



## SYLLABUS

Marks: 100 (100 questions)

Time: 02 Hours

## Ph.D. (Chemical Engineering)

Marks: 100 (100 questions)

## Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

## Subject Paper(50%)

**Process Calculations and Thermodynamics:** Laws of conservation of mass and energy; use of tie components; recycle, bypass and purge calculations; Degree of freedom analysis. First and Second laws of thermodynamics. First law application to close and open systems. Second law and Entropy, Thermodynamic properties of pure substances: equation of state and departure function, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibria.

**Fluid Mechanics and Mechanical Operations:** Fluid statics, Newtonian and non-Newtonian fluids, Bernoulli equation, Macroscopic friction factors, energy balance, dimensional analysis, shell balances, flow through pipeline systems, flow meters, pumps and compressors, packed and fluidized beds, elementary boundary layer theory, size reduction and size separation; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, mixing and agitation; conveying of solids.

**Heat Transfer:** Conduction, convection and radiation, heat transfer coefficients, steady and unsteady heat conduction, boiling, condensation and evaporation; types of heat exchangers, evaporators and their design.

**Mass Transfer:** Fick's law, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stagewise and continuous contacting and stage efficiencies; HTU & NTU concepts design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption.

**Chemical Reaction Engineering:** Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis.

**Instrumentation and Process Control:** Measurement of process variables; sensors, transducers and their dynamics, transfer functions and dynamic responses of simple systems, process reaction curve, controller modes (P, PI, and PID); control valves; analysis of closed loop systems including stability, frequency response and controller tuning, cascade, feed forward control.

**Plant Design and Economics:** Process design and sizing of chemical engineering equipment such as compressors, heat exchangers, ultistage contactors; principles of process economics and cost estimation including total annualized cost, cost indexes, rate of return, payback period, discounted cash flow, optimization in design.

**Chemical Technology:** Inorganic chemical industries; sulfuric acid, NaOH, fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; polymerization industries; polyethylene, polypropylene, PVC and polyester synthetic fibers.

## Ph.D. (Chemistry)

Marks: 100 (100 questions)

## Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

## Subject Paper (50%)

**Inorganic Chemistry:** Chemical periodicity; Structure and bonding in homo-and hetero-nuclear molecules, including shapes of molecules (VSEPR Theory); Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents; Main group



elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds; Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms; Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications; Organo-metallic compounds: synthesis, bonding and structure, and reactivity. Organo-metallics in homogeneous catalysis; Cages and metal clusters; Analytical chemistry-separation, spectroscopic, electro-and thermo analytical methods; Bioinorganic chemistry: photo-systems, porphyrins, metallo-enzymes, oxygen transport, electron-transfer reactions; nitrogen fixation, metal complexes in medicine; Characterization of inorganic compounds by IR, Raman, NMR, EPR, Mossbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques; Nuclear chemistry: nuclear reactions, fission and fusion, radio analytical techniques and activation analysis.

**Physical Chemistry:** Basic principles of quantum mechanics: Postulates; operator algebra; exactly-solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling; Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications; Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle; Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated  $\pi$ -electron systems; Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules; Molecular spectroscopy: Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities–selection rules; basic principles of magnetic resonance; Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions; Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities –calculations for model systems; Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance –Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations; Chemical kinetics: Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions; Colloids and surfaces: Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis; Solid state: Crystal structures; Bragg's law and applications; band structure of solids; Polymer chemistry: Molar masses; kinetics of polymerization; Data analysis: Mean and standard deviation; absolute and relative errors; linear regression; co-variance and correlation coefficient.

**Organic Chemistry:** IUPAC nomenclature of organic molecules including regio-and stereoisomers; Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction; Aromaticity: Benzenoid and non-benzenoid compounds–generation and reactions; Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzyne and nitrenes; Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways; Common named reactions and rearrangements –applications in organic synthesis; Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations; Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups; Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction –substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution–optical and kinetic; Pericyclic reactions –electrocyclisation, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Principles and applications of photochemical reactions in organic chemistry; Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S); Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids; Structure determination of organic compounds by IR, UV-Vis,  $^1\text{H}$  &  $^{13}\text{C}$  NMR and Mass spectroscopic techniques.



**Interdisciplinary topics:** Chemistry in nano-science and technology; Catalysis and green chemistry; Medicinal chemistry; Supramolecular chemistry; Environmental chemistry

### Ph.D. (Computer Science & Engineering)

**Marks: 100 (100 questions)**

#### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

#### Subject Paper (50%)

**Programming Concepts:** Programming in C; Functions, Recursion, Parameter passing, Scope, Binding; Abstract data types, Arrays, Stacks, Queues, Linked Lists, Trees, Binary search trees, Binary heaps.

