THE BHAWANIPUR EDUCATION SOCIETY COLLEGE

A MINORITY RUN COLLEGE. AFFILIATED TO UNIVERSITY OF CALCUTTA
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Selection Syllabus for B.Sc. Part III Honours Papers

Physics (H)

Paper V

1. Central force problem

Motion under central force; Nature of orbits in an attractive inverse square field; Kepler's laws of planetary motion. Rutherford scattering as an example of repulsive potential.

2. *Mechanics of Ideal Fluids*

Streamlines and flowlines; Equation of continuity; Euler's equation of motion; Streamline motion - Bernoulli's equation and its applications. Definition of Newtonian and non-Newtonian fluids.

3. Lagrangian and Hamiltonian formulation of Classical Mechanics

Generalised coordinates, constraints and degrees of freedom; D'Alembart's principle; Lagrange's equation for conservative systems (from D'Alembert's principle; variational principle not required) and its application to simple cases; Generalised momentum; Idea of cyclic coordinates, its relation with conservation principles; Definition of Hamiltonian, Hamilton's equation (derivation by Legendre transformation) and its application to simple cases.

SPECIAL THEORY OF RELATIVITY (25 Marks) LECTURES

Galilean transformation and invariance of Newton's laws of motion, non-invariance of Maxwell's equations. Michelson-Morley experiment and explanation of the null result.

Concept of inertial frame. Postulates of special theory; simultaneity; Lorentz transformation along one of the axes – length contraction, time dilatation and velocity addition theorem, Fizeau's experiment. Four vectors. Relativistic dynamics : variation of mass with velocity; energy momentum relationship.

Covariant and contravariant vectors. Contraction. Covariant, contravariant, and mixed tensors of rank-2, transformation properties. The metric tensor (flat space-time only). Raising and lowering of indices with metric tensors. (Consistent use of any one convention --- diag(-1,1,1,1) or diag(1,-1,-1,-1).) Example of common four-vectors: position, momentum, derivative, current density, four-velocity.

Concept of space-time: Euclidean and Minkowski. Invariant intervals in 1+1 and 3+1 dimensions (use Minkowski space-time). Space like, time-like and light like four vectors. Light cone. Causality and simultaneity in different frames.

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Unit-II

QUANTUM MECHANICS II

1. Time dependent and time independent Schrodinger equation

Eigenstates, normalization and orthonormality.

2. Simple applications of Quantum Mechanics

One dimensional potential well and barrier, boundary conditions, bound and unbound states. Reflection and transmission coefficients for a rectangular barrier in one dimension – explanation of alpha decay. Free particle in one dimensional box, box normalization, momentum eigenfunctions of a free particle. Linear harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state, parity of wave function.

3. Schrodinger equation in spherical polar coordinates

Angular momentum operators and their commutation relations; eigenvalues and eigenfunctions of L2 and Lz; theorem of addition of angular momenta [statement with examples]. The hydrogen atom problem – stationary state wavefunctions as simultaneous eigenfunctions of H, L2, and Lz; radial Schrodinger equation and energy eigenvalues [Laguerre polynomial solutions to be assumed]; degeneracy of the energy eigenvalues.

ATOMIC PHYSICS (25 Marks)

1. Atomic Spectrum

Good quantum numbers, and selection rules. Stern-Gerlach experiment and spin as an intrinsic quantum number. Incompatibility of spin with classical ideas. Bohr-Sommerfeld model. Fine structure. Study of fine structure by Michelson interferometer.

2. Vector atom model

Magnetic moment of the electron, Lande g factor. Vector model – space quantization. Zeeman effect. Explanation from vector atom model.

3. Many electron model

Pauli exclusion principle, shell structure. Hund's rule, spectroscopic terms of many electron atoms in the ground state.

4. Molecular spectroscopy

Diatomic molecules – rotational and vibrational energy levels. Basic ideas about molecular spectra. Raman effect and its application to molecular spectroscopy (qualitative discussion only).

5. Laser Physics

Population inversion, Einstein's A and B coefficients; feedback of energy on a resonator; 3-level and 4-level systems.

Paper VI

Unit-I

NUCLEAR & PARTICLE PHYSICS I (25 Marks)

1.Bulk properties of nuclei

Nuclear mass, charge, size, binding energy, spin and magnetic moment. Isobars, isotopes and isotones; mass spectrometer (Bainbridge).

2. Nuclear structure

Nature of forces between nucleons, nuclear stability and nuclear binding, the liquid drop model (descriptive) and the Bethe-Weizsacker mass formula, application to stability considerations, extreme single particle shell model (qualitative discussion with emphasis on phenomenology with examples).

3. Unstable nuclei

(a) Alpha decay : alpha particle spectra – velocity and energy of alpha particles. Geiger-Nuttal law.

(b) Beta decay : nature of beta ray spectra, the neutrino, energy levels and decay schemes, positron emission and electron capture, selection rules, beta absorption and range of beta particles, Kurie plot.

