SYLLABI FOR SPECIAL PH.D. ENTRANCE TEST FOR THE FACULTY OF ENGINEERING

Paper-I (Common to all engineering courses , MCQ type)

APPLIED MATHEMATICS

Linear Algebra*:* Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

Calculus*:* Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.
Set Theory & Algebra*:* Sets; Relations; Functions; Groups; Partial Orders; Lattice; Boolean Algebra.

Combinatorics*:* Permutations; Combinations; Counting; Summation; generating functions;
recurrence relations; asymptotics.

Graph Theory*:* Connectivity; spanning trees; Cut vertices & edges; covering; matching; independent sets; Colouring; Planarity; Isomorphism.

Differential equations*:* First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, power series solutions, Legendre polynomials and Bessel's functions of the first kind and their properties.

Partial Differential Equations Separation of variables method , Laplace equation , Solutions of one dimensional heat and wave equations and Laplace equation.

Complex variables *:*Analytic functions, Cauchy's integral theorem, Taylor and Laurent series, Residue theorem., solution integrals.

Probability and Statistics*:* Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions. Correlation and regression analysis.

Numerical Methods*:* Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step

methods for differential equations, numerical solutions of first order differential equation by Euler's method and 4th order Runge-Kutta method.

Transform Theory: Fourier transform, Laplace transform, Z-transform.

Paper-II (Subjective type)

Engineering Course : CONSTRUCTION TECHNOLOGY AND MANAGEMENT

Structural Engineering

Mechanics: Bending moment and shear force in statically determinate beams. Simple stress and strain relationship: Stress and strain in two dimensions, principal stresses, stress transformation, Mohr's circle. Simple bending theory, flexural and shear stresses, unsymmetrical bending, shear centre. Thin walled pressure vessels, uniform torsion, buckling of column, combined and direct bending stresses.

Structural Analysis: Analysis of statically determinate trusses, arches, beams, cables and frames, displacements in statically determinate structures and analysis of statically indeterminate structures by force/ energy methods, analysis by displacement methods (slope deflection and moment distribution methods), influence lines for determinate and indeterminate structures. Basic concepts of matrix methods of structural analysis.

Concrete Structures: Concrete Technology- properties of concrete, basics of mix design. Concrete design- basic working stress and limit state design concepts, analysis of ultimate load capacity and design of members subjected to flexure, shear, compression and torsion by limit state methods. Basic elements of prestressed concrete, analysis of beam sections at transfer and service loads.

Steel Structures: Analysis and design of tension and compression members, beams and beam- columns, column bases. Connections simple and eccentric, beam–column connections, plate girders and trusses. Plastic analysis of beams and frames.

Geotechnical Engineering

Soil Mechanics : Origin of soils, soil classification, three-phase system, fundamental definitions, relationship and interrelationships, permeability & seepage, effective stress principle, consolidation, compaction, shear strength.

Foundation Engineering: Sub-surface investigations- scope, drilling bore holes, sampling, penetration tests, plate load test. Earth pressure theories, effect of water table, layered soils. Stability of slopes-infinite slopes, finite slopes. Foundation types-foundation design requirements. Shallow foundations-bearing capacity, effect of shape, water table and other factors, stress distribution, settlement analysis in sands & clays. Deep foundations–pile types, dynamic & static formulae, load capacity of piles in sands & clays, negative skin friction.

Water Resources Engineering

Fluid Mechanics and Hydraulics: Properties of fluids, principle of conservation of mass, momentum, energy and corresponding equations, potential flow, applications of momentum and Bernoulli's equation, laminar and turbulent flow, flow in pipes, pipe networks. Concept of boundary layer and its growth. Uniform flow, critical flow and gradually varied flow in channels, specific energy concept, hydraulic jump. Forces on immersed bodies, flow measurements in channels, tanks and pipes. Dimensional analysis and hydraulic modeling. Kinematics of flow, velocity triangles and specific speed of pumps and turbines.

Paper-II (Subjective type)
contd.

