Syllabus for Part-A: Mathematics

(1) Calculus:
Functions of single and two variables: limit, continuity, differentiability, mean value theorems,Theorems of integral calculus, improper integrals, partial derivatives, total derivatives, maxima and minima, double and triple integrals; gamma functions, gaussian integral and its variations;

(2)Vector Calculus:
Gradient, divergence and curl, directional derivatives, line, surface and volume integrals, Stokes, Gauss and Green's theorems.

(3) Differential Equations:
Order, degree, linear and non-linear differential equations, homogeneous and inhomogeneous differential equations, Ordinary Differential Equations of first order, linear Ordinary differential equations of second and nth order, solution of second order partial differential equations by separation of variables;

(4) Linear Algebra:
vector spaces, linear transformations, inner products, determinants, inverse, rank, system of linear equations, Eigenvalues and eigenvectors, diagonalisation of matrices, Cayley-Hamilton theorem;

Syllabus for Part-B:
Section: ChE – Applied Chemistry

1. **Nomenclature of organic compounds**

2. **Functional Groups Chemistry:** methods of preparation, properties and application of organic compound with different functional groups

3. **Fundamental properties and Structure and Bonding**: Theory of bonding – Primary and secondary bonding, Structure of atom, ionization, electron affinity, variation is size and ionization energy across groups and periods in periodic table, coordination number and crystal structure (SC, BCC, FCC, HCP).

4. **Polymer and Surface Chemistry**: Types of polymerization, Important polymers in daily use, concepts of surface tension, surfactants, micellization and various applications of surfactants

5. **Solution properties:** Concepts of mole, molarity, normality, mole fraction, colligative properties, Roult's law and deviation

6. **Ionic equilibrium –** Acids and bases, Arrhenius concept, Lowry brownsted proton concept, Lewis concept, Dissociation of weak acid and weak base, Dissociation of water, pH, Buffer solutions, Salt Hydrolysis, Solubility product

7. **Electrochemistry -** Galvanic cell, Hydrogen electrode, Calomel electrode, Single electrode potential, Electrical energy and free energy change in the reaction, Nernst equation, Standard electrode potential- Electrochemical series, ionic conductivity,.

8. **Instrumental methods of analysis:** IR, UV-Vis, NMR and Mass spectroscopic techniques.

9. **Fundamentals of :**
   - **Chromatography methods**: GLC, HPLC, TLC, HPTLC, ion chromatography, hyphenated techniques like GC-MS, LC-MS.
   - **Imaging Techniques**: SEM, TEM

Syllabus for Part-B:
Section: ChE – Chemical Engineering & Materials Engineering

Thermodynamics:

The First law of thermodynamics, Volumetric Properties of Pure fluids, Heat Effects, The Second Law of Thermodynamics, Applications of thermodynamics to flow processes, Production of Power from Heat, Refrigeration and Liquefaction, Thermodynamics Properties of fluids, Vapor-Liquid Equilibrium, Solution Thermodynamics: Theory and Applications, Chemical Reaction Equilibria, Phase Equilibria

Mass Transfer Operations:

Molecular diffusion in fluids; mass transfer coefficients in laminar and turbulent flow; theories of mass transfer; interphase mass transfer and equilibrium between phases; gas-liquid contacting equipment; gas-liquid absorption; drying, Distillation, Liquid-Liquid Extraction, Leaching, Adsorption, Humidification, Crystallization

Fluid Mechanics:

Properties of Fluids, Fluid Statics, Fluids Kinematics and Dynamics, Laminar, Viscous Flow and Flow measurement devices, Hydraulic pumps, Flow over Immersed Bodies

Heat Transfer:

Introduction to three modes of heat transfer, Conduction, Convection, Radiation, Heat transfer with phase change, Heat Exchange equipments

Reaction Engineering:

Introduction; basic concepts in chemical kinetics; collection and analysis of rate data; isothermal reactor design; nonelementary homogeneous reactions; multiple reactions in isothermal reactors; nonisothermal reactor design; analysis of nonideal reactors, Kinetics of Heterogeneous reactors

Process Calculation:

Introduction; material balances for steady state processes without reaction; material balances for steady state processes with reaction; material balance for combustion systems; material balance for multi-unit systems; gas mixtures ;multiphase equilibrium; energy balances for processes without reaction; energy balances for processes with reaction; psychrometry.