**Theory of Computation:** Regular languages and finite automata, Context free languages and Push-down automata, Recursively enumerable sets and Turing machines, NP completeness. Distributed Computing, Introduction to Grid and Cloud Computing, Issues of Grid and Cloud Computing.

**Digital Logic:** Logic functions, Minimization, Design and synthesis of combinational and sequential circuits; Number representation and computer arithmetic (fixed and floating point).

**Computer Organization and Architecture:** Machine instructions and addressing modes, ALU and data-path, CPU control design, Memory interface, I/O interface (Interrupt and DMA mode), Instruction pipelining, Cache and main memory, Secondary storage.

**Algorithms:** Analysis, Asymptotic notation, Notions of space and time complexity, Worst and average case analysis; Design: Greedy approach, Dynamic programming, Divide-and-conquer; Tree and graph traversals, Connected components, Spanning trees, Shortest paths; Hashing, Sorting, Searching.

**Operating System:** Processes, Threads, Inter-process communication, Concurrency, Synchronization, Deadlock, CPU scheduling, Memory management and virtual memory, File systems, I/O systems, Protection and security.

**Databases:** ER-model, Relational models, Database design (integrity constraints, normal forms), Query languages (SQL), Transactions and concurrency control. Data Warehouse environment, Architecture of a data warehouse methodology" analysis, design, construction and administration, Extracting models and patterns from large databases, data mining techniques, regression, clustering, summarization, dependency modeling, link analysis, sequencing analysis, mining scientific and business data.

**Computer Networks:** LAN technologies (Ethernet, Token ring), Flow and error control techniques, Routing algorithms, Congestion control, TCP/UDP and sockets, Basic concepts of hubs, switches, gateways, and routers. Mobile Ad-hoc Networks, Technologies for Ad-hoc Network, Issues in Ad-hoc wireless Networks, IEEE 802.11 Basic Sensor Network Architectural Elements, Applications of Sensor Networks, Comparison with Wireless Networks, Challenges and Hurdles. Architecture of Wireless Sensor Networks (WSNs), Hardware components

**Image Processing:** Digital Image Fundamentals, image formation, geometric and photometric models, digitization including sampling, quantization and digital image visual details.

**Discrete Mathematics:** Introduction to Sets and Proposition, Basic principles of counting and probability, Relations and Functions, Mathematical logic Graphs and Planer graphs, Recurrence relations and recursive algorithms, groups, rings and Boolean algebra.

**Software Engineering and ERP:** Information processing, System development model, ERP concepts and technologies, ERP implementation strategies.

**Modern Technologies:** IOT, Block chain, Machine learning, Cloud, Fog and Edge computing.



### Ph.D. (Electrical and Instrumentation Engineering)

Marks: 100 (100 questions)

#### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

#### Subject Paper (50%)

**Electrical Technology and Networks:** Introduction to electrical systems, DC and AC circuits, basic electrical components, electromagnetism, alternating quantities, AC power, single phase series and parallel circuits, resonance, Comparison between Magnetic and Electric circuits, Electromagnetic Induction, Magnetic Effects of Electric Current, Current carrying conductor in Magnetic field, Law of Electromagnetic Induction, Self-Inductance, Mutual Inductance, Coupling Coefficient between two magnetically coupled Circuits, Transformer: principle, construction, working, efficiency, application. D.C. Generator: principle, construction, working, application, D.C. Motor: principle, construction, working, application. Three phase Induction Motor: principle, construction, working, application. Nodal and mesh analysis, network theorems, superposition. Thevenin, Norton, reciprocity, Millman's, Tellegen's theorems, star-delta transformation, steady state sinusoidal analysis using phasors, Fourier series, linear constant coefficient differential and difference equations; time domain analysis and frequency domain analysis of RLC series and parallel circuits, convolution, 2-port network parameters, driving point and transfer functions, state equation for

networks, attenuators (lattice, T-type, P-type, L-type, ladder type, balanced), conventional filters, passive network synthesis (positive real functions, LC network, synthesis of dissipative network, two terminal R-L and R-C network).

**Electronics Principles:** Characteristics and equivalent circuits (large and small signal) of diodes (pn junction, zener, schottky, varactor), BJT, JFETs, UJT, and MOSFET; clipping, clamping, rectifier; biasing and bias stability of transistor and FET amplifiers, single and multistage coupling, differential, operational, feedback and power. Analysis of amplifiers, frequency response of amplifiers. op-amp circuits, filters, sinusoidal oscillators, criterion of oscillation, function generators and wave-shaping circuits, power supplies, display units.

