

GATE

INFORMATION BROCHURE

**GRADUATE
APTITUDE
TEST IN
ENGINEERING**

**QUALIFYING
EXAMINATION FOR
ADMISSION TO
MASTER'S DEGREE
COURSES IN
ENGINEERING
AND
TECHNOLOGY**

**FEBRUARY
26, 1983**

**CONDUCTED BY
THE INDIAN INSTITUTES OF TECHNOLOGY
AND**

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GATE 1983

Graduate Aptitude Test in Engineering

1. GENERAL INFORMATION

In pursuance of the recommendations of the Nayudamma Review Committee on Postgraduate Engineering Education, GRADUATE APTITUDE TEST IN ENGINEERING (GATE) will be conducted for the first time on Saturday the 26th February 1983 on all India basis to select candidates for admission to all post-graduate engineering courses at the five Indian Institutes of Technology (at Bombay, Delhi, Kanpur, Kharagpur and Madras) and the Indian Institute of Science, Bangalore. Other engineering institutions are also likely to admit only those who qualify at the GATE. These courses, which will lead to Master's degree in Engineering and Technology, will be of 3 semesters duration (18 months). The responsibility of conducting this examination in 1983 has been entrusted to a committee representing the five IITs and the IISc, Bangalore.

While qualifying at the GATE is essential for every candidate seeking admission to any one of the postgraduate engineering courses at any of the above six Institutes, final selection will be guided by the procedures laid down by the Institute to which the candidate would seek admission. Only those who are admitted after qualifying at the GATE will be entitled to scholarships for 18 months.

Examinations will be held at different centres all over the country, as listed elsewhere in the Brochure.

2. STRUCTURE OF EXAMINATION

All students who hold a Bachelor's Degree in Engineering/ Technology or those who are presently in the final year of one such course are eligible to appear at the Engineering Stream of GATE. Those who have completed AMIE or any other equivalent examination recognized by the Union Public Service Commission for the purpose of employment are also eligible to appear for this Stream. M. Sc degree holders in Agricultural Sciences/Chemistry/Earth Sciences/Life Sciences/Mathematics/ Materials Science/Physics/Regional Planning or those who are in the final year of one such course are eligible to take the Science Stream of GATE, as they are eligible for consideration or admission to some of the M. Tech. Courses.

2.1 PAPERS OF THE GATE EXAMINATION

It is noted that the candidates securing admission to M. Tech. in branches of engineering of a multi-disciplinary nature could be either B. Tech./B.E./B.Sc. (Engg) graduates or M.Sc. degree holders in Science. Hence the following examination pattern will be followed :

For B.Tech./B.E./B.Sc. (Engg)/
B.Arch. candidates seeking
admission to M.Tech./M.Arch./
M.C.P. Programmes
(Engineering Stream)

Paper I :

General Engineering
Sciences: 2 Hours
(40% weightage)
(common to all branches)

Paper II :

Any one paper from the list
of disciplines given below,
as chosen by the candidate :
3 Hours
(60% weightage)

For M.Sc. candidates
seeking admission to
M. Tech.
Programmes
(Science Stream)

Paper I :

General Science :
2 Hours
(40% weightage)
(common to all branches)

Paper II :

Any one paper from the
list of disciplines given
below, as chosen by the
candidate : 3 Hours
(60% weightage)

The question papers will be such that they will emphasize the fundamentals, ensure objective evaluation and will have discrimination capability.

Paper I

Engineering stream : General Engineering Sciences

The candidate has the option to answer six out of the following nine sections (all of which will carry equal weightage) fully for being eligible for consideration for 100% marks.

Analytical Mathematics; Basic Electrical Technology; Basic Electronics; Elementary Materials Science; Engineering Mechanics; Fluid Mechanics; General Physical Sciences; Management Sciences; Thermodynamics.

Science stream : General Science

The candidate will have to answer one of the three sections from Group A made up of Mathematics, Physics and Chemistry and in all three out of the six sections consisting of Agricultural Sciences, Chemistry, Earth Sciences, Life Sciences, Mathematics and Physics. All sections will carry equal weightage.

Paper II

Engineering stream :

Candidates who have obtained or will obtain before June 1983 a Bachelor's degree in any branch of engineering or AMIE or other similar professional qualifications recognized by the Union Public Service Commission as equivalent to B.E. B.Tech., B.Sc. (Engg) for the purpose of employment will have to choose one discipline from the following list

Aeronautical; Agricultural; Architecture; Bio-Chemical Engineering; Ceramics and Glass Technology; Chemical; Civil; Computer Science and Engineering; Electrical and Electronics (combined) Electronics and Communication; Electrical (Power) Mechanical; Metallurgical; Mining; Naval Architecture; Production and Industrial Engineering; Textile Engineering Fibre Science and Technology

Science stream :

Candidates who have obtained or will obtain before June 1983 a Master's degree in any branch of science will have to choose one discipline from the following list.

Agricultural Sciences; Chemistry; Earth Sciences; Life Sciences; Materials Science; Mathematics; Physics; Regional Planning.

The Syllabi and the model questions for Papers I and II for both Engineering and Science Streams are given in sections 3 & 4.

2.2 GATE 1983

The GATE 1983 will be held on Saturday the 26th February 1983 as per the following schedule :

Date	Subject of Examination	Time
26th February 1983	Paper I: in General Engineering Sciences or General Science	9.00 A.M. to 11.00 A.M.
	Paper II: in the discipline chosen by the candidate	1.00 P.M. to 4.00 P.M.

N.B. : The candidate will not be permitted to take the examination if he/she is late by more than half an hour. No candidate will be allowed to leave the examination hall in the first half hour of examination.

2.3 APPLICATION PROCEDURE

The completed application form, along with the registration fee, should be sent prior to the last date specified to the Indiar Institute of Technology/Indian Institute of Science concerned according to the following pattern.

Examination Centre at which the candidate
wishes to appear

Ahmedabad, Amravathi, Aurangabad, Baroda,
Bhopal, Bombay, Bilaspur, Gwalior, Indore,
Karad, Jabalpur, Morvi, Nadiad, Nagpur,
Ponda (Goa), Pune, Raipur, Rewa, Sangli,
Surat, Ujjain, Vallabh Vidya Nagar, Vidisha

Aligarh, Bhiwani, Chandigarh, Delhi, Jaipur,
Jodhpur, Kurukshetra, Ludiana, New Delhi,
Patiala, Pilani, Roorkee, Srinagar, Udaipur

Agra, Allahabad, Gorakhpur, Kanpur,
Lucknow, Patna, Varanasi

Institute to which the completed application form is to be sent	Address Postal	Address Telegram/ Telephone/Telex
Indian Institute of Technology Powai, Bombay	Chairman, GATE Indian Institute of Technology Powai Bombay-400 076	Technology Bombay Phone : 581421 584141 Telex : 011-2385
Indian Institute of Technology Delhi	Chairman, GATE Indian Institute of Technology Hauz Khas New Delhi - 110 016	Technology New Delhi Phone : 666979 Telex : 031-3687
Indian Institute of Technology Kanpur	Chairman, GATE Indian Institute of Technology Kanpur-208 016	Technology Kanpur Phone : 40066 Telex : 0325-296

Examination Centre at which the candidate wishes to appear	Institute to which the completed application form is to be sent	Address	
		Postal	Telegram/ Telephone/Telex
Agartala, Bhagalpur, Burla, Calcutta, Dhanbad, Durgapur, Jalpaiguri, Jalukbari, Jamshedpur, Jorhat, Kharagpur, Muzaffarpur, Ranchi, Roorkela, Silchar	Indian Institute of Technology Kharagpur	Chairman, GATE Indian Institute of Technology Kharagpur-721 302	Technology Kharagpur Phone : 221-224 (4 lines) Telex : 021-2760
Ananthapur, Annamalai Nagar, Calicut, Cochin, Coimbatore, Hyderabad, Kakinada, Karaikudi, Madras, Madurai, Palghat, Quilon, Salem, Tirupathi, Trichur, Trichy, Trivandrum, Vijayawada, Waltair, Warangal	Indian Institute of Technology Madras	Chairman, GATE Indian Institute of Technology Madras-600 036	Technology Madras Phone : 414794 Telex : 041-7362
Bangalore, Bellary, Bidar, Bijapur, Chitradurga, Dharwar, Gulbarga, Hassan, Manipal, Mysore, Raichur, Shimoga	Indian Institute of Science Bangalore	Chairman, GATE Indian Institute of Science Bangalore-560 012	Science Bangalore Phone : 34411 No Telex

The request for application form should be accompanied by a crossed Indian Postal Order for Rs. 5.00 drawn in favour of the concerned IIT/IISc (e.g. 'Indian Institute of Technology, Bombay') along with a self-addressed envelope (22 cm × 32 cm) stamped for Rs. 4.50. Money Orders will not be accepted.

Application forms will be issued from 1st December till 24th December 1982 only.

The application form should be completed, as per instructions given and should be accompanied by a registration fee of Rs.45.00 which is non-refundable. A crossed demand draft in favour of the concerned IIT/IISc (e.g. 'INDIAN INSTITUTE OF TECHNOLOGY, MADRAS') for the above amount (of Rs. 45.00) along with the completed application form and other enclosures should reach the concerned Chairman-GATE on or before 7th January 1983.

Scheduled Caste (SC) / Scheduled Tribe (ST) candidates are exempted from payment of the registration fee.

2.4 ADMIT CARD

The eligible candidates will receive their Admit Cards in early February 1983. In case the Admit Card is not received by any candidate before 15th February 1983 he/she should write immediately to the Chairman-GATE of the concerned IIT/IISc.

Candidates are requested to fill in clearly the disciplines of the GATE examination in the Admit Card of the application form.

2.5 SPECIAL CONCESSIONS

Seats are reserved for SC/ST candidates at the various Institutions as per existing rules. However, SC/ST candidates are also expected to appear at GATE 1983.

SC/ST candidates are exempted from the payment of the registration fee of Rs. 45.00. These candidates, however, have to support their claim by a Caste Certificate signed by a

competent authority. The authorities competent to sign such a Certificate are given below : District Magistrate; Additional District Magistrate; Collector; Deputy Collector; Deputy Commissioner; Additional Deputy Commissioner; Sub-Divisional Magistrate not below the rank of First Class Stipendary Magistrate; Taluka Magistrate; Executive Magistrate or Chief Presidency Magistrate; Additional Chief Presidency Magistrate; Revenue Officer not below the rank of Tahsildar or Administrator; Secretary to Administrator; Divisional Officer (Lakshadweep).

The Caste Certificate signed by authorities other than the officers mentioned above will not be valid.

2.6 SPECIAL INSTRUCTIONS

All candidates should strictly abide by the regulations laid down for the conduct of the GATE. Any candidate found adopting malpractices in the Examination will be disqualified. Candidates should bring their own slide rule and instrument box. **The use of electronic calculator is permitted during the examination.** However, exchange of calculators between candidates during the examination is strictly forbidden.

Admissions to Postgraduate courses in Engineering will be done by the individual institutions separately. Advertisements in this regard will appear in newspapers and the candidates are expected to respond to the same enclosing their GATE score and complying with all other requirements/instructions contained therein.

2.7 RESULTS

The results of the GATE will be declared on the basis of percentile/fractile classification within each discipline and not on the basis of absolute marks.

2.8 TIME TABLE OF EVENTS

1.	Last date for issue of Application Forms	24.12.1982
2.	Last date for receipt of completed Application Forms	7.1.1983
3.	Last date for despatch of Admit Cards by the respective IIT/IISc	10.2.1983
4.	GATE 1983	26.2.1983
5.	Publication of Results of GATE 1983	15.4.1983

3. SYLLABI

3.1 PAPER I

3.1.1 Engineering Stream : General Engineering Sciences

Section 1 : Engineering Mechanics

Units, scalars, vector algebra, forces in a plane and forces in-space, equivalent systems of forces and couples, equilibrium of particles, links and rigid bodies, friction in wedges, screws, bearings, pulleys, rope, belt, plane and space trusses, chains, cables. Distributed force systems, virtual work.

Kinetics, kinematics of particles.

Kinetics of particles (equations of motion, rectilinear, curvilinear and central force motions, projectiles) work-energy principle, conservation of energy, impulse-momentum principle, impacts.

Plane motion of rigid bodies.

Section 2 : Fluid Mechanics

Fluid properties, types of flow, fluid statics, forces on fully and partially submerged bodies, stability of floating bodies.

Fluid kinematics, acceleration of a fluid particle, velocity potential and stream function, irrotational flows.

Ideal fluid flow, bernoulli equation, applications, flow measuring devices.

Momentum and angular momentum principles as applied to fluid in a control volume, applications to jets, propellers, rotodynamic machines etc.

Introduction to viscous flows, concept of drag, flow through pipes, dimensional analysis and similitude techniques.

Section 3 : Thermodynamics

Basic concepts, work and heat interactions. First law. Steady flow energy equation. Second law. Reversibility. Carnot's theorem. Absolute temperature scale. Inequality of Clausius. Entropy principle and its applications. Available energy.

Properties of pure substances and ideal gases. p - u , p - T , T - s , and h - s diagrams. Nozzles and diffusers. Steam power and air standard cycles.

Section 4 : Basic Electrical Technology

D.C. circuits. Network theorems. Alternating currents and voltages. A.C. circuits. Resonance. Three-phase circuits. Energy and power relations in single and three-phase circuits. Mutual inductance. Magnetic circuits. Transformers. Basic principles of D.C. generators, D.C. motors and A.C. machines. Electrical measuring instruments. Moving coil, moving iron and dynamometer types.

Section 5 : Basic Electronics

Semiconductors. PN junction. Bipolar and field effect transistors. Common-base, Common-collector and FET amplifiers. Calculations of gain, input impedance and output impedance. Band width, frequency response. Power amplifiers. Biasing and bias stabilization. Rectifiers and filters. Oscillators. Feedback amplifiers. Operational amplifiers, digital circuits. Logic gates. Logic design. NMOS, PMOS, CMOS circuits.

Section 6 : Elementary Materials Science

Atomic structure and chemical bonding. Crystallography and crystal structure determination. Packing of atoms in solids. Point, line and surface imperfections. Phase diagrams of one and two component systems. Diffusion in solids. Phase transformations particularly those occurring in steels. Elastic and plastic properties of materials. Creep, fatigue and fracture. Strengthening mechanisms in solids. Conductors, semiconductors and insulators. Magnetic properties of materials.

Section 7: Analytical Mathematics

Functions of single and several real variables, sequences, series, differentiation, Taylor series, maxima and minima, integration, multiple integrals, Green's, Stokes and Gauss's Theorems. Functions of a complex variable, analytic functions, singularities mappings, Cauchy's integral theorems and formula, Taylor and Laurent expansions, residues, vector algebra and analysis-Fourier series, expansion of functions.

Matrices, Determinants, linear equations, linear transformations, vector spaces, characteristic values and vectors, Cayley Hamilton Theorem, Canonical forms. Ordinary differential equations and special functions, existence and uniqueness of solutions, first and second order equations, series solutions-ordinary and singular points, Bessel functions, Legendre Polynomials, orthogonal expansion of functions.

Partial differential equations, formation, first order equations, second order linear equations, Laplace, wave and heat conduction equations, initial and boundary value problems.

Integral transforms, Fourier integral theorem, Fourier and Laplace transforms, Applications to differential equations.

Probability and statistics, basic concepts and principles.

Section 8: General Physical Sciences

Elementary topics in statics, dynamics, pulses, wave motion, physical optics, interference, diffraction, Huygens Principle, polarisation, optical instruments.

Sound wave propagation, Doppler effect.

Calorimetry, laws of thermodynamics, entropy, kinetic theory of gases, surface tension, transport phenomena, thermal conductivity, thermoelectricity.

Magnetism, magnetic circuit, electric potential, current, interaction with magnetic field. Motion of a charged particle/conductor in a magnetic field, forces between current carrying conductors, electric nature of matter.

Atomic and modern physics, elementary concepts, photo-electric emission, dual nature of matter, uncertainty principle Bohr's model, energy levels, quantum number, exclusion principle, shape of orbitals, ionization energy, binding energy, fission, fusion, reactors, isotopes, applications, x-rays, laser.

Chemical bonds, ionic, covalent, metallic and Van der Waals bonds, chemical kinetics, order of reaction, expression for rate constants, theory of reaction rate.

Electrolytic solutions, pH, acids, bases and buffers, electrical conductivity, galvanic cells, standard electrode potential, electro-chemical corrosion, discussion of sulphur and phosphorous block elements with respect to correlation of properties on the basis of electronic configuration.

Bonding in complexes, their colour and magnetic properties. Nomenclature in organic chemistry, electronic effects, types of reaction and introduction to reaction mechanisms, polymers and chemistry of life processes.

Note

In all the above topics only exposure to basic concepts are expected.

Section 9: Management Sciences

Functions of management, decision making, internal organisation, forms of ownership.

Product development, methods study and work measurement, plant location and layout.

Break even analysis, depreciation, selection from economic alternatives.

Production control, material management, maintenance, motivational aspects, personnel selection and training.

Job evaluation and wage payments.

3.1.2 Science Stream : General Science**GROUP A***Section 1 : Chemistry*

Atomic structure and periodicity : Bohr's atomic model, quantum numbers, electronic configuration of elements, periodic table and periodic properties.

Chemical bonding : ionic bonding, lattice energy, covalent bonding, VB theory, hybridization, resonance, MO theory (diatomics only), VSEPR theory, dipole moment, polarity, bond length, bond energy, hydrogen bond.

Solutions : Raoult's law, lowering of vapour pressure, effect of solutes on boiling and freezing points of solvents.

Thermodynamics : first law, thermochemistry, second law, entropy, free energy.

Chemical equilibrium : gaseous equilibria, K_c , K_p , K_x , ionic equilibria, solubility product, common ion effect, hydrolysis, pH, buffer solutions.

Chemical kinetics : rates of reaction, first order reaction, Arrhenius equation, energy of activation, catalysis.

Electrochemistry : conductance in solution, EMF, galvanic cells, electrode potential and free energy, Nernst equation.

Representative elements : variation in properties of elements in groups and periods, properties of halides, oxides, hydroxides and oxyacids.

Transition elements (3rd series only) : general properties. Coordination compounds : stereochemistry (4 and 6 coordination numbers) magnetic moments (spin only), high spin and low spin complexes, valence bond theory.

Resonance and inductive effects : organic acids and bases. Stereochemistry, optical and geometrical isomerism.

Elementary aspects of the preparation and properties of alkenes, alkynes, alcohols, alkyl halides, aldehydes, ketones, carboxylic acids, benzene and monosubstituted benzenes.

Elementary aspects of carbohydrates.

Section 2 : Mathematics

Elements of set theory : sets and operations, De Morgan's law, relations and functions, inverse mappings.

Algebra : complex numbers, Argand diagram, real and imaginary parts, absolute value and conjugation, triangle inequality, De Moivre's theorem, powers and roots, permutation and combination, binomial theorem; theory of equations; relations between roots and coefficients, symmetric functions of roots, Descartes's rule of signs.

Matrices : addition and multiplication, determinants, inverse of a matrix, solutions of simultaneous equations in two or three unknowns.

Inequalities : sequences and series, tests for convergence.

Vectors : scalar and vector products, triple products, gradient, divergence, curl; simple applications.

Trigonometry : trigonometric identities, trigonometric equations, properties of triangles, summation of trigonometric series.

Analytic geometry: two dimensional : straight line; conic section-pair of straight lines, circle, ellipse, parabola, hyperbola, general equation of second degree; three dimensional : plane, straight line.

Calculus ; functions of one variable : limit, continuity, differentiability, maxima and minima, Roll's theorem, mean value theorem, L'Hospital rule, Taylor's and Maclaurin's expansions, integrals as anti-derivatives, integrals as the limit of a sum, definite integrals, mean value theorem of integral calculus, double integrals and their applications, improper integrals; functions of two variables; limit, continuity, partial derivatives.

Ordinary differential equations: formulation, first order equations with constant coefficients, Cauchy-Euler equation, simple nonlinear second order equations.

Probability and Statistics: probability, axioms of probability, conditional probability, independence, random variables; standard distributions-binomial, poisson and normal; *Statistics*: frequency distributions: mean, median and mode, standard deviation.

Section 3: Physics

Newtonian mechanics, conservation laws, rotational dynamics, central force problem, gravitation-forced and natural vibrations, damping, wave motion, fluid mechanics, Bernoulli's theorem, viscosity, elasticity and inelasticity, temperature measurement heat transfer, blackbody-radiation laws, photoelectric effect, kinetic theory, ideal and real gases, distribution of molecular velocities, equipartition law, specific heats, thermodynamics, heat engines, Gauss' law, fields and potentials, electric circuits, d.c. and a.c.

Magnetic effects of electric current, force on current carrying conductors, motion of charged particles in electric and magnetic fields, magnetism of materials, Maxwell's equations, diffraction, interference and polarization, optical instruments, aberrations, lasers, deBroglie waves, uncertainty principle, Schrodinger wave equation, hydrogen atom, spectra, quantum numbers, Xrays, nuclear structure, radioactivity, nuclear reactions, fission, re-actors, fusion, elementary particles, electronics of p-n junction and Junction transistor.

