Syllabus for Ph.D. Entrance Test under Engineering & Technology

(Mechanical Engineering, Computer Engineering, Information Technology, Electronics Engineering, Electronics and Telecommunication Engineering)

PAPER 1 (common to all disciplines)

1. Logical Reasoning
2. Numerical Ability
3. General Aptitude (Research Aptitude)

MECHANICAL ENGINEERING

PAPER 2

Section 1: Applied Mechanics and Design

- **Engineering Mechanics**: Resultant of force system, Equilibrium of forces, Trusses, Friction, Kinematics of particles and rigid bodies in plane motion, Kinetics of particle – Newton second law, Work Energy Principle, Impulse and momentum (linear),Collisions.
- Strength of Materials: Stress and strain, elastic constants, Poisson's ratio, thermal stresses; Mohr's circle for principal stresses; thin cylindrical and spherical shells; shear force and bending moment diagrams; stresses in beams; short columns subjected to eccentric loading, core of section, deflection of beams for simple cases; torsion of circular shafts; Euler's theory of columns; testing of materials with universal testing machine; testing of hardness and impact strength
- Theory of Machines: Displacement, velocity and acceleration analysis of plane mechanisms; cams and followers; Flexible connectors (Belt and rope drive), gear trains; clutches, brakes, flywheel and governors; gyroscope, balancing of rotating and reciprocating masses.
- Mechanical Vibrations: Linear Free and forced single degree of freedom vibration; longitudinal and torsional systems, viscous damping; under damped, critical damped and over damped system, logarithmic decrement, vibration isolation and transmissibility; critical speeds of shafts.
- Machine Design: 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 and helical gears, rolling contact bearings, hydrodynamic journal bearings, flange coupling, helical spring.

Section 2: Fluid Mechanics and Thermal Sciences

- **Fluid Mechanics and Machinery**: Fluid properties; fluid statics, manometry, buoyancy, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; viscous flow of incompressible fluids, boundary layer, Laminar Pipe Flow, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings. Flow Measurements, Turbine; impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines. Turbine Characteristics and Centrifugal Pump.

- **Thermodynamics:** Thermodynamic systems and processes; properties of pure substances, behavior of ideal and real gases; Zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; application of first and second law to flow and non flow processes. Third law of thermodynamics, Thermodynamic property charts and tables, availability and irreversibility; Fuels and Combustion: Types of fuels and their properties, Calculation of air fuel ratio and conversion of volumetric to gravimetric and Vice-versa. Properties of Steam, Vapor power cycles, Steam Nozzle, Working and analysis of different types of Steam turbines, concepts of regeneration and reheat. Steam condensers and Evaporator. Gas power cycles: Such as Air-standard Otto, Diesel, and dual cycles, Fuel air cycles and actual cycles. Working and types of Internal Combustion engines, Combustion in SI and C I Engine, Fuel supply systems in I C Engine, Testing and Performance of Internal Combustion Engines. Refrigeration and Air Conditioning: Refrigerants, Air refrigeration cycle and Vapour compression refrigeration cycle; properties of moist air, psychrometric chart, basic psychrometric processes and analysis of air conditioning system and cryogenics.
- **Heat-Transfer**: Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction; lumped parameter system, Heisler's charts (for time and space variable); heat transfer in Internal and external flows: thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, Free and forced convection heat transfer correlations, effect of turbulence; Analysis of heat exchanger performance, LMTD and Effectiveness - NTU methods; radiative heat transfer, Stefan- Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis; radiation heat transfer between two bodies, radiation shielding.

Section 3: Materials, Manufacturing and Industrial Engineering

- **Engineering Materials**: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials. Casting, Forming and Joining Processes: Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.
- **Machining and Machine Tool Operations:** Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, design of jigs and fixtures.
- **Metrology and Inspection:** Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly.
- **Computer Integrated Manufacturing**: Basic concepts of CAD/CAM and their integration tools.
- **Production Planning and Control**: Forecasting models, aggregate production planning, scheduling, materials requirement planning.
- **Inventory Control:** Deterministic models; safety stock inventory control systems.
- **Operations Research:** Linear programming, simplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.

COMPUTER ENGINEERING & INFORMATION TECHNOLOGY

Section 1: Mathematics

- **Engineering and Discrete Mathematics**: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Groups.
- **Calculus:** Limits, continuity and differentiability, Maxima and minima, Mean value theorem, Integration.
- **Linear Algebra:** Matrices, determinants, linear equations, eigenvalues and eigenvectors Probability: Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem.

