filtration theory, collection efficiency, pressure drop, design considerations, sizing, and costing of filtration units.
5	Climate Change and Adaptation	The climate system, and interaction among the sub-systems, Earth's natural greenhouse Effect and Dark Heating, radiation balance, Climates of the past, natural versus anthropogenic causes of climate change, enhanced greenhouse effect, climate forcing, Runaway greenhouse effect, CO_2 emissions and the Earth's carbon reservoirs, The Intergovernmental Panel on Climate Change (IPCC), Weather and climate, Global wind systems, importance of monsoons, El-nino and southern oscillations, general global circulation, Understanding the Social Theory of Climate Change, Recent Climate change-human intervention, emission scenarios/pathways, Changes in climate extremes, long and short term climate changes, regional patterns of climate change, temperature response, air quality response, irreversibility, tipping point and abrupt changes, Climate change impacts on: fresh water resources-surface and groundwater, drought and soil moisture, wetlands, glaciers melting, terrestrial ecosystem-geographic shifts in terrestrial habitats, vegetation-climate interaction, loss of biodiversity, agriculture and food supply, marine environment- sea level rise, ocean current and circulation, ocean acidification, coastal lives, marine ecosystem, Adaptive capacity, adaptation to climate change, Carbon sequestration, Mitigation technologies and potential in 2030, Zero carbon future, temperature stabilization, mitigation- carbon dioxide removal, Climate change preparedness.

4. Title of the Minor: **Data Science**

Minor will be offered to: - **Electronics/EXTC, Electrical, Mechanical, Production, Civil, Textile**

Sr. No.	Name of the Course	Brief Curriculum
1	Introduction to Data Science.	• Introduction to Data Science, Different Sectors using Data science, Purpose and Components of Python in Data Science. • Data Analytics Process, Knowledge Check, Exploratory Data Analysis (EDA), EDA-Quantitative technique, EDA- Graphical Technique, Data Analytics Conclusion and Predictions. • Feature Generation and Feature Selection (Extracting Meaning from Data). Feature Selection algorithms. • Data Visualization- Basic principles, ideas and tools for data visualization, Examples of inspiring (industry) projects • Applications of Data Science, Data Science and Ethical Issues- Discussions on privacy, security, ethics, A role of data scientist.
2	Python for Data Science and Data Analysis.	• Basics of Python including data types, operators, variables, expressions, control structures using sample dataset, objects and functions. Python sequence data structures including String, Array, List, Tuple, Set, and Dictionary, hashes. • Data Analysis libraries: Using Pandas ,Data Frames, Numpy multi-dimentional arrays, and SciPy libraries to work with a various dataset. • Exploratory data analysis :Data preprocessing (data loading, dealing with missing values and outliers, data wrangling, filtering data, Data Normalization , Data Formatting ,data cleaning), • More APIs relevant to Data Processing.
3	Introduction to ML with python	• Introduction – Types of learning - Essential Libraries and Tools - scikit-learn - NumPy - SciPy - matplotlib – pandas and editors. • Data Pre-processing, data cleaning and for mating, Feature extraction for supervised and unsupervised learning. • Supervised Learning – Regression - Linear Regression, Logistic Regression , Classification - Nearest- Neighbours, Decision Trees, Naive Bayes, SVM. • Unsupervised Learning and Pre-processing - Challenges in Unsupervised Learning - Pre-processing and Scaling - Different Kinds of Pre-processing - Applying Data Transformations -Scaling Training and Test Data. Clutsering Algorithms and Evaluation of algorithms. • Evaluating Machine Learning algorithms and Model Selection - Cross-Validation - Cross-Validation in scikit-learn – Types and Benefits of Cross-Validation.

4	Data Visulization and Processing Tools	• Data import and visualization, Introduction to various plots: Implement data visualization techniques and plots using Python libraries, such as Matplotlib, Seaborn • Create different types of charts and plots such as line, area, histograms, bar, pie, box, scatter, and bubble. • Corelation Visualization and Analysis. • Dimentionality Reduction Algorithms. PCAAnalysis. • APIs for advanced processing for various learning models.
5	Web Data Mining	• Data Mining Foundations, Association Rules and Sequential Patterns, Basic Concepts of Association Rules, Apriori Algorithm, Frequent Itemset Generation, Association Rule Generation, Data Formats for Association Rule Mining. • Link Analysis, Social Network Analysis, Page Rank Algorithm, Web Crawling, A Basic Crawler Algorithm – Breadth First Crawlers, Preferential Crawlers, Implementation Issues – Fetching, Parsing, Stopword Removal, Link Extraction, Spider Traps, Page Repository, Universal Crawlers, Focused Crawlers. • **C**oncepts of Information Retrieval, IR Methods, Vector Space Model , Web Page Pre-processing, Stopword Removal, Stemming, Web Page Preprocessing, Duplicate Detection, Inverted Index, Query and Retrieval, Web Search, Meta Search. • Web Usage Mining, Data Collection and Preprocessing, Sources and Types of Data, Key Elements of Web Usage Data Preprocessing, Data Modeling for Web Usage Mining, Discovery and Analysis of Web. Case studies such as Opinion Mining, Sentiment Classification, Usage Patterns, Session and Visitor Analysis, Cluster Analysis and Visitor Segmentation, Analysis of Sequential and Navigation Patterns.