GROUP B

Section 4 : Agricultural Sciences

Basic principles of plant structure and functions : cells and tissues, physiology of crop plants-photosynthesis, respiration, plant nutrients and its uptake, water movement and transpiration, growth and reproduction, plant genetics, breeding and evolution.

Principles and practices of crop production : Cropping patterns in India—mixed, multiple and relay cropping, crop rotation, study of important field and horticultural crops, tillage, seeds, seeding practices and vegetative propagation, fertilizers and manures, irrigation and water management, diseases and pests, weed control, post harvest operations and processing, storage, industrial uses.

Nature and properties of soils : Genesis, soil classification, soil groups of India, physical properties, soil and plant-water potential, chemical properties, ion exchange phenomenon, nitrogen fixation, problems of acidity and alkalinity, soil microbiology, soil and water conservation.

Agroecology : Crops in relation to environment, geographical distribution, agroclimatic zones with special reference to Indian crops.

Section 5 : Earth Sciences

Earth and its setting in planetary systems : Internal structure and composition of the earth ; major features of continents and oceans ; earth processes ; weathering, soil formation, action of rivers, wind, glaciers, ocean waves and currents ; Volcanism ; Earthquakes ; isostasy, orogeny and mountain building, minerals, their properties and classification, ore-forming processes and ore distribution in India ; rocks, their properties and classification ; structure in rocks, fossils and stratigraphic principles ; geochronology and geologic time scale ; atmospheric phenomena ; geomagnetism.

Section 6 : Life Sciences

Biological organization : Cell structure and functions, microscopic techniques, cell organelles, cell types, chemical constituents of the cell—DNA, RNA, proteins.

Physical basis of heredity : Structure of chromosomes, cell division, mitosis and meiosis, chromosomal aberrations, ploidy, Mendelian and non-Mendelian inheritance, linkage, gene concept, gene action, genetic code, gene mutation.

Energy transformation and metabolism: Respiration, transport of solutes, photosynthesis, growth and reproduction, hormones, vitamins, antigens and antibodies, antibiotics.

Ecosystems, carbon and nitrogen cycle, interspecific interactions, origin of life and theories of evolution, hybridization and selection, important classes of microbes- protozoa, fungi, bacteria, viruses, plant and animal diseases.

3.2 PAPER II

3.2.1 Engineering Stream

(A) Aeronautical Engineering (AE)

Basic principles of fluid mechanics. Joukowski transformation. Airfoil theory. Laminar and turbulent flows, viscous effects, boundary layers, transition and separation. Compressible flows. Mach waves, shock waves and expansion waves. Transonic flow. Wind tunnel testing.

Atmosphere and its properties, classification of airfoils. Planform effects, lift and drag estimation, high lift and drag increase devices. Performance of airplanes fitted with constant thrust and constant power engine(s)-range, endurance, glide, climb, turning, take off and landing. Static stability-stick fixed and stick free. Elements of dynamic stability. Principles of flight testing.

Classification of airbreathing and rocket propulsion systems and their operating principles. Propeller theory, performance of different types of engines-effect of altitude and forward speed. Gas turbine engine components, construction and performance.

Analysis of wing. Shear centre. Bending and torsion of closed and open tubes. Multicell tubes. Columns and beam columns. Bending and buckling of plates and sheet stringer combination. Analysis of fuselage. Experimental techniques-strain gauges, photoelasticity. Vibration of single and two

degree of freedom systems-undamped and damped systems-free and forced oscillations. Multidegree freedom systems.

Classification of aircraft and airplanes. Selection/design of main aerodynamic parameters of the airplane. Flight envelope. Load estimation. Structural design of airplane components.

Basic principles of aircraft instruments.

(B) Agricultural Engineering (AG)

Section A : Farm machinery and power : Functional components, operation and adjustments, field capacity, performance, cost of operation and design considerations of tillage and earth moving machinery, weeders, planters, seed drills, fertilizer applicators, spraying and dusting equipments, harvesting and threshing machinery and farm transport equipment, kinematics and dynamics of farm machines, velocity, acceleration force analysis and balancing of agricultural machines and tractors.

Farm engines and tractors, selection, operation, adjustment, performance, design considerations and economics of use. Tractor chassis design mechanism and force analysis, hitch systems and simple and hydraulic circuits, power transmission traction, losses in tractor power and tractor-reliability.

Electrical power generation, transmission and distribution, alternators and generators, electrical motors used in agricultural operations, illumination wiring, measurement and control.

Section B : Soil and water conservation : Rainfall and runoff, hydrograph of storm, unit hydrograph, base flow separation, flood routing. Method of irrigation, infiltration equations, advance and recession functions, design of channels, centrifugal pumps, pump characteristics, steady and unsteady flow into wells. Design of surface and subsurface drainage systems, steady and unsteady state drainage design, leaching and salinity control.

Shear strength of soils, active and passive earth pressures on retaining walls, critical height for cohesive soils, stresses below foundations, minimum depth of foundations, bearing capacity of soils consolidation, compaction seepage.

Section C : Agricultural processing and structures : Methods of preservation, drying and dehydration, determination of moisture content in agri. products, equilibrium moisture content, psychrometry, air flow measurement, air blowers, drying methods and dryers, cleaning, sorting and grading, size reduction, mechanical separation, mixing and packing. Dairy product processing, pasteurization, concentration, evaporation, spray - drying and freeze - drying.

Functional requirements of storage structures, planning and layout of farm buildings, poultry dairy buildings, farm fences, grain storage structures, design of columns, beams and trusses, design of flat and silo storage, aeration, material handling equipment, storage insects, pests microorganisms and their control, storage management, hygiene and control of quality of stored products.

(C) Architecture (AR)

History : Vedic villages & settlements, South Indian and Orissan temple architecture, contemporary architecture -Le Corbusier, Louis Kahn, Doshi, Charles Correa, etc.

Man and Environment : Climatic influence on architecture and settlements. Radiation, heat flow through building elements, air flow, ventilation, sunpath diagram. Building acoustics acoustic shape of rooms, acoustic materials, standards of good acoustics, acoustical design of cinema, auditorium, theatre. Comfort conditions, principles of cooling and heating, air-handling, mechanical ventilation, A/c ducts, space conditioning in buildings. Housing, basic principles of unit and layout

designs dwelling types, neighbourhood design, landscape planning landscape materials and principles of design, plants and environmental quality, history of landscape design. Elements of city planning (various concepts of city planning).

Sociological attribute of built-environment, their relationships, life cycle of a family and living needs.

Technology: Structural systems, theory of structures, design of elementary concrete and steel structures, foundations. Building materials-brick, timber, concrete, steel, plastics, aluminium, fire resisting quality of materials. Building services-basic principles of sanitation and waste water disposal, testing of drainage layout, plumbing of multi-storied buildings.

Economics: Economics of land and real properties freehold and lease, principles of valuation-new and existing property, sellers values, distress sale value, annual value etc.

Visual design: Aesthetic appreciation of known or given architectural and planning examples.

(D) Bio-Chemical Engineering (BI)

Application of concepts of chemical and physical sciences to biological processes. Structure, function and reproduction of microbial cells and living systems. Concept of asepsis and sterilization-mass cultivation, separation of cells and organnels, chemical nature of cells and the function.

Basic chemical engineering; units and dimensions, material and energy balances, thermodynamics, transport phenomena and reaction engineering. Principles of process control.

Biochemical engineering - definition and scope; growth, maintenance and product formation. Techniques of cell cultivation, batch, continuous, fed batch cultures; agitation and aeration; scale up. Bioreactor types; air and medium sterilization. Enzyme kinetics; production and recovery processes. Immobilized enzymes and cells. Principles of biological waste treatments, rheology of biological fluids. Preservation of biological materials.

(E) Ceramics and Glass Technology (CG)

Thermodynamics : Enthalpy, entropy, free energy change, activity, chemical equilibria.

Crystal chemistry, defects in solids, X-ray crystallography, powder diagrams, Laue patterns.

Phase rule and phase diagrams, two and three component systems, ternary systems for porcelains, electrical insulators, silica and alumino-silicates, magnesite and chrome-magnesite refractories.

Diffusion in solids, mechanisms and activation energies. Reaction kinetics, phase transformations, nucleation and growth, grain growth, sintering and densification. Physical properties : thermal expansion and thermal conductivity, strength, elasticity and fracture, plastic deformation in single and polycrystalline materials, creep of polycrystalline and glass phase bonded ceramic materials, viscous flow in glass and glassy systems, thermal stress. ionic and electronic conduction, dielectric constant, loss factor and breakdown strength-

Hard and soft ceramic magnetic materials, permeability, hysteresis, loss factor, domains.

Refractories : Raw materials, manufacture, properties, silica, alumino-silicates, magnesite, chrome, dolomite, fusion cast refractories, insulating refractories, steel plant practice, special refractories.

Whiteware, tiles, electrical ceramic insulators, decoration, ceramic glazes.

Glass batch calculation and batch reaction, melting and refining, continuous, plate, sheet and tube drawing, automatic-shaping, tempering and annealing.

Refractory cements, castables, abrasives.

Electronic ceramics : ferrites, ferroelectric, varistors, thermistors.

Technical ceramics, alumina, zirconia, carbides, borides, nitrides, silicides.

Glass ceramics, optical and fibreglass.

Nuclear ceramic fuels and moderators.

(F) Chemical Engineering (CH)

Material and energy balance calculations for processes involving bypass, recycle and purge, with and without chemical reactions: examples from combustion of fuels and process industries.

Newtonian and non-Newtonian fluids. Fluid statics, conservation equations, Bernoulli equation. Dimensional analysis. Introduction to boundary layer theory. Elements of flow of compressible fluids, Flow through pipes, fittings, packed and fluidized beds. Flow meters, pumps and compressors.

Modes of heat transfer and basic equations. Steady-state and unsteady-state conduction. Heat transfer by convection and radiation. Boiling, condensation and evaporation. Heat exchangers.

Molecular and eddy diffusion, Fick's law. Interphase mass transfer. Stagewise and continuous contacting devices, stage efficiencies. Distillation: batch, continuous, azeotropic and

extractive. Absorption. Humidification and dehumidification. Drying. Extraction: solid-liquid and liquid-liquid. Principles of crystallization, adsorption and ion-exchange.

Size reduction and size separation. Free and hindered settling. Thickening. Jigging. Classification. Flotation. Filtration. Mixing and agitation. Conveying of solids.

Laws of thermodynamics. Equations of state. Thermodynamic functions. Refrigeration. Thermodynamic equilibria. Phase rule. Thermodynamic properties of mixtures. Phase equilibria: vapor-liquid, liquid-liquid and solid-liquid. Chemical equilibria. Heats and free energies of reactions.

Kinetics of homogeneous reactions. Theories of reaction rates. Single and multiple reactions. Interpretation of kinetic data. Design of ideal reactors. Introduction to heterogeneous reactions.

Measurement of - temperature, pressure, flow, level, composition, pH, concept of feedback control. Modes of control. Controller mechanisms. Control valves and transmitters. Block diagrams. Response of first- and second-order systems. Control system stability.

Principles of process cost estimation and analysis. Process and mechanical design of equipment: vessels under external and internal pressures, heat exchangers, evaporators and packed and plate columns.

Process engineering principles involved in chemical industry Chlor-alkali, soda ash, mineral acids, fertilizers, petroleum and petrochemicals, pulp and paper, sugar, industrial alcohol and heavy organic chemicals. Fuels: solid, liquid and gaseous.

(G) Civil Engineering (CI)

Structural Engineering ;

Structural Mechanics : Stresses and strains, elastic constants, bending and torsion, Euler loads, analysis of determinate structures, strain energy and virtual work principles,

static and kinematic indeterminacies, analysis of indeterminate structures, influence lines, energy theorems and applications.

Concrete and Steel Structures : Design of R.C members by working stress and ultimate load methods including limit state design, design of footings, retaining walls, underground and overhead water tanks principles of prestressing, design of tension and compression members of steel, plate girders, connections.

Hydraulics and Water Resources Engineering :

Hydraulics : Equations of continuity, momentum and energy, equations of motion, flow in pipes and open channels, hydraulic jump, flow past immersed bodies, principles of modelling,

Hydrology : Hydrologic cycle, rainfall and runoff, unit hydrograph, flood estimation and routing, ground water hydraulics,

Irrigation and Water Power Engineering : Water requirement of crops, design of lined and unlined channels, head works, cross drainage works, dams, spillways, stilling basins, water conductor systems, pumps and turbines.

Geotechnical Engineering :

Soil Mechanics : Origin of soils, soil classification, permeability, capillarity and seepage, stress distribution in soils, compaction, one dimensional theory of consolidation, shear strength, earth pressures, retaining walls, stability of slopes

Foundation Engineering : Bearing capacity, settlement analysis, principles of design of shallow and deep foundations.

Environmental Engineering : Quality of water, unit operations and processes for water treatment, characteristics of waste water, sewerage systems, unit operations and processes in waste water treatment.

Surveying : Surveying by chain, compass, plane table and theodolite, triangulation, tacheometry, levelling, errors.

Transportation Engineering : Principles and modes of transportation, geometric design, design and construction of rigid and flexible pavements.

Materials and Construction Technology : Brick and brick-work, cement and concrete, timber, quantity surveying, bar charts, principles of construction management.

(H) Computer Science and Engineering (CS)

1. Hardware Systems : (30%)

Digital Electronics and Logic Design : Wave shaping circuits, logic families, flip flops; Boolean Algebra, minimization techniques; design of combinational and sequential circuits; design with MSI, LSI.

Computer Organization and Architecture : Number representation and arithmetic; functional organization; instruction sets, addressing techniques and their realization; memory organization; I/O devices and modes of data transfer; interrupts; micro programming.

Digital Hardware Design : Hardware description languages; ALU design ; control unit design, microprogrammed control unit implementation; Memory processor interface; microprocessors and system design using microprocessors.

2. Software Systems : (30%)

Programming and Methodology : Basic programming concepts, recursion; structured programming; stepwise refinement; program verification principles; documentation and validation.

Programming Languages : Syntax of programming languages; Data and Control structures; Scope and binding, parameter passing; Execution environment; study of languages like FORTRAN, PASCAL, ALGOL, LISP, SNOBOL.

Systems Programming :

Assembly language programming; Design of assemblers, loaders, linkers, macro processors; Text editors; I/O programming; Language processors.

Operating Systems : Batch, multi programming, time sharing systems; processor management; memory management; synchronization, concurrency and deadlocks; protection.

3. Theoretical computer science : (25%)

Discrete Structures : Sets, relations, functions; graphs; algebraic structures; counting techniques, recurrence equations, generating functions.

Formal Languages and Automata : Regular expressions and finite automata; turing machines and computability; regular context free and LR (k) grammars, their relation to automata.

Data Structures and Algorithms : Stacks, queues, lists, trees; binary trees, balanced trees, 2-3 trees; hashing; file structures, sorting and searching; analysis of simple algorithms, lower bounds.

4. Computer Applications : (15%)

Numerical Methods; Information, systems; Simulation and modelling; data communications; artificial intelligence. operations research.

1) Electrical and Electronics (combined) (EE)

1. *Networks & Linear Systems* : Analysis of DC and AC circuits; network theorems; steady state and transient analysis; resonance phenomena; polyphase and coupled circuits; two-port networks and filters; linear transformations and matrices; laplace and fourier transforms; transfer functions, block diagrams and signal-flow graphs; Routh and Nyquists, criteria; Bode plots, root-loci; design of lag and lead compensators; State variable formulation and system response.

2. *Electrical & Electronic Measurements* ; Measurement of voltage, current and power; galvano-meters; moving coil, moving iron, dynamometer and induction type of meters; energy meter; peak, average and rms detecting meters; DC and AC potentiometers and bridges; Q-meters; measurement of frequency; magnetic measurements ; VTVM; oscilloscope; transducers; instrument transformers; high voltage measurements.

3. *Electronic Devices & Circuits* ; Principles of semiconductors; junction diodes, transistors, FET's equivalent circuits, biasing and bias stability, thermal stability; RC coupled amplifiers-frequency response, feedback techniques; emitter followers; oscillators and sweep generators; linear IC's and OPAMPS.

Linear wave shaping circuits, multivibrators; digital application of OPAMPS; Boolean algebra and de Morgan's theorem; logic circuits and gates; counters shift registers; memories; sequential circuits.

4. *Elements of Communication Systems*; Signal analysis; AM, FM modulators and demodulators; bandwidth requirements; multiplexing.

5. *Electric & Magnetic Fields* : Systems of point and line charges; Coulomb's law; vector analysis; energy storage and forces; methods of images; Inter action of currents and fields; scalar and vector potentials; self and mutual inductance calculations; Maxwell's equations.

6. *Electrical Machines* : Magnetic circuits; constructions, analysis and performance of transformers, DC machines, 3-phase induction machines and synchronous machines-salient and non-salient pole; single phase induction motors; starting, braking and speed control.

7. *Power Systems* : Generating stations; transmission lines and cables, line parameters; fault analysis, symmetrical components; voltage and p.f. control; load flow; system stability; circuit breakers and protective relaying; over voltages in power systems and distribution systems; corona, bundle conductors.

8. *Industrial and Power Electronics* : Thyristors, firing-circuits, single-phase and 3-phase AC regulators and line commutated converters and inverters; commutation methods; choppers; forced commutated inverters; HF inverters; principles of cyclo-converters, power supplies; industrial drives; induction and dielectric heating.

(J) Electronics and Communication (CR)

Network : Network Theorems. Nodal and mesh analysis. Two port networks and parameters. Immittance and transfer functions. Response of linear systems to different excitations. Second order closed loop control system. Bode plots. Stability criteria. Tuned circuits. Transmission lines. Impedance transformation and matching. Image parameters and constant-k filters.

Analogue Circuit : Principles of PN Junction diodes, bipolar and field-effect transistors. Characteristics and parameters of devices. Biasing and equivalent circuits of BJT, FET and OP-Amp. Single and multistage amplifiers. Differential amplifiers. Negative feed-back. Turned amplifiers. Oscillators. Power amplifiers. Active RC-filters. Wave shaping and function generators. Rectifiers and power supplies. Silicon controlled rectifiers and power control. Timing circuits.

Digital Circuits and Techniques : Switching circuits and Boolean functions. Minimization of switching functions. Logic gates. Digital IC families. Arithmetic circuits. Code converters. Multiplexers. Flip-flops. Counters. Shift registers. Memories. Comparators. A to D and D to A converters.

Communication Principles and Circuits : Spectral analysis of signals and distortionless transmission. Linear modulation and de-modulation. Angle modulation and demodulation. Sampling and pulse modulation. Pulse code and delta modulation. Modulation and detection circuits. Frequency and time division multiplexing. Radio transmitters and receivers. Noise temperature and noise figure. Comparison of modulation systems.

Electromagnetics : Maxwell's equations. Wave equation. Reflection and refraction of electromagnetic waves. Poynting theorem. Standing waves and VSWR. Transmission line charts. Waveguides. Dipoles. Antennas. Ground wave, sky wave and tropospheric wave propagation.

Other topics : Principles of klystrons, magnetrons and travelling wave tubes.

Cathode ray oscilloscopes. Electronic voltmeters and multi-meters. Bridges.

Principles of operation of radar, television, digital computers and microcomputers.

Communication satellites and microwave communication.

(K) Electrical (Power) (EP)*Part A*

Circuits and Systems: Network theorems; steady state, transient analysis; Laplace transforms; transfer functions; signal flow graphs.

Control Theory: System representations; stability analysis of feedback systems; Routh-Hurwitz, Nyquist, Bode, root-locus techniques; compensation; state variable theory.

Measurements: Measurement of voltage, current, power, energy; potentiometers; bridges; magnetic measurements; instrument transformers; cathode-ray oscilloscope; digital multimeters; transducers.

Electric and Magnetic Fields: Electric fields of point, line, surface charges; magnetic field of conductors, solenoids; calculation of capacitance, inductance; force, stored energy; Maxwell's equations; magnetic circuits.

Electronics and Communication: Solid-state devices; amplifiers; oscillators; multivibrators; operational amplifiers; Basic logic circuits; thyristorized choppers, rectifiers, inverters; Signal analysis; radio communication.

Computation: Analog computation; AD/DA converters; digital computer fundamentals; FORTRAN programming; scientific applications.

Part B

Electrical Machines: D. C. machines; generator, motor characteristics; armature reaction; commutation. Transformers: Characteristics; auto-transformers; 3-phase transformers; harmonics; parallel operation. Synchronous machines: generator, motor characteristics; Impedances; D.Q-axis transformation; saturation; parallel operation. Induction machines: motor generator characteristics; wound and cage rotors, single-

phase induction motors. Electrical drives; starting, braking, speed control of d.c., induction, synchronous motors; load characteristics; applications.

Power Systems: Generation: planning, operation, economics of hydro, thermal, nuclear power plants; unconventional energy sources. Transmission and distribution: line parameters; short long line performance; Circle diagrams; mechanical design; distribution networks; underground cables; corona; radio interference; economics.