(c)Gamma decay : gamma ray spectra and nuclear energy levels, isomeric states. Gamma absorption in matter – photoelectric process, Compton scattering, pair production (qualitative).

NUCLEAR & PARTICLE PHYSICS II (25 Marks)

1. Nuclear reactions

Conservation principles in nuclear reactions. Q-values and thresholds, nuclear reaction cross-sections, examples of different types of reactions and their characteristics. Bohr’s postulate of compound nuclear reaction, Ghoshal’s experiment

2. Nuclear fission and fusion

Discovery and characteristics, explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements. Chain reaction and basic principle of nuclear reactors. Nuclear fusion: energetics in terms of liquid drop model.

3. Elementary particles

(a) Four basic interactions in nature and their relative strengths, examples of different types of interactions. Quantum numbers – mass, charge, spin, isotopic spin, intrinsic parity, hypercharge. Charge conjugation. Conservation laws.

(b) Classifications of elementary particles – hadrons and leptons, baryons and mesons, elementary ideas about quark structure of hadrons – octet and decuplet families.

4. Particle Accelerator and Detector

Cyclotron – basic theory, synchrotron, GM counter

5. Nuclear Astrophysics

Primordial nucleosynthesis, energy production in stars, pp chain, CNO cycle. Production of elements (qualitative discussion)

Unit-II

SOLID STATE PHYSICS I (25 Marks)

1. Crystal Structure

Crystalline and amorphous solids, translational symmetry. Elementary ideas about crystal structure, lattice and bases, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, f.c.c. and b.c.c. lattices. Laue and Bragg equations. Determination of crystal structure with X-rays.

2. Structure of solids

Different types of bonding- ionic, covalent, metallic, van der Waals and hydrogen. Band theory of solids, Periodic potential and Bloch theorem, Kronig-Penny model, energy band structure. Band structure in conductors, direct and indirect semiconductors and insulators (qualitative discussions); free electron theory of metals, effective mass, drift current, mobility and conductivity, Wiedemann-Franz law. Hall effect in metals : Phenomenology and implication.

SOLID STATE PHYSICS II (25 Marks)

1. Dielectric properties of materials

Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization – molecular field in a dielectric; Clausius-Mosotti relation.

2. Magnetic properties of materials

Dia, para and ferro-magnetic properties of solids. Langevin's theory of diamagnetism and paramagnetism. Quantum theory of paramagnetism, Curie's law. Ferromagnetism : spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis.

3 Lattice vibrations

Elastic and atomic force constants; Dynamics of a chain of similar atoms and chain of two types of atoms; optical and acoustic modes; interaction of light with ionic crystals. Einstein's and Debye's theories of specific heats of solids.

4. Superconductivity

Introduction (Kamerlingh-Onnes experiment), effect of magnetic field, Type-I and type-II superconductors, Isotope effect. Meissner effect. Heat capacity. Energy gap. Ideas about High-Tc superconductors.

Paper VIIA

Unit-I

STATISTICAL MECHANICS (25 Marks) LECTURES

1.Microstates and macrostates

Classical description in terms of phase space and quantum description in terms of wave functions. Hypothesis of equal *a priori* probability for microstates of an isolated system in equilibrium. Interactions between two systems – thermal, mechanical and diffusive. Statistical definition of temperature, pressure, entropy and chemical potential. Partition function of a system in thermal equilibrium with a heat bath.

2. Classical statistical mechanics

Maxwell-Boltzmann distribution law. Calculation of thermodynamic quantities for ideal monoatomic gases.

3. Motivations for quantum statistics

Gibbs' paradox. Identical particle and symmetry requirement. Derivation of MB, FD and BE statistics as the most probable distributions (micro-canonical ensemble). Classical limit of quantum statistics.

4. Quantum statistical mechanics

Bose-Einstein statistics: Application to radiation – Planck's law. Rayleigh Jeans and Wien laws as limiting cases, Stefan's law. Fermi-Dirac statistics: Fermi distribution at zero and non-zero temperatures. Fermi energy and its expression in terms of particle density. Degenerate and non-degenerate Fermi gas. Electron specific heat of metals at low temperature. Saha equation for thermal ionization and its application to astrophysics.

ELECTROMAGNETIC THEORY (25 Marks)

1. Generalization of Ampere's Law

Displacement Current, Maxwell's Field Equations, Wave equation for electromagnetic (EM) field and its solution – plane wave and spherical wave solutions, transverse nature of field, relation between E and B; energy density of field, Poynting vector and Poynting's theorem, boundary conditions.

2. EM Waves in an isotropic dielectric

Wave equation, reflection and refraction at plane boundary, reflection and transmission coefficients, Fresnel's formula, change of phase on reflection, polarization on reflection and Brewster's law, total internal reflection.

3. EM waves in conducting medium

Wave equation in conducting medium, reflection and transmission at metallic surface – skin effect and skin depth, propagation of E-M waves between parallel and conducting plates – wave guides (rectangular only).