Syllabus for Part-B:
Section: ICT- Computer Science

Discrete Mathematics: Logic, Counting, Recursion, Algorithm Complexity, Trees and Graphs.

Algorithms and Data Structures: Functions, Recursion, Abstract data types: Arrays and linked lists; Stacks, Queues, Trees, Binary search trees, Binary heaps, Hashing and Graphs.

Analysis of algorithms: Growth of functions and Asymptotic notation, Recurrence Equations, Algorithm Design techniques: Divide-and-Conquer, Greedy approach, Dynamic programming; Tree Traversals (In-order, pre-order and post-order walks on binary search trees) and graph traversals (breadth-first search, depth-first search) Minimum Spanning trees and algorithms for finding them in connected weighted undirected graphs (Prim's and Kruskal's algorithms); Shortest paths in weighted graphs (Dijkstra's algorithm and BFS); Sorting, Searching and rank-finding algorithms for totally ordered sets.

Operating Systems: File systems; I/O systems. UNIX system calls; Memory management: virtual memory, memory allocation and management algorithms;
process management:
Processes; threads. Inter-process communication; concurrency, synchronization. Deadlocks.

Computer Networks:
ISO/OSI stack. LAN technologies (Ethernet, Token ring). Flow and error control techniques. Routing algorithms. Congestion control. TCP/UDP and sockets. IP(v4), ICMP. Application layer protocols (dns, smtp, pop, ftp, http).

Syllabus for Part-B:

Section: ICT - Communication and Signal Processing

Probability and Random Processes

Basic Probability: Sample space and events; axiomatic definition of probability, Joint and conditional probabilities, independence, total probability; Bayes' rule and applications,

Random variables: Definition of random variables, continuous and discrete random variables, cumulative distribution function (cdf) for discrete and continuous random variables; probability mass function (pmf); probability density functions (pdf) and properties, Jointly distributed random variables, conditional and joint density and distribution functions, independence; Function of random a variable, pdf of the function of a random variable; Function of two random variables; Sum of two independent random variables, Expectation: mean, variance and moments of a random variable

Some special distributions: Uniform, Gaussian and Rayleigh distributions; Binomial, and Poisson distributions; Multivariate Gaussian distribution, Central limit theorem and its significance

Random process: Random process: realizations, sample paths, discrete and continuous time processes, examples, Probabilistic structure of a random process; mean, autocorrelation and auto covariance functions, Stationarity: strict-sense stationary (SSS) and wide-sense stationary (WSS) processes, Autocorrelation function of a real WSS process and its properties, cross-correlation function , Ergodicity and its importance

Signals and Systems

Elementary signals and their basic properties, Linear shift invariant systems and its properties, Convolution integral and convolution sum, System described by Differential equations and Difference equations, Fourier Series and its properties, Fourier transform and its properties, Sampling and Signal reconstruction, Discrete Fourier transform and its properties

Textbook(s) :

1. Signals and Systems, Alan V Oppenheim, Alan S Willsky, S. Hamid Nawab, 1997, 2/e, Pearson education, Low price edition
2. Signals and Systems, Simon Haykin and Barry Van Veen, 2/e Wiley
3. Probability, Random Variable and Stochastic Processes, A Papoulis, McGraw Hill