5. .Title of the Minor: AI ML

Minor will be offered to: - Electronics/EXTC, Electrical, Mechanical, Production, Civil, Textile

Sr.No	Name of the Course	Brief Curriculum
1	Introduction to AI & Machine Learning	Defining Artificial Intelligence, Defining AI techniques, Using Predicate Logic and Representing Knowledge as Rules, Representing simple facts in logic, Computable functions and predicates, Procedural vs Declarative knowledge, Logic Programming, Mathematical foundations: Matrix Theory and Statistics for Machine Learning.
2	Introduction to Data Analytics.	Introduction to Data Science, Different Sectors using Data science, Purpose and Components of Python in Data Science. Data Analytics Process, Knowledge Check, Exploratory Data Analysis (EDA), EDA- Quantitative technique, EDA- Graphical Technique, Data Analytics Conclusion and Predictions. Feature Generation and Feature Selection , Data Visualization.
3	Deep Learning and Neural Network	Information flow in a neural network, understanding basic structure and ANN. Training a Neural network, how to determine hidden layers, recurrent neural network. Convolutional neural networks, image classification and CNN. RNN and LSTMs. Applications of RNN in real world.
4	Special topics in Artificial Intelligence	Bayesian Filtering; Recurrent Neural Networks, Deep Neural Networks, Deep Reinforcement Learning. Self-Play Networks, Generative Adversarial Networks, Learning from Concept-Drifting Data Streams. Audio Signal Processing Basics, An introduction to neurocomputing and its possible role in AI.
5	Applications of AI	Linguistic aspects of natural language processing, A.I. And Quantum Computing, Applications of Artificial Intelligence (AI) in business. Emotion Recognition using human face and body language, Robotic Processes Automation for supply chain management. AI-Optimized Hardware, Digital Twin i.e. AI Modelling

6. Title of the Minor: MINOR IN ELECTRIC VEHICLES

Minor will be offered to:- All disciplines

Sr. No.	Name of the Course	Brief Curriculum
1	ELECTROMECHANICAL ENERGY CONVERSION	This course introduces the principles of electromechanical energy conversion, focusing on the fundamental concepts necessary for understanding electric vehicles (EVs). Topics include the basics of electromagnetic fields, Faraday's Law of Induction, and the operation of electromechanical devices such as transformers, generators, and electric motors. Students will learn about different types of electric motors used in EVs, including DC motors, induction motors, and permanent magnet motors.
2	CONVENTIONAL VEHICLES AND COMPONENTS OF ELECTRIC VEHICLES	This course provides an overview of conventional internal combustion engine vehicles and their key components. Topics include the fundamental principles of engine operation, fuel systems, transmission, and exhaust systems, etc. Students will learn about the various subsystems that make up a traditional vehicle, including braking, steering, and suspension systems. Comparisons between conventional and electric vehicles will be drawn to highlight the differences and the motivations for transitioning to electric vehicles. Architecture of EVs, including electric motors, power electronics, onboard chargers, and inverters. The course covers the role of regenerative braking systems and how they improve efficiency. Students will also learn about thermal management systems and their importance in maintaining optimal performance and safety. Case studies and simulations will help students understand the integration and operation of these components in real-world EVs.
3	BATTERY MANAGEMENT SYSTEM	This course covers the crucial role of battery management systems (BMS) in electric vehicles, covering the principles and technologies involved in managing and optimizing battery performance. Topics include battery chemistry, charging and discharging cycles, state of charge (SOC) and state of health (SOH) estimation, and thermal management. Students will learn about the design and implementation of BMS, including protection mechanisms, balancing techniques, and communication protocols. The course will also provide insights into the challenges and solutions in BMS, ensuring the safe and efficient operation of EV batteries.
4	HYBRID ELECTRIC VEHICLES	This course introduces the concepts and technologies behind hybrid propulsion systems that combine internal combustion engines with electric powertrains. Topics include the different types of hybrid configurations (series, parallel, and series-parallel), energy management strategies, and the advantages and challenges of hybridization. Students will study the components unique to HEVs, such as power split devices and regenerative braking systems. Case studies and practical examples will illustrate the real-world applications of HEVs.
5	SOCIO-ECONOMIC IMPACT OF EV	This course explores the broader implications of electric vehicle (EV) adoption on society and the economy. Topics include the environmental benefits of EVs, such as reductions in greenhouse gas emissions and pollution. Students will examine the economic impact, including job creation in the EV industry, changes in the automotive market, and the effects on oil dependency. The course also addresses the challenges and opportunities in the transition to EVs, such as infrastructure development, government policies, and consumer acceptance.