Engineering Course : CONSTRUCTION TECHNOLOGY AND MANAGEMENT

Hydrology: Hydrologic cycle, rainfall, evaporation, infiltration, stage discharge relationships, unit hydrographs, flood estimation, reservoir capacity, reservoir and channel routing. Well hydraulics.
Irrigation: Duty, delta, estimation of evapo-transpiration. Crop water requirements. Design of: lined and unlined canals, waterways, head works, gravity dams and spillways. Design of weirs on permeable foundation. Types of irrigation system, irrigation methods. Water logging and drainage, sodic soils.

Environmental Engineering

Water requirements: Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water. Sewage and sewerage treatment, quantity and characteristics of wastewater. Primary, secondary and tertiary treatment of wastewater, sludge disposal, effluent discharge standards. Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment Unit operations and unit processes of domestic wastewater, sludge disposal.
Air Pollution: Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits.
Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).
Noise Pollution: Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

Transportation Engineering

Highway Planning: Geometric design of highways, testing and specifications of paving materials, design of flexible and rigid pavements.
Traffic Engineering: Traffic characteristics, theory of traffic flow, intersection design, traffic signs and signal design, highway capacity.
SURVEYING
Importance of surveying, principles and classifications, mapping concepts, coordinate system, map projections, measurements of distance and directions,

leveling, theodolite traversing, plane table surveying, errors and adjustments, curves.

Paper-II (Subjective type)

Engineering Course: Manufacturing Technology

Engineering Materials: Structure and properties of engineering materials, heat treatment, stress-strain diagrams for engineering materials.
Metal Casting: Design of patterns, moulds and cores; solidification and cooling; riser and gating design, design considerations.
Forming: 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.
Joining: Physics of welding, brazing and soldering; adhesive bonding; design considerations in welding.
Machining and Machine Tool Operations: Mechanics of machining, 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, principles of
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 and probabilistic models; safety stock inventory control systems.
Operations Research: Linear programming, simplex and duplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM.

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

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

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 gears, rolling and sliding contact bearings, brakes and clutches.

Fluid mechanics and thermal sciences:

Fluid Mechanics: Fluid properties; fluid statics, manometry, buoyancy; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and

Engineering Course: Manufacturing Technology

momentum; Bernoulli's equation; viscous flow of incompressible fluids; boundary layer; elementary turbulent flow; flow through pipes, head losses in pipes, bends etc.

Heat-Transfer: Modes of heat transfer; one dimensional heat conduction, resistance concept, electrical analogy, unsteady heat conduction, fins; dimensionless parameters in free and forced convective heat transfer, various correlations for heat transfer in flow over flat plates and through pipes; thermal boundary layer; effect of turbulence; radiative heat transfer, black and grey surfaces, shape factors, network analysis; heat exchanger performance, LMTD and NTU methods.

Thermodynamics: Zeroth, First and Second laws of thermodynamics; thermodynamic system and processes; Carnot cycle. Irreversibility and availability; behaviour of ideal and real gases, properties of pure substances, calculation of work and heat in ideal processes; analysis
of thermodynamic cycles related to energy conversion.

Applications: *Power Engineering*: Steam Tables, Rankine, Brayton cycles with regeneration and reheat. *I.C. Engines*: air-standard Otto, Diesel cycles. *Refrigeration and air-conditioning*: Vapour refrigeration cycle, heat pumps, gas refrigeration, Reverse Brayton cycle; moist
air: psychrometric chart, basic psychrometric processes. *Turbomachinery:* Pelton-wheel, Francis and Kaplan turbines — impulse and reaction principles, velocity diagrams.

Paper-II (Subjective type)

Engineering Course: Instrumentation and Control Engineering:

Basics of Circuits and Measurement Systems: Kirchoff's laws, mesh and nodal Analysis. Circuit theorems. One-port and two-port Network Functions. Static and dynamic characteristics of Measurement Systems. Error and uncertainty analysis. Statistical analysis of data and curve fitting.

Transducers, Mechanical Measurement and Industrial Instrumentation: Resistive, Capacitive, Inductive and piezoelectric transducers and their signal conditioning. Measurement of displacement, velocity and acceleration (translational and rotational), force, torque, vibration and shock. Measurement of pressure, flow, temperature and liquid level. Measurement of pH, conductivity, viscosity and humidity.