**Power Electronics-** Introduction to thyristor family V-I characteristics of SCR, SUS, PUT, SCS, GTO, LASCR. Principle of operation of SCR. Two transistor analogy. Turn on methods of a thyristor Switching characteristics of thyristors during turn-on and turn-off. Gate characteristics. Firing of thyristors. Gate triggering circuits. Series and parallel, operation of SCRs and their triggering circuits. Thyristor specifications; such as latching current and holding current,  $dv/dt$  and  $di/dt$ , PTV etc. Protection of SCR from over voltage and over current. Snubber circuits. Power dissipation. Introduction to phase angle control. Single phase half wave controlled rectifiers. Single phase half controlled and fully controlled bridge rectifiers. Three phase fully controlled bridge rectifiers. Effect of resistive, inductive and resistive cum inductive loads. Basic circuit and principle of operation of Dual Converter, circulating current mode and non-circulating current mode of operation. Introduction to inverter. Operating principle and already state analysis of single phase, voltage source, bridge inverter. Modified McMurray half-bridge and full bridge inverter. Three phase bridge inverter. Voltage control (PWM control etc.) and reduction of harmonics in the inverter output voltage.

**Digital electronics and microprocessors:** Number systems and arithmetic (binary, Gray, BCD, Excess-3). Boolean algebra, minimization of Boolean functions, logic gates, IC families, combinational and sequential circuits, sample and hold circuits, ADCs and DACs, semiconductor memories, ALU design, microprocessor (8085), architecture, programming, memory and I/O interfacing chips (8255, 8253, 8251, 8279, 8259), introduction to microprocessor 8086 and microcontroller 8051.

**Transducers and Instrumentation:** Measurement of voltage, current, power, energy and power factor for Bridges and potentiometers, PMMC moving iron, dynamometer and induction type instruments, instrument transformer, digital voltmeters and multi-meters, phase, time and frequency measurement, Q-meter, oscilloscope, potentiometric recorders, error analysis, transducers-elastic, resistive, inductive, capacitive, thermo-electric, piezo-electric, photo-electric, electro-mechanical, electro-chemical and ultrasonic measurement of displacement, velocity, acceleration, shock, vibration, force, torque, power, strain, stress, pressure, flow, temperature, humidity, viscosity and density.



**Control Theory :** Basic control system components, block diagram description, signal flow graphs, reduction of block diagrams, input test signals, properties of systems, linearity, time-invariance, stability, open loop and closed loop (feedback) systems, properties of linear time-invariant (LTI) systems, transient and steady state analysis of LTI system and frequency response. LTI control system analysis, root loci, Routh Hurwitz criterion, polar plots, Bode and Nyquist plots, elements of lead and lag compensations, state space representation of systems, state equations, decomposition, direct, cascade and parallel, solution of state equations, Laplace method, Calay-Hamilton method, diagonalization method and Sylvester method. Digital control, Configuration of the basic Digital control scheme, Principles of signal conversion, Basic Discrete-Time signals, Time-Domain Models for Discrete – Time Systems, Transfer function Model, Stability in the Z-Plane & Jury stability criterion, Sampling as impulse modulation, Sampled spectra & Aliasing, Filtering, Practical aspects of the choice of sampling rate, Principles of Discretization

**Programming concepts:** Algorithms, programming in C and C++, data types, console/file input and output, arrays, structures, pointers, functions, command line arguments, passing of parameters from one function to other, concept of OOPs.

**Power Systems:** Basic power generation concepts; transmission line models and performance; cable performance, insulation; corona and radio interference; distribution systems; per-unit quantities; bus impedance and admittance matrices; load flow; voltage control; power factor correction; economic operation; symmetrical components; fault analysis; principles of over-current, differential and distance protection; solid state relays and digital protection; circuit breakers; system stability concepts, swing curves and equal area criterion, HVDC transmission and FACTS concepts.

#### Ph.D. (Electronics & Communication Engineering)

**Marks: 100 (100 questions)**

##### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration).

##### Subject Paper (50%)

**Electronic Devices and Circuits:** Semiconductor physics, diffusion current, drift current, mobility, and resistivity. Generation and recombination of carriers; p-n junction diode, Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED, p-i-n and avalanche photo diode, Basics of LASERs. Device technology: integrated circuits fabrication process, oxidation, diffusion, ion implantation, photolithography. Small Signal Equivalent circuits of diodes, BJTs, MOSFETs and analog CMOS. Simple diode circuits, clipping, clamping, rectifier. Biasing and bias stability of transistor and FET amplifiers. Amplifiers: single and multi-stage, differential and operational, feedback, and power. Frequency response of amplifiers. Simple op-amp circuits. Filters. Sinusoidal oscillators; criterion for oscillation; single-transistor and op-amp configurations. Function generators and wave-shaping circuits, 555 Timers. Power supplies.