Switchgear and Protection : Symmetrical components; fault analysis; conventional, solid state relays; protection of lines, generators, motors, transformers; arc extinction; fuses; air, oil, air-blast, SF₆, vacuum circuit breakers. System analysis: matrix formulation: load flow, stability. High voltage systems: production, measurements of ac, dc, impulse voltages; insulation coordination, overvoltage protection.

(L) Mechanical Engineering (ME)

Stress - strain relations, complex stresses, theories of failure. Beams-shear force, bending moment, bending and shear stresses, slope and deflection; torsion, combined bending and torsion; buckling of column; thin and thick cylinders.

Simple mechanisms - velocity, acceleration and force analysis; flywheels; balancing; cams; gears and gear trains; Vibration and critical speeds (single degree freedom).

Design of machine elements - fasteners, coiled springs, couplings, clutches, brakes, belt and rope drives, gears, sliding and rolling contact bearings, collar friction and power screws.

Thermodynamic cycles, fuels and combustion, compression-ignition and spark-ignition engines. Carburetion, injection and ignition. Performance and testing of engines.

Fundamental equations of energy transfer in turbo-machines; gas Turbines and jet propulsion, fans, blowers and compressors; steam generation, steam engines, nozzles and diffusers, steam turbines. Flow through pipes; impact of jets; water turbines; centrifugal and reciprocating pumps; specific speed and laws of similarity.

Modes of heat transfer, electrical analogy; one dimensional steady state conduction through walls and cylinders. Fins. Dimensional analysis of forced and free convection, radiation, heat exchangers, vapour compression systems, refrigerants, psychrometric properties and psychrometric processes.

Measurement of mechanical quantities-pressure, flow, temperature, displacement, force and power.

Structure of metals, phase diagram, alloys, heat treatment techniques, work hardening, properties of engineering materials, foundry processes, moulding practice, different casting methods; welding; plastic working and metal forming, mechanics of metal cutting, feeds and speeds, principles of machine tools, different machining operations; cutting tool materials; jigs and fixtures; principles of production metrology.

(M) Metallurgical Engineering (MT)

Solution thermodynamics. Phase rule and phase equilibria, Ellingham diagram. Metallurgical kinetics, principles of ore dressing. Principles of pyro, hydro and electrometallurgy. Physical chemistry of metal refining processes. Production and purification of some industrially important metals. metallurgical fuels. Furnaces and refractories. Corrosion and protection.

Crystal structure of metals: binary and ternary phase diagrams, free-Energy composition diagrams. Free electron and zone theory of metals, stability of solid solutions and intermetallic phases. Diffusion, nucleation and growth. Phase transformations-solidification, martensitic, order-disorder, eutectoidal, precipitation; principles of X-ray metallography, metallography and heat treatment of common ferrous, non-ferrous metals and alloys.

Elements of elasticity and plasticity. Elements of dislocation theory; plastic deformation of metals. Recovery, recrystallisation and grain growth. Fatigue, creep and fracture.

Foundry technology, primary and secondary methods of fabrication. Powder metallurgy, joining of metals, destructive and non-destructive testing of metals.

(N) Mining Engineering (MI)

Exploratory boring methods; difficulties in boring; borehole surveying and logging, location of main mine entries; sinking of vertical and inclined shafts by ordinary methods; special methods of shaft sinking. Drivage of horizontal and inclined drifts and tunnels in rock; drivage of coal headings.

Classification, characteristics, and composition of explosives used in underground coal and metal mines and opencast mines. Fuses, detonators, blasting devices and accessories. Blasting design and practices in underground coal and metal mines and opencast mines.

Classification of rocks; physico-mechanical properties of rocks, their testing. Theories of rock failure; stress distribution around mine openings; measurement of in-situ stresses in rock mass. Ground movement and methods of control; mining subsidence. Supports and support systems for faces and roadways in coal and metal mines.

In-the-seam and horizon systems of layout of coal mines; development and extraction of coal seams by pillar and longwall mining methods; choice of method; face machinery, their salient constructional features, selection, operation and performance; face organization. Special methods of working thick seams.

Classification and choice of metalliferous mining methods; mine layout and development with different stoping methods; methods of stoping; stope development, rock breaking, handling of broken ore, waste and materials; ground control, support and stope design.

Opencast mine layout, opening-up; earth excavation; rock drilling and blasting, excavation and loading and transportation; choice of methods and equipment. Openpit design and slope stability.

Mine gases, occurrence, properties, detection and control. Sources of heat and humidity in mines, concepts and measurement of thermal comfort; control of mine climate; air-conditioning in mine. Laws of air-flow; air distribution, control and measurement; mine resistance; natural ventilation; mine fans, types, characteristics, installation and testing. Ventilation surveys; ventilation planning. Mine dust, health hazard, air-borne dust sampling, dust prevention and suppression.

Drills, drill steels and bits for drilling in coal and rock. Mining wire ropes, their construction, selection, deterioration, examination and testing. Rope haulages, mine locomotives and belt conveyors, their salient constructional features, selection and maintenance. Drum and friction hoisting systems; general engineering features of drum and friction hoists; cage and skip hoisting; shaft guides. Mine pumps, their types, construction, selection, installation, operation and maintenance; pumping calculations.

Mine fires and explosions, their causes, prevention and control; sampling of mine atmospheres. Mine rescue apparatus; mine rescue and recovery. Water dangers in mines, their causes, prevention and control. Mine lighting, miners' lamp, light sources, photometric assessment.

(O) Naval Architecture (NA)

Geometry of ship form, hydrostatics, stability at small and large angles, cross-curves of stability, dynamical stability, stability criteria for ships, launching, docking and grounding, flooding and subdivision, damage stability, grain loading. Deadweight, capacity, tonnage and freeboard. Safety systems: fire fighting, life saving, navigation lights, sounds and signals, collision prevention.

Ship resistance components, model testing, Froude's similarity law, frictional resistance, boundary layer, form resistance, separation, hull roughness and fouling, wave resistance, estimation of effective power, hull form design. Aerofoils, induced velocities, screw propeller geometry, propeller coefficients, hull propeller interaction, cavitation, blade strength, propulsion experiments, trial and service performance, circulation theory, methodical series, propeller design, miscellaneous propulsion devices.

Surface waves, statistical representation of the sea, spectral density. Coupled and uncoupled ship motions in regular waves; motions in irregular waves: encounter spectra, response amplitude operator, deck wetness, slamming, speed loss, model experiments. Control loop, motion stability of ocean vehicles, hydrodynamic derivatives. Turning circle, zigzag and spiral manoeuvres, control surface design, manoeuvring in restricted waters, model experiments.

Longitudinal bending of ships, strength of transverse bulkhead, superstructures, columns, discontinuities. Statically determinate and indeterminate structures: superposition method, area moment theorem, three moment theorem, moment distribution, strain energy. Influence line diagrams, inelastic bending, plastic analysis. Sources of ship vibration, determination of vertical, horizontal and torsional vibration frequencies of ship hull vibration.

Shipbuilding materials - properties and tests, structural components and their functions, hull fittings and outfit, ship construction processes - hull construction, launching, outfitting, tests and trials; hull preservation and maintenance. Production planning and control, material control, shipyard functions and organisational structure; shipyard and location and layout; advanced outfitting, computer application in shipbuilding.

Ship types, selection of main parameters-basic ship and statistical approaches, weight and volume, cargo storage and handling, hull openings, accommodation arrangement, access. Tenders, contracts, specifications, cost estimation.

Selection of ship machinery, types of propulsion plants — steam and gas turbines, diesel engines, fuel types, power transmission, ship auxiliaries, piping, electrical system, engine room layout.

(P) Production and Industrial Engineering (PI)

Machining Processes: Geometry of cutting tools, tool materials, cutting forces - Merchant's model, tool temperature, wear and life, cutting fluids, machinability. Machine tools and machining operations; turning, drilling, boring, milling, shaping, planing, gear cutting, broaching, grinding and superfinishing. Jigs and fixtures—general principles of design.

Metrology: Precision linear and angular measurements by mechanical and optical methods, limits and fits, limit and pneumatic gauging, flatness and surface finish measurements, measurement of screw threads and gears.

Mechanical and non-destructive testing methods.

Casting: Cast metals, patterns; materials and allowances, mould and core making materials and methods; sand testing, casting processes. Melting. Foundry practice of cast iron, steel and non-ferrous metals; solidification, gating and risering, casting defects and inspection.

Welding: Gas welding and cutting, arc welding, shielded arc welding, electrodes, resistance welding, forge and friction welding, weldability. Joint specification, defects and inspection.

Metal Forming: Conditions for yielding of metals, stress-strain relations in elastic and plastic deformation, sliplines, cold and hot working processes—blanking, punching, deep drawing, forging, rolling, extrusion, wire and tube drawing, high energy rate forming.

Processing of Plastics and Non-Conventional Materials: Manufacturing with plastics, ceramics and composites. Elements of powder metallurgy.

Non-Conventional Machining Processes : Electric discharge, ultrasonic and electrochemical machining, lasers and their applications in manufacturing, electron beam and abrasive jet machining and cutting.

Manufacturing Systems : Process engineering, machining in-accuracy, dimensional and tolerance analysis, part print analysis, manufacturing process planning, group technology, numerically controlled machine tools and use of computers in manufacturing.

Industrial Engineering : Production management functions, systems concept, make or buy decisions, break-even analysis, economic-choice of production alternatives.

Balance sheet, Discounted cash flows, depreciation accounting. Product life cycle.

Forecasting : Moving average, simple exponential smoothing, least squares methods.

Production scheduling : Master schedule, routing, ordering and lot sizing, loading, progress control. Sequencing problems, SPT, Johnson's algorithm, 2 job m-machine problem.

Heuristic methods of assembly line balancing, line of balance, basic concepts and models of aggregate production planning.

Materials management functions, inventory costs, ABC analysis, EOQ model, quantity discounts, buffer stock determination, codification, standardization, value analysis.

Quality planning : Process capability studies, control charts for variables and attributes, acceptance sampling plans, component and system reliability, failure time distributions. MTBF.

Concepts of preventive maintenance and replacement analysis.

Method study techniques : Motion economy principles, micromotion analysis, time study techniques, PMTS, work sampling.

Job evaluation, merit rating, wage incentive plans.

Plant location factors, types of layout, relationship and travel charts, materials handling equipment selection.

Linear programming; graphical, simplex methods; transportation, assignment models. Sensitivity analysis. Decision making under risk and uncertainty. Elementary dynamic programming. Simple single server queue. CPM, PERT techniques, activity crashing.

(Q) Textile Engineering/Fibre Science and Technology (TF)

(The Candidate has to attempt either Part A or Part B)

Part A; Textile Engineering

Textile Fibres : Fibre dimensions, units of measurements, conversions from one system to another. Fibre forming polymers. Outline of the main high polymers in relation to natural and manmade fibres. The concept of order in fibres and polymers: crystallinity and orientation. Physical structures of the principal natural and manmade fibres. Basic concepts of the methods of investigating fibre structure, detailed study of fibre properties, such as mechanical properties, electrical properties, moisture relations, optical properties and fibre friction. Relations between fibre properties and structure of fibres.

Yarn technology : Basic principles common to all systems. Distinguishing features of the different systems.

Mixing and blending : Blending efficiency, randomization and index of blend irregularity. Modern methods of opening and cleaning of fibrous materials. The technology of carding with particular reference to modern developments and processing techniques. Control of product quality and waste. Causes of irregularity introduced by drafting. The development of modern drafting systems. Basic principles and techniques of preparing materials for combing. The effect on product quality of machine settings and timings. Recent developments. Functions and synchronization of the various mechanisms

concerned with roving production. Twist insertion and package formation in ring spinning. Forces acting on traveller and yarn. Traveller and ring designs. Causes of end breakage. Principles of doubling and cabling and their effects on the properties of yarns. Principles of tow conversion, tow to yarn spinning. Principles of unconventional methods of yarn production such as open-end, self twist and twistless spinning. Principles of texturing by false twist, stuffer box, edge crimping, knit-de-knit and air bulking.

Weaving Technology: Function of preparatory processes. Principles of cheese and cone winding machines; yarn clearing by mechanical and electronic means; package build; mathematical analysis of winding. Random and precision wound packages. Warping and beaming: principles of creel design and creeling systems in common use; beam warping, horizontal section warping. Details of mechanisms. Weft preparation: principles of manual, semi-automatic and automatic pirn winding machines. Traversing methods and tension considerations; Unifil mechanism. Sizing: purpose; methods and ingredients used. Drying, moisture regain and stretch control.

Sley movement; geometry of warp shed; shed depth; shed timing; influence on cloth appearance and weaving performance. Weft insertion; the methods available, relevant dynamics and critical appraisal: checking; theory and control of pick-spacing; cloth take-up, warp tension; critical analysis of dobby and jacquard shedding principles.

Warp and weft stopmotions, warp protection; weft supply and selection, e.g. box motions, weft replenishment, unifil loom winders, weft accumulators. etc. Special fabrics, e.g., terry, velvet, leno; mechanisms essential to their production.

New weaving machines—principles underlying various new systems of weft insertion. Package faults and their remedies.

Textile Structures: Simple geometry of single and poly yarns. Yarns diameter and density. Fibre migration. Theories of fibre migration. Indices of migration. Migration in blended

yarns. Theoretical treatment of yarn strength and irregularity. Twist strength relationship. Strength of blended yarns. Hamberger's model and later modifications.

Elements of fabric geometry. Cloth setting theories. Pierce's equations and later modifications. Relation of fabric properties to simple geometry. Crimp interchange in woven fabrics. Cover factor.

Testing and Quality Control: measurement of length, fineness, crimp and foreign matter of fibres. Analysis of fibre blends. Tensile testing for fibres, yarns and fabrics. Principles of operation and mechanics of CRL, CRT and CRE type tensile testers. Evenness testing of slivers and yarns. Tests for compressibility, resilience, rigidity, crease recovery and drape. Bursting strength, resistance to wear, tear, air permeability, shrinkage, dye fastness and thermal transmission. Sampling techniques. Sample size and sampling errors. Techniques of quality control. Frequency distributions, control charts, snap studies. Design of experiments. Analysis of variance. Correlation analysis to determine relationship between various factors. Tests of significance.

Part B : Fibre Science and Technology

Polymer Chemistry : Chain growth and step growth polymerizations, free radical, anionic and cationic polymerizations. Methods for molecular weight determination, molecular weight distribution. Chemical and physical structure of fibre forming polymers.

Fibre Chemistry & Production : Chemical aspects of fibre structure, properties of natural and synthetic fibres, effect of acid, alkali, oxidising agents, heat, light etc. On properties of fibres. Principles of melt spinning, dry and wet spinning, production of viscose, cellulose acetate, nylon 6 & 66, polyester and acrylic fibres. Synthesis of basic raw materials for producing man-made fibres.

Colour Chemistry: Chemistry of dye intermediates, sulphonation, nitration, amination, diazotisation, coupling etc., color and chemical constitution, chemistry of vat acid, basic, reactive,

azoics, pigments etc., identification of dyes in substance and fibres.

Chemical Processing : Introduction to various preparatory processes, the chemical and mechanical finishing of textile materials. Anti-shrink, wash-n-wash, water repellency, rot proofing, flame retardancy, shrinkproofing of woollens. Principles of finishing of man-made fibres and blends. Influence of state of material on choice of type of dye and the dyeing method. Dyeing of natural and synthetic fibres by batch and continuous methods. Dyeing of blends. Methods for colour measurement. Role of fibre structure in dyeing.

Methods of printing. Assistants used in textile printing and their functions. Printing techniques of different fibre fabrics with various classes of dyes.

Structure and Properties of Fibres : The concept of order in fibres and polymers: crystallinity and orientation. Physical structure of the principal natural and man-made fibres. Basic concepts of the methods of investigating fibre structure. Detailed study of fibre properties, such as mechanical, electrical properties, moisture relations and optical properties. Structure-property relationship.

3.2.2 Science Stream

(A) Agricultural Sciences (AS)

GROUP-A

Applied Botany : Cell theory. Structure of organelles-cell membrane, mitochondria, plastids, golgibodies, lysosomes, endoplasmic reticulum, vacuoles. Structure and morphology of chromosomes. Cell division-mitosis and meiosis. Nucleic acids and their role in cellular metabolism. Molecular mechanism of growth and differentiation of higher plants. Critical appreciation of laws of inheritance. Interaction of factors. Physical basis inheritance, linkage, crossing over and mapping. Polyploidy, chromosome aberration. Sex determination. Mutation. Plant

breeding techniques-back cross, interspecific and intergeneric hybridization. Contribution of plant breedings for improvement of crop plants. Theories of evolution. Mechanism of evolution. Isolation and adaptation.

Role of plant physiology in agriculture, horticulture and forestry. Water relations of plants-absorption, conduction, transpiration. Mineral nutrition. Physiology of seed germination and dormancy. Growth and development. Photosynthesis. Respiration. Movement. Protein metabolism.

Economic botany of cereals, pulses, fibre, timber and drugs. Geographical distribution of economic plants. Ecological factors. Plant succession and climax formation. Ecological adaptation. Plant communities. Units of vegetation. Plant anatomy-tissues and tissue systems, apical meristem, root and shoot apices. Primary and secondary growth of plant organs.

Structure, growth, reproduction and classification of viruses, bacteria, fungi, algae, bryophytes, pteridophytes, gymnosperms, angiosperms.

GROUP B

Farm Management Technology

Farm Crops, Cropping and Resource Management : agricultural crops for humid, sub-humid, semi-arid and arid regions; cropping system and cropping pattern, cropping principles and practices; theoretical concepts involved in growth; agro-biological principles and their validity; industrial uses of crops and their importance in national economy; agro-resource management and farm organization.

Soil Productivity and Management : Soil fertility and productivity problems, essentials of plant growth, soil productivity in relation to physical and chemical characteristics; management of acid, saline and alkali soils; soil management in relation to crop production; management of soil physical, chemical and biological environment,

Mineral Nutrition and Water Management: Nutritional need of crops; principles and methods of fertilizer application and irrigation, fertilizer and water management; irrigation requirement of crops; scheduling of fertilization and irrigation of field crops.

Physiology and Protection of Field Crops: weeds and weed control practices and pest management in field crops; physiology of field crops and methods of determining yield potential of various agricultural crops.

Design and principles of field experimentation.

GROUP - C

Soil Technology

Rocks and minerals in relation to soil; soil genesis, formation, classification; major soil groups of India, their characteristics and distribution.

Soil structure, significance and evaluation.

Soil organic matter, its nature and properties, its significance in soil.

Structure and characteristics of principal clay minerals; role of soil colloids in soil productivity, ion exchange and fixation, ionic activity, absorption and release of ions; soil solution and mechanism of ion absorption by plant roots.

Acid and salt affected soils, principles and methods of their reclamation.

Fertilizer practices in relation to different soil types, methods of application; essential and micro-nutrients, concept of nutrient availability, methods of evaluating available nutrients in soils.

Soil water, infiltration and permeability, their measurement and significance; dynamics of soil water, effect of soil moisture

on plant growth; conservation of moisture in dryland farming areas and problem of excess water.

Soil temperature variation and its effect on plant growth.

Soil air composition, exchange and significance.

(B) Chemistry (CY)

Electronic configuration of atoms; periodicity in properties (ionization energy, electron affinity, electronegativity, atomic and ionic radii, etc.). Types of chemical bonds and bond energies. Shapes of molecules. V.B., M.O. and ligand field theories. Transition metal chemistry and coordination complexes. Elements of symmetry. Types of solids, metals, semi-conductors and insulators their electrical and magnetic properties, structure of AX type solids. Radio active decay, parent daughter equilibrium; nuclear reactions fission and fusion. Instrumental methods of chemical analysis (atomic absorption, flame photometry, emission and absorption spectrophotometry). Ion exchange.

Schrodinger wave equation; particle in a box problem; hydrogen molecule ion and hydrogen molecule. Molecular orbitals, correlation diagrams. Rotational, vibrational and Raman spectroscopy. NMR and ESR methods. Neutron, electron and X-ray diffraction. Kinetic theory of gases; Maxwell law of distribution of speeds; non-ideal behaviour and critical phenomena. First, second and third law of thermodynamics. Entropy and probability; free energy and equilibrium constant. Ideal and non-ideal solutions; fugacity and activity, phase rule and phase equilibria. Electrolytic conduction, redox potentials and cells (galvanic, concentration, fuel cells). Kinetics of first, second and third order reactions, theories of reaction rates, catalytic reactions.

General methods of preparation and reactions of alkenes, alkynes, halides, alcohols, aldehydes, ketones, acids, phenols, nitro, amino, and diazo-compounds. Reaction intermediates-carbanions, carbonium ions, carbenes, nitrenes, and benzyne.

Application of resonance, steric and electronic effects to explain reactivity and acidity of various compounds. Stereoisomerism (optical, and geometrical), configuration and conformation (compounds containing upto six carbon atoms only). Aromaticity and aromatic substitution. General mechanism and characteristics of nucleophilic and electrophilic substitution in aliphatic and aromatic compounds, electrophilic addition to carbon-carbon and carbon-heteroatom multiple bonds, elimination reactions, molecular rearrangements (only pinacol-pinacolone, benzil-benzilic and, Beckmann, Hoffmann, Curtius, Schmidt, Claisen, Fries and benzidine rearrangements). Orbital symmetry, Woodward - Hoffmann rules, pericyclic reactions and electrocyclic rearrangements. Reagents for oxidation and reduction in organic synthesis. Elementary applications of UV, IR, and NMR techniques for structure determination.