Syllabus for Part-B:
Section: ICT - VLSI Systems

Basic Electronics – Circuits and Devices

1. Introduction
   - 1.1. Electric Circuit Variables and their Units – Voltage, Current, Power, Energy
   - 1.2. Circuit Elements
     - 1.2.1. Active & Passive Elements
     - 1.2.2. Resistors
     - 1.2.3. Independent Sources (Current Source and Voltage Source)
     - 1.2.4. Voltmeters and Ammeters
     - 1.2.5. Dependent Sources
       - 1.2.5.1. Current Dependent Voltage Source
       - 1.2.5.2. Voltage Dependent Voltage Source
       - 1.2.5.3. Current Dependent Current Source
       - 1.2.5.4. Voltage Dependent Current Source
     - 1.2.6. Transducers
     - 1.2.7. Switches
2. Resistive Circuits
   - 2.1. Kirchhoff's Laws
   - 2.2. Series Resistors and Voltage Division
   - 2.3. Parallel Resistors and Current Division
   - 2.4. Series Voltage Sources and Parallel Current Sources
3. Methods of Analysis of Resistive Circuits
   - 3.1. Node Voltage Analysis of Circuits with Independent Current Sources
   - 3.2. Node Voltage Analysis of Circuits with Independent Current and Voltage Sources
   - 3.3. Node Voltage Analysis with Dependent Sources
   - 3.4. Mesh Current Analysis with Independent Voltage Sources
   - 3.5. Mesh Current Analysis with Independent Current and Voltage Sources
   - 3.6. Mesh Current Analysis with Dependent Sources
4. Circuit Theorems
   - 4.1. Source Transformations
   - 4.2. Superposition
   - 4.3. Thevenin’s Theorem
   - 4.4. Norton’s Equivalent Circuit
   - 4.5. Maximum Power Transfer
5. The Operational Amplifier
   - 5.1. The Ideal Operational Amplifier
   - 5.2. Nodal Analysis of Circuits Containing Ideal Operational Amplifiers
   - 5.3. Designing Using Operational Amplifiers
     - 5.3.1. Implementing Linear Algebraic Equations
     - 5.3.2. Operational Amplifier configurations such as: Inverting, Non-Inverting, (Inverting) Summing, Non-Inverting Summing, Non-Inverting (Unity gain) Summing, Difference, Current Source, Voltage follower, Current to Voltage converter, Voltage to Current converter, Comparator, etc.

5.3.3. Operational Amplifier Models: Finite Gain Model, Offset Model, Finite Gain & Offset Combined Model, and practical Spice model (LM741.sub)

5.4. Characteristics of Practical Operational Amplifiers

6. Energy Storage Elements
   - 6.1. Capacitors
     - 6.1.1. Current, Voltage, Power and Energy in Capacitors
     - 6.1.2. Series and Parallel Capacitors
   - 6.2. Inductors
     - 6.2.1. Current, Voltage, Power and Energy in Inductors
     - 6.2.2. Series and Parallel Inductors
   - 6.3. Initial and final (steady-state) Conditions of Switched Circuits (consisting of DC Sources, Resistors, Capacitors, Inductors, and Switches)
   - 6.4. Step Response of RC circuits
7. Sinusoidal Steady-State Analysis
   - 7.1. Sinusoidal Sources (polar form and rectangular form), and phasors
   - 7.2. Impedances (polar form and rectangular form)
     - 7.2.1. Series and Parallel Impedances
   - 7.3. AC Circuit Analysis using Complex Numbers
     - 7.3.1. Mesh and Node Equations
     - 7.3.2. Thevenin and Norton Equivalent Circuits
     - 7.3.3. Superposition
8. Semiconductors
   - 8.1. Fundamental of Intrinsic Semiconductors
   - 8.2. Extrinsic Semiconductors
     - 8.2.1. Doping, Energy Levels and Band Diagrams, Carrier Concentrations, etc.
   - 8.3. PN Junction/Diode
     - 8.3.1. Band Diagrams, Depletion Region and its width
     - 8.3.2. Forward and Reverse Biasing,
     - 8.3.3. IV Characteristics and related models/approximations
     - 8.3.4. Diode circuit analysis, using Load Line
9. Diode Based Circuits
   - 9.1. Half-Wave Rectifier
   - 9.2. Transformer
   - 9.3. Conventional Full-Wave Rectifier
   - 9.4. Bridge Full-Wave Rectifier
   - 9.5. Clippers: Positive level clipper & Negative level clipper
   - 9.6. Capacitor based Filter
   - 9.7. Peak Inverse Voltages in Rectifiers
   - 9.8. Zener Diode
     - 9.8.1. IV Characteristics, and Load Line
     - 9.8.2. Zener Based Regulator
   - 9.9. LED
10. Bipolar Junction Transistor (BJT)
    - 10.1.Fundamentals of NPN and PNP BJTs
    - 10.2.BJT IV characteristics (for configurations: Common Base, Common Emitter, Common Collector)