**Digital Systems:** Boolean algebra, minimization of Boolean functions; logic gates; digital IC families (DTL, TTL, ECL, MOS, CMOS). Combinatorial circuits: arithmetic circuits, code converters, multiplexers, decoders, PROMs and PLAs. Sequential circuits: latches and flip-flops, counters and shift-registers. Sample and hold circuits, ADCs, DACs. Semiconductor memories. Microprocessor(8085): architecture, programming, memory and I/O interfacing.

**Signal Processing:** Laplace transform, continuous-time and discrete-time Fourier series, continuous-time and discrete-time Fourier Transform, DFT and FFT, z-transform. Sampling theorem. Linear Time-Invariant (LTI) Systems: definitions and properties; causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay. Signal transmission through LTI systems.

**Control Theory:** Basic control system components; block diagrammatic description, reduction of block diagrams. Open loop and closed loop (feedback) systems and stability analysis of these systems. Signal flow graphs and their use in determining transfer functions of systems; transient and steady state analysis of LTI control systems and frequency response. Tools and techniques for LTI control system analysis: root loci, Routh-Hurwitz criterion, Bode and Nyquist plots. Control system compensators: elements of lead and lag compensation, elements of Proportional-Integral-Derivative (PID) control. State variable representation and solution of state equation of LTI control systems.



**Communication Systems:** Random signals and noise: probability, random variables, probability density function, Auto-correlation, power spectral density. Analog communication systems: amplitude and angle modulation and demodulation systems, spectral analysis of these operations, superheterodyne receivers; elements of hardware, realizations of analog communication systems; signal-to-noise ratio (SNR) calculations for amplitude modulation (AM) and frequency modulation (FM) for low noise conditions. Fundamentals of information theory and channel capacity theorem. Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation schemes: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), matched filter receivers, bandwidth consideration and probability of error calculations for these schemes. Basics of TDMA, FDMA and CDMA, wireless and cellular communication, GSM, wireless networks and sensors.

**Electromagnetics, Microwaves and optical fibers:** Elements of vector calculus: divergence and curl; Gauss' and Stokes' theorems, Maxwell's equations: differential and integral forms. Wave equation, Poynting vector. Plane waves: propagation through various media; reflection and refraction; phase and group velocity; skin depth. Transmission lines: characteristic impedance; impedance transformation; Smith chart; impedance matching; S parameters, pulse excitation. Waveguides: modes in rectangular waveguides; boundary conditions; cut-off frequencies; dispersion relations. Strip line structures, basics of Antennas: Dipole antennas, antenna parameters, microwave components and circuits. Basics of propagation in dielectric waveguide, basics of optical fibers and optical fiber waveguides: total internal reflection, acceptance angle, numerical aperture, mode, step index and graded index fiber. Basic of optical source, optical detector and non-linear optics.

#### Ph.D. (English)

**Marks: 100 (100 questions)**

##### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

##### Subject Paper (50%)

**Literary Critical Theory: Main features and major exponents/works:** New Criticism, Stylistics, Structuralism, Deconstruction, Discourse Analysis, Feminism, Post Colonialism, Postmodernism

**Study of Language:** Study of Language, Speech Mechanism, Vowels, Consonants, ELT

**Indian English Literature:** Nissim Ezekiel, Kamala Das, A.K. Ramanujan, Mulk Raj Anand, Raja Rao, R.K. Narayan, Bhabani Bhattacharya, Manohar Magonkar, Anita Desai, Arun Joshi, Nayantara Sehgal, Shashi Deshpande, Shobha De, Amitav Ghosh, Kiran Desai, Githa, Hariharan, Girish Karnad, Mahesh Dattani, Vijay Tendulkar, Nirad C. Chaudhary, Khushwant Singh

**Drama:** British Drama, Greek Drama, Shakespearean Drama, Jacobean Drama, Restoration Drama, Theatre of the Absurd, American Drama, African American Theatre

**Poetry:** Chaucer, Metaphysical Poetry, Neo Classical Poetry, Romantic Poetry, Victorian Poetry, Post Modernist Poetry, American Poetry.