7. Title of the Minor: Entrepreneurship development, business communication, business development and management (Entrepreneurship & Startups)

Minor will be offered to: - Computer/IT, Electronics/EXTC, Electrical, Mechanical, Production, Civil and Textile

Sr. No	Name of the Course	Brief Curriculum
1	Orientation Programme in Entrepreneurship	Module-I: **Introduction to Entrepreneurship** Meaning and concept of entrepreneurship, the history of entrepreneurship development, role of entrepreneurship in economic development, Myths about entrepreneurs, agencies in entrepreneurship management and future entrepreneurship types of entrepreneurs. Module-II: **The Entrepreneur** Why to become an entrepreneur, the skills/ traits required to be an entrepreneur, Creative and Design Thinking, the entrepreneurial decision process, skill gap analysis, and role models, mentors and support system, entrepreneurial success stories. Module-III: **E-Cell** Meaning and concept of E-cells, advantages to join E-cell, significance of E-cell, various activities conducted by E-cell Module-IV: **Communication** Importance of communication, barriers and gateways to communication, listening to people, the power of talk, personal selling, risk taking & resilience, negotiation Module-V: **Introduction to various form of business organization** (Sole proprietorship, partnership, corporations, Limited Liability company), mission, vision and strategy formulation.
2	Exploring Business Opportunity	Module-I: **Self-Discovery** Natural born entrepreneur, the reluctant entrepreneur, the hidden traits, discovers your own strength. Module-II: **Idea Generation** Sources of business ideas, how to find & assess ideas? Where to find data for ideation? What is a good problem? Opportunity recognition. Module-III: **Idea Evaluation** Design thinking for finding solutions, prototyping, idea evaluation, entrepreneurial Outlook, value proposition design, customer insight, ideas development , capstone project presentation. Module-IV: **Feasibility Analysis** Product/Service Feasibility Analysis, Industry & competition analysis, environment analysis, financial feasibility analysis.
3	Developing a Business Model	Module-I: **Team** Finding your team, art of team formation, teamwork planning, chief mentor/ founder & Co founders, team formation, and delegation of work. Module-II: **Preparation of Business model/Plan** Meaning and significance of a business plan, components of a business plan, and feasibility study, Iterating the MVP, Digital Presence for Ventures, Clarifying the value proposition, Guidelines for writing BP, pre- requisites from the perspective of an investor. Module-III: **Business Model** The importance and diversity of business models, how business models emerge, potential fatal flaws of business models, components of an effective business model, core strategy, strategic resources, partnership network, customer interface. Module-IV: **Product/ Market Fit** Understanding basics of unit economics, cost and profitability, Refining the product/service, Establish the success and operational matrix, Starting Operations. Customer Validation: Evaluate the efficiency with which customers can be captured and kept, Early insights on cost of customer acquisition, Other Stakeholder Validation, Customer Development and Experience.

4	Translating Business Model Into Start-up	Module-I: **Gaining marketing Intelligence** Identify the vertical you will operate in and the business opportunity, understand your customers and accurately assess market opportunity, minimum viable product and the lean method. Module-II: **Develop and validate business model for your venture** Value Proposition, Customer Segments, Channels and Partners, Revenue Model and Streams, Key Resources, Activities, and Costs Customer Relationships and Customer. Module-III: **Development Processes** Translate Business Model into a Business Plan, Visioning for venture, Take product or service to market, Deliver an investor pitch to a panel of investors, Identify possible sources of funding for your venture – customers, friends and family, Angels, VCs, Bank Loans and key elements of raising money for a new venture. Module-IV: **Business Plan & Startup-I** Get to market Plan, Effective ways of marketing for start-ups – Digital and Viral Marketing; Hire and Manage a Team, Managing start- up finance: The Concept of Costs, Profits, and Losses, Manage your Cash Flow, analyse your Financial Performance, budgeting. Module-V: **Business Plan & Startup-II** Establishing an ethical culture for a firm, Legal and regulatory aspects for starting up specific to your venture, Enhancing the growth process and creating scalability (customers, market share, and/or sales), Thorough understanding of market size, costs, margins, delivery channels, customer acquisition costs, Identify areas to build efficiency (product making, service delivery, and channels - key areas of the BM Canvas are identified by now), Finalize business model and plan, Have a 1-2 year roadmap and trajectory. Module-VI: **Obtaining Business Licenses and permits** Business Licenses, business permits, choosing a form of business organization, sole proprietorship, partnership, corporations, Limited Liability company.
5	Entrepreneurship: Growth	Module-I: **Growth Opportunities** Characteristics of high growth new ventures, strategies for growth, and building the new venture capital, discovering and assessing opportunities for growth, developing a growth mind-set and visioning for growth, review the robustness and relevance of business model vis-à-vis current market situation, map financing decisions to business models and reiterating business models Module-II: **Retention & Expansion Strategies** Characteristics of high growth new ventures, strategies for growth, and building the new venture capital, discovering and assessing opportunities for growth, developing a growth mind-set and visioning for growth, review the robustness and relevance of business model vis-à-vis current market situation, map financing decisions to business models and reiterating business models Module-II: **Retention & Expansion Strategies** Dealing with stagnation of customer base and developing customer base: expansion to new markets –options and strategies, product Life Cycle – Product Road Map; Getting to Plan B, project to Process: Build, adapt, test, and establish key processes and systems that enable efficiency, continuous and sustained innovation Module-III: **Developing the organizational capabilities for growth** Develop strong leadership capabilities, ability to delegate and manage key leadership tasks. o Streamline operations and organizational design to accommodate growth, Implement new and effective approaches to marketing and communication for customers, suppliers, and employees, Acquire new resources for strategic growth: executive hires. Module-IV: **Planning and streamlining financial/ Legal processes** Managing cash for growth, Balance between profitability and growth costs, Role of business services –accountant, lawyer, Understanding legal requirements, and compliance issues, Exit options :Evaluating opportunities for acquisition; Growth financing, Scalability & efficiency improvements, IPR.