4. Dispersion

Equation of motion of an electron in a radiation field : Lorentz theory of dispersion – normal and anomalous; Sellmeier's and Cauchy's formulae, absorptive and dispersive mode, half power frequency, band width.

5. Scattering

Scattering of radiation by a bound charge, Rayleigh's scattering (qualitative ideas), blue of the sky, absorption.

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Economics (H)

Paper VA

International Economics

1 Basic Models of Trade

1.1 Ricardian Model: Comparative advantage.

1.2 One factor economy: production possibility frontier, relative demand and relative supply and autarkic terms of trade.

1.2 Trade in Ricardian world: determination of international terms of trade, complete specialiszation, gains from trade.

2 Resources, Comparative Advantage, and Income Distribution

2.1 Model of two factor economy: Assumptions, Factor prices and commodity prices (Stolper-Samuelson effect)-correspondence, Resources & output, Rybzynski effect.

2.2 Effects of International Trade between two factor economies, Relative prices and and the pattern of Trade, Trade and distribution of Income, Factor Price Equalization.

2.3 Empirical studies - Leontief Paradox.

3 The Standard Trade Model

3.1 Production Possibilities and relative supply, relative prices and demand, welfare effects of changes in terms of trade, determining relative prices.

3.2 Economic growth: shift of RS curve, growth and production possibility frontier, RS and terms of trade, International effects of growth, International transfers of income: shifting RD curve, Transfer problem, effects of transfer on terms of trade, Tariffs and export subsidies.

3.3 Offer curves: Derivation, International Equilibrium.

4 Trade Policy

4.1 Partial equilibrium analysis: Tariff- cost and benefit, effective rate of protection and intermediate goods, quota, tariff- quota equivalence and nonequivalence, export subsidy, voluntary export restraint.

4.2 General Equilibrium Analysis: Distinction between small and large open economy, welfare effects of tariff in a small country, optimum tariff for large

open economy, Metzler's paradox.

4.3 Tariff & Import Quotas in presence of monopoly.

5 Accounting, Income Determination and Exchange Rates

5.1 Balance of payment accounts; national income accounting in an open economy; monetary account;

5.2 Determination of national Income, multiplier analysis, the transfer problem, introduction of foreign country and repercussion effect.

5.3 Fixed and Flexible Exchange rates: Adjustments, Demand & Supply of foreign exchange, Effects of exchange rate changes on domestic prices and terms of trade, Marshall-Lerner condition, J-curve effect.

Paper VB:

Public Finance

1. Introduction to public economics

1.1 The nature, scope and significance of public economics

2. Forms and Functions of Government

2.1 Different forms of government – unitary and federal. Tiers of government in the federal form- Central, State, Local (Introductory discussion with examples).

2.2 Functions of Government - Economic functions -allocation, distribution and stabilization.

2.3 Regulatory functions of the Government and its economic significance

3 Federal Finance

3.1 Federal Finance: Different layers of the government, Inter governmental transfer—horizontal vs. vertical equity.

3.2 Grants—merits and demerits of various types of grants—unconditional vs. conditional grants, tied grants, matching grants.

4 Public Goods and Public Sector

4.1 Concept of public goods—characteristics of public goods, national vs. local public goods, determination of provision of public good

4.2 Externality, concept of social versus private costs and benefits, merit goods, club goods.

4.3 Provision versus production of public goods. Market failure and public provision. Pricing of public goods—vertical summation

5. Government Budget and Policy

5.1 Government budget and its structure – Receipts and expenditure - concepts of current and capital account, balanced, surplus, and deficit budgets, concept of budget deficit vs. fiscal deficit, functional classification of budget. Concept of Revenue Deficit.

5.2 Budget, government policy and its impact. Budget multipliers.

6. Revenue Resources

6.1 Concept of tax, types of tax – direct tax and indirect tax, canons of taxation, subsidy, transfer policy.

6.2 Principles of taxation -Ability to Pay principle (brief discussion), Benefit Approach (Actual Examples)

6.3 Tax Design - introduction – truth seeking mechanism.

7. Tax Structure 8

7.1 Effects of income tax on work effort, saving and risk bearing (just brief ideas).

7.2 Excess burden of indirect taxes

7.3 VAT, Goods and Services Tax (pros and cons).

7.4 Non-tax revenue resources-earnings from public undertakings, interest on loans.

8. Distribution and Stabilization 10

8.1 Instruments for stabilization

8.2 Public Debt---internal and external.

8.3 Public Finance and Public Choice: The Role of State.

Paper VIA: Comparative Development Experience

1. International comparisons of development

1.1 Differences in initial conditions of development of less developed countries and present day developed countries.

1.2 Nature of development gap prevailing at present between developed and less developed countries.

2 Genesis of capitalism

2.1 Different types of social organization, feudalism, precapitalist societies other than feudalism, capitalism in the West, development of the Third World

2.2 Industrial revolution in Great Britain - Causes – Why Great Britain became the pioneer? – Characteristics - Effects

3 Industrialization Experiences in Early Part of 20th Century

3.1 The Great Debate in Soviet Union on the assignment of priority on development of heavy industry in the process of planned economic development.