(C) Earth Sciences (ES)

Landforms, volcanism, gravity and isostasy, seismicity and internal constitution of the earth, radiometry and age of the earth; continental and oceanic crust, plate tectonics, geosynclinal concept, orogeny, classification of geotectonic elements; geometry and genesis of folds, faults and joints; cleavage, schistosity and lineation. Stratigraphic principles, breaks in stratigraphic record, facies changes, stratigraphic correlation; Indian stratigraphy, zone and index fossils, important microfossils.

Crystal forms, symmetry, twinning and imperfections, projections, properties of rock-forming minerals. Origin, mineralogy, structure and texture of igneous and metamorphic rock suites; magmatic differentiation, metamorphic facies, metamorphic differentiation and metasomatism; clastic and non-clastic sedimentary rocks, provenance, environments and dispersal patterns of sediments. Processes of ore formation, controls and localization of ore deposits; ore minerals under reflected light; elements of mineral beneficiation; origin, characteristics and uses of important mineral deposits of India, estimation of ore reserves, grade and exploitation; strategic, critical and essential minerals; mineral resources in national economy.

Engineering properties of rocks, rocks as construction materials; origin and classification of soils; geological criteria for site evaluation and location of dam-sites and tunnels; landslides; coastal erosion; geology of major river valley projects in India. Hydrologic cycle, ground water in various rock types; confined and unconfined aquifers, pump tests and aquifer evaluation; ground water provinces of India. Principles and methods of geological, geochemical and geophysical prospecting, geochemical anomalies and dispersion patterns. Electrical, magnetic, gravity and seismic methods of prospecting for metallic and non-metallic mineral deposits, coal, petroleum and ground water; geophysical logging techniques Elements of air photo and satellite imagery interpretation.

(D) Life Sciences (LS)

Origin of life. Physical organisation of protoplasm. Micro-molecules and macromolecules - nucleic acids, proteins, carbohydrates and lipids. Biomembranes - structure, function. Biological transport processes. Primary, secondary, tertiary and quaternary structure of protein - enzymes, coenzyme and vitamins. Regulatory enzymes and enzyme inhibition. Intermediary metabolism. Hormone action. Bioenergetics.

Physical and chemical basis of heredity. Cell cycle differentiation and de-differentiation. Genetic exchange. Numerical and structural variation of chromosome. Cytoplasm - membrane system, concept and function. Microtubules structural and functional interdependence of cellular - organelles. Central dogma. Autocatalytic and heterocatalytic aspects of DNA. Structure and function of gene. Genetic code. Operon concept.

Community composition. Productivity and energy flow - community dynamics. Biogeochemical cycle - carbon, nitrogen, Phosphorus and water cycle. Human ecology. Factors of evolution and natural selection. Mutation and selection. Basic concept of speciation.

Prokaryotes as distinct from eukaryotes. Growth, reproduction, metabolism and classification of bacteria. Microbial role in cyclic transformation of nitrogen. Mutation and genetic

recombination in bacteria. Microbiology of soil, water and food. Structure, chemistry and replication of viruses. Recombination and lysogeny.

(E) Materials Science (MS)

Structure and bonding in materials; ionic, covalent metallic, hydrogen and van der waals bends; lattice energy, atomic packing, symmetry, crystal classes, Miller indices; structure determination by x-ray diffraction, amorphous and glassy state.

Equilibrium phase diagrams, solid state transformations-nucleation and growth, solidification, recovery recrystallization and grain growth; transformation in steels and precipitation; thermodynamics of materials.

Point, line and surface defects; diffusion-Fick's laws.

Mechanical properties of materials-elementary elasticity, plastic deformation in crystalline materials-strain hardening, effect of micro structure on mechanical properties.

Mechanisms of oxidation and corrosion; Electrical properties of solids-electronic and ionic conductivity; free electron theory and band theory of solids; intrinsic and extrinsic semi conductors.

Dielectric properties-polarisation, frequency and temperature dependence of dielectric constant and dielectric loss; piezo and ferroelectricity; optical properties-absorption, reflection, refraction, scattering, luminescence, principles of lasers.

Magnetic properties - ferro, ferri and antiferro-magnetism; hysteresis, coercive force, anisotropy, Curie and Nee temperatures; magnetic domains; hard and soft magnets, ferrites.

(F) Mathematics (MA)

Functions of one or more variables, continuity, differentiability, maxima and minima of functions of several variables, Lagrange multipliers, implicit function theorem, Riemann-Stieltjes integral, Lebesgue measure and integration on \mathbb{R} , convergence of infinite series and integrals, fourier series and integrals, multiple integrals, Green's, Stokes' and divergence theorems.

Functions of a complex variable, analytic functions, conformal transformations, Cauchy's integral theorem, power series, uniform convergence of a series of analytic functions, Taylor and Laurent expansions, residues and contour integration.

Finite dimensional vector spaces, linear transformations, matrix representation of linear transformations, matrix algebra, systems of linear equations, eigen-values and eigen vectors, diagonalization, Cayley-Hamilton theorem, quadratic forms, symmetric and positive definite forms.

Linear programming, model building, simplex method, duality.

First order ordinary differential equations, existence and uniqueness theorems. Linear second order equations with variable coefficients, ordinary and singular points. Series solutions. Legendre and Bessel functions and their properties. Sturm-Liouville problem. First order system of differential equations.

Linear and quasi-linear first order partial differential equations, method of characteristics. Second order linear equation in two independent variables, classifications. Canonical forms. Cauchy, Dirichlet and Neumann problems. Green's functions. Solutions of Laplace, wave and diffusion equations in two independent variables and applications to physical problems.

And one of the following three topics :

1. Forces in three dimensions. Poincot's central axis. Principle of virtual work. Rigid dynamics. Holonomic systems. Lagrange's equations. Small oscillations.
2. Numerical solution of a single nonlinear equation. Interpolation. Numerical solution of linear algebraic systems. Numerical differentiation and integration. Solution of initial value problem for differential equations.
3. Probability theory, sample spaces, conditional probability, Bayes theorem. Scalar and vector random

variables. Distributions and their properties. Joint distributions. Weak and strong laws of large numbers. Central limit theorems.

(G) Physics (PH)

Generalised co-ordinates and momenta. Action principle, Euler-Lagrange equations. Hamilton-Jacobi equations, action-angle variables, rigid-body motion, collisions.

Principles of quantum mechanics, Schrodinger equation and application to simple problems, uncertainty principle and commutation relations, angular momentum, indistinguishability of identical particles, exclusion principle, potential scattering.

Gauss' law, Biot-Savart law, electromagnetic induction, Maxwell's equations, propagation in free space and dielectric media, wave guides, radiation from a moving charge, special relativity, Lorentz invariance.

Ensembles and extension-in-phase space, classical and quantum statistics, partition function and calculation of equilibrium thermodynamic quantities, thermodynamic potentials-free energy, internal energy, entropy.

Atomic and molecular spectroscopic states, electronic configuration, selection rules and term values, X-Ray and optical spectra, Electron and neutron diffraction. Resonance spectroscopy-NMR and EPR.

Elements of crystallography, X-ray diffraction methods, bonding in solids, simple structures, free electron theory, band theory, metals, insulators and semiconductors, transport properties, dia-para-and ferromagnetism, exchange interaction, elementary excitations in solids-phonons, magnons, superconductivity.

Stability of nuclei, nuclear forces, binding energy, radio activity and α , β , γ , decay theories, detectors, passage of

charged particles and radiation through matter, nuclear models, nuclear reactions, fission and chain reactions, fusion.

Transistor characteristics, amplifiers, oscillators, simple network theory, feedback, multivibrators, scaling circuits, logic circuits.

Production and measurement of high and low temperatures, high vacuum; measurement of high and low currents, voltages and resistances.

(H) Regional Planning (RP)

Social equity and economic growth, socio-cultural indicators, ethnology and comparative ethnology, Indian ethnology and ethography, race, language, caste, religion and culture, marriage-family-kinship and social stratification, social control and law, anthropological perspectives on political organisation.

Tribal and rural communities in India, peasant societies and rural development, promotion of educational and economic interests of scheduled castes and tribes, tribal welfare, detribalisation-accultuation and synchronisation, agents, promoters and barriers of change. Tribal development-experiences and prospects.

City as a mosaic of social worlds, ecological structure and factor structure of urban areas, residential, differential and social change, social area analysis. The spatial pattern-urban residential differentiation problems of slums and ghettos, housing and urban social environment. Urban policies for ways out urbanism and the city, modes of production and modes of economic integration (city hinterland relationship, industrialism society and social change).

Problems of under development, balanced and unbalanced growth, underemployment and factor disequilibrium, models and mechanisms of development, external disequilibrium in under-developed structures. Theories of under development, policies

for growth and development. Techniques of production, choice of techniques, distribute of profits and behaviour of the household; the market mechanism and planning, control by the state.

Measures of central tendency, linear regression and correlation, correlation coefficients, testing hypothesis, systems of simultaneous equation and application, econometric computation. Probability, sampling techniques, vital statistics and analysis of migration.

Regional economic theories and models, development pole theory, regional dispersion and intra-regional concentration. Regional equilibrium analysis, regional economic growth policies, resource mobility in the space economy, integration of regional and urban growth economies.

Urbanisation and growth of urban areas, theory of land rent and land use, analysis of urban structure, trends in suburbanisation of urban areas, size distribute of urban areas. Welfare economies and urban problems, urban transportation problems, pollution and urban environmental quality.

Input-output analysis, multiplier analysis, regional forecasting, econometric models, static, equilibrium analysis, comparative static analysis, optimisation problems, linear and non-linear programming. Indian economies-land and people, natural resources, agriculture and land reforms, irrigation, power and transportation; industrial development policies and plans. national income, five year plans.

Location and land use theory, central place theory, spatial interactions, urbanisation, metropolitan growth, megalopolitan development.

City growth and city structure, morphology of settlements. population clusters, size and spacing of settlements, hierarchies of settlements, growth poles, growth centres and growth points.

Identification of regions, types of regions, regional resources, regional economic programmes. Man power and employment, regional geography of India-agricultural, industrial and others.

Rural development perspectives in India, production planning in the traditional sectors. Diversification of activities, agricultural extension, institutional bottlenecks and credit facilities, marketing of agricultural output, social services, rural development administration.

Interior of the earth, mountain building theories, evolution, of landscape - fluvial, glacial, morphometric analysis, drainage pattern analysis, types of topography, soil types and regions, ocean basins and currents, elements of climate, factors of weather and climate, hydrological cycles, planetary wind system and pressure belts, precipitation types and spatial distribution pattern, climatic types and regions, national vegetation its types and distribution.

Population explosion. Food crisis. Floods and droughts. River valley projects. Energy crisis resources. Environment.

Agriculture in Indian economy, planning for profitable use of land, water, labour and equipment, principles of farm management.

Study of crops, improved varieties and inputs. Weeds and weed control. Principles of irrigation and drainage.

Study of soils, nutrients, organic manures and common fertilisers, principles of soil conservation.

Political theories, foreign constitutions, Indian constitution. International relations: Theories: organisations and their functions, law of peace. Foreign policy of India.

4. MODEL QUESTIONS

The questions given in this section are *illustrative only*. The full question papers will consist of many more questions.

4.1 PAPER I

4.1.1 Engineering Stream : General Engineering Sciences

Section 1 : Engineering Mechanics

1. A rope is wrapped twice around a rough pole with a coefficient of friction μ . It is subjected to a force F_1 at one end. A gradually increasing force F_2 is applied at the other end till the rope just starts slipping. At this instant the ratio of F_2 to F_1 is
 - a) 1
 - b) $e^{4\pi\mu}$
 - c) $e^{2\mu}$
 - d) $e^{360\mu}$
2. A mass of 4kg is sliding from rest down a smooth inclined plane. The plane makes 30° with horizontal. After travelling 4m along the incline the mass hits a spring of stiffness 100 kN/m and comes to a halt. What is the compression of the spring? Take $g = 10\text{m/s}^2$.

Section 2 : Fluid Mechanics

1. In the steady, laminar flow of an incompressible, Newtonian liquid through a circular pipe, the shear stress across the cross section of the pipe

- a) varies linearly from zero at the axis to a maximum at the pipe wall.
- b) is constant.
- c) is maximum at the axis of the pipe.
- d) varies parabolically. 1

2.2 The Velocity field in a fluid flow is given by

$$\bar{U} = 3x \underline{i} + 4y \underline{j}$$

Calculate the acceleration of the fluid particle at the point $x=1$ and $y=2$. 2

Section 3 : Thermodynamics

1. The entropy always increases for a
 - a. closed system.
 - b. open system.
 - c. isolated system.
 - d. pure substance. 1

2. The efficiency of the Otto cycle depends on
 - a. the source and sink temperatures.
 - b. the compression ratio.
 - c. the amount of gas working in the cycle.
 - d. the amount of heat addition. 1

3. A cyclic heat engine produces 1 kW work in a cycle. If the cycle efficiency is 40%, find the rate of heat rejection.

2

Section 4: Elementary Electrical Technology

1. Which of the following curves (fig. 4.1) represents the torque (T) - speed (S) characteristic of a d.c. shunt motor?

1

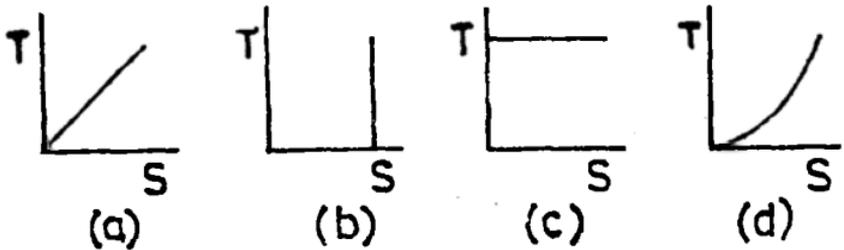


fig. 4.1

2. For the circuit given in figure 4.2, determine the current through the 1 ohm resistor

2

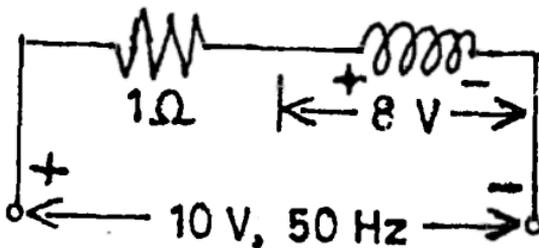


fig. 4.2

Section 5: Basic Electronics

1. The d. c. beta (or h_{FE}) of the transistor of fig. 5.1 is 100 and $I_{CO} = 25 \mu A$. Neglecting V_{be} , calculate the quiescent collector current, I_C .

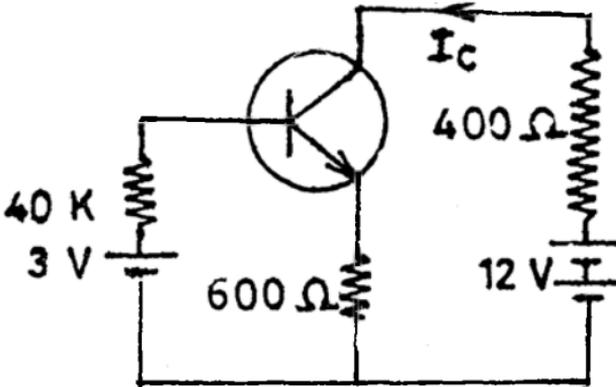


fig. 5.1

2. It is required to determine the logical output of the circuit of fig. 5.2 built using NAND gates. Pick the correct answer from the list given below :

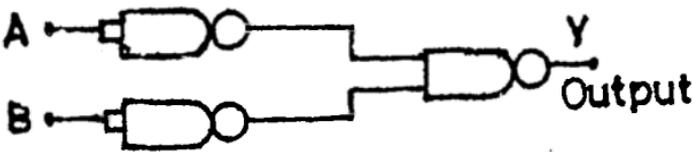


fig. 5.2

- | | |
|------------------------|--------------------------------|
| a. $A \cdot B$ | d. $A \oplus B$ |
| b. $A + B$ | e. $\bar{A}\bar{B} + \bar{A}B$ |
| c. $\bar{A} + \bar{B}$ | f. None of the above |

Section 6: Elementary Materials Science

1. The triple point in a one component system is characterised by the following degrees of freedom :

- a. 0
- b. 1
- c. 2
- d. 3
2. Find the Miller indices of a plane which makes intercepts of a 0.3nm along the a axis, 0.2nm along the b axis and 0.1nm along the c axis of a cubic crystal.
3. The units in which diffusion coefficient is expressed are —
4. Draw typical stress level — number of cycles (S—N) curves for a 0.4 % carbon steel and an aluminium alloy.

Section 7: Analytical Mathematics

1. The derivative of the function $f(x) = |x|$ at $x=0$
- a. = 0
- b. = 1
- c. = -1
- d. does not exist.
2. What is the general solution of the system $AX=B$, where A, X, B are real matrices A, X, B are

$$A = \begin{Bmatrix} 1 & 0 & 2 \\ 0 & -1 & 0 \\ -2 & 0 & -4 \end{Bmatrix}, \quad X = \begin{Bmatrix} x_1 \\ x_2 \\ x_3 \end{Bmatrix}, \quad B = \begin{Bmatrix} 1 \\ 0 \\ 1 \end{Bmatrix}$$

Section 8: General Physical Sciences

1. Of two forms of carbon, C, (graphite and diamond) graphite is electrically conducting whereas diamond is not. Why?
2. 30 mole of CO_2 and 60 mole of N_2 are mixed isothermally. If the total pressure is 180mm of mercury, what is the partial pressure of CO_2 ?
3. A glass convex lens of focal length 'f' is completely immersed in glycerine, its focal length *increases/decreases/remains unaltered*.
4. A wire carries electron current down through a magnetic field directed west to east. The wire is deflected towards *north/east/west/south*.
5. Space lattice of Aluminium is *FCC/BCC/HCP*.
6. What is the essential difference between Bohr's model and Rutherford's model of atom ?
7. Can one use A.C. current for electroplating? why?

Section 9: Management Sciences

1. The chart used to review the overall sequence of an operation by focussing either the movement of operator or material is called a

a. SIMO chart	c. Flow process chart
b. Gantt chart	d. Operation chart
2. A firm is considering three capacity alternatives A, B and C. Alternative A would have an annual fixed cost of Rs. 100,000 and variable cost of Rs. 22 per unit. Similar

costs for alternatives B and C are Rs. 120,000, Rs. 20 and Rs. 80,000, Rs. 30 respectively. Revenue is expected to be Rs. 50 per unit. Which alternative would require the lowest volume of output to generate an annual profit of Rs.50,000?

2

4.1.2. Science Stream: General Science

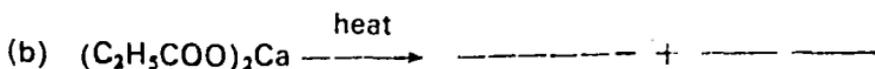
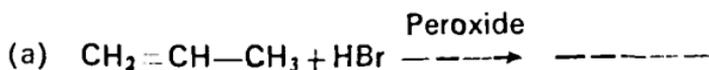
GROUP A

Section I: Chemistry

Questions 1-4 carry 1 mark each and questions 5-7 carry 2 marks each. (The time required in minutes to solve these questions should not be more than the total marks allotted).

1. Which compound is least stable at a given temperature?
 - A. MgCO_3
 - B. CaCO_3
 - C. SrCO_3
 - D. BaCO_3
2. Which of the following will not give precipitate with alcoholic AgNO_3 .
 - A. Chlorobenzene
 - B. Benzyl chloride
 - C. Acetyl chloride
 - D. t-Butyl chloride

3. HBr is a stronger acid than HF. If molar solutions of the acids are compared, which of the following statements would be correct?
- HBr solution will have lower freezing point.
 - HF solution will have lower freezing point.
 - Both will have same freezing point.
 - It is not possible to tell from the information given.
4. Which of the following has zero dipole moment?
- H₂O
 - Cl₂O
 - CO₂
 - SO₂
5. What is the magnetic moment (spin only value) of [Fe(CN)₆]³⁻ which is a low spin complex? (Atomic number of Fe=26).
6. Complete the following equations.



7. For H₂Te, K₁=10⁻⁶ and K₂=10⁻¹². What is the Te²⁻ concentration in a 0.5M solution of H₂Te buffered at pH 4?

Section 2 : Mathematics

Place a tick mark (\checkmark) against the correct answer for the questions 1-3. These questions carry *one* mark each.

1. If ${}^n C_{12} = {}^n C_8$, then the value of $22C_n$ is
 - A. 20
 - B. 231
 - C. 520
 - D. 121
2. The differential equation whose general solution $y=cx+c^2$ will be
 - A. first order and linear
 - B. first order and nonlinear
 - C. Second order and linear
 - D. Second order and nonlinear
3. A single letter is selected at random from the word "PROBABILITY". The probability that it is a vowel is
 - A. $3/11$
 - B. $2/11$
 - C. $4/11$
 - D. none of these

Fill in the blanks with correct answers for the questions 4-5. These questions carry *two* marks each.