6	Entrepreneurship Expansion	Module-I: **Expansion model** Geographical/Franchising/Licensing routes to new market expansion Module-II: **Maximizing Profits** Testing price elasticity, Cost reduction through scaling up, Expanding offerings, other revenue streams (partnerships) Module-III: **Renewal** Similar to Take-off and Resource Maturity of SMEs Module-IV: **Harvesting Rewards** Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy

8. Title of the Minor: MINOR IN MANAGERIAL ECONOMICS AND IPR IN MANUFACTURING SECTOR

Minor will be offered to:- All disciplines

Sr. No.	Name of the Course	Brief Curriculum
1	Elements of Business Management in Manufacturing sector	Overview of manufacturing sector, nature of business management, Management principles, Types of capital for micros, small, medium and large scale industries and start ups.
2	Sem IV –Cost economics in manufacturing	Types of costing, Break even analysis, Profitability, Appraisal of business, Variance costing etc.
3	Retail & Supply chain management	Distribution channels and logistics in manufacturing sector, Retail operation and retail pricing, understanding international business, strategic cost management
4	Certification & Sustainability compliances in manufacturing sector	Environmental Legislations in manufacturing sector, International and National policy regarding certification, Environmental auditing, eco-labeling-for manufacturing sector
5	Innovation - New Product Development & IPR	Role of innovation in business development, concept of 'concurrent engineering', phases of product development, concept of 'Design Review', Failure modes and Effect analysis, Capturing values by protecting innovation, types of Intellectual Property rights and Patent protection strategies

9 Title of the Minor: MINOR IN INTERNET OF THINGS

Minor will be offered to:- All branches excluding Electrical, Electronics and Electronics & Telecommunication

Sr. No.	Name of the Course	Brief Curriculum
1	BASICS OF ELECTRONIC CIRCUITS	This course introduces the foundational concepts of electronic circuits essential for IoT systems. It covers diode-based circuits including rectifiers, clippers, clampers, Zener diodes, LEDs, and photodiodes. It then explores Bipolar Junction Transistors (BJTs) and their use in amplifier and switching circuits, followed by FETs and MOSFETs with similar applications. The course also includes differential amplifiers and operational amplifiers (Op-Amps) with practical circuits such as inverting, non-inverting amplifiers, adders, subtractors, integrators, and differentiators. Emphasis is placed on both DC and AC circuit behavior, equipping students with core electronic skills needed for real-world hardware interfacing and IoT system design.
2	DIGITAL ELECTRONICS	This course introduces the core principles of digital electronics, crucial for designing logical control systems in IoT. It begins with number systems, binary arithmetic, and basic logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR) along with their truth tables. Students then study Boolean algebra, its theorems, and logic simplification techniques using Karnaugh Maps. The course continues with the design of combinational logic circuits such as comparators, code converters, multiplexers, demultiplexers, encoders, decoders, and binary adders/subtractors. It concludes with sequential logic systems, covering latches and flip-flops (SR, JK, D, T, Master-Slave), which are fundamental to memory and timing operations in digital systems.
3	SENSORS AND TRANSDUCERS	This course covers types and characteristics of transducers and sensors, including resistive, capacitive, inductive, elastic, and active types. It introduces conventional and smart sensors, their principles, applications, and selection criteria for electronic systems and IoT.
4	PRINCIPLES OF IOT	This course introduces IoT concepts, components, and architecture. It covers IoT standards, protocols, and wireless sensor networks. Students learn about sensors, actuators, and open hardware like Arduino and Raspberry Pi. The course includes IoT software platforms (e.g., AWS, Azure, Node-RED) and concludes with prototyping IoT applications using real-world examples and APIs.
5	INDUSTRIAL IOT	IoT enables predictive maintenance of machinery and optimization of manufacturing processes.It Focuses on smart grid technology, efficient energy distribution, and wireless communication systems. It Facilitates smart city initiatives, infrastructure monitoring, and traffic management systems. Involves the development of robust, secure networks and efficient data processing algorithms. IoT applications are in process automation, real-time monitoring of chemical plants, and safety management.