3.2. The Great Depression of the 1930's and recovery – Experiences of USA and Great Britain.

4. Post Second World War Development Scenario

4.1 Global Change, Welfare state and mixed economy.

4.2 Post War global institutions: International Monetary Fund, World Bank, United Nations Conference on Trade and Development.

4.3 Trade and Strategies of Development: Infant industry, Import substitution versus export promotion in less developed countries. Illustrations from South Asia, Latin America and East Asia.

4.4 Foreign Finance, Investment and Development: Private foreign direct investment and Multinational Corporations, private portfolio investment, development assistance debate.

5 Development and underdevelopment as historical processes 5

5.1 Dependency Approach.

5.2 Unequal exchange.

6 Evolution of New international economic order

6.1 Neo liberalism, Washington consensus, North-South Divide, Recasting of IMF and World Bank.

6.2 General Agreements on Tariff and Trade (GATT) and the Dunkel Draft controversy-World Trade Organization (WTO).

6.3 Economic Integration and Regional Trading Blocs.

6.4 Global Polarization.

7 Development policies and role of the state

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Selection Syllabus for B.Sc. Part III Honours Papers

7.1 Nature of Development planning, Rationale for development planning.

7.2 Washington Consensus, New Consensus and the State

8 Some Recent Development Experiences 6

(i) China, (ii) Africa (iii) Argentina.

Paper VIB: Contemporary Economic Issues: India and West Bengal

Group A Contemporary Economic Issues –India.

1. Economic Reform in India Since 1991

1.1. Background of Indian Economic Reforms – New Economic Policy. Redefining India's development strategy. Changing Role of State and Market.

1.2 Industrial Policy, Disinvestment policy and Privatization.

1.3 Financial sector reforms including banking reform. Monetary Policy of RBI.

1.4 Fiscal Policy Reform – tax reform, debt management, FRBM act and subsidies.

1.5 External sector reforms: Foreign Exchange market, balance of payments, reform, convertibility, export-import policy, foreign direct investment.

2 Agriculture, Poverty and Social Security

2.1 Post-reform Agricultural Performance and its Crisis.

2.2 Poverty and exclusion, NREGA, social security for unorganized workers and forest policy.

3 Post-reform performance of Indian Economy

3.1 Appraisal of Indian Economic Reform. India's Growth Experience.

4. Indian economy: Some Current and Future Issues 18

4.1 Inclusive development

4.3 Food security, Food Procurement and Public Distribution System.

4.4 Migration and Urbanization.

4.5 Land acquisition, SEZ and Industrialisation.

4.6 Demographic dividend.

Group B Contemporary Economic Issues -West Bengal

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5 West Bengal Economy: An Overview

5.1 West Bengal Economy Structure and Growth – based on state domestic product (SDP) data and employment data from National Sample Survey and Census of India.

5.2 West Bengal Economy in relation to India and major states in recent decades: in terms of indicators on - per capita SDP, per capita consumption (rural and urban), income growth, human development.

6 Growth and Development of West Bengal Economy

6.1 Land Reforms, agricultural growth and related current problems- growth of non-farm rural sector

6.2 Industrial development – problems and prospects; Tertiary sector growth – Informalisation in manufacturing and tertiary sectors.

6.3 Poverty alleviation, Employment generation, self-help-group and social security: Problems and policies

Paper VIIA: Statistics & Basic Econometrics

1 Joint Probability Distribution

Joint Probability Distribution – Idea of Independence, Marginal and Conditional Distribution. Expectation of the product of two variates.

2 Sampling Theory

2.1 Population and Sample, Parameter and Statistic, Random Sampling - Methods of Drawing Random samples –with replacement and without replacement, Random sampling Numbers.

2.2 Sampling Distribution,Standard Error.

3 Sampling Distribution

3.1 Sampling Distributions associated with Normal Population, Expectation and Standard Error of Sample Mean for with replacement and without replacement random samples,

3.2 Chi-Square Distribution, Student t Distribution, F-Distribution (definition and important properties only-Idea of degrees of freedom.

3 Classical Statistical Inference

4.1 Estimators-Desirable properties of estimators -Unbiasedness, Minimum

Variance, Consistency and Sufficiency

4.2 Point Estimation - Maximum Likelihood Estimators and their properties –

4.3 Maximum Likelihood estimation of the parameters of Binomial, Poisson and Normal Distributions.

4.4 Confidence Intervals -Testing of Hypothesis -p-Values -Type-I and Type -II Errors

4.5 Simple applications of tests for the Mean and Variance of a Univariate Normal Population.

5 Elementary Econometrics

5.1 Classical Linear Regression Model (CLRM): Specification of the Model- Assumptions- Linearity in variables and parameters, Estimation of the Error Variance

5.2. Gauss Markov Theorem, Goodness of fit: R square –Coefficient of Determination

5.3 Inference in the Linear Regression Model- Confidence interval for the parameters and the Testing of Hypotheses -Prediction with the Simple Regression model.