4. If $z = \left(\frac{1}{3}\right)^{y/x}$, then the total differential

$$dz =$$

5. The sum of the series

$$\cos \alpha + \cos \left(\alpha + \frac{2r\pi}{n} \right) + \cos \left(\alpha + \frac{4r\pi}{n} \right) +$$

to n terms is equal to.....

Answer the questions 6-8 in the space provided. These questions carry *two* marks each.

6. Show that if $f(x) = \sqrt[n]{a - x^n}$, $x > 0$, then $f(f(x)) = x$. Find the inverse of f .

7. Change the order of integration and evaluate

$$\int_0^1 \int_y^1 \frac{-x^2}{e} dx dy$$

8. Invert the coefficient matrix of the following system of algebraic equations

$$y - 2z = 3$$

$$3x + z = 4$$

$$x + y + z = 1$$

and hence solve.

9. Find the particular solution of

$$\frac{d^2y}{dx^2} = 2y^3, \quad y(0) = 1, \quad y'(0) = 1.$$

Section 3: Physics

Place a tick mark (\surd) against the appropriate answer.

Each question carries one mark.

- A solenoid is 0.5 meter long and has 400 turns of wire carrying a current of 0.5 amp. If the magnetic induction produced is 0.4 weber/m², the permeability of the material (in SI units) is

 - A. 2×10^{-3}
 - B. 4×10^{-3}
 - C. 1×10^{-3}
 - D. 5×10^{-3}

- Water flowing through a pipe of 0.2 meter diameter at the speed of 1 m/s enters a narrow section of diameter 0.05 m. If the pressure in the larger section is p Newtons/m², the pressure in the narrower section is

 - A. $p + 1.5 \times 10^3$ Newtons/m²
 - B. $p - 1.5 \times 10^3$..
 - C. $p - 7.5 \times 10^3$..
 - D. $p + 7.5 \times 10^3$..

3. The nucleus of the atom ${}^7\text{N}^{14}$ can have the spin
(in units of $h/2\pi$)
- A. $1/2$
 B. $3/2$
 C. 1
 D. $7/2$
4. The magnetic moment of the H^- ion is
- A. 1 Bohr magneton
 B. 2 Bohr magnetons
 C. Zero
 D. $\frac{1}{2}$ Bohr magneton

Answer the following questions in the blank spaces provided

5. A particle with charge $+3.2 \times 10^{-19}$ Coulombs moves with a speed of 6×10^5 m/s along the + X axis in region of uniform magnetic induction 5×10^{-4} weber/m² along + Y axis. The force on the particle is balanced by a uniform electric field of magnitude.....volts/meter acting in the direction.....
6. The mean free path of molecules in atmospheric air is of the order of.....meters.
7. Which of the three Kepler's laws of planetary motion is valid in general for the motion of a body under central force potential? (Write the law).....
3. At room temperature (say 27°C), the value of kT is approximatelyeV where k is the Boltzmann constant.

GROUP B

Section 4: Agricultural Sciences

All questions carry one mark each.

Put a tick [✓] in the appropriate place for questions 1 & 2

1. Saline soils are characterised by:
 - A. $pH > 8.5$
 - B. Presence of excess Na_2CO_3
 - C. Dense vegetation
 - D. Electrical conductivity $> 4m$ mhos/cm.
2. Consumptive use of water is equal to:
 - A. Equal to transpiration
 - B. Equal to Evapotranspiration
 - C. More than Evapotranspiration
 - D. None of the above

Fill in the blanks with correct word/words:

3. Tensiometer can measure soil upto _____.
4. Blue green algae fixes _____ in the soil.

State TRUE or FALSE by placing a tick (✓) mark in the appropriate box indicating correct answer:.

- | | TRUE | FALSE |
|---|--------------------------|--------------------------|
| 5. Energy and nutrient uptake and environment utilization are ecosystem components. | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. Nitrate nitrogen is held better on the soil micelle than ammonical nitrogen. | <input type="checkbox"/> | <input type="checkbox"/> |

Section 5: Earth Sciences

1. The radius of the earth is about
 - A. 1000 km
 - B. 3000 km
 - C. 5000 km
 - D. 6000 km

2. Gondwana rocks are famous for mineral resources of
 - A. Coal
 - B. Iron
 - C. Copper
 - D. Manganese

3. Galena is an ore of _____

4. The crustal depth under the continents is _____ than that under the oceans.

5. Define an isoclinal fold.

6. Name the surface waves produced by an earthquake.

7. What process sustains the Himalayas on the crust of the earth?

Section 6: Life Sciences

Questions 1-3 carry *one* mark each, and questions 4-6 carry *four* marks each.

For question 1 & 2, place a tick mark (✓) in the appropriate place.

1. Hemophilia is a hereditary disease in males. The gene for the disease is located in :
- 21st chromosome
 - All autosomes
 - Cytoplasmic DNA
 - Sex-chromosome
2. A polyploid having chromosome set from different sources, such as different species is termed as :
- Autopolyploid
 - Monoploid
 - Aneuploid
 - Allopolyploid
3. Which of the following bases does not occur in DNA?
- Adenine
 - Guanine
 - Uracil
 - Thymine
4. State TRUE or FALSE by placing a tick mark in the box.
- | | | |
|--|--------------------------|--------------------------|
| a. Secondary structure of proteins is due to | TRUE | FALSE |
| S-S bonds | <input type="checkbox"/> | <input type="checkbox"/> |
| b. Viruses are obligate parasites | <input type="checkbox"/> | <input type="checkbox"/> |

c. All isotopes are radio active.

d. Viruses are acellular.

5. For each of the vitamin listed, match the type of deficiency disease, by entering the number of the answer in the box

Answer

- | | | |
|---------------------------|--------------------------|-----------------------------------|
| a. Vitamin K | <input type="checkbox"/> | I. Pellagra |
| b. Vitamin A | <input type="checkbox"/> | II. Disturbance in blood clotting |
| c. Niacin | <input type="checkbox"/> | III. Xerophthalmia |
| d. Vitamin B ₆ | <input type="checkbox"/> | IV. Dermatitis |

6. Fill in the blank with a one word answer.

- a. Animal lacking pigment in skin, hair and eyes is a _____
- b. The molecule formed by the transcription of DNA is a _____
- c. The study of interrelationships between living organisms and environment is termed as _____
- d. The name of a sulfur containing essential amino acid is _____

4.2 PAPER II

4.2.1 Engineering Stream

(A) Aeronautical Engineering (AE)

1. Tick the Right Answer(s) :

- (i) In steady flow of a fluid, the acceleration of any fluid particle
- a. can be zero
 - b. is never zero
 - c. is always zero
 - d. does not depend on the co-ordinates
- (ii) The lift-curve slope of thin airfoil in an ideal fluid flow
- a. is an absolute constant
 - b. depends on the thickness distribution
 - c. depends on the camber
 - d. depends on the leading edge radius
- (iii) Flow behind a plane oblique shock is
- a. always supersonic
 - b. always subsonic
 - c. sometimes supersonic and sometimes subsonic
 - d. transonic

- (iv) Heat treatment of steel increases its
- young's modulus
 - ultimate tensile strength
 - ultimate compressive strength
 - thermal conductivity
- (v) The isochromatic fringes in photoelasticity relate to
- sum of shear stresses
 - difference of shear stresses
 - sum of principal stresses
 - difference of principal stresses
- (vi) In steady inverted slight, an aircraft experiences a load factor of
- 1 g
 - 0 g
 - 1 g
 - 10 g

2. Define/explain the following :

- vorticity
- boundary layer
- turbulent flows
- shock wave
- taper ratio
- dihedral effect

- g. degree of reaction of a compressor
- h. hypergolic propellant
- i. enthalpy of a reaction
- j. surgin :
- k. shear centre
- l. ultimate stress
- m. redundant structure
- n. natural frequency
- o. forced vibration

3. Distinguish between :

- a. rotational and irrotational flows
- b. ideal fluid and a perfect gas
- c. stick fixed and stick free stability
- d. parasite drag and induced drag
- e. turbofan and bypass engine
- f. pulse jet and ram jet
- g. Euler buckling and torsion buckling
- h. monocoque and semi-monocoque structures
- i. isotropic and orthotropic materials
- j. damped and undamped oscillations

4. If the stream function in a two dimensional incompressible irrotational flow is $\phi = 2xy$, calculate the velocity at $x=1, y=1$. Find also the velocity potential Φ . Sketch a couple of streamlines.

5. a. On one-dimensional flow considerations, write down the general thrust equation of an airbreathing thrust producer.
- b. In turboprop and turbofan engines the total thrust is realised from two different fluid streams : (turboprop : propeller stream and jet-pipe stream). Write down the thrust equations for these engines. Clearly list the assumptions involved.
- 6 a. Explain the term "steady coordinated level turn". Write down the equations of motion in this flight.
- b. "Head wind is good during take-off run but bad for range performance". Explain.
- 7 In a spring mass system (k_1, m) with the natural frequency f_1 , if a second spring k_2 is added in series with the first spring, the natural frequency lowers to $(f_1/2)$. Determine k_1 in terms of k_2 .

(B) Agricultural Engineering (AG)

1. Seeds are released from a vertical rotor planter and fall by gravity into the furrow bottom 9 cm below. The peripheral speed of the rotor is 0.3m/sec and ground speed is 5 km/h. How far does the seed move horizontally if the rotor turns in the same direction as the ground wheel?
2. Typical field efficiency of most tillage operations lies within a range of _____
- (a) 30% to 45%
- (b) 50% to 65%
- (c) 75% to 90%
- (d) 90% to 95%

3. A channel having trapezoidal cross-section is carrying water, at a depth of 0.3 m. Bed width is 60 cm. Side slopes are 1:1. Manning's roughness coefficient is 0.02. Bed slope is 1 in 1000.
Therefore the discharge is _____ litres/sec
242 litres/sec, 138 litres/sec, 525 litres/sec, 440 litres/sec.
4. A 15 cm dia. tube well is drilled in a confined aquifer of 15 m thickness. The hydraulic conductivity of the aquifer is 6.0 m/hour. The radius of influence is 300 m. If the well is operated at 2 m draw down, what will be the discharge ?
5. Theoretical power required for vertical lifting of grains by a bucket elevator at the rate of 4 tonnes/hour to a height of 30 m is _____ kw
(0.123, 0.221, 0.327, 0.432, 0.473)
6. 3 tonnes of shelled corn at 22 percent moisture content (wet basis) is dried to 13 percent moisture content (wb). Determine (a) the dry basis moisture content (b) the amount of bone dry material in kg (c) quantity of water removed during drying in kg.

(C) Architecture (AR)

- Q. 1. Explain within 100 words the purpose of curing of concrete.

Answer : The purpose of curing is twofold. Firstly, it is required to prevent or replenish the loss of water which is essential for the process of hydration and, therefore, for hardening. Secondly, it prevents the concrete from losing moisture too quickly before it has acquired enough strength to resist contraction stresses.

2. (✓) Tick mark the correct answer :

A propped cantilever is a

- i) statically determinate structure ()
- ii) statically indeterminate structure (✓)
- iii) Frame structure ()

D) Bio-Chemical Engineering (BI)

PART I

1. A given mass of gas occupies a volume of 240ml at a pressure of 950 torr. The volume of double the given mass of gas if the pressure was altered to 570 torr will be
 - A. 480 ml
 - B. 400 ml
 - C. 800 ml
 - D. 145 ml

2. The ΔG^0 value for the alcoholic fermentation of glucose (D-glucose \longrightarrow 2 ethanol + 2 CO₂), if ΔG^0_r (kcal/mole) for D-glucose, ethanol, carbon dioxide are -219.22, -43.99, -94.45 respectively is
 - A. -57.66 kcal
 - B. +57.66 kcal
 - C. -496.10 kcal
 - D. +496.16 kcal

3. In partial differential equations
 - A. There is one dependent variable and one independent variable.
 - B. Two dependent variables and one independent variable.

- C. Two independent variables and one dependent variable.
 - D. Two dependent variables and two independent variables.
4. The nuclear membrane of eucaryotes is distinguished from other membranes of the nucleocytoplasmic regions by its
- A. Porosity
 - B. Macrostructure
 - C. Thickness
 - D. Ultrastructure
 - E. Composition
 - F. Membrane bound enzymes
5. The size of a bacterial spore lies in the range of
- A. 10-20 μ
 - B. 5-10 μ
 - C. 50-100 μ
 - D. 30-40 μ
 - E. 1-2 μ
6. The units of viscosity is
- A. gms/cm/sec
 - B. gms/cm/sec²
 - C. gms/cm²/sec
 - D. gms cm/sec

7. In an immobilized reactor with diameter of 10 cms a substrate is flowing at the rate of 5 cm/sec. If the substrate specific gravity is 1.0 and the viscosity is 1 poise the Reynolds number for the flow is
- 50
 - 500
 - 1000
 - 5000
8. For a simple enzyme catalysed reaction following Michaelis-Menten form, the ratio of the substrate concentration required for 80% of V_{max} to the concentration required for 20% of V_{max} is
- 16
 - 4
 - 8
 - 2
9. Oxygen analyser measures gas phase oxygen in bioreactor based on the _____ property of oxygen.
- Thermal
 - Paramagnetic
 - Electrical
 - Chemical
10. In a microbial fuel cell the following biothermochemical reaction is used to produce electrical energy
- $$C_6H_{12}O_6 + 6 O_2 \xrightarrow{\text{cells}} 6 CO_2 + 6H_2O + 673 \text{ kcals/mole}$$

The amount of electrical energy equivalent to the bithermochemical energy per gram mole glucose oxidized is

- A. 6 watt hour
 B. 1.5 " "
 C. 2 " "
 D. 780 " "

PART II

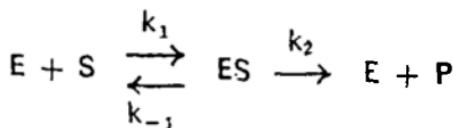
1. A current of 5 amp at 220 volts is passed through a heater immersed in water at 100°C. If the heater is operated for one hour a) how much water will be evaporated? b) how much work will be done? c) what will be the change in internal energy? The heat of vaporization of water at 100°C is 53.9 cal/gm, the density of the water vapour is 0.5977 gms/litre and that of liquid water is 0.9584 g/ml.

(5 marks)

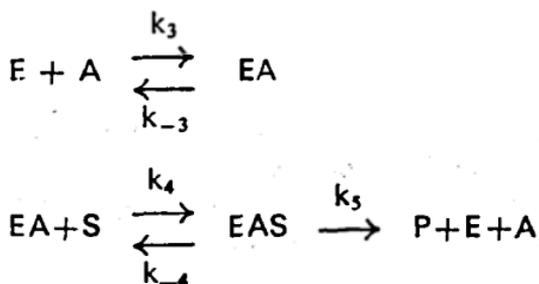
2. What is the physical significance of entropy?

(2.5 marks)

3. An enzyme (E) converts a substrate (S) into a product (P) according to the following mechanism



An activator (A), if present in the solution along with S, combines with the enzyme (E) and activates the reaction by the following additional pathways.



Using Pseudo steady state assumption (PSS), derive an expression for the ratios of reaction rates in the presence and absence of the activator. Will the PSS assumption be valid for low values of activator concentrations?

(10 marks)

4. Calculate the freeze drying time for a biologically perishable solid material, 1.5 cm thick placed between freeze drier plates spaced at a distance of 1.5 cm from each side at 150°C. Assume the process is performed at 4 torr, corresponding to an ice temperature of 1°C.

Thermal conductivity of the material $k_f = 8.2 \times 10^{-5}$ cal/cm/sec/°C at 4 torr of nitrogen. Partial density of ice, $\rho_i = 0.8$ g/ml. Latent heat of sublimation $h_{sg} = 670$ cal/g. The material, surface temperature = 65°C

$\epsilon_r = 0.9$ (emissivity of radiator)

$\epsilon_m = 0.8$ (emissivity of dried material)

Conductivity of water at 100 °C

$k_w = 5.62 \times 10^{-5}$ cal/cm-sec °C

(10 marks)

(R) Ceramics and Glass Technology (CG)

1. Mark whether the following statements are true or false.
- a. Higher activation energy for diffusion for a given temperature range implies a larger change in D with T .

Ans. True, $\frac{dD}{dT} = \frac{-Q}{R} D$ and is dependent on Q

- b. A glass forming silicate melt is easily crystallised in presence of impurities. Ans: True.
- c. In crystallisation from melt the growth rates after nucleation can be increased by decreasing the melt temperature. Ans: False. True answer "be increased by increasing melt temperature".

- d. While grain growth occurs in solid the larger grains tend to grow and the smaller grains tend to shrink.

Ans: True.

- e. During sintering pores may grow by moving with the grain boundaries and subsequent coalescence.

Ans: True.

2. Mark the correct statement.

- a. *First law of thermodynamics*

- i) defines relationship of heat changes between reactants and products.
- ii) states that internal energy change in any reaction is the algebraic sum of enthalpy change and the work done on/by the system.
- iii) says that the entropy change is given by heat change divided by the temperature.
- iv) correlates the free energy change with enthalpy and entropy changes.

3. a. If the set temperature of a tile glaze is $625\text{ }^{\circ}\text{C}$ estimate the thermal expansion coefficient of the glaze material if the surface stress after cooling to $25\text{ }^{\circ}\text{C}$ is to be 10 kN/cm^2 compressive. The young's modulus $E_{\text{glaze}} = E_{\text{body}} = 7 \times 10^3\text{ kN/cm}^2$ and thermal expansion coefficient $\alpha_{\text{body}} = 7.10^{-6}\text{ cm/cm }^{\circ}\text{C}$

Soln: Let $a_{gl} = x \times 10^{-6}$ cm/cm—°c. The glaze stress neglecting its thickness is given by

$$\sigma_{gl} \text{ tensile} = E (T - T_o) (a_{gl} - a_b)$$

$$\therefore -10 = 7 \times 10^3 (600) (x - 7) 10^{-6}$$

$$\text{or } (7 - x) = \frac{10^6}{4.2 \times 10^5} = \frac{10}{4.2} = 2.38.$$

$$x = 7 - 2.38 = 4.62$$

$$\therefore a_{gl} = 4.62 \times 10^{-6} \text{ cm/cm—}^\circ\text{C}$$

- b. Explain how quartz helps in improving glaze fit in porcelain bodies.

Soln: When additional quartz is added to glaze composition it reduces a_{gl} . On the other hand extra quartz in the body increases a_{body} due to α - β quartz transformation in the body. Net effect is an increase in the value of $(a_b - a_{gl})$ and a resultant stress (compressive) increase of the glaze.

F) Chemical Engineering (CH)

1. Joule-Thompson coefficient is given by 1

(a) $(\delta T / \delta P)_H$

(b) $(\delta P / \delta T)_V$

(c) $(\delta S / \delta P)_T$

(d) $(\delta H / \delta T)_P$

2. A pseudoplastic fluid is one : 1

(a) whose apparent viscosity decreases with increase in rate of shear.

(b) whose apparent viscosity remains constant with increase in rate of shear.

(c) whose apparent viscosity increases with rate of shear.

- (d) which requires a threshold stress that must be applied before flow can occur.
3. Fill in the blanks : 1
 The raw materials for the production of fertilizer grade urea are : _____
4. Which of the following types of closures or heads can withstand the highest internal pressure (for a given vessel diameter and head thickness)? 1
- A. elliptical
 B. hemispherical
 C. flat
 D. torispherical
5. To measure the flow rate of nitrogen flowing through a pipe line, 0.44 kg/min. of CO_2 is introduced at a point in the pipe line. The concentration of CO_2 measured for downstream is 0.10%. Estimate the mass flow rate of nitrogen. 2
6. Fill in the blanks : 2
- (a) One commonly used device for separation of particles based on their sizes alone, without the use of any fluid is
- (b) One commonly used device for separation of particles based on their differential rates of settling is
7. Fill in the blanks : 4
- (i) The transfer function of a proportional - integral controller is
- (ii) For a process with proportional control, the offset can be reduced by.....the proportional sensitivity of the controller.
- iii) A Chromatograph works on the principle of.....

iv) For a control system to be stable, the real parts of the roots of the characteristic equation must be

.....