10 Title of the Minor: MINOR IN SIGNAL PROCESSING AND IMAGING

Minor will be offered to:- CS, IT, Civil, Production, Mechanical, Textile and other Non-circuit Engineering branches

Sr. No.	Name of the Course	Brief Curriculum
1	SIGNALS AND SYSTEMS	This course introduces CT and DT signals, system classification, impulse response, and convolution. It covers Z-transforms, their properties, and system realization using FIR/IIR models. Students learn difference equations, convolution methods, and stability analysis. The course ends with frequency domain analysis using pole-zero plots and system classification based on frequency and phase response.
2	DIGITAL SIGNAL PROCESSING	This course covers linear phase FIR systems, DFT and FFT techniques, FIR filter design using windows and frequency sampling, and IIR filter design using analog approximations and transformations.
3	DIGITAL IMAGE PROCESSING	This course introduces image processing fundamentals including image acquisition, digitization, and color models. It covers various image transforms (DFT, DCT, Wavelet), image enhancement techniques (histogram equalization, filtering), and image segmentation methods (edge detection, clustering, morphological operations). It also addresses image compression concepts and standards like JPEG and JPEG2000. Applications focus on real-world engineering and design problems.
4	PATTERN RECOGNITION	This course focuses on applying pattern recognition techniques to signal processing problems. It begins with the fundamentals of pattern recognition systems and their role in signal classification. Key topics include Bayesian decision theory for signal categorization, Gaussian models for signal distribution, and parameter estimation techniques. It emphasizes unsupervised learning (e.g., K-means clustering) for analyzing signal features and uses PCA for reducing signal data dimensionality. The course concludes with Hidden Markov Models (HMMs), widely used in speech, biomedical, and sequential signal pattern analysis
5	APPLICATIONS OF SIGNAL AND IMAGE PROCESSING	Vibration analysis for machinery health monitoring. Remote sensing for structural health and environmental monitoring. Enhancing communication systems through noise reduction and data compression. Medical imaging techniques such as MRI and ultrasound for diagnostics. Real-time image processing for immersive experiences in Virtual Reality. Image enhancement and restoration in digital forensics. Deep learning for image classification and segmentation. Develop textiles with integrated signal processing for health monitoring or environmental sensing. Use of ultrasonic and X-ray signals to assess product integrity without damage. Identifying anomalies in production processes through signal analysis.

11. Title of the Minor: MINOR IN CYBERSECURITY

Sr. No.	Name of the Course	Brief Curriculum
1	FUNDAMENTALS OF CYBERSECURITY	This course introduces the core concepts of cybersecurity. It begins with security goals, types of cyberattacks (passive, active, web, email), OSI security architecture, and malware (viruses, worms, trojans). It then covers cybercrimes and the Information Technology Act, 2000, including digital signatures and electronic evidence. Students learn number theory fundamentals like modular arithmetic and prime numbers, which are foundational for encryption. The course concludes with traditional symmetric-key ciphers, including substitution and transposition techniques, stream/block ciphers, and classical encryption methods like the Hill and Playfair ciphers.
2	MODERN CRYPTOGRAPHY	This course covers advanced cryptographic techniques essential for secure communication. It begins with symmetric-key cryptography, focusing on block cipher design, DES, and AES algorithms. Next, it introduces asymmetric-key cryptography, including RSA, Diffie-Hellman, and Elliptic Curve Cryptography (ECC). The course then covers message integrity and authentication, using hash functions (SHA), HMAC, DAA, and CMAC. It concludes with digital signatures and key management, discussing standards, digital certificates (X.509), and protocols like Kerberos.
3	NETWORK SECURITY	This course introduces the principles and threats related to network security. It covers network security models, attacks on the TCP/IP suite, and real-time communication security. Students learn about IP and email security, including SSL/TLS, PGP, and firewall configurations. It addresses network vulnerabilities such as DoS, spoofing, man-in-the-middle attacks, and defense tools like NIDS and firewalls. The course also explores web security (e.g., SQL injection, XSS) and wireless network security, including threats like WEP vulnerabilities and methods for securing adhoc and sensor networks.
4	IOT AND CLOUD SECURITY	This course covers security principles for IoT and cloud environments. It begins with IoT and cloud architecture, service models (IaaS, PaaS, SaaS), and design principles like encryption and layered defense. Students study vulnerabilities and attack surfaces in IoT/cloud systems, and trust models including authentication and privacy frameworks. It explores secure communication, network protocols, and back-end data protection in IoT. The course concludes with cloud security controls for IoT and hands-on penetration testing, using tools for scanning, exploitation, and interface debugging.
5	ETHICAL HACKING AND DIGITAL FORENSICS	