5.4 Concepts of Heteroscadasticity and Autocorrelation problems.

6 Time Series Data

6.1 Time Series: Introduction, Components, Measurements: Secular Trend (Free hand curve fitting, Moving averages, fitting mathematical curves), Seasonal fluctuation (monthly averages, ratio to moving averages, ratio to trend)

Paper VIIB: Applied Economics

Group B: Mathematical Economics

1 Theory of the Consumer

Utility maximization, Lagrangian multiplier, Indirect Utility function, Roy's Identity, Derivation of Slutsky's equation, Slutsky's Equation in elasticity form, Compensated demand curve

Different forms of Utility Function—Separable, quasi-linear, homogeneous and homothetic

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Labour-leisure choice

2 Theory of the Firm

2.1 Output maximization, Cost minimization, Homogeneous and homothetic production functions, Elasticity of substitution, CES production function, Relationship between average cost and marginal cost

2.2 Factor demand curves, output elasticity, Analysis of firms in competitive equilibrium and monopoly, imposition of taxes

2.3 Analysis of factor demands in the long run

2.4 Fixed coefficient production functions, Leontief Input-Output system.

3 Games and Decisions

Two person matrix games, solving matrix games with mixed strategies

Sequential Games and Decisions

4 Inter-temporal Choice Theory

4.1 n-period utility maximization, Time preference, Stocks and flows

5 Behaviour under uncertainty

5.1 Uncertainty and Probability, State preference approach for preferences

5.2 Expected Utility Hypothesis, Risk aversion and its measures.

6 Comparative Statics

6.1 Generalisation to n variables: First and Second order conditions

6.2 Profit maximisation: n factors and Utility Maximisation

6.3 National Income Model, IS-LM Model

6.2 Simple Trade Models

7 Application of Difference and Differential Equations

7.1 Cobweb Model

7.2 Multiplier-Accelerator Interaction Model

7.3 Linear Systems via Eigen values

7.4 Solution of linear systems by substitution

7.5 Phase diagrams of linear systems

7.6 Solow model.

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Paper VIIIA

Indian Economic History

1 Economic condition in India on the eve of British rule

2 Aspects of Economic Policies under in British India

2.1 Land policy

2.2 Policy of Discriminating Protection

2.3 Early Industrial Development and Managing Agency System

2.4 Currency and monetary policy

2.5 Infrastructure and Transport

3 Impact of British rule on India

3.1 Deindustrialisation

3.2 Commercialisation of agriculture

3.4 Economic Drain

4 Early Economic planning initiatives during British rule

CHEMISTRY (H)

Paper V (100 M)

CHT 31a

Unit I. Chemistry of coordination compounds

Isomerism, reactivity and stability: Determination of configuration of cis- and trans- isomers by chemical methods. Labile and inert complexes, substitution reaction on square planer complexes, trans effect (example and applications). Stability constants of coordination compounds and their importance in inorganic analysis. Structure and bonding: VB description and its limitations. Elementary Crystal Field Theory: splitting of dn configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy in weak and strong fields; pairing energy. JahnTeller distortion. Metal-ligand bonding (MO concept, elementary idea), sigma- and pibonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples). Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of dn ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only); d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$ -$3d^9$ ions and their spectroscopic

ground states; selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra (elementary idea).

Unit II. Chemistry of d- and f- block elements

General comparison of 3d, 4d and 5d elements in term of electronic configuration, elemental forms, metallic nature, atomization energy, oxidation states, redox properties, coordination chemistry, spectral and magnetic properties. f-block elements: electronic configuration, ionization energies, oxidation states, variation in atomic and ionic (3+) radii, magnetic and spectral properties of lanthanides, comparison between lanthanide and actinides, separation of lanthanides (by ion-exchange method). Chemistry of some representative compounds: $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, $K_2[Ni(CN)_4]$, H_2PtCl_6, $Na_2[Fe(CN)_5NO]$.

CHT 31b

Unit I. Organometallic Compounds

18-electron rule and its applications to carbonyls (including carbonyl hydrides and carbonylates), nitrosyls, cyanides, and nature of bonding involved therein. Simple examples of metal-metal bonded compounds and metal clusters. Metal-olefin complexes: zeises salt (preparation, structure and bonding), Ferrocene (preparation, structure and reactions). Hapticity(η) of organometallic ligands, examples of mono tri and penta-hapto cyclopentadienyl complexes. Simple examples of fluxional molecules. Coordinative unsaturation: oxidative addition and insertion reactions. Homogeneous catalysis by 13 organometallic compounds: hydrogenation, hydroformylation and polymerization of alkenes (Ziegler-Natta catalysis).