**Fiction:** Women Novelists, Victorian Novelists, Early 20<sup>th</sup> Century Novelists, English Novelists of Post 1950's, American Novelists

**Diasporic Literature:** V.S. Naipaul, Salman Rushdie, Bharati Mukherjee, Vikram Seth, Rohinton Mistri

**Post Colonial Literature:** Chinua Achebe, Wole Soyinka, Nadine Gordimer, Michael Ondaatje, Margaret Atwood

#### Ph.D. (Food Engineering & Technology)

**Marks: 100 (100 questions)**

##### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

##### Subject Paper(50%)

**Food Analysis:** Texture analysis of foods, Microscopic techniques in food analysis (light microscopy, SEM, TEM, XRD, particle size analysis, image analysis etc.), Thermal methods in food analysis (Differential scanning calorimetry and others),



Chromatographic methods in food analysis and separation, Enzymatic methods of food analysis, application of biosensors in food analysis.

**Food Quality and Management:** Quality attributes- physical, chemical, nutritional, microbial, and sensory; their measurement and evaluation; Total Quality Management; GMP/GHP; GLP, GAP; Sanitary and hygienic practices; HACCP; Indian & International quality systems and standards like Food Safety and Standards Act, 2006, ISO and Food Codex.

**Food Engineering:** Engineering properties of foods, steady state and unsteady state heat transfer, Mass transfer, Death rate kinetics, thermal process calculations, heat and mass balance in single effect and multiple effect evaporator, methods to improve steam economy, Drying Rates, theories of drying, Freezing curves, freezing time calculations, membrane separation techniques, centrifugation and fluidization, viscometry and food rheology.

**Food Process Technology:** Mechanism and application of High Pressure processing, Ultrasonic processing, Microwave and radio frequency processing high intensity light, pulse electric field, ohmic heating, IR heating, inductive heating and hurdle technology in food processing and preservation.

**Food Process Equipment Design:** Basic Scientific and Engineering principles of equipment design, Riveted and welded joints, corrosion mechanism and corrosion control, Design of vessels and storage tanks.

**Bioprocess Engineering:** Fundamentals of growth kinetics, Media sterilization, Air Sterilization, Bioreactor fermenter, Aeration and Agitation. Bioprocess instrumentation, Bioprocess modeling and simulation and its application in industrial fermentation, scale-up of fermentation processes.

### Ph.D. (Management)

**Marks: 100 (100 questions)**

#### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

#### Subject Paper (50%)

**Unit-1:** Managerial Economics-Demand Analysis, Production Function, Cost-Output relation, Market Structures, Pricing Theories, Capital Budgeting; The concept and significance of organizational behavior, Personality-Perception-Values-Attitude-Learning & Motivation; Communication-Leadership-Managing Change, Organizational Development, Concepts & perspectives on HRM HRP- Objectives, Process & Techniques, Job Analysis-Selection-Induction-Training & Development, Performance Appraisal & Evaluation, Industrial Relations & Trade Unions, Dispute resolution and Grievance management

**Unit-2:** Financial Management-Nature & Scope, Capital Budgeting Decisions, Capital Structure & Cost of capital Dividend policy-Determinants, Mergers & Acquisitions, Marketing Information System & marketing research, Demand measurement & Forecasting, Market Segmentation-Targeting & positioning, Product life cycle, Pricing methods & strategies, Marketing Management, Marketing Mix, Customer Relation shift Management, Role & Scope of Production management, Facility Locations- Layout Managing & Analysis, Production Scheduling, Statistical Quality Control

**Unit-3:** Probability Theory, Probability, Distribution-Binomial, Poisson, Normal, Correlation & Regression Analysis, Sampling Theory & Sampling Distribution, Tests of Hypothesis-t, Z,F, chi-square tests, Concepts of corporate strategy-Ans off's growth vector, BCG Model, Porters generic strategies,Competitive strategy & Corporate Strategy, Competitive advantage of nations,RTP & WTO, Innovation & Entrepreneurship, Concept of Govt. Policy for promotion of small & Tiny Enterprises, Detailed Business Plan Preparation –Managing small industries –sickness in small enterprises

**Unit-4:** Ethics & Management System, Value based organizations, Ethical pressure on individual in organization Environmental ethics, Social responsibilities of Business, Corporate Governance, Research-Meaning, types, objectives, process survey based research-types of survey-specific-periodic & transaction drivers, Identification of research problem analysis of research problem, Categorization & sampling, Planning a survey Project-resources budget-schedule, Preparation of Questionnaire,-Data Collection analysis & compilation of Survey report.



### Ph.D. (Mathematics)

Marks: 100 (100 questions)

#### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

#### Subject Paper (50%)

**Linear Algebra:** Finite dimensional vector spaces; Linear transformations and their matrix representations, rank; systems of linear equations, eigen values and eigen vectors, minimal polynomial, Cayley-Hamilton theorem, diagonalization, Hermitian, Skew-Hermitian and unitary matrices; Finite dimensional inner product spaces, Gram-Schmidt orthonormalization process, self-adjoint operators.