12. Title of the Minor: Contract Law, Arbitration, and Valuation

Sr. No	Name of the Course	Brief Curriculum
1	Legal Framework for Construction	**Introduction to Construction Law:** Overview of construction law and its importance, Key legal concepts and terminologies, **Legal Frameworks and Regulatory Environment:** Overview of relevant laws and regulations (e.g., Planning and Construction Law of 1965 in Israel) National and international standards and codes **Construction Contracts:** Types of construction contracts, Key clauses and contract negotiation, Contract management and administration **Liability and Risk Management:** Legal responsibilities and liabilities in construction, Risk assessment and mitigation strategies, Insurance and bonding **Construction Dispute Resolution:** Common disputes in construction projects, Mediation, arbitration, and litigation processes, Case studies on dispute resolution **Regulatory Compliance and Ethics:** Compliance with environmental, safety, and building codes, compliance with labour laws, Ethical considerations in construction practice, Professional responsibility and conduct **Emerging Issues in Construction Law:** Impact of technology on construction law, Legal challenges in sustainable construction, Recent legal developments and case studies, Learning Outcomes
2	Contracts, Claims, and Dispute Management	**Introduction to Contract Management** Definition and importance of contract management, Types of contracts and key elements, Contract lifecycle: initiation, execution, and closure **Contract Formation and Negotiation** Key principles of contract law, Drafting and reviewing contracts, Negotiation techniques and strategies **Contract Administration** Effective contract management practices, Roles and responsibilities in contract administration, Monitoring performance and compliance **Claims and Insurance Management** Types of claims and insurances (e.g., delay, disruption, acceleration), Identifying and documenting claims, Claim analysis and preparation **Dispute Avoidance and Resolution** Techniques for preventing disputes, Alternative Dispute Resolution (ADR) methods: mediation, arbitration, Litigation process and strategies **FIDIC Contracts and Claims** Overview of FIDIC contract types, FIDIC claims procedures and management, Case studies on FIDIC disputes **Legal and Ethical Considerations**

		Legal frameworks and regulations impacting contracts and claims, Ethical issues in contract and dispute management, Professional responsibility and conduct **Case Studies and Practical Applications** Real-world case studies and examples, Practical exercises and role-plays, Group discussions and presentations
3	Project Accounting and Cost Management	**Introduction to Project Accounting and Cost Management** Definition and importance, The Project Accountant, Project Pricing Methodologies: Cost Plus Pricing, Fixed Fee Pricing, Contractual Modifiers. **Project Billing and Revenue** Progress Billings, Project Revenue Recognition, Percentage of Completion Method, Completed Contract Method, Contract Modifications, Measurement of Progress Completion. **Construction financing and control** Cost associated with constructed facilities, Techniques for cost estimation, effect of scale on construction cost, Measurement of Progress Completion, cost control in construction. **Project Cost Management** , Progress Monitoring, Cost Variance Reporting, Change Order Management, Allowance Management, Contingency Management, The Sunk Cost Consideration. **Decision Making Tools** Marginal Costing, Techniques of Marginal Costing, Application of Marginal Costing in Decision Making, Differential Cost Analysis, Transfer Pricing, Methods of Transfer Pricing. **Budgeting and Budgetary Control** Budgetary Control and Preparation of Functional and Master Budgeting, Fixed, Variable, Semi-variable Budgets, Financial statements for projects, Zero Based Budgeting (ZBB). **Tools for Financial Analysis and Planning** Financial Ratio Analysis, Fund Flow Analysis, Cash Flow Analysis **Project Measurements** Learning Curve, Cost Variance, Net Present Value, Breakeven Analysis, Return on Assets.
4	Construction Safety, Quality, and Risk Management	**Introduction to Construction Safety** Importance of safety in construction, Common hazards and risks, Regulatory frameworks and safety standards. Basic terminology in safety, types of injuries, safety pyramid. Accident patterns, theories of accident-causation.Personal Protective Equipment (PPE). **Safety Management Systems** Components of a safety management system, Implementing safety protocols, Monitoring and continuous improvement. Types of PPE and their uses, Proper usage and maintenance of PPE, Employer and employee responsibilities. **Planning for safety** Safety budget, safety culture, Introduction to OSHA regulations, Role of stakeholders in safety, Site safety programs - Job hazard analysis, accident investigation & accident indices-violation, penalty. **Construction Quality Management** Definition and importance of quality in construction, Quality control vs. quality assurance, Tools and techniques for quality management. **Standards and Compliance** Industry standards for quality, Compliance with legal and regulatory requirements, Quality certifications and audits. **Risk Management Process** Identifying risks, Analyzing and evaluating risks, Implementing risk controls. Introduction to risk management, Types of risks in construction (e.g., financial, legal, strategic), Risk assessment and mitigation strategies. **Best Practices for Construction Safety and Quality** SoPs (Safe Operating Procedures) – Construction equipment, materials handling-disposal & hand tools. Awareness and training programs, Effective communication and documentation, Use of proper equipment and technology.
5	Appraisal Implementation	**Introduction to Infrastructure Projects**

	for Infrastructure Projects	Definition and importance of infrastructure projects, Types of infrastructure projects (e.g., transportation, energy, water), Overview of the project lifecycle **Project Appraisal Techniques** Feasibility studies, Cost-benefit analysis, Environmental and social impact assessments Risk analysis and management **Financial Analysis and Funding** Financial feasibility and economic viability, Sources of financing (public, private, PPP) Budgeting and financial planning, Investment appraisal techniques (NPV, IRR, payback period) **Legal and Regulatory Framework** Regulatory requirements and compliance, Contracts and procurement processes, Stakeholder engagement and management **Project Planning and Scheduling** Project planning tools and techniques, Work breakdown structure (WBS), Critical path method (CPM) and Gantt charts, Resource allocation and management **Project Implementation** Construction management, Quality assurance and control, Health, safety, and environmental management, Monitoring and evaluation **Project Management Software** Introduction to project management software (e.g., MS Project, Primavera), Application of software in project planning and control, Case studies and practical exercises **Case Studies and Best Practices** Analysis of successful infrastructure projects, Lessons learned and best practices, Group projects and presentations

13. Title of Minor : Quantum Technology

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

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.