Unit II. Bioinorganic Chemistry

Elements of life: essential major, trace and ultratrace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$, and Zn^{2+}).Metal ion transport across biological membrane Na^+-ion pump, ionophores. Biological functions of hemoglobin and myoglobin, cytochromes and ferredoxins, carbonate bicarbonate buffering system and carbonicanhydrase. Biological nitrogen fixation, Photosynthesis: Photosystem-I and Photosystem-II. Toxic metal ions and their effects, chelation therapy (examples only), Pt and Au complexes as drugs (examples only), metal dependent diseases.

CHT 31c

Unit I. Electrochemical and spectral analysis, and analytical separation

Electrochemical methods: Conductometry, Potentiometry, pH-metry. Electrogravimetry, Coulometry. Spectrophotometry: Lambert-Beer law, Limits to Beer's law, Principle of spectrophotometric estimation of iron, manganese and phosphorous. Principles and instrumentations of atomic absorption and atomic emission spectrometry; estimation of sodium and potassium in water samples. Ion exchange resins and their exchange capacities, principle and simple applications of ion exchange separation. Chromatographic separations: General description and classification of chromatographic methods,

thin layer, paper and column chromatographic techniques and their simple applications, Rf-values and their significance, elution in column chromatography, migration rates of solutes, band broadening and column efficiency, column resolution.

Unit 2. Statistical methods in chemical analysis and environmental analysis Errors in chemical analysis: Accuracy and precision of measurements, determinate indeterminate, systematic and random errors in chemical analysis with examples, absolute and relative errors; source, effect and detection of systematic errors; distribution of random errors, normal error curve, standard deviations, standard deviation of calculated results- sum or difference, product or quotient, significant figures, rounding and expressing results of chemical computations. Principles for determination of BOD, COD, DO, TDS, in water samples. Detection and estimation of As, Hg, Cd, Pb, NH_4^+ , and F^- , NO_3^- , NO_2^- in water sample. Detection, collection and principles of estimation of CO, NOx, SO_2, H_2S and SPM in air samples.

CHT 31d

Unit I: Gravimetric and tritimetric methods of analysis

Requirements of gravimetry: properties of precipitates and precipitating regents, particle size and filterability of precipitates, colloidal and crystalline precipitates coprecipitation and post-precipitation drying and ignition of precipitates, principles of gravimetric estimation of chloride, phosphate, zinc, iron, aluminum and magnesium singly. 14 Primary and secondary standard substances in acid-base, redox, complexometric (EDTA) and argentometric titrations. Principle and application of redox tritimetric estimation based on the use of the following reagents: $KMNO_4$, $K_2Cr_2O_7$, I_2, $Na_2S_2O_3.5H_2O$, $KH(IO_3)_2$ and $KBrO_3$. Principle of argentimetric estimation of chloride using adsorption indicators. Principle of complexometric EDTA titration, metal ion indicators (examples), masking and demasking reactions, estimation of Cu-Zn, Fe-Al and Ca-Mg mixture by EDTA titration methods. Dissolution, scheme of analysis and principles of estimation of the constituents of the following materials: dolomite, pyrolusite, chalchopyrites, Portland cement, basic slag, brass, steel and type metal.

Unit II. Thermodynamics of dissolution

Acidities of cations, factors influencing acidities (effects of charge and size); basicities of anions, factors influencing basicities (size and charge effects). Hydration energies of ions, Born-equation, enthalpy change associated with dissolution, solubility rules, thermodynamic interpretations of the rules; application of the rules for precipitation reactions, uses of the rules in quantitative and qualitative analysis, complexation reactions and their roles in dissolution processes.

Paper VIA (75 M)

CHT 32a

Unit I. Carbanion chemistry and cyclic stereochemistry

Carbanions: formation of enols and enolates (metal), alkylation of enolates, reactions of enolates with carbonyls (aldehydes, ketones and esters), conjugate addition of enolates. Cyclic Stereochemistry: Baeyer strain theory.

Conformational analysis: cyclohexane, mono and disubstituted cyclohexane, symmetry properties and optical activity. Conformation & reactivity in cyclohexane system: elimination (E2), rearrangement, nucleophilic substitution (SN1, SN2, NGP), oxidation of cyclohexanol, esterification, saponification, lactonisation.

Unit II. Spectroscopy UV, IR, NMR (elementary)

UV Spectra: Electronic transition (σ-σ*, n-σ*, π-π* and n-π*), relative positions of λmax considering conjugative effect, steric effect, solvent effect, red shift (bathochromic shift), blue shift (hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples). IR Spectra: Modes of molecular vibrations, application of Hooke's law, characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=O functions; factors effecting stretching frequencies (H-bonding, mass effect, electronic factors, bond multiplicity, ring size). PMR Spectra: Nuclear spin, NMR active nuclei, principle of proton magnetic resonance, equivalent and non-equivalent protons, chemical shift δ), shielding / deshielding of protons, up-field and down-field shifts. NMR peak area (integration), diamagnetic anisotropy, relative peak positions of different kinds of protons (alkyl halides, olefins, alkynes, aldehyde H), substituted benzenes (toluene, anisole, nitrobenzene, halobenzene, dinitrobenzenes, chloronitrobenzene), first order coupling (splitting of the signals: ordinary ethanol, bromoehane, dibromoehanes), coupling constants.