8. It is desired to concentrate a 10% aqueous solution of A to a 50% solution in a triple effect evaporator. Saturated steam at 131°C is used. The pressures in the first, second and third effects are such that the saturation temperatures are 119°C, 103°C and 51°C. The respective boiling point elevations are 5°C, 7°C and 40°C. What are the effective temperature differences for heat transfer in each of the effects? 3
9. (a) Obtain the units of the rate constant of an n^{th} order reaction.
- (b) How is the temperature sensitivity of the reaction rate dependent on (i) the activation energy level, and (ii) the temperature level. 3
10. A granular material is dried from 30% moisture to 8% moisture (dry basis), in a period of 5 hours in an industrial drier. The critical and equilibrium moisture contents are 15% and 0% respectively. Calculate the time required to dry the material under identical conditions from 40% to 5% moisture. 4

(G) Civil Engineering (CI)

Instructions to candidates :

1. Answer *All* Questions in Part A.
2. Answer *Any Two* sections from Part B.

PART A

1. Encircle the correct answer or fill in the blank as the case may be :

- i. An R. C. column is resting on a footing of trapezoidal section. The section at which the diagonal tension shear capacity has to be satisfied, is at a distance of

- $d/2$ from the face of the column.
- d from the face of the column.
- d from the centre of the column,

where 'd' is the effective depth of the footing. 1

- ii. An I-girder is found to be just insufficient to carry the loads coming on it. A steel plate is available. The steel plate should be welded

- to the bottom of the girder.
- to the top of the girder.
- to its web.

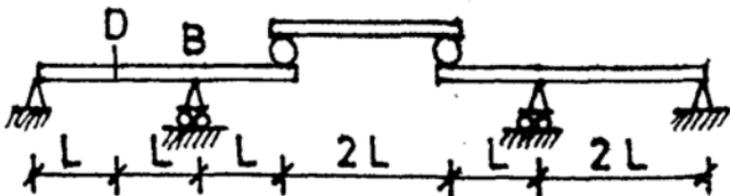
1

- iii. The ultimate compressive strain in concrete of a member, subjected to pure bending, is

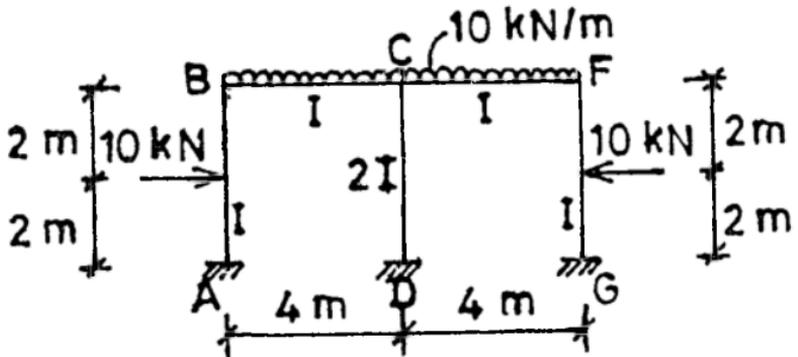
- 0.0015
- 0.002
- 0.0035

1

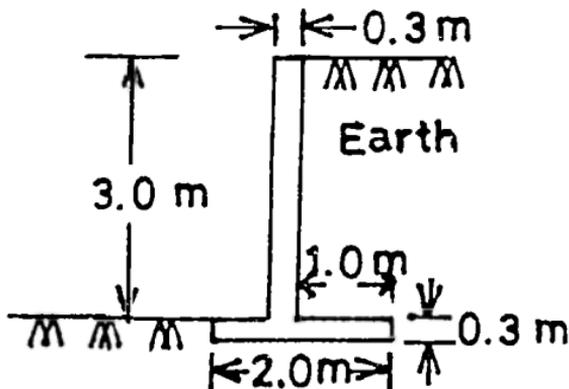
2. a. State the Maxwell-Betti reciprocal theorem. 1
 b. Sketch the influence lines for moment at D and reaction at B of the beam shown below (exact values not required): 2



3. Determine, using any suitable method, the bending moments at the joints of the following frame, and draw the bending moment diagram. 4



4. A cantilever retaining wall is shown in the figure. It is retaining a cohesionless soil of angle of internal friction 30° . The friction coefficient between the base and the soil is 0.4. The soil weighs 20 kN per cubic metre.
- check the stability of the wall assuming suitable factors of safety;
 - sketch the typical arrangement of reinforcing steel in the wall and in the base. 7



5. Encircle the correct answer.

(i) Which of the following principles are used in water distribution system analysis?

- (1) Continuity
- (2) Momentum
- (3) Moment of momentum
- (4) Energy
- (a) 1,2
- (b) 1,3
- (c) 1,4
- (d) 2,4

(ii) For water flowing at a Froude number less than unity through a channel contraction with horizontal bottom, in the direction of flow :

- (a) both depth and velocity increase.
- (b) both depth and velocity decrease.
- (c) depth increases and velocity decreases.
- (d) depth decreases and velocity decreases.

6. (i) Water flowing down a spillway at the rate of $90\text{m}^3/\text{sec}$ per meter length of spillway leaves the apron horizontally with a mean velocity of $12\text{m}/\text{sec}$. Determine the head water elevation considering apron elevation to be zero. Determine the tailwater depth necessary for a hydraulic jump to form.

(ii) What is the boundary layer thickness for fully developed pipe flow?

7. Encircle the correct answer or fill up the blank as the case may be.

- (i) A plate load test is useful to estimate
 - (a) bearing capacity of foundations.

- (b) settlement of foundations.
- (c) both bearing capacity and settlement of foundations. 1
- (ii) The bearing capacity of a strip footing on a saturated clay is 120 kN/m^2 . The bearing capacity of a circular footing (diameter = width) will be (a) more than (b) equal to (c) less than that of the strip footing and the value of cohesion is _____ 2
- (iii) Relative density is expressed as
- (a) $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$ (c) $\frac{e_{\max} - e_{\min}}{e_{\max} - e}$
- (b) $\frac{\nu_{\max} - \nu}{\nu_{\max} - \nu_{\min}}$

in which e is the void ratio and ν is the density 1

8. Determine the safe depth of a cut at a slope angle $i = 40^\circ$ which is to be constructed in a silty clay soil with cohesion of 50 kN/m^2 , angle of friction $\Phi = 15^\circ$ and density $\nu = 19 \text{ kN/m}^3$. The required factor of safety is 1.5 and the stability number for $i = 40^\circ$ and $\Phi_m = 10^\circ$ is 0.098. 5

PART B

SECTION-I

9. Encircle the correct answer and fill in the blanks as the case may be :
- (i) In water treatment rapid gravity filters are adopted to remove: 1
- (a) dissolved organic substance.
- (b) dissolved solids and dissolved gases.
- (c) floating solids and dissolved inorganic solids.
- (d) bacteria and colloidal solids.
10. A small town has a population of 50000. The per capita water consumption is 100 l/d, eighty percent of which

contributes to the sewage flow. Design a primary settling tank given the following data: 4

(i) Surface loading 7500 lpd/m²

(ii) detention period 12 hrs.

11. It is proposed to adopt slow sand filter bed to treat the surface water for domestic supply to a town having a population of 25000. The per capita water consumption is 80 l/d. Calculate the area of filter bed needed. 2

SECTION II

12. Encircle the correct answer :

(i) The difference between the most probable value of a quantity and its observed value is

(a) true error

(b) weighted observation

(c) Conditional error

(d) residual error 1

(ii) In a triangulation survey, the distance from the station to the point of tangency is given by

(a) $\sqrt{h(0.0673)^{-1}}$

(b) $\sqrt{h}(0.0673)^{-1}$

(c) $h(0.0673)$

(d) $\sqrt{h(0.0673)}$ 1

13. In a two peg test of a dumpy level the following readings were taken :

- | | | |
|------|--|--|
| (i) | The instrument
at C, midway
between A and B
$AB=100m$ | Staff reading as A = 1,682
Staff reading as B = 1,320 |
| (ii) | The instrument
near A | Staff reading as A = 1,528
Staff reading as B = 1,178 |

With the instrument at A, what should be the staff reading as B in order to place the line of collimation truly horizontal?

3

Section III

14. Encircle the correct answer ;

- (i) Camber for road is provided for
- (a) effective drainage
 - (b) counteracting the centrifugal force 1
 - (c) having proper sight distance

(ii) The binder normally used in flexible pavement construction is

- (a) cement
- (b) lime
- (c) bitumen 1

15. Calculate the minimum non-passing sight distance on a national highway in a rolling terrain where there is a descending gradient of 6%, assuming reaction time of 2.5 sec and the coefficient of friction between tire and road surface as 0.4 3

Section IV

16. Encircle the correct answer :

- (i) In order to obtain the best workability of concrete the preferred shape of aggregate is

- (a) Rounded
- (b) Angular
- (c) Elongated

1

17. Sketch in plan two successive courses of an one and a half brick thick brickwall, made in English Bond, one end of the wall being connected to another one and a half brick thick wall. 4
18. A large building is partly founded on piles and partly on rafts. Piling is expected to take 6 weeks and rafts can be completed in 4 weeks. Subsequently, all columns are cast and the beams and slabs of the floor are then taken up. Prepare a net-work of the activities. You may add on activities which you think must be included. 2

(H) Computer Science and Engineering (CS)

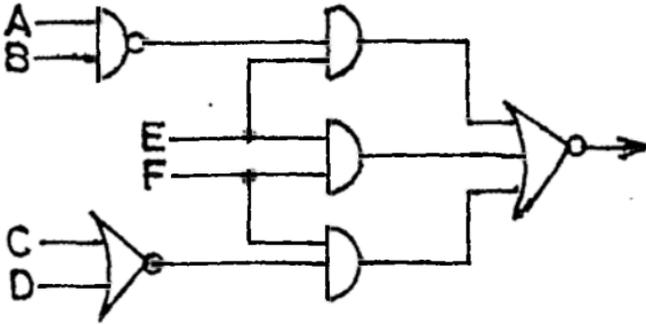
Multiple Choice Questions

1. The assignment statement
- $$Y = \text{SIN}(\text{SIN}(X + Y/Z))$$
- (a) calls SIN function recursively.
 - (b) has nested calls on SIN.
 - (c) calls SIN sequentially.
 - (d) none of the above.
2. The hexadecimal number A3 is
- (a) equal to the decimal number 179.
 - (b) less than the decimal number 170.
 - (c) greater than the decimal number 172.
 - (d) equal to the decimal number 173.
3. Let $f(x) = 0$ if $x = 1$,
- $$= x \times f(x-1) + x^2, \text{ otherwise.}$$

The value of $f(4)$ is

- (a) 53
- (b) 29
- (c) 50
- (d) 100
- (e) 148

4.



The function generated by the network above is

- (a) $A'B'E + EF + C'D'F$
 - (b) $(E' + ABF')(C + D + F')$
 - (c) $(A'B' + E)(E' + F')(C + D + F')$
 - (d) $(A + B)E' + E'F' + CD'F$
5. Of the following, which best approximates the ratio of the number of nonterminal nodes to the total number of nodes in a complete K-ary tree of depth N ?
- (a) $1/K$
 - (b) $K - 1/K$
 - (c) $\log_{10}(1/N)$
 - (d) $N - 1/N$

II. Non-Multiple Choice Questions

- 6. (a) Draw the schematic for a many to one decoder matrix with inputs from flip flops and 16 output lines.
- (b) Design a half adder using only NoR gates.

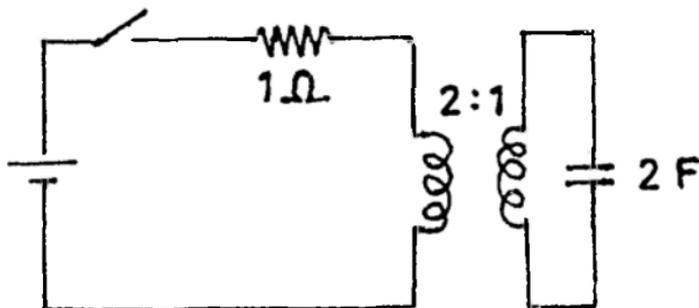
7. Some computers do not have indirect addressing. Show how without using indirect addressing one could write subroutines called by reference
- using indexing
 - using base-displacement addressing.
8. Find a context-free grammar generating expressions whose operators are $+$, $-$, \times , and $/$ and whose identifiers are either id or strings of the form $\text{id} (\langle \text{expression} \rangle, \langle \text{expression} \rangle, \dots, \langle \text{expression} \rangle)$ representing subscripted identifiers such as $A (B + C, 2)$.
9. A 3×3 matrix is inverted using Gaussian method. Each operation gives a computational error, upper bound being 10^{-8} . Calculate the upper bound of error in the elements of inverse computed.

I) Electrical and Electronics (Combined) (EE)

Part A (Multiple Choice Questions)

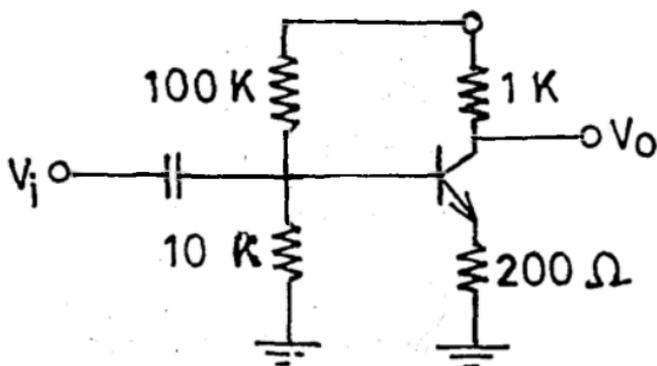
1. Given $F(s) = \frac{1}{(s+2)(s^2+1)}$ the corresponding inverse Laplace transform $f(t)$ is
- $e^{-2t} \sin t$
 - $e^{-2t} + \sin t$
 - $e^{-2t} \cos t$
 - $e^{-2t} \sin(t - \tau) d\tau$
2. An over-excited synchronous motor draws current at
- lagging power factor
 - leading power factor
 - unity power factor

3. The time constant of the circuit shown in the figure is
- (A) 2 secs
 (B) 1 sec
 (C) $\frac{1}{2}$ sec
 (D) 4 secs



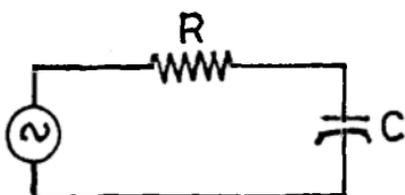
4. To protect a galvanometer during transport
- (A) the terminals are kept shorted.
 (B) critical damping resistance is connected across the terminals.
 (C) The terminals are kept open circuited.
 (D) A capacitor is connected across the terminals.
5. In a thyristor the gate is connected to
- (A) the middle of P-N junction,
 (B) the P-layer adjacent to the cathode.
 (C) the N-layer adjacent to the anode.
 (D) the P-N junction nearer the cathode.
6. For a wound rotor induction motor the
- (A) torque is highest when the rotor is shorted.
 (B) torque increases as the rotor resistance is increased.

- (C) torque is inversely proportional to speed.
 (D) torque is maximum for a particular value of the rotor resistance.
7. In a low level AM modulation————power amplifiers are used to boost up the power
- (A) Class B
 (B) Class C
 (C) Class D
 (D) Class A
8. The sampling frequency should be at least————the maximum frequency of the signal to be transmitted.
- (A) 2
 (B) 3
 (C) 1
 (D) 10
9. In the transistor amplifier shown the transistor has $\beta = 100$ and $h_{ie} = 1000$ ohms. The given $\frac{V_o}{V_i}$ of the amplifier is about
- (A) 5
 (B) 10
 (C) 100
 (D) 500



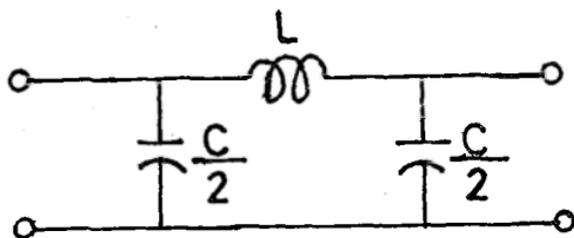
10. In an RC series circuit connected to a sinusoidal voltage source as shown in the figure the rms voltage across R and C are 8V and 6V respectively. Then the voltage across the source is_____.

- (A) 14 V
 (B) 2V
 (C) 14 V or 2 V
 (D) 10V



PART B

1. A circuit with an external resistance R is powered by N batteries. The emf of each battery is E_0 and the internal resistance r_0 . The N batteries are so arranged so that m of them are connected in series and in n parallel groups. Find the number of the groups n and the number of the batteries m in each group for which (a) maximum current will be observed in the circuit; (b) the Maximum power is dissipated in the circuit.
2. In a plate modulated amplifier circuit the carrier output is 5 kW. For a 50 percent modulation (1) calculate the power in each side band, if the plate efficiency is 75%.
3. A star connected load with impedance per phase of $3 + j4$ ohms is connected across a 3 phase 100 V supply. If the conductor of phase 'a' breaks, determine the sequence.
4. Write an expression for the cut off frequency of the section proto type low-pass filter illustrated.



(J) Electronics and Communication (EC)

Part A

Note : 1. Attempt all questions.

2. Each question carries $\frac{1}{2}$ mark.

3. Indicate the correct alternative against each question by marking \checkmark against a, b or c.

- The impedance of a parallel connected LCR network at resonance is
 - purely resistive
 - purely reactive
 - complex
- An emitter follower has a quiescent current of 1 mA and an emitter resistance of $5\text{k}\Omega$. Its output resistance is approximately
 - $25\ \Omega$
 - $5\ \text{k}\Omega$
 - $1\ \Omega$
- If $Z = X \oplus Y$, then $X =$
 - $\overline{Y \oplus Z}$
 - $Y + Z$
 - $Y \oplus Z$

PART B

Note : 1) Attempt all questions.

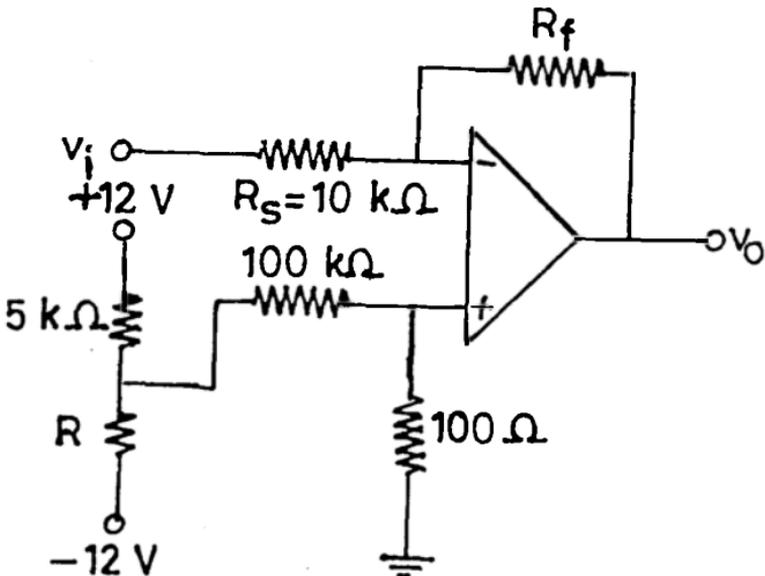
2) Numbers against each question indicate marks.

3) Answer each question only in the space provided below the question.

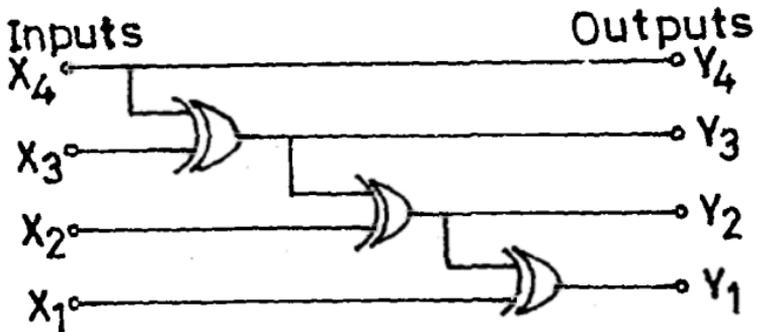
1. For the inverting amplifier shown in the figure

- a) Calculate the value of the resistance R_f for a gain of -10 .
- b) The value of the resistance R to null an input offset of 5 mV .

The Op-Amp may otherwise be considered ideal. 4



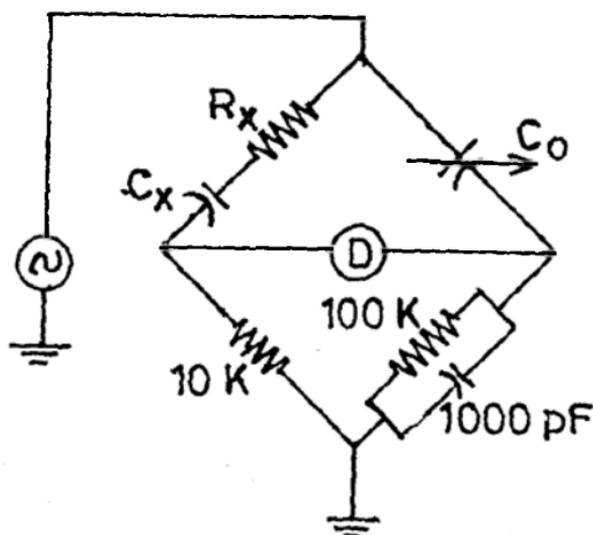
2. For the combinational circuit shown, complete the truth table. Identify the circuit.