10.3. BJT Biasing (based on Q-point – intersection of BJT IV characteristics and R_C load line)

10.3.1. BJT Biasing Schemes and DC Analysis: Base Bias, Base Bias with Single Supply, Voltage Divider Bias, Emitter Bias, Emitter Bias with two Supplies (pos and neg), Emitter Feedback Bias, Collector Feedback Bias, Collector and Emitter Feedback Bias, etc

11. BJT based Single-stage Amplifiers
    11.1. Analysis of Amplifiers:
        11.1.1. DC Analysis based on Q-point (Calculating all DC current and DC node voltages)
        11.1.2. AC Analysis: Input Impedance, Output Impedance, Small-Signal Gain
    11.2. Amplifiers:
        11.2.1. Common Emitter Amplifier
        11.2.2. Swamped Common Emitter Amplifier
        11.2.3. Base biased Amplifier
        11.2.4. Two supply Emitter biased Amplifier
        11.2.5. Common Collector or Emitter Follower Amplifier
        11.2.6. Common base Amplifier
12. Metal Oxide Semiconductor Field Effect Transistor (MOSFET)
    12.1. Introduction to VLSI: VLSI industry and Scaling, Yield, CMOS concepts, etc
    12.2. Fundamentals of MOS CAP, and MOSFETs (NMOS and PMOS transistors)
        12.2.1. IV Characteristics of MOSFET
            12.2.1.1.
        12.2.2. Analysis of NMOS based circuits: Resistive Load NMOS circuit, concept of current mirror
        12.3. CMOS logic circuits: standard gates and compound gates
        12.3.1. PMOS network and NMOS network, and transistor sizing
    12.4. Pass transistor logic: NMOS based and transmission gate based
    12.5. Elmore RC delay analysis of standard gates, using RC model for NMOS/PMOS transistors, and dependency of delay on input switching sequence

Digital Logic Circuits

13. Number Systems: Representations: Signed 2's Complement, Signed 1's Complement, Signed Magnitude, BCD, etc.
14. Boolean Algebra: Axioms and theorems, De-Morgan's law, Duality, Expression manipulation using axioms and theorems.
15. Combinational Logic: Canonical forms, Two-level simplification, Logic minimization using K-map method and Quine McCluskey tabular method, Minimization for product-of-sum form, Minimization for sum-of-products form,
    15.1. Combinational Circuits: Multiplexers, De-multiplexers, Decoders, Encoders, Priority Encoders, Hazard-free circuits, etc.
16. Arithmetic circuits: Adders, Half-adder, Full-adder, BCD-adder, Ripple-carry adder, Carry-lookahead adder, Combinational multiplier, Comparators, Barrel shifters/rotaters, etc.
17. Sequential Logic/Elements: Simple circuits with feedback, Basic latches, Clocks, SR latch, Master-slave latch based flip-flop, J-K flip-flop, T flip-flop, D flip-flop,

17.1. Sequential Circuits: Storage registers, Shift registers, Ripple counters, Synchronous counters,

17.2. Finite State Machines (Moore / Mealy machine), FSM with single/multiple inputs and single/multiple outputs, etc.

18. Memory and Programmable Logic: Concepts/Operation of Random Access Memory and Read Only Memory, Programmable Array Logic and Programmable Logic Array
19. (Verilog) Hardware Description Language: Verilog programming, using structural & hierarchical modeling, Behavioural specification, Dataflow Modeling, creating Testbench, etc.