**Complex Analysis:** Analytic functions, conformal mappings, bilinear transformations; complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle; Taylor and Laurent's series; residue theorem and applications for evaluating real integrals.

**Real Analysis:** Sequences and series of functions, uniform convergence, power series, Fourier series, functions of several variables, maxima, minima; Riemann integration, multiple integrals, line, surface and volume integrals, theorems of Green, Stokes and Gauss; metric spaces, completeness, Weierstrass approximation theorem, compactness; Lebesgue measure, measurable functions; Lebesgue integral, Fatou's lemma, dominated convergence theorem.

**Ordinary Differential Equations:** First order ordinary differential equations, existence and uniqueness theorems, systems of linear first order ordinary differential equations, linear ordinary differential equations of higher order with constant coefficients; linear second order ordinary differential equations with variable coefficients.

**Algebra:** Fundamental theorem of arithmetic, divisibility in  $\mathbb{Z}$ , congruence, Chinese Remainder Theorem, Euler's  $\phi$  function, primitive roots. Normal subgroups and homomorphism theorems, automorphisms; Group actions, Sylow's theorems and their applications; Euclidean domains, Principal ideal domains and unique factorization domains. Prime ideals and maximal ideals in commutative rings; Fields, finite fields.

**Functional Analysis:** Banach spaces, Hahn-Banach extension theorem, open mapping and closed graph theorems, principle of uniform boundedness; Hilbert spaces, orthonormal bases, Riesz representation theorem, bounded linear operators.

**Numerical Analysis:** Numerical solution of algebraic and transcendental equations: bisection, secant method, Newton-Raphson method, fixed point iteration; interpolation: error of polynomial interpolation, Lagrange, Newton interpolations; numerical differentiation; numerical integration: Trapezoidal and Simpson rules, Gauss Legendre quadrature, method of undetermined parameters; least square polynomial approximation; numerical solution of systems of linear equations: direct methods (Gauss elimination, LU decomposition); iterative methods (Jacobi and Gauss-Seidel); matrix eigenvalue problems: power method, numerical solution of ordinary differential equations: initial value problems: Taylor series methods, Euler's method, Runge-Kutta methods.

**Partial Differential Equations:** Linear and quasilinear first order partial differential equations, method of characteristics; second order linear equations in two variables and their classification; Cauchy, Dirichlet and Neumann problems; solutions of Laplace, wave and diffusion equations in two variables; Fourier series and Fourier transform and Laplace transform methods of solutions for the above equations.

**Mechanics:** Generalized coordinates, Lagrange's equations, Hamilton's canonical equations, Hamilton's Principle and principle of least action, two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of rigid body about an axis.

**Topology:** Basic concepts of topology, product topology, connectedness, countability and separation axioms, Urysohn's Lemma. Compactness.

**Probability and Statistics:** Probability space, conditional probability, Bayes theorem, independence, Random variables, joint and conditional distributions, standard probability distributions and their properties, expectation, conditional expectation, moments, sampling distributions, Testing of hypotheses, standard parametric test based on *normal*  $\chi^2, t, F$ -distributions.

**Linear programming:** Linear programming problem and its formulation, convex sets and their properties, graphical method,



basic feasible solution, simplex method, big-M and two phase methods; infeasible and unbounded LPP's, alternate optima; Dual problem and duality theorems, Balanced and unbalanced transportation problems, u -u method for solving transportation problems; Hungarian method for solving assignment problems.

### Ph.D. (Mechanical Engineering)

**Marks: 100 (100 questions)**

#### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

#### Subject Paper (50 % of Content)

**Engineering Materials:** Structure and properties of engineering materials and their applications; effect of strain, strain rate and temperature on mechanical properties of metals and alloys; heat treatment of metals and alloys, its influence on mechanical properties.

**Engineering Mechanics:** Free body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion, including impulse and momentum (linear and angular) and energy formulations; impact.

**Strength of Materials:** Stress and strain, stress-strain relationship and elastic constants, Mohr's circle for plane stress and plane strain, thin cylinders; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; strain energy methods; thermal stresses.

**Theory of Machines and Design:** Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of slider-crank mechanism; gear trains; flywheels.

Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; *principles* of the design of machine elements such as bolted, riveted and welded joints, shafts, spur gears, rolling and sliding contact bearings, brakes and clutches.

**Vibrations:** Free and forced vibration of single Degree of freedom systems; effect of damping; vibration isolation; resonance, critical speeds of shafts.

**Thermal Engineering:** Fluid mechanics - fluid statics, Bernoulli's equation, flow through pipes, equations of continuity and momentum; thermodynamics - zeroth, first and second law of thermodynamics, thermodynamic system and processes, calculation of work and heat for systems and control volumes; air standard cycles; basics of internal combustion engines and steam turbines; heat transfer - fundamentals of conduction, convection and radiation, heat exchangers.