Inputs				Outputs			
X_4	X_3	X_2	X_1	Y_4	Y_3	Y_2	Y_1

4

3. In the Schering bridge shown, the value of C_0 is 100pF at balance. Determine the values of C_x and R_x .



2

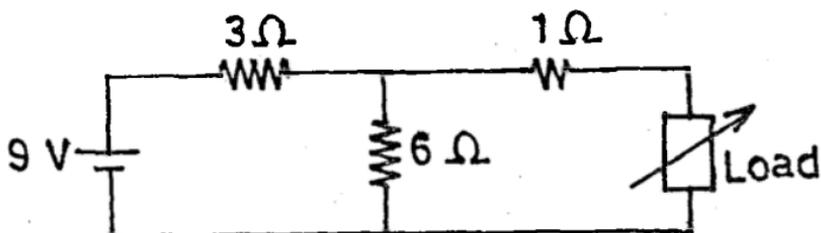
4. Determine the Doppler frequency of a target moving with a radial velocity of 120m/sec that a 3 cm radar would register. 2
5. For an interlaced scan television system, sketch the vertical blanking interval showing all the details for an odd field and an even field. 2
6. Derive an expression for the free space path loss between two points of a line-of-sight radio relay link in terms of the distance between these points and the frequency of operation of the link. 2

(K) Electrical (Power) (EP).

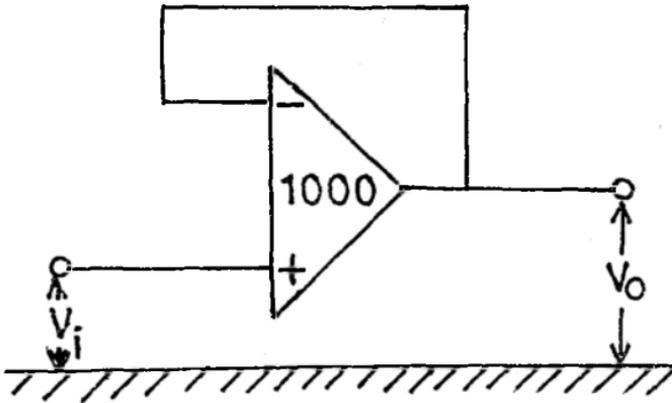
GROUP 1: Objective Questions

1. The maximum power that can be distributed in the load in the circuit shown is,
 - A) 3 watts
 - B) 6 watts

- C) 6.75 watts
 D) 13.5 watts
 E) None of the above

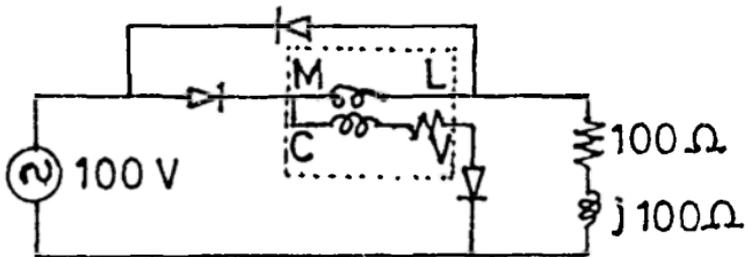


2. The open loop transfer function of a system is $K(T_1 s + 1)/s^2 \times (T_2 s + 1)$. The maximum number of poles of the closed loop transfer function that can lie in the RHP of the s -plane is
- A) none B) one C) two D) three
3. A three phase transmission line has a reactance of 13 ohms/phase. If $|V_S| = |V_R| = 33$ kV, the maximum power transmitted per phase would be
- A) 40.2 MW B) 27.9 MW C) 38.1 MW D) 58.3 MW
4. A 3 kVA, 200 V/100 V two-winding transformer is used as a 300V/100V autotransformer. Its rating would be
- A) 3 kVA B) 4.5 kVA C) 6 kVA D) 1.0 kVA
5. The voltage gain of the operational amplifier circuit shown (given open loop gain of 1000) is
- A) Zero
 B) 1000/1001
 C) 1001/1000 D) 1000 E) 1



GROUP 2 ; Conventional Questions

1. Determine the reading on the wattmeter connected in the circuit shown. Assume ideal elements.



2. A salient pole machine having direct and quadrature axis reactances of 1.8 p.u and 1.0 p.u, respectively is connected to an infinite bus of voltage 1.0 p.u. The output power and lagging reactive power of the machine are 0.6 p.u. and 0.4 p.u. respectively. Determine the excitation voltage E_f (magnitude and phase angle with respect to infinite bus).
3. A 59 MVA, 11 kV star connected alternator has positive, negative and zero sequence reactances of 0.3, 0.25 and 0.1 ohm respectively. The star point of the alternator is

earthed through a 1 ohm resistor. A double line to earth fault occurs at the terminals of the machine. Determine the fault current.

(L) Mechanical Engineering (ME)

PART A

Put a tick \surd mark in appropriate places.

Choose the correct answer out of the four alternatives given under each question and put a tick (\surd) mark in the appropriate place A,B,C or D. Each question carries one mark.

1. In Fourier law of conduction heat transfer the heat flux is proportional to
 - a. temperature difference.
 - b. fourth power of the higher temperature.
 - c. gradient of the temperature.
 - d. square root of the temperature difference.

2. Steel springs are heat treated to
 - a. increase the ultimate strength.
 - b. increase their modulus of elasticity.
 - c. raise their yield point.
 - d. reduce percentage elongation.

3. The number of instantaneous centres of rotation in a mechanism is equal to
 - a. the number of links in the mechanism.
 - b. the number of joints in the mechanism.
 - c. the number of combinations of two links that can be formed of its links.
 - d. the number of combinations of two joints that can be

4. The main advantage of using worm gears is
 - a. low power loss
 - b. high velocity ratio
 - c. ease of manufacture
 - d. minimum cost

5. The maximum peripheral speed of a grinding wheel is limited by
 - a. the work material
 - b. the diameter of the wheel
 - c. the drive limitations
 - d. the kind of bond used in the wheel

6. The moment of momentum of water in a hydraulic turbine reduces by 8000 N-m. When the turbine rotates at 600 r.p.m. the power generated is equal to
 - (a) 1000 kW
 - (b) 800 kW
 - (c) 503 kW
 - (d) 615 kW

7. The enthalpy drop in a steam turbine nozzle is 80 kJ/kg of steam. The nozzle efficiency is 0.9. The velocity of steam at the exit of nozzle (accelerating from rest) is
 - (a) 439 m/sec
 - (b) 379 m/sec
 - (c) 519 m/sec
 - (d) 269 m/sec

8. The work required for compression of an ideal gas between two given pressures in a reciprocating compressor is minimum when the compression process is
 - (a) isentropic
 - (b) polytropic

- (c) isothermal
(d) adiabatic

PART B

Note: Marks for each question are indicated on the right margin.

1. Two flat pulleys 20 cms dia. and 120 cms dia. respectively are mounted on two parallel shafts 3 m apart and are connected by an open belt. The large pulley rotates at 180 rpm. The belt weighs 1 kg per meter run. Coefficient of friction between belt and pulley is 0.25. The tension on tight side of the belt is 140 kg. Determine the tension on the slack side of the belt. 4

2. In an orthogonal machining test with a tool of rake angle 10 degrees and clearance angle 6 degrees, a thickness of cut of 1 mm and a width of cut of 5 mm, a chip of 5 mm thickness was produced. Calculate the average orientation along which the material yields (shear plane angle with respect to direction of cut). 3

3. a) An impulse turbine stage has a mean blade velocity of 100 m/s and a nozzle angle of 25 degrees. The velocity of steam leaving the nozzle is 300 m/s. The absolute velocity of steam leaving the blades is in the axial direction. Calculate the mass flow of steam to produce 100 kW of power. 3

3. (b) Calculate the heat transferred to the surroundings from a surface of 5 m² area of emissivity 0.6 if the temperature of the surface is — 400°K and that of the surroundings is 27°C.
(Take $\sigma = 4.9 \times 10^{-8}$ kcal/h m² °K⁴) 2

4. (a) It is required to cool and dehumidify air from 32°C and 80% relative humidity to a temperature of 22°C and 50% relative humidity. Saturation pressures for

water at 32°C and 22°C are 4.75×10^{-2} bar and 2.64×10^{-2} bar respectively. The atmospheric pressure is 1.0132 bar. Determine the amount of moisture to be removed per kg of dry air. 2

4. (b) From a test on a 6 cylinder four stroke diesel engine the indicated mean effective pressure was found to be 3.8 kg/cm^2 . The speed of the engine was 350 rpm. The bore and stroke were 34 cms and 38 cms respectively. Calculate the indicated horse power. 2

(M) Metallurgical Engineering (MT)

I. Mark the following statements True (T) or False (F).

1. The direction $[1\bar{1}0]$ is contained in the plane (111).
2. Martensite in steels has a smaller volume than the parent austenite.
3. For diffusion to take place, the existence of a concentration gradient is essential.
4. A mineral is a combination of ores.
5. The finer the grain size of a steel, the larger the ideal critical diameter.

II. Mark the correct answer with a tick (\checkmark) mark.

1. The major load and indenter used for Rockwell B scale is
 - (a) 100 kg, $\frac{1}{16}$ " ball
 - (b) 150 kg, $\frac{1}{16}$ " ball
 - (c) 100 kg, diamond pyramid.
 - (d) 60 kg, $\frac{1}{8}$ " ball.

2. Barrelling in a compression specimen is due to
- end restraint
 - misalignment
 - anisotropy in material
 - porosity in material
3. Spherical metal powders are usually produced by
- electrolytic process
 - atomization
 - reduction
 - milling

III. Answer the following numerical problems.

a. X-rays with a wavelength of 0.58 \AA are used for calculating the spacing of (200) planes in nickel, the reflection angle for which is 9.5° . What is the size of the unit cell.

b. The vapour pressure in millimeters of mercury of solid ammonia is given by

$$\ln P = 23.03 - \frac{3754}{T}$$

Find ΔH°

c. Severely cold worked copper has a stored energy of 10^6 J/m^3 . The grain boundary energy γ_{gb} for copper is 0.5 J/m^2 . Calculate the critical size for a nucleus of recrystallised copper.

- IV. a. Explain how dislocation multiplication occurs in crystals.
- b. Explain why mild steel exhibits a sharp yield point whereas copper does not.
- c. Explain why back reflection x-ray cameras are preferred for precision work.

- V. Sketch the —T-T-T diagram for a plain carbon eutectoid steel. What is the modification in the diagram with addition of a small amount of molybdenum.

(N) Mining Engineering (MI)

1. The number of blows/min of modern compressed air rock drills is
 - a. 1000 to 1500
 - b. 1600 to 2200
 - c. 2300 to 2800

2. What are the flammable limits of the following gases?
 - a. Methane
 - b. Carbon monoxide
 - c. Hydrogen

Answer: a. Lower 5% Upper 14%
 b. Lower 13% Upper 72%
 c. Lower 4% Upper 72%

(O) Naval Architecture (NA)

1. During an inclining experiment, the ship is heeled to an angle:
 - a. Less than 5 degrees
 - b. 10 degrees
 - c. 12 degrees

2. An oceangoing cargo ship is required to have an initial metacentric height of:
 - a. 0.05 m
 - b. 0.15 m
 - c. 0.30 m

3. What are :
- margin line
 - permeability, and
 - floodable length?
4. One gross register ton is equal to
- 1 cubic metre
 - 100 cubic feet
 - 1 British ton
 - 1 metric ton
5. A well-designed bulb reduces the resistance of ship in all loading conditions.

Yes/No

6. Define cavitation number.
7. Rolling will be maximum for
- head seas
 - bow seas
 - beam seas
 - quartering seas
 - following seas
8. Which of the following hydrodynamic derivatives of a normal oceangoing ship are always negative
- $Y_v, N_v, N_r, Y_\delta, N_\delta$
9. What will happen to a ship moving at a high speed in a narrow canal when it goes off the canal centerline ?
10. What is the material used for sacrificial anodes ?
11. In the steel stockyard of a shipyard, we would find

- (a) scrap steel
 - (b) steel plates and sections
 - (c) machinery made of steel
12. What is the difference between a wind lass and a capstan?
13. The main parameter considered for assigning freeboard is :
- (a) length
 - (b) displacement
 - (c) depth
14. A rectangular pontoon 60 m long and 10 m wide is divided longitudinally into four equal holds. It is floating on an even keel at a draught of 1.5 m when the forwardmost hold is damaged and becomes open to the sea. Calculate the resulting draughts forward and aft.
15. A beam of uniform cross-section has a uniform load distribution of 500 kN per m. The beam is built in at one end and simply supported at the other. Find, using the Area-moment method, the bending moment at the built-in end.

(P) Production and Industrial Engineering (PI)

Objective questions :

1. In deep drawing, wrinkling occurs mostly due to
- (a) insufficient pressure on blank holder
 - (b) excessive reduction
 - (c) insufficient clearance between punch and die
 - (d) excessive clearance between punch and die
 - (e) insufficient lubrication

Answer : a, b, c, d, e

2. The smallest diameter holes can be made by
- (a) ultrasonic machining

- (b) electrodischarge machining
- (c) electrochemical machining
- (d) lasers
- (e) all of the above.

Answer : a, b, c, d, e

3. Pick the unrelated term out of the following.

- (a) line jobbing production
- (b) functional batch production
- (c) line mass production
- (d) automated mass production
- (e) functional jobbing production

Answer : a, b, c, d, e

4. The objective in the Johnson's n jobs, 2 machines algorithm is to minimise

- (a) the total elapsed time.
- (b) the number of tardy jobs
- (c) average job lateness
- (d) the maximum lateness of any job in the shop
- (e) the average completion time for the entire set of jobs.

Answer : a, b, c, d, e

Thought type questions :

1. Given a tangential cutting force 200 kg, a cutting speed of 30m/min, feed of 1 mm rev. and a work piece diameter of 10 cm, find the power required at the tool bit and time of turning 75mm length.
2. Describe the operation of the inert gas tungsten arc welding process. In what respects is it superior to conventional arc welding?
3. Three light bulbs were tested simultaneously starting at time zero. First failure among the three occurred at 120 hrs and the second bulb to fail out of the three failed at 180 hrs.

hrs. The third bulb had not failed at 190 hrs. Assuming negative exponential failure time density for each bulb and independence of bulb life times find the maximum likelihood estimate mean lifetime of a bulb.

(Q) Textile Engineering/Fibre Science and Technology (TF)

PART A : Textile Engineering

1. a. A system spins 0.5 tex fibre to 65.5 tex with CV of 11.1. What is the index of irregularity of the yarn. What would be the CV% of a 41 tex yarn spun to the same index of irregularity?
- b. Derive the crimp balance equation for a relaxed fabric. Find the relaxed state parameters of a cotton fabric which has loom state parameters as follows :

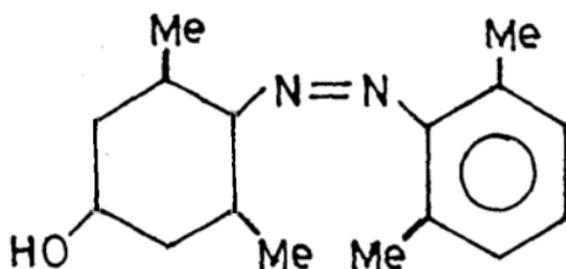
	<i>Warp</i>	<i>Weft</i>
Yarn tex	20	40
Crimp %	7.5	20
Threads/cm	25	20

2. a. What is 'Blending Delay Time'. How has this factor influenced the design of modern blowroom lines?
- b. What are the conditions for forward and backward slip in a drawframe?
- c. What is the influence of cylinder speed on hook formation in a card?
3. a. Derive expressions for actual displacement, velocity and acceleration of the shuttle during picking using a linear picking cam.
- b. In 25 cm distance in the shuttle box, shuttle has to be accelerated from rest to 15 cm/sec velocity. Find the maximum value of acceleration for a linear picking cam if the alacrity of the picking system is 100 s^{-1} .

4. a. Define primary creep, secondary creep, degree of elasticity and degree of resilience.
- b. After saponifying some regenerated cellulose acetate fibre back to cellulose (still in the form of fibre) it was found that the regenerated cellulose fibre was not as strong as the original acetate fibre. It was also found, however, that the average DPs and the shapes of the DP distribution curves were the same for the two fibres. Would you have expected this result? Explain. If not, what could be the reason for this result.

PART B : Fibre Science and Technology

- Write the structural features of acid, basic, mordant and reactive dyes.
- Give reasons for the following :
 - Cis-form of the following monoazo dye is colorless, which changes to colored form on standing :



- Coupling of diazonium compounds with phenols occurs in alkaline solutions whereas, with primary aromatic amine it occurs in acidic conditions.
 - Cotton after crosslinking is invariably weakend, whereas rayon gains in strength due to crosslinking.
- (a) Point out the differences between ionic and radical polymerization.

- (b) Discuss the mechanism of sulphonation and nitration of aromatic hydrocarbons.
4. (a) Which of the following thickeners is suitable for reactive printing :
- i) starch ii) guar gum
 - iii) sodium alginate iv) carboxymethyl cellulose.
- (b) What is the basic difference in resist and discharge style of printing.
5. What is the difference between
- i) plastics, rubbers and fibres
 - ii) thermoplastics and thermosets
 - iii) bulk and solution polymerization
6. Give a chemical test to distinguish between :
- i) PVA and cotton
 - ii) Wool and silk
 - iii) PET and polyethylene
 - iv) Acrylic and nylon

4.2.2 Science Stream

(A) Agricultural Sciences (AS)

Group-A Applied Botany

1. Which of the following organelles do NOT contain any DNA ?
- (a) chloroplast
 - (b) mitochondria
 - (c) nucleolus
 - (d) lysosome
2. Give the correct technical term (on the dotted line) for the following :

- (a) The nutritive tissue used by the embryo of angiosperms _____
3. Fill up the blank :
 (a) A polyploid in which all chromosomes come from the same species is known as _____
4. Draw a labelled diagram only of each of the following :
 (a) Monocot vascular bundle
5. Mention two cases of each of the following :
 (a) Symbiosis

GROUP B : Farm Management Technology

- I. Strike out the portion(s) not applicable leaving only the correct one :
- On a clear day rate of photosynthesis is maximum at 7.00 A.M. / 12.30 P.M. / 4.00 P.M.
- II. Fill up the blanks with appropriate word(s) :
- A chemical substance commonly used to induce rooting of cuttings
- III. Answer 'yes' or 'No'
- Production is maximised by making marginal product more than zero
- IV. Match the items in column II against those in column I by writing the appropriate alphabet in the bracketed space

Column I

Column II

- | | |
|----------------------------------|----------------------------|
| 4. Luxury consumption () | A. Photo insensitive crops |
| 5. High water-use-efficiency () | B. High nutrient levels |

6. Grown in all the seasons () C. Scheduling of irrigation

V. Answer the following without any comments or lengthy statements.

7. Principles of irrigation (i)
(ii)
(iii)
(iv)

VI. Differentiate between the following terms. Restrict your answer to 3 lines only.

8. Dry farming and dry land farming

9.

10.

11.

12.

13.

VII. Define the following terms.

14.

15.

16.

17.

18.

19.

VIII. Numerical on scheduling of irrigation or soil fertilization

20. Prepare a schedule of fertilization for a crop providing informations on

(i) level of fertilization

(ii) Quantity of each fertilizer

(iii) Time and method of application.

Necessary assumptions to be made.

IX. Numerical on plant protection chemical.

21. Calculate the cost of application of a given insecticide/fungicide/herbicide in given area on the basis of the following.

(i) cost of labour, Rs./day

(ii) cost of insecticide/fungicide/herbicide, Rs./litre or kg

(iii) Rate application : kg or litre of a.i./ha.

Assume necessary data.

Group-C Soil Technology

I Fill up the blank with suitable word or words :

1) Humid-region soils dominated by silicate clays and humus are generally _____ in reaction.

II For each of the following questions, several answers are given, of which only ONE is correct. Give the correct answer in the bracket provided.

2) Symbiotic nitrogen fixation in legume requires the presence of

(a) fungi

(b) bacteria

(c) nematodes

(d) actinomycetes

(

III. Match the items in Column-II against those in Column-I by writing the appropriate alphabet in the bracketed space.

Column-I

Column-II

- | | | |
|---------------|------------|---------------------------|
| 3) Overliming | () | A. Organic soil |
| 4) Peat | () | B. Layer lattice mineral |
| 5) Kaolinite | () | C. Phosphate availability |

IV State whether the following statements are "TRUE" or "FALSE".

- 6) Thermal conductivity of a compacted soil is more than that of a loose soil.

V. Answer the following without comments or statements.

7) Methods of identification of clay minerals are

- a)
- b)
- c)
- d)

VI. Differentiate between the following pairs of terms. Restrict the answer to TWO LINES only.

- 8) pH and pF

VII. Answer in ONE sentence the significance of the following :

- 9) Inflection point in clay titration.

(B) Chemistry (CY)

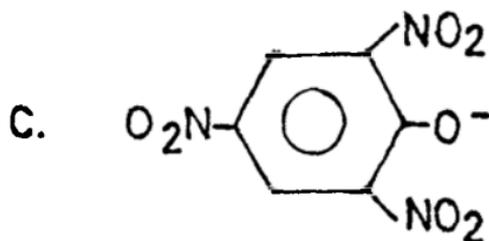
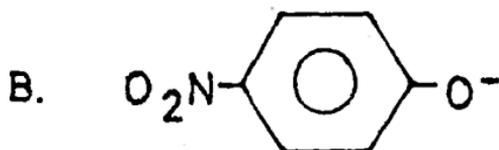
Note: The question paper consists of two parts. PART A (objective) wherein all questions have to be answered and PART B, out of which any six questions have to be answered.