19.1.Design digital logic blocks using Verilog , such as: decoders, multiplexers, adders, ALU, Counters, Shift-registers, Register bank / Memory, FSM, etc.

Suggested Books:

Basic Electronics – Circuits and Devices

- Introduction to Electric Circuits, by James A. Svoboda & Richard C. Dorf, 6th Edition, Wiley
- Grob's Basic Electronics, by Mitchel E. Schultz, 10th Edition, Tata McGraw-Hill
- Engineering Circuit Analysis, by William H. Hayt & Jack E. Kemmerly & Steven M. Durbin, 6th Edition, Tata McGraw-Hill
- Semiconductor Device Fundamentals, by Robert F. Pierret, Adisson Wesley
- CMOS VLSI design: A circuits and systems perspective, by Weste, Neil H. E., Harris, David & Banerjee, Ayan, 3rd Edition, Pearson Education
- Morris Mano, and Michael Ciletti, Digital Design, 4th Edition, Pearson - Prentice Hall
- Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, 2nd Edition, Prentice Hall
- Stephen Brown, and Zvonko Vrsaniec, Fundamentals of Digital Logic with Verilog Design, 2nd Edition, McGraw Hill

SYLLABUS FOR Ph.D. ADMISSION TEST :: MECHANICAL ENGINEERING

1. MechE : Thermo-fluids

1A. Thermodynamics

Thermodynamic concepts and definitions; Zeroth, first and second laws of thermodynamics; Properties of pure substances, ideal and real gases; Thermodynamic relations; Analysis of processes and cycles. Availability and irreversibility.

1B. Fluid mechanics

Fluid properties; Fluid statics; Control-volume analysis of mass, momentum and energy; Differential equations of continuity and momentum; Bernoulli's equation; Dimensional analysis; Viscous flow of incompressible fluids, boundary layer, Basics of turbulent flow; Flow through pipes; Hydraulic pumps and turbines.

1C. Heat Transfer

Modes of heat transfer in applications; Heat conduction equation, conduction resistance; Extended surfaces; Unsteady conduction - lumped parameter system; Convection fundamentals, boundary layers and equations for mass, momentum and energy transport; Dimensionless parameters in free and forced convection and correlations; Effects of turbulence; Heat exchanger performance, LMTD and NTU methods; Radiative transfer and its laws Radiative properties of surfaces; View factors; Radiation enclosure and network analysis.

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2. MechE : Mechanics, Mechanisms and Design

2A. Engineering Mechanics

Free-body diagrams and equilibrium; Trusses and frames; Virtual work; Kinematics and dynamics of particles and of rigid bodies in plane motion; Impulse and momentum (linear and angular) and energy formulations; Collisions.

2B. Solid Mechanics

Stress and strain, elastic constants, Poisson's ratio; 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; Energy methods; Strain gauges and rosettes; Measurement of properties, e.g. Young's modulus, hardness, etc.

2C. Kinematics and dynamics of machines and Vibrations

Displacement, velocity and acceleration analysis of planar mechanisms; Dynamic analysis of linkages; Cams; gears and gear trains, flywheels; Balancing of reciprocating and rotating masses; Gyroscope.

Free and forced vibration of single degree of freedom systems, Effect of damping; Vibration isolation; Resonance; Critical speeds for shafts.

2D. Machine Design

Design for static and dynamic loading; Failure theories; Fatigue strength and S-N diagram; Principles of the design of machine elements, such as, bolted, riveted and welded joints, shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs, etc.

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