Analog Electronics: Characteristics of diode, BJT, JFET and MOSFET. Diode circuits. Transistors at low and high frequencies, Amplifiers , single and multi-stage. Feedback amplifiers. Operational amplifiers, characteristics and circuit configurations. Instrumentation amplifier. Precision rectifier. V-to-I and I-to-V converter. Op-Amp based active filters. Oscillators and signal generators.

Digital Electronics: Combinational logic circuits, minimization of Boolean functions. IC families, TTL, MOS and CMOS. Arithmetic circuits. Comparators, Schmitt trigger, timers and mono-stable multi-vibrator. Sequential circuits, flip-flops, counters, shift registers. Multiplexer, S/H circuit. Analog-to-Digital and Digital-to-Analog converters. Basics of number system. Microprocessor applications, memory and input-output interfacing. Microcontrollers.

Signals, Systems and Communications: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first- and second order systems. Convolution, correlation and characteristics of linear time invariant systems. Discrete time system, impulse and frequency response. Pulse transfer function. IIR and FIR filters. Amplitude and frequency modulation and demodulation. Sampling theorem, pulse code modulation. Frequency and time division multiplexing. Amplitude shift keying, frequency shift keying and pulse shift keying for digital modulation.

Electrical and Electronic Measurements: Bridges and potentiometers, measurement of R,L and C. Measurements of voltage, current, power, power factor and energy. A.C & D.C current probes. Extension of instrument ranges. Q-meter and waveform analyzer. Digital voltmeter and multi-meter. Time,

phase and frequency measurements. Cathode ray oscilloscope. Serial and parallel communication. Shielding and grounding.

Control Systems and Process Control: Feedback principles. Signal flow graphs. Transient Response, steady-state-errors. Routh and Nyquist criteria. Bode plot, root loci. Time delay systems. Phase and gain margin. State space representation of systems. Mechanical, hydraulic and pneumatic system components. Synchro pair, servo and step motors. On-off, cascade, P, P-I, P-I-D, feed forward and derivative controller, Fuzzy controllers.

Analytical, Optical and Biomedical Instrumentation: Mass spectrometry. UV, visible and IR spectrometry. X-ray and nuclear radiation measurements. Optical sources and detectors, LED, laser, Photo-diode, photo-resistor and their characteristics. Interferometers, applications in metrology. Basics of fiber optics. Biomedical instruments, EEG, ECG and EMG. Clinical measurements. Ultrasonic transducers and Ultrasonography. Principles of Computer Assisted Tomography.

Paper-I (Industrial Chemistry, MCQ type)

APPLIED MATHEMATICS

Linear Algebra*:* Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

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recurrence relations; asymptotics.

Differential equations*:* First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, power series solutions, Legendre polynomials and Bessel's functions of the first kind and their properties.

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Probability and Statistics*:* Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions. Correlation and regression analysis.

Numerical Methods*:* Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations, numerical solutions of first order differential equation by Euler's method and 4th order Runge-Kutta method.

Paper-II (Subjective Type)

Course: Industrial Chemistry :

1. **Reaction Kinetics**: Rate constant, order of reaction, molecularity, activation energy, zero, first and second order kinetics, catalysis and elementary enzyme reactions.
2. **Chemical reaction Engineering :** Theories of reaction rates Kinetics of homogeneous reactions, introduction to different types of reactors, analysis of reversible, irreversible, series, parallel reaction schemes.
3. **Chemical Equilibria:** Colligative properties of solutions, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer and their applications in chemical analysis, equilibrium constants (Kc, Kp and Kx) for homogeneous reactions,
4. **Thermodynamics:**. **Basic Concepts** : Thermodynamic Systems ,Thermodynamic properties and equilibrium; State of a system.Concept of temperature and Heat. **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.
5. **Fluid Mechanics** Fluid statics, Newtonian and non-Newtonian fluids, Bernoulli equation, flow through pipeline systems, flow meters, pumps and compressors, packed and fluidized beds
6. **Heat Transfer:** Conduction, convection and radiation, heat transfer coefficients, steady and unsteady heat conduction, boiling, condensation and evaporation; types of heat exchangers and their design.
7. **Mass Transfer:** Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies;
8. **Chemical Technology:**
   Fertilizers : Manufacture of Ammonia, Urea
   Paper: Manufacture of paper ,
   Oils and Fats: Properties and classification of oils, manufacture of vegetable oils by expression and solvent extraction, hydrogenation of oils