CHT 32b

Unit I. Synthetic strategies and Asymmetric synthesis

Retrosynthetic analysis: disconnections, synthons, donor and acceptor synthons, functional group interconversion, C-C disconnections and synthesis [one group and twogroup (1,2 to 1,6-dioxygenated], reconnection (1,6-di carbonyl), natural reactivity and umpolung, protection-deprotection strategy [alcohol, amine, carbonyl, acid] Strategy of ring synthesis: thermodynamic factor, synthesis through enolate anion chemistry and carbonyl condensation reactions (including acetoaceticester & malonic ester synthesis) ,synthesis through rearrangement (including pinacol, Favorski), synthesis of large rings, high dilution technique and acyloin reaction, Stobbe condensation. Asymmetric synthesis: stereoselective and stereospecific reactions, diastereoselectivity and enantioselectivity (only definition), diastereoselectivity: addition of nucleophiles to C=O, adjacent to a stereogenic centre (Felkin-Anh model).

Unit II. Carbohydrate chemistry

Monosaccharides: Aldoses upto 6 carbons, structure of D-glucose & D-fructose (configuration & conformation), anomeric effect, mutarotation. reactions: osazone formation, bromine – water oxidation, stepping–up (Kiliani method) and stepping–down (Ruff's & Wohl's method)of aldoses. Disaccharides: glycosidic linkages, structure of sucrose.

CHT 32c

Unit I. Carbocycles and Heterocycles

Polynuclear hydrocarbons: syntheses and reactions of naphthalene, anthracene and phenanthrene. Heterocyclic compounds: reactivity, orientation and important reactions of furan, pyrrole, pyridine, indole, synthesis (including retrosynthetic approach) pyrrole: Knorr pyrrole synthesis and Hantzsch synthesis. Hantzsch pyridine synthesis. Indole: Fischer, Madelung and Reissert synthesis, Skaurp quinoline and Bischler-Napieralski Synthesis of isoquinoline.

Unit II. Amino acids, peptides and nucleic acids

Amino acids: Synthesis: (Strecker, Gabriel, acetamido malonic ester, azlactone); isoelectric point, ninhydrin reaction. Peptides: peptide linkage, syntheses of peptides using N-protection & Cprotection, solid phase synthesis; peptide sequence: C–terminal and N–terminal unit determination (Edmann, Sanger & dansyl chloride). Nucleic acids: pyrimidine & purine bases (only structure & nomenclature), nucleosides and nucleotides, DNA: Watson-Crick model, complimentary base –pairing in DNA.

Paper VIIA (75 M)

CHT 33a

Unit I. Properties of solids, interfaces and dielectrics

Crystal, crystal planes, law of rational indices, Calculation of fraction occupied for simple cubic, bcc, and fcc. Miller indices. Bragg's law and its applications for the 16 determination of crystal structure for cubic system single crystal. Crystal structures of NaCl and KCl. Special features of interfaces compared to bulk. Surface dynamics: Physical and chemical adsorption. Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm (no derivation required). Gibbs adsorption isotherm and surface excess. Heterogeneous catalysis (single reactant). Colloids: lyophobic and lyophilic sols. Origin of charge and stability of lyophobic colloids. Coagulation and Schultz-Hardy rule. Zeta potential and Stern double layer (qualitative idea). Tyndall effect. Electrokinetic phenomenon (qualitative idea only). Electrical properties of molecules: Polarizability of atoms and molecules, dielectric constant and polarisation, molar polarisation for polar and non-polar molecules. Clausius-Mosotti equation and Debye equation (both with derivation) and their application. Determination of dipole moments.

Unit II. Quantum Chemistry – II

Simple Harmonic Oscillator: setting up of the Schrodinger stationary equation, energy expression (without derivation), expression of wave function for n = 0 and n = 1 (without derivation) and their characteristic features. Stationary Schrodinger equation for the H-atom in polar coordinates, separation of radial and angular (θ, ϕ) parts. Solution of ϕ-part and emergence of quantum number 'm'; energy expression (without derivation), degeneracy. Hydrogenic wave functions up to n = 2 (expression only); real wave function. Concept of orbitals and shapes of s and p orbitals.