Programme Name	B. Tech. Computer Engineering	Semester	III
Course Code			
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: 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			

Unit	Course **Contents**	**Contact Hrs**	**CO**
1	Quantum Technologies – four verticals, Motivation for Quantum Technologies	(1 Hour)	
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	(4-5 Hours)	

	• No cloning theorem • Simulating classical systems – Feynman's idea of a quantum simulator and the birth of the field		
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)	
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)	
5	Quantum Communications : Basics of digital communication, Quantifying classical information –	(8-10	

	Shannon entropy, Basic ideas of quantum communication, security, eavesdropping, Overview of quantum communication achievements, Terrestrial – fibre-based, Free space, Satellite-based	Hours)	
6	**Topics on Quantum Materials are to be covered in the other portions of the course wherever required and are not listed separately here.**		

References Books:

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)

QT 02: Foundations of Quantum Technologies, 3:0 (Mandatory)

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.

Programme Name	B. Tech. Computer Engineering	Semester	IV
Course Code			
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:			

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

Unit	Course **Contents**	**Contact 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 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	**(16 - 18 Hours)**	

	■ 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		
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**)	
3	● Information Science ○ Digital communication and information ■ Quantifying information in terms of Shannon entropy ○ Basic ideas of quantum information	(3-4 **Hours**)	

	○ Decoherence and noise ● Introductory ideas of Kraus operators		
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**)	

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)

QT 03: Basic Programming Lab (2:1)

(Out of QT 03 and QT 04, at least ONE is mandatory)

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

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

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

Unit	Course **Contents**	**Contact Hrs**	**CO**
1	● Basics of programming ○ Data structures, classes, Object-oriented programming ○ Data storage and retrieval, Memory allocation ○ Scientific plotting, documentation of codes		
2	● Simple algorithms and benchmarking run time ○ Sorting ○ Searching ○ Arithmetic algorithms like GCD, Prime factorisation		
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		

4	● Numerical techniques in linear algebra ○ Matrix inverse ○ Eigenvalue problem ○ Diagonalisation of matrices ○ Singular value decomposition		
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		
	● 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	● Applications to EM theory (e.g. magnetic field simulation) ○ Electrostatic charge distributions ○ Magnetostatic current distributions ● Finite Element techniques for electromagnetic simulations		

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).

QT 04: Basic Laboratory Course for Quantum Technologies (2:1)
(Out of QT 03 and QT 04, at least ONE is mandatory)

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

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 outcomes:

Students of this course learn

1. Basic experimental techniques in optics
2. Basic experimental techniques in characterizing resonators and RLC circuits
3. Basic digital circuits
4. Fundamental techniques in RF engineering

5. Interfacing instruments with computers and carry out data acquisition

Unit	Course **Contents**	**Contact Hrs**	**CO**
1	● Optics ○ Interferometry – wavelength measurements, intensity measurements ○ Diffraction – single slit, grating ○ Microscopy – magnification, aberration ○ Polarization optics – PBS, HWP, QWP		
2	● RLC circuits ○ Series and parallel RLC circuits – Verifying the quality factor formulae ○ Extracting intrinsic losses		
3	● Digital circuits ○ Adder, Multiplier ○ Encoder, Decoder ○ D flipflop, shift registers ○ How to use common Integrated Circuit chips		
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		
5	● Interfacing instruments with a computer		
6	● 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		
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)		
8	● Running simple algorithms on cloud-based quantum processors (optional)		

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)

QT 05: Introduction to Quantum Computation 3:0

(Out of QT 05, QT 06, QT 07 and QT 08, at least ONE is mandatory)

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

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.
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.

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

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).
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

(Out of QT 05, QT 06, QT 07 and QT 08, at least ONE is mandatory)

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

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.

Unit	Course **Contents**	**Contact Hrs**	**CO**
1	● Basics of Polarization optics ○ Quarter and half-wave plates ○ Polarizing beam splitters		
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		
3	● Digital communication – information theory (basics) ○ Information entropy ○ Noiseless channel encoding ○ Noisy channel encoding		
4	● No cloning theorem ● Quantum Memories ● Quantum repeaters ● Entanglement and Bell Theorems ● Bell Measurements and Tests ● Quantum Teleportation protocol ● Quantum Dense coding		
5	● Quantum Key Distribution protocols ○ BB84 ○ E91 ○ BBM92. ○ B92 ○ COW ○ DPS		

6	• Quantum Networks and Quantum Internet
	• Survey of Hardware implementations
	  ○ Free space communications
	  ○ Satellite based communications
	  ○ Fibre optics-based 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).