Section 2: Computer Engineering and Information Technology

- **Digital Logic**: Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic
- **Programming and Data Structures and Algorithms:** Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, graphs, searching, sorting, hashing, Algorithm design techniques: greedy, dynamic programming and divide-and-conquer.
- **Computer Organization and Operating System:** Machine instructions and addressing modes. ALU, Memory hierarchy: cache, main memory and secondary storage, I/O interface, Processes, threads, inter-process communication, concurrency, deadlock and synchronization, CPU scheduling. Memory management and virtual memory, File systems, Basics of High-Performance Computing.
- **Theory of Computation and Compiler Design**: Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and context-free languages, pumping lemma. Turing machines and undecidability. Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation.
- **Database Management:** ER-model, Relational model, relational algebra, SQL, Integrity constraints, normalization forms, Transactions deadlock handling and concurrency control, File organization, indexing (B and B+ trees), Concepts of Data Mining and Warehousing.
- **Computer Networks and Security**: TCP/IP Layering concepts, LAN technologies, Data link layer and Flow and error control techniques, routers and routing algorithms, congestion control, Application layer protocols, Wireless Networks Basics, Network and Information security, authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls, IDS.
- **Artificial Intelligence, Computer Vision and Big Data Analytics**: Machine learning algorithms: regression, clustering and classification, Neural networks and Fuzzy systems, Image and Video processing, analysis and interpretation, Big Data processing, analytics and management. Data Visualization techniques.

ELECTRONICS ENGINEERING, ELECTRONICS AND TELECOMMUNICATION ENGINEERING

- **Network Theory**: Nodal and Mesh analysis; Network theorems: superposition, Thevenin and Norton's, maximum power transfer; Wye-Delta transformation; Steady state sinusoidal analysis using phasors; Time-domain circuit analysis; Solution of network equations using Laplace transform; Frequency domain analysis of RLC circuits; Linear 2-port network parameters: driving point and transfer functions; State equations for networks.
- **Electronic Devices & Circuits:** Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; Generation and recombination of carriers; Poisson and continuity equations; P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photodiode and solar cell; Integrated circuit fabrication process: oxidation, diffusion, ion implantation, photolithography, and twin-tub CMOS process; HDL, VHDL, Nanotechnology, MEMS
- **Analog Circuits:** Small signal equivalent circuits of diodes, BJTs and MOSFETs; Simple diode circuits: clipping, clamping, and rectifiers; Single-stage BJT and MOSFET amplifiers: biasing, bias stability, mid-frequency small-signal analysis, and frequency response; BJT and MOSFET amplifiers: multi-stage, differential, feedback, power and operational; Simple op-amp circuits; Active filters; Sinusoidal oscillators: criterion for oscillation, single-transistor, and op-amp configurations; Function generators, wave-shaping circuits, and 555 timers; Voltage reference circuits; Power supplies: ripple removal and regulation.
- **Digital Circuits:** Number systems; Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates and their static CMOS implementations, arithmetic circuits, code converters, multiplexers, decoders, and PLAs; Sequential circuits: latches and flip-flops, counters, shift-registers, and finite state machines; Data converters: sample and hold circuits, ADCs and DACs; Semiconductor memories: ROM, SRAM, DRAM; 8-bit microprocessor (8085): architecture, programming, memory, and I/O interfacing.
- **Signal & Systems**: Definitions and properties of 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; Multi-rate signal processing; signal processing; filter design; correlation; wavelet basics; adaptive filters.
- **Control Systems**: Basic control system components; Feedback principle; Transfer function; Block diagram representation; Signal flow graph; Transient and steady-state analysis of LTI systems; Frequency response; Routh-Hurwitz and Nyquist stability criteria; Bode and root-locus plots; Lag, lead and lag-lead compensation; State variable model and solution of state equation of LTI systems.
- **Communication Systems**: Random processes: autocorrelation and power spectral density, properties of white noise, filtering of random signals through LTI systems; Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, super heterodyne receivers, circuits for analog communications; Information theory: entropy, mutual information and channel capacity theorem; Digital communications: PCM, DPCM, digital modulation schemes, amplitude, phase, and frequency-shift keying (ASK, PSK, FSK), QAM, MAP, and ML decoding, matched filter receiver, calculation of bandwidth, SNR and BER for digital modulation; Fundamentals of error correction, Hamming codes; Timing and frequency synchronization, inter-symbol interference and its mitigation; Basics of TDMA, FDMA and CDMA

- **Electromagnetic theory**: Electrostatics; Maxwell's equations: differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector; Plane waves and properties: reflection and refraction, polarization, phase & group velocity, propagation through various media, skin depth; Transmission lines: equations, characteristic impedance, impedance matching, impedance transformation, S-parameters, Smith chart; Waveguides: modes, boundary conditions, cut-off frequencies, dispersion relations; Antennas: antenna types, radiation pattern, gain, and directivity, return loss, antenna arrays; Basics of radar; Light propagation in optical fibres.
- **Micro-Processors and Micro-controllers**: 8085 Microprocessor Architecture, CPU, address bus, data bus, and control bus; Input/output devices; buffers; encoders, latches, and memories; Peripheral Devices and Memory Organization, Interrupts; Instruction Set; Programming and Debugging; Subroutine, IC 8259, 8257, 8255, 8253, 8155 chips and their applications; A/D conversion, memory, keyboard, and display interface (8279); 8086 Microprocessor Architecture and Instruction; Memories; 8051, ARM7, Arduino, Raspberry Pi
- **General Engineering**: Physics, Chemistry, Maths (Linear Algebra; Vector Analysis; Complex signal Analysis; Numerical Methods; Probability and Statistics)

Somaiya Institute for Research and Consultancy (SIRAC) is the nodal center for building organic linkages across research disciplines within Higher Educational Institutes of the Somaiya Vidyavihar University. SIRAC coordinates Ph.D. programmes in accordance with the Statutes and Ordinances of the University.