**Metal Casting:** Casting processes - types and applications; patterns - types and materials; allowances; moulds and cores - materials, making, and testing; casting techniques of cast iron, steels and nonferrous metals and alloys; solidification; design of casting, gating and risering; casting inspection, defects and remedies.

**Metal Forming:** Stress-strain relations in elastic and plastic deformation; concept of flow stress, deformation mechanisms; hot and cold working - forging, rolling, extrusion, wire and tube drawing; sheet metal working Processes, analysis of rolling, forging, extrusion and wire /rod drawing; metal working defects.

**Advanced Welding Processes:** Welding processes - manual metal arc, MIG, TIG, plasma arc, submerged arc, electro slag, thermit, resistance, forge, friction, and explosive welding, inspection of welded joints, defects and remedies; - ultrasonic, electron beam, laser beam; thermal cutting.

**Machining and Machine Tool Operations:** Basic machine tools; machining processes, mechanics of machining, Merchant's analysis; selection of machining parameters; tool materials, tool wear and tool life, thermal aspects of machining, cutting fluids, machinability; principles and applications of nontraditional machining processes - USM, AJM, WJM, EDM and Wire cut EDM, LBM, EBM, PAM, CHM, ECM.

**Metrology and Inspection:** Limits, fits, and tolerances, interchangeability, selective assembly; linear and angular measurements by mechanical and optical methods, comparators; design of limit gauges; interferometry; measurement of



straightness, flatness, roundness, squareness and symmetry; surface finish measurement; inspection of screw threads and gears; alignment testing of machine tools.

**Computer Integrated Manufacturing:** Basic concepts of CAD, CAM, CAPP, cellular manufacturing, NC, CNC, DNC, Robotics, FMS, and CIM. Principles of good product design, tolerance design; quality and cost considerations; product life cycle; concurrent engineering.

**Facility Design:** Facility location factors and evaluation of alternate locations; types of plant layout and their evaluation; computer aided layout design techniques; assembly line balancing; materials handling systems.

**Production Planning and Inventory Control:** Forecasting techniques ,aggregate production planning; MRP and MRP-II; order control and flow control; routing, scheduling and priority dispatching; push and pull production systems, concept of JIT manufacturing system; logistics, distribution, and supply chain management; inventory models

**Operations Research:** Linear programming, simplex method, duality and sensitivity analysis; transportation and assignment models; network flow models, constrained optimization and Lagrange multipliers; simple queuing models; dynamic programming; simulation - manufacturing applications; PERT and CPM,

**Quality Management:** Quality - concept and costs, quality circles, quality assurance; statistical quality control, acceptance sampling, zero defects, six sigma; total quality management; ISO 9000; design of experiments - Taguchi method.

**Reliability and Maintenance:** Reliability, availability and maintainability; distribution of failure and repair times; determination of MTBF and MTTR, reliability models; system reliability determination; preventive maintenance and replacement, total productive maintenance - concept and applications.

#### Ph.D. (Physics)

**Marks: 100 (100 questions)**

#### Research Methodology (50%)

Research Aptitude, Reasoning, Data interpretation, information technology, people and Environment, Numerical Ability, Numerical Analysis, Statistics, Communication Ability, Higher education system (Governance, Policy and administration)

#### Subject Paper(50%)

**Mathematical Methods of Physics:** Dimensional analysis; Vector algebra and vector calculus; Linear algebra, matrices, Cayley Hamilton theorem, eigenvalue problems; Linear differential equations; Special functions (Hermite, Bessel, Laguerre and Legendre); Fourier series, Fourier and Laplace transforms; Elements of complex analysis: Laurent series-poles, residues and evaluation of integrals; Elementary ideas about tensors; Introductory group theory, SU(2), O(3); Elements of computational techniques: roots of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, solution of first order differential equations using Runge-Kutta method; Finite difference methods; Elementary probability theory, random variables, binomial, Poisson and normal distributions.

**Classical Mechanics:** Newton's laws; Phase space dynamics, stability analysis; Central-force motion; Two-body collisions, scattering in laboratory and centre-of-mass frames; Rigid body dynamics, moment of inertia tensor, non-inertial frames and pseudoforces; Variational principle, Lagrangian and Hamiltonian formalisms and equations of motion; Poisson brackets and canonical transformations; Symmetry, invariance and conservation laws, cyclic coordinates; Periodic motion, small oscillations

and normal modes; Special theory of relativity, Lorentz transformations, relativistic kinematics and mass–energy equivalence.