QT 07: Introduction to Quantum Sensing 3:0

(Out of QT 05, QT 06, QT 07 and QT 08, at least ONE is mandatory)

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

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

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

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)		

Course References:

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
(Out of QT 05, QT 06, QT 07 and QT 08, at least ONE is mandatory)

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

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

Unit	Course **Contents**	**Contact 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)		
2	● 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		

4	• 2D materials
	  ○ Graphene and its properties – single and few layers
	  ○ Transition Metal Dichalcogenides – Electronic and Optical Properties		

5	• Topological Phases of matter
	  ○ Basics of Topology
	  ○ Geometric phases - Berry Phase
	  ○ Aharonov Bohm effect
	  ○ Topological phases of matter		

6	Survey of material growth techniques • Molecular beam epitaxy • Chemical vapor deposition, MOVPE • Pulsed laser deposition, etc. • Crystal growth techniques		

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)

QT 09: Engineering Foundations of Quantum Technologies 3:0 (optional / additional)

This course is meant to cover topics in electrical, electronics and communication engineering, as well as in computer science that are relevant to Quantum computation, Communications and Sensing. This is a survey course and not meant for a rigorous treatment of each topic.

Programme Name	B. Tech. Computer Engineering	Semester	VII
Course Code			
Course Title	Engineering Foundations of Quantum Technologies		
Course Scheme	(L-T-P: 3-0-0) (TA-MST-ESE : 20-30-50)		
Credits	3		
Course Type	Elective-II (Quantum Technologies)		

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

Unit	Course Contents	Contact 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 hours	

2	• Electrical Networks
	  ○ Analog RLC circuits – resonances, impedances, quality factors
	  ○ Transmission line basics
	  ■ Telegrapher equations, wave impedance, impedance matching, transmission line resonators
		4 hours	

3	• Computer Science ○ Basics of computer architecture	**15 hours**	

	■ 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 ■ Time and Space complexity ■ P vs NP, NP-completeness		
4	● Electrical Communications ○ Analog Communications ■ Quadrature amplitude modulation ■ Heterodyne and Homodyne demodulation	**1 hour**	
5	● Electrical Communications ○ Analog Communications ■ Quadrature amplitude modulation ■ Heterodyne and Homodyne demodulation	**1 hour**	
6	● 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	**6 hours**	

	○ Quantum limits on noise in linear amplifiers		
7	● Digital Communications ○ Information entropy ○ Noiseless channel encoding ○ Noisy channel encoding	**4 hours**	
8	● 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 hours**	

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 Press (2006)

QT 10: Solid State Physics for Quantum Technologies 3:0 (optional / additional)

Programme Name	B. Tech. Computer Engineering	Semester	VII
Course Code			
Course Title	Solid State Physics for Quantum Technologies		
Course Scheme	(L-T-P: 3-0-0) (TA-MST-ESE : 20-30-50)		
Credits	3		
Course Type	Elective-II (Quantum Technologies)		

Course Outcomes:

Students of this course learn

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

Unit	Course **Contents**	**Contact Hrs**	**CO**
1	● Structure of solids – ○ Symmetry, Bravais lattices ○ Laue equations and Bragg's law, ○ Brillouin Zones ● Atomic scattering and structure factors		
2	● Characterisation of crystal structures – XRD etc		
3	● Bonding in solids – ○ van der Waals and Repulsive interactions, ○ Lennard Jones potential, ○ Madelung constant		

4	● 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		
5	● Beyond the Free electron model ○ Kronig-Penney Model ○ Periodic potential – Bloch Theorem ○ Band theory ○ Tight binding model		
6	● 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	● Magnetism ○ Dia-, Para-, and Ferromagnetism ○ Langevin's theory of paramagnetism ○ Weiss Molecular theory		
8	● 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. 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).

QT 11: Quantum Optics 3:0 (optional / additional)

Programme Name	B. Tech. Computer Engineering	Semester	VII
Course Code			
Course Title	Quantum Optics		
Course Scheme	(L-T-P: 3-0-0) (TA-MST-ESE : 20-30-50)		
Credits	3		
Course Type	Elective-II (Quantum Technologies)		

Course Outcomes:

Students of this course learn

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

Unit	Course **Contents**	**Contact Hrs**	**CO**
1	● 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		
2	● 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		
3	● Phase-space representations of states of light ○ Wigner distribution ○ P-function and the notion of non-classicality with some examples of nonclassical states like squeezed states and their applications ○ Husimi Q function		
4	● 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		
5	● Open quantum systems ○ Fermi golden rule ○ Born-Markov Lindblad Master Equation		

Course References:

1. AICTE Prescribed Textbook: Physics (Oscillations, Waves and Optics), A. B. Bhattacharya & Atanu Nag, Khanna Publishing House (2025)
2. Introductory Quantum Optics, Christopher Gerry and Peter Knight, Cambridge University Press (2004)
3. Quantum Optics, D. F. Walls, Gerard J. Milburn, 2nd Edition, Springer (2008)
4. Quantum Optics: An introduction, Mark Fox, Oxford University Publishers (2006)
5. Quantum Optics for Beginners, Z. Ficek and M. R. Wahiddin, 1st edition, Jenny Stanford Publishing (2014)