Petroleum: Petroleum refining and petrochemicals with particular reference to Ethylene and acetylene via steam cracking of hydrocarbons, Manufacture of Ethylene dichloride, Vinyl chloride, Ethylene oxide

Polymerization industries; polyethylene, polypropylene, PVC and polyester synthetic fibers

Nanotechnology: Introduction, properties of nano particles like optical properties, reactivity, synthesis of nano particles by RF plasma process.

9. **Instrumental methods of Analysis** :

i Chromatography: Introduction to chromatography, principles, classification of chromatographic techniques.Gas – liquid chromatography – theory, instrumentation and applications. HPLC – instrumentation, method, column efficiency and applications.

ii Spectroscopy

Paper-II (Subjective Type) **contd.**

Course: Industrial Chemistry :

a) IR Spectroscopy: Principle, modes of vibrations of atoms in polyatomic molecules, instrumentation, selection rules, identification of organic compounds on the basis of infrared spectra.

b) UV-Vis Spectroscopy: Introduction, laws of absorption, origin of spectra, types of transitions, selection rules, identification of organic compounds using UV-VIS spectroscopy

c) NMR*:* Principle, chemical shift, spin-spin coupling shift reagents, instrumentation, spectra and molecular structure, identification of organic compounds on the basis of NMR.

d) Thermo analytical methods: Principle, classification of methods.

TGA – Instrumentation, factors affecting results and analysis of data. Simple applications. **DTG** – Instrumentation**,** analysis of data and applications. **DTA –** Principle, Instrumentation and simple applications.

Paper-I (MCQ type)

Course : Engineering Education

TECHNICAL EDUCATION SYSTEM & RESEARCH

- **Technical Education System in India:** Organizational structure of technical education (National Regional and Sate level), Aims and objectives, National and state level advisory and regulatory bodies (MHRD, AICTE, NBA, CABE, DTEs/SBTEs), Challenges and Prospect of Technical, Education (on account of liberalization, privatization, globalization of economy).

- **Policy initiatives to improve quality:** World Bank Assisted Project, (WBAP) Technical Education Quality Improvement programme (TEQIP), National Project on Technology Enhanced Learning, Washington Accord.

- **Research:** Need, concept and types of research **(**Descriptive, Correlational, ex-post facto, experimental & evaluation research; Basic, Applied and Action research), Tools/Measuring instruments (questionnaires, interview schedules and observation schedules).

- **Project Proposal & Report Writing:** Components of project proposal and research report.

Paper II : (Subjective Type)

Course: ENGINEERING EDUCATION

- **Management:** Concept, nature and characteristics, Functions of Management (Planning Organizing, Staffing, Directing & Controlling), Managerial Skills (Leadership, Motivation, Decision making).

- **Entrepreneurship Development:** Nature and scope of entrepreneurship, concept and characteristics of entrepreneur, entrepreneurial support system (SIDO, SIDBI/NSIC, NRDC, DOI, DIS, SSIE, SISI, Banks etc.), special schemes for technical entrepreneurs.

- **Curriculum Development:** Concept of curriculum, stages in the development of curricula, (Need analysis, curriculum design, implementation nd evaluation), approach to curriculum design (scientific, DACCUM, Competence based approach) CIPP model of Curriculum Evaluation.

- **Performance Evaluation:** Concept and types of evaluation, norms and criterion referenced evaluation, techniques of evaluation (written test, oral test, performance test, port folio, rubrics, on-line evaluation) reliability and validity: concept and types, setting question paper (theory and practical).

- **Learning and Instruction:** Learning and instruction-concept, varieties of learning, events of instruction, individual differences and learning (intelligence, learning styles, personality differences), learning to learn skills (concept mapping, brain mapping, mnemonics, pattern matching).

- **HRD and Training Methods:** Mission and purposes of HRD, components of HRD (individual, career and organizational development), stages of HRD, on-the-job and off-the-job training methods, training climate and training evaluation.