**Electromagnetic Theory:** Electrostatics: Gauss' Law and its applications; Laplace and Poisson equations, boundary value problems; Magnetostatics: Biot-Savart law, Ampere's theorem, electromagnetic induction; Maxwell's equations in free space and linear isotropic media; boundary conditions on fields at interfaces; Scalar and vector potentials; Gauge invariance; Electromagnetic waves in free space, dielectrics, and conductors; Reflection and refraction, polarization, Fresnel's Law, interference, coherence, and diffraction; Dispersion relations in plasma; Lorentz invariance of Maxwell's equations; Transmission lines and wave guides; Dynamics of charged particles in static and uniform electromagnetic fields; Radiation from moving charges, dipoles and retarded potentials.

**Quantum Mechanics:** Wave-particle duality; Wave functions in coordinate and momentum representations; Commutators and Heisenberg's uncertainty principle; Matrix representation; Dirac's bra and ket notation; Schroedinger equation (time-



dependent and time-independent); Eigenvalue problems such as particle-in-a-box, harmonic oscillator, etc.; Tunneling through a barrier;

Motion in a central potential; Orbital angular momentum, Angular momentum algebra, spin; Addition of angular momenta; Hydrogen atom, spin-orbit coupling, fine structure; Time-independent perturbation theory and applications; Variational method; WKB approximation; Time dependent perturbation theory and Fermi's Golden Rule; Selection rules; Semi-classical theory of radiation; Elementary theory of scattering, phase shifts, partial waves, Born approximation; Identical particles, Pauli's exclusion principle, spin-statistics connection; Relativistic quantum mechanics: Klein Gordon and Dirac equations.

**Thermodynamic and Statistical Physics:** Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; Phase space, micro- and macrostates; Microcanonical, canonical and grand-canonical ensembles and partition functions; Free Energy and connection with thermodynamic quantities; First- and second-order phase transitions; Classical and quantum statistics, ideal Fermi and Bose gases; Principle of detailed balance; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation; Random walk and Brownian motion; Introduction to nonequilibrium processes; Diffusion equation.

**Electronics:** Semiconductor device physics, including diodes, junctions, transistors, field effect devices, homo and heterojunction devices, device structure, device characteristics, frequency dependence and applications; Optoelectronic devices, including solar cells, photodetectors, and LEDs; High-frequency devices, including generators and detectors; Operational amplifiers and their applications; Digital techniques and applications (registers, counters, comparators and similar circuits); A/D and D/A converters; Microprocessor and microcontroller basics.

**Experimental Techniques and data analysis:** Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test; Transducers (temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors), measurement and control; Signal conditioning and recovery, impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding; Fourier transforms; lock-in detector, box-car integrator, modulation techniques.

**Atomic & Molecular Physics:** Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; Hyperfine structure and isotopic shift; width of spectral lines; LS & JJ coupling; Zeeman, Paschen Back & Stark effect; X-ray spectroscopy; Electron spin resonance, Nuclear magnetic resonance, chemical shift; Rotational, vibrational, electronic, and Raman spectra of diatomic molecules; Frank – Condon principle and selection rules; Spontaneous and stimulated emission, Einstein A & B coefficients; Lasers, optical pumping, population inversion, rate equation; Modes of resonators and coherence length.

**Condensed Matter Physics:** Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bonding of solids; Elastic properties, phonons, lattice specific heat; Free electron theory and electronic specific heat; Response and relaxation phenomena; Drude model of electrical and thermal conductivity; Hall effect and thermoelectric power; Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, band theory of metals, insulators and semiconductors; Superconductivity, type – I and type - II superconductors, Josephson junctions; Defects and dislocations; Ordered phases of matter, translational and orientational order, kinds of liquid crystalline order; Conducting polymers; Quasicrystals.

**Nuclear and Particle Physics:** Basic nuclear properties: size, shape, charge distribution, spin and parity; Binding energy, semi-empirical mass formula; Liquid drop model; Fission and fusion; Nature of the nuclear force, form of nucleon-nucleon potential; Charge-independence and charge-symmetry of nuclear forces; Isospin; Deuteron problem; Evidence of shell structure, single- particle shell model, its validity and limitations; Rotational spectra; Elementary ideas of alpha, beta and gamma decays and their selection rules; Nuclear reactions, reaction mechanisms, compound nuclei and direct reactions; Classification of fundamental forces; Elementary particles (quarks, baryons, mesons, leptons); Spin and parity assignments, isospin, strangeness; Gell-Mann-Nishijima formula; C, P, and T invariance and applications of symmetry arguments to particle reactions, parity non-conservation in weak interaction; Relativistic kinematics.