Data : $R_2 \text{ cal} = \text{deg}^{-1} \text{ mole}^{-1} = 0.082 \text{ lit. atm. deg}^{-1} \text{ mole}^{-1} = 8.314 \text{ J deg}^{-1} \text{ mole}^{-1}$. Electron mass = $5.486 \times 10^{-4} \text{ amu}$.
 Electron charge = $4.8 \times 10^{-10} \text{ csu}$. Atomic weight: K = 39.1.

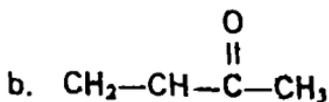
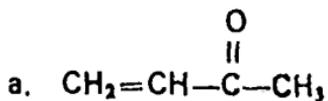
PART A

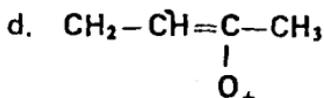
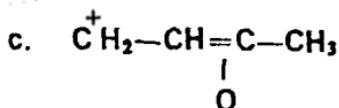
1. Indicate the correct answer/choice by writing the appropriate letter A, B, C or D against each question.

i. Which of the following anions is the best leaving group in β elimination reactions?



ii. Which of the following is not a resonance structure of



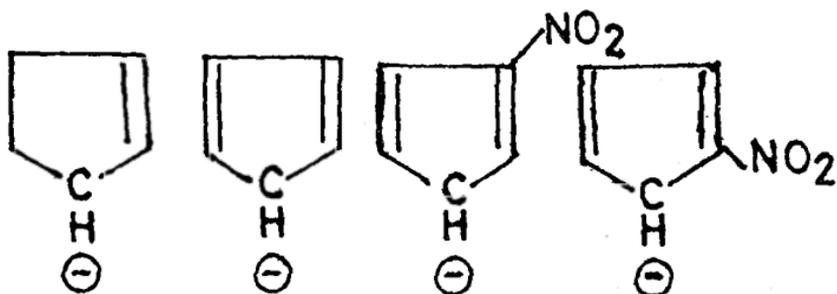


- (iii) An isotope which has too high neutron/proton ratio can gain stability by :
- β -emission
 - γ -emission
 - H-emission
 - electron capture
- iv. The clausius-clapeyron equation is very useful in the field of
- quantum chemistry
 - molecular orbital theory
 - thermodynamics
 - kinetic theory of gases
- v. According to the Maxwell-Boltzman distribution law of gas, the average translational kinetic energy is
- $kT/2$ per molecule
 - kT per molecule
 - $3 kT/2$ per molecule
 - RT per molecule

.. a. Arrange the following in increasing order of the property indicated

(i) Cl, Br, I, F (ionization energy)

ii)



(Stability of carbon ion)

iii) copper, graphite, sodium chloride, nickel arsenide
(electrical conduction)

iv) CH_4 , C_2H_4 , C_2H_2 , C_2H_6 (S-Character)

v) HCl, HF, HBr, HI (acid strength)

vi) aniline, para nitro aniline, para chloro aniline
(basic character)

3. Match the following metals with the analytical reagents by writing letter A,B,C, or D in the answer column

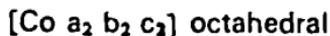
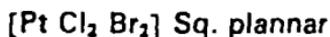
Metal	Analytical Reagent	Answer
(i) Nickel	(a) 1-nitroso-2-naphthol	
(ii) Tungsten	(b) Dithizone	
(iii) Lead	(c) Dithol	
(iv) Uranium	(d) Dimethyl glyoxime	

4. Fill up the blanks :

- i. Boyle temperature of a gas is the temperature at which the gas _____ .
- ii. In case of salts for which the hydration energy is greater than the lattice energy, the solubility _____ with temperature.
- iii. Solubility product of a sparingly soluble salt of type MX_3 can be expressed in terms of solubility S , as _____
- iv. Between Tl^{1+} and Tl^{3+} the more stable ion is _____

PART B

5. a. Draw structures and tell which, if any, can exist as optical isomers
- 3



- b. How many isomers are there for the following (draw the possible structures) :
- 3



6. a. Indicate the geometry and type of hybridisation involved in
- 2



- b. What is lanthanide contraction? Why are properties of the lanthanides so similar?
- 2

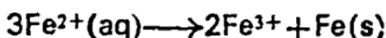
- c. Name *Four* elements the compounds of which should not be heated in platinum crucibles under reducing conditions to prevent attack on platinum 2

7. a. Given $\text{Fe}^{3+}(\text{aq}) + e = \text{Fe}^{2+}(\text{aq}) \quad E^\circ = +0.77\text{V}$



Calculate

- i. E° for the disproportionation reaction



- ii. K , the equilibrium constant for reaction in (i) at 25°C

- iii. E for the reaction $3\text{Fe}^{2+}(\text{aq}, 0.01\text{M}) \longrightarrow 2\text{Fe}^{3+}(\text{aq}, 0.010\text{M}) + \text{Fe}(\text{s})$ at 25°C . 3

- b. Calculate ΔG at 25°C if one mole of N_2O_4 at 10.0 atm is changed into 2 moles of NO_2 at 1 atm. ΔG° for the reaction $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$

at 25°C is 1160 cal. 3

8. a. Explain why : $2 \times 1 = 2$

- i. Benzoic acid reacts with methanol to give methyl benzoate whereas 2, 6-dimethyl benzoic acid fails to do so under identical conditions.

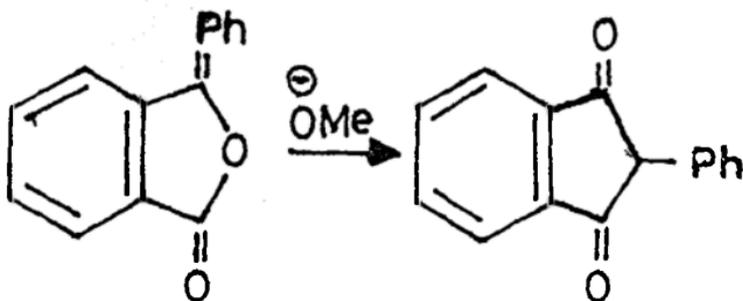
- ii. Iodine is used as a catalyst for aromatic brominations with bromine

b.

1 × 4 = 4

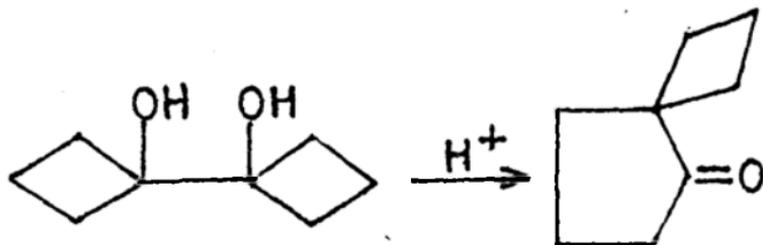
i. How will you synthesize meta nitrophenol from phenol. Give reagents and reactions.

ii. Give the mechanism for the following transformation.



iii. An aromatic dibromo compound A, with molecular formula $\text{C}_7\text{H}_6\text{Br}_2$ was found to react readily with aqueous sodium hydroxide to give $\text{C}_7\text{H}_7\text{BrO}$ and only one bromine atom was replaced. The product did not dissolve in aqueous NaOH. Give a plausible structure to A.

iv. Rationalize the following rearrangement reaction.



(C) Earth Sciences (ES)**Instructions :**

1. For Part I choose the correct answer for the multiple choice questions by putting a tick against the appropriate letter A, B, C or D.
2. For Part II give precise answers in the space provided or fill up the blanks, wherever necessary,

PART I**Multiple choice questions**

1. The depositional environment of the siwalik sediments was essentially
 - A. glacial
 - B. deltaic
 - C. fluvial
 - D. deep marine

2. The optical property of calcite is
 - A. low birefringence
 - B. marked pleochroism
 - C. twinkling effect
 - D. ϵ higher than that of Canada Balsam

3. The Tatrot stage belongs to the
 - A. middle Gondwanas
 - B. upper Siwaliks
 - C. lower Siwaliks
 - D. basal Aravallis

PART II

Short answer questions.

1. Isostasy implies that the surface topographic variations are _____ in the subsurface.
2. Mention the metamorphic facies to which each of the following mineral assemblages belong
 - a. hypersthene - diopside - labradorite- magnetite-ilmenite
 - b. albite-epidote-hornblende-chlorite-quartz
3. Indicate a typical time-drawdown curve for a well operating in an aquifer very close to the aquifer boundary.
4. How are longitudinal wave velocity, transverse wave velocity and Poisson's ratio related in the case of earth materials?
5. How can a 'boudinage' structure develop in a brittle rock which (is surrounded by a more ductile material)?

(D) Life Sciences (LS)

1. Tick the right answers.
 - a. The first living organism appeared on the earth at about
 - i. 3 billion years ago
 - ii. 3 million years ago
 - iii. 30,000 years ago
2. Give a diagrammatic representation of the cell cycle in the space provided below :
3. Fill up the blank :
 - a. Lithophytes are a group of plants which are adapted to _____ habitat.
4. Differentiate between the following pairs of terms in three lines only :

a. Transformation and transduction.

5. Define the following terms in the space provided below :

a. Community

(E) Materials Science (MS)

1. For an FCC lattice having identical atoms at all lattice sites the intensity of x-ray diffraction lines will be zero for every reflection for which $(h+k+l)$ is an odd number.

a. TRUE

b. FALSE

2. In the diamond structure the highest surface density of atom occurs in

a. (111) plane

b. (110) plane

c. (100) plane

3. Which of the following materials possesses high ionic conductivity near room temperature ?

a. sodium chloride

b. silicon iodide

c. mercuric bromide

4. Which of the following takes place during the annealing of a cold worked metal

a. deformation of grains

b. increase in yield strength

c. increase in ductility

5. Making use of Bragg's law determine the angles at which the (111) and (200) planes of nickel crystal will diffract x-rays of wave length $\lambda = 1.54 \text{ \AA}$. Ni is FCC with $a = 3.52 \text{ \AA}$.

6. A $\frac{1}{2}$ inch thick plate is decreased in thickness according to the following schedule : 0.5, 0.25 in. Calculate the true strain and engineering strain in each step.
7. Find all the slip systems that have the following slip planes (i) $(1\bar{1}1)$ in an FCC crystal and (ii) $(1\bar{1}0)$ in a BCC crystal.
8. Calculate the kinetic energy and the de Broglie wavelength of an electron that falls through a potential of (a) 500 volts (b) 5000 volts.
9. The resistivity of silver at room temperature is 1.6×10^{-8} ohm m. Calculate the collision time for electron scattering.
10. Indium phosphide (InP) has an energy gap of 1.29 eV. The electron and hole mobilities for this semiconducting compound are 0.46 and $0.015 \text{ m}^2 \text{ v}^{-1} \text{ s}^{-1}$ respectively at 300K. Calculate its conductivity

(F) Mathematics (MA)

PART A

Encircle the correct answer in Questions 1—5.

Fill in the blanks in Questions 6—12.

1. In the region $|z| \leq 1$, the series

$$\sum_{n=1}^{\infty} \frac{z^n \sin n_j z}{n(n+1)}$$

- (i) Converges absolutely and uniformly .
- (ii) Converges absolutely but not uniformly.
- (iii) Converges uniformly but not absolutely.
- (iv) none of these.

2. Let $L(\mathbb{R}^n, \mathbb{R}^m)$ denote the linear space of all linear transformations from \mathbb{R}^n to \mathbb{R}^m . Then the dimension of $L(\mathbb{R}^n, \mathbb{R}^m)$ is

- (i) m (ii) n (iii) mn (iv) $m+n$.

3. The series $\sum_{n=2}^{\infty} \frac{\sin nx}{\log n}$

(i) Converges for $|x| \leq \pi$;

(ii) does not converge for some real x .

(iii) Converges for all real x , but is not the Fourier series of any continuous function.

(vi) none of these.

4. Let $f(x) = \begin{cases} x-1 & \text{if } x \text{ is rational,} \\ 0 & \text{if } x \text{ is irrational.} \end{cases}$

Then the set of points where f is continuous is $\{ - : - - \}$.

5. If the radius of convergence of the series $\sum_{n=1}^{\infty} a_n Z^n$ is R

then the radius of convergence of the series $\sum_{n=1}^{\infty} \frac{a_n}{n} Z^{3n}$ is ..

6. The residue of $\frac{1}{Z-1} \frac{e}{Z-1}$ at $Z = 1$ is

Part B

1. (a) Let $\sum a_k$ be a divergent series of positive terms and

let $s_n = \sum_1^n a_k$. Show that

(i) $\sum \frac{a_k}{s_k}$ is divergent

(ii) $\sum \frac{a_k}{s_k}$ is convergent.

(b) Discuss the convergence of the integral

$$\int_2^{\infty} \frac{\cos x}{\log x} dx .$$

2. (a) Give an example of a sequence of Riemann integrable functions which converges to a function which is not Riemann integrable but Lebesgue integrable.

(b) Let $g(x) = \begin{cases} x+5, & x < -1 \\ 2, & -1 \leq x < 0 \\ x^2, & 0 \leq x \end{cases}$

Is g Lebesgue measurable?

3. (a) Find an analytic function $w=f(z)$ which maps the region $0 \leq y \leq x-1$ onto the unit disc $|w| \leq 1$.

(b) Use contour integration to evaluate

$$\int_0^{\infty} e^{-x^2} \cos 2sx dx.$$

4. (a) Establish the following results:

(i) For each $n \geq 1$, the Legendre polynomial P_n is a polynomial of degree exactly n .

(ii) The P_n 's form an orthogonal set.

(b) Establish the recursion formula

$$J_p'(x) = \frac{1}{2} \{J_{p-1}(x) - J_{p+1}(x)\}.$$

5. (a) Let x be normally distributed with mean 10 and variance 4. Find the probability that x lies between 11 and 14.

- (b) An inspector checks each carton at the end of a production line. If the article is satisfactory, it is then stacked in a rack made to contain n cartons. If the probability that a carton is faulty is p , where p is constant and the faulty items are randomly distributed throughout the production run, find the n th carton completes the rack.

OR

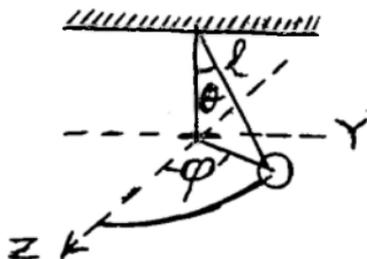
- (a) The spherical pendulum consists of a mass on a wire of length l , free to move in polar angle θ and azimuth angle ϕ .

- (i) Set up the Lagrangian for this physical system.
 (ii) Develop the Lagrangian equations of motion.

- (b) Three forces act along the straight lines

$$x=0, y=z+a; \quad y=0, z=x+a; \quad z=0, x=y+a.$$

Show that they cannot reduce to a single couple.



(G) Physics (PH)

1. Indicate the correct answer by putting a tick mark (\checkmark) in the appropriate place :
- a. An accelerated charge emits radiation in the direction of the acceleration.
 TRUE FALSE
- b. At any temperature a gas can be liquefied by the application of sufficiently high pressure.
 TRUE FALSE

2. Fill in the blanks :

- a. An n-type silicon sample can be made p-type by doping with.....
- b. The magnetic field due to a dipole at a great distance r is..... proportional to..... of r .

3. Indicate the correct answers by putting a tick mark in the appropriate box. Note that there may be more than one correct answer for a question.

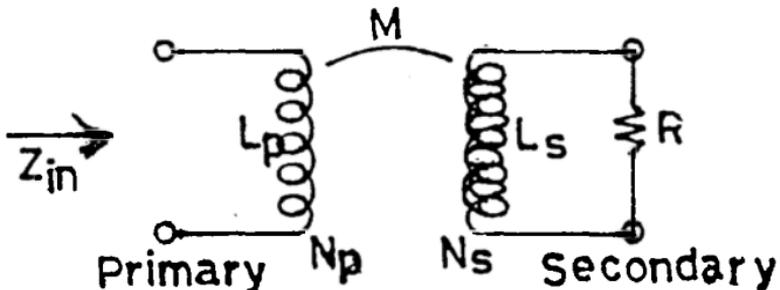
- a. If L_x , L_y , L_z and L^2 are respectively the x, y, z components and the square of the total orbital angular momentum operators of a system, one can simultaneously measure

- i) L_x , L_z and L^2
- ii) L_x and L^2
- iii) L_x and L_y
- iv) All of them.

- b. A nucleus ${}_A M^Z$ decays to ${}_A M^{Z-1}$ by positron emission. The 'Q' value is given by the mass differences

- i) ${}_A M^Z - {}_A M^{Z-1}$
- ii) ${}_A M^Z - {}_A M^{Z-1} - 2m_e$
- iii) ${}_A M^Z - {}_A M^{Z-1} + 2m_e$
- iv) ${}_A M^Z - {}_A M^{Z-1} - mc$

4. For a transformer connected as shown below



the input impedance (Z_{in}) looking into the primary terminals is

$$Z_{in} = j \omega L_P - \frac{(j \omega M)^2}{R + j \omega L_S},$$

where L_P , L_S and M are respectively the primary self inductance, the secondary self inductance and the mutual inductance. Under what conditions this expression reduces to

$$Z_{in} \approx R \left(\frac{N_P}{N_S} \right)^2$$

where N_P and N_S are the number of turns of the primary and the secondary respectively.

5. Four small balls of mass m each are at one end of a wagon of mass M and length L . The balls are thrown with horizontal velocity v one after the other such that they strike the opposite wall and get stuck. How much the wagon would have moved after all the balls have reached the other end ?
6. Sodium emits the D_1 line 5896 \AA due to a transition ${}^2P_{\frac{1}{2}} \rightarrow {}^2S_{\frac{1}{2}}$. What is the magnetic field at which the lower Zeeman level of the upper state coincides with the upper Zeeman level of the lower state ?

(H) Regional Planning (RP)

Multiple choice :

1. Match the books against the authors —

(a) Asian Drama	Jagdish Bhagwate & P. Desai
(b) Quiet crisis in India	John F. Lewis
(c) India Planning for Industrialization	G. Myrdal

2. Answer in Yes/No

- (a) Even for a "giffen good" the demand curve has the negative slope.
- (b) Least square method is always the best linear unbiased estimator of all linear estimators under all conditions.
- (c) pH value of acidic soil is always less than 7.

Descriptive Questions:

- 3. Analyse the regional imbalances in levels of development in India.
- 4. Comment on the principles and applications of multiple correlation and partial correlation analysis.
- 5. Write short notes on :
 - a. detribalization
 - b. leadership development and factionalism
 - c. polar front theory

Model Answers :

- 1.
 - a. G. Myrdal
 - b. John P. Lewis
 - c. Jagdish Bhagwati & P. Desai
- 2.
 - a. No
 - b. No
 - c. Yes

5. CENTRES OF EXAMINATION

The GATE 1983 will be held at the following towns/cities. The venues of examination will be given in the Admit cards to be sent to the candidates in due course.

Agarthala, Agra, Ahmedabad, Aligarh, Allahabad, Amravathi, Ananathapur, Annamalainagar, Aurangabad.

Bangalore, Baroda, Bellary, Bhagalpur, Bhiwani, Bhopal, Bidar, Bijapur, Bilaspur, Bombay, Burla.

Calcutta, Calicut, Chandigarh, Chitradurga, Cochin, Coimbatore.

Delhi, Dhanbad, Dharwar, Durgapur.

Gorakhpur, Gwalior, Gulbarga.

Hassan, Hyderabad.

Indore.

Jabalpur, Jaipur, Jalpaiguri, Jalukbari, Jamshedpur, Jodhpur, Jorhat.

Kakinada, Kanpur, Karad, Karaikudi, Kharagpur, Kurukshetra.

Lucknow, Ludhiana.

Madras, Madurai, Manipal, Morvi, Muzaffarpur,
Mysore.

Nadiad, Nagpur, New Delhi.

Palghat, Patiala, Patna, Pilani, Ponda, Pune.

Quilon.

Raichur, Raipur, Ranchi, Rewa, Roorkee, Roorkeela.

Salem, Sangli, Shimoga, Silchar, Srinagar, Surat.

Tirupathi, Trichur, Trichy, Trivandrum.

Udaipur, Ujjain.

Vallabhvidya Nagar, Varanasi, Vidisha, Vijayawada.

Waltair, Warangal.

6. SPECIAL INSTRUCTION

It may be noted that admissions to all Master's Degree Courses in Engineering and Technology at the Indian Institutes of Technology (at Bombay, Delhi, Kanpur, Kharagpur and Madras) and the Indian Institute of Science (Bangalore), either by Course work (see Section 2 of the Brochure) or by Research, regardless of the names by which they are known will be restricted only to those who qualify through the GATE. This is likely to be the practice in other Engineering Institutions also.