CHT 33b

Unit I. Phase equilibrium and colligative properties

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Definitions of phase, component and degrees of freedom. Phase rule and its derivations. Definition of phase diagram. Phase equilibria for one component system – water, CO_2. First order phase transition and Clapeyron equation; Clausius-Clapeyron equation - derivation and use. Liquid vapour equilibrium for two component systems. Ideal solution at fixed temperature and pressure. Principle of fractional distillation. Duhem-Margules equation. Henry's law. Konowaloff's rule. Positive and negative deviations from ideal behaviour. Azeotropic solution. Liquid-liquid phase diagram using phenol-water system. Solidliquid phase diagram. Eutectic mixture. Nernst distribution law. Solvent extraction. ΔG, ΔS ΔH and ΔV of mixing for binary solutions. Vapour pressure of solution. Ideal solutions, ideally diluted solutions and colligative properties. Raoult's law. Thermodynamic derivation of colligative properties of solution (using chemical potentials) and their inter-relationships. Abnormal colligative properties.

Unit II. Statistical thermodynamics and the third law

Macrostates and microstates, thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation). Applications to barometric distribution. Partition function and Einstein’s theory of heat capacity of solids. Limitations of Einstein’s theory and Debye's modification (qualitative). 17 Nernst heat theorem. Approach to zero kelvin, adiabatic demagnetisation. Planck’s formulation of third law and absolute entropies.

CHT 33c

Unit I. Kinetics and photochemistry

Collision theory (detailed treatment); outline of Transition State theory. Primary kinetic salt effect. Lindemann theory of unimolecular reaction. Potential energy curves (diatomic molecules), Frank-Condon principle and vibrational structure of electronic spectra. Bond dissociation and principle of determination of dissociation energy (ground state). Decay of excited states by radiative and non-radiative paths. Fluorescence and phosphorescence, Jablonsky diagram. Laws of photochemistry: Grotthus-Draper law, Stark-Einstein law of photochemical equivalence and Lambert-Beer’s law; quantum yield and its measurement for a photochemical process, actinometry. Photostationary state. Photosensitized reactions. Kinetics of HI decomposition, H_2-Br_2 reaction, dimerisation of anthracene.

Unit II. Spectroscopy

Rotational spectroscopy of diatomic molecules: rigid rotor model, selection rules, spectrum, characteristic features of spectral lines (spacing and intensity). Determination of bond length, effect of isotopic substitution. Vibrational spectroscopy of diatomic molecules: SHO model, selection rules, spectra; anharmonicity and its consequences on energy levels, overtones, hot bands. Raman Effect.

Characteristic features and conditions of Raman activity with suitable illustrations. Rotational and vibrational Raman spectra. Rule of mutual exclusion with examples.

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MATHS (H)

Module IX

Analysis III (50 marks)

1. Compactness in IR : Open cover of a set. Compact set in IR, a set is compact iff it is closed and bounded.

[2]

2. Function of bounded variation (BV) : Definition and examples. Monotone function is of BV. If *f* is on BV on [a,b] then *f* is bounded on [a,b]. Examples of functions of BV which are not continuous and continuous functions not of BV. Definition of variation function. Necessary and sufficient condition for a function *f* to be of BV on [a,b] is that *f* can be written as the difference of two monotonic increasing functions on[a,b]. Definition of rectifiable curve. A plane curve $\gamma = (f,g)$ is rectifiable if *f* and *g* both are of bounded variation (statement only). Length of a curve (simple problems only).

[8]

3. Riemann integration :

(a) Partition and refinement of partition of a closed and bounded interval. Upper Darboux sum U (P,f) and lower Darboux sum L(P,f) and associated results. Upper integral and lower integral. Darboux's theorem. Darboux's definition of integration over a closed and bounded interval. Riemann's definition of integrability. Equivalence with Darboux definition of integrability (statement only). Necessary and sufficient condition for Riemann intergrability. [6]

(b) Continuous functions are Riemann integrable. Definition of a set of measure zero (or negligible set or zero set) as a set covered by countable number of open intervals sum of whose lengths is arbitrary small. Examples of sets of measure zero : any subset of a set of measure zero, countable set, countable union of sets of measure zero. Concept of oscillation of a function at a point. A function is continuous at *x* if its oscillation at *x* is zero. A bounded function on a closed and bounded interval is Riemann integrable if the set of points of

discontinuity is a set of measure zero (Lebesgue's theorem on Riemann integrable function). Problems on Riemann integrability of functions with sets of points of discontinuity having measure zero.

[5]

(c) Integrability of sum, scalar multiple, product, quotient, modulus of Riemann integrable functions. Properties of Riemann integrable functions arising from the above results.

[3]

(d) Function defined by definite integral ( )

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a

$\int f\,t\,dt$ and its properties.

Antiderivative (primitive or indefinite integral).

[4]

(e) Fundamental theorem of integral calculus. First mean value theorem of integral calculus. Statement of second mean value theorems of integrals calculus (both Bonnet's and Weierstrass' form).

[2]

4. Sequence and Series of functions of a real variable :

(a) Sequence of functions defined on a set : Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Dini's theorem on uniform convergence (statement only). Weierstrass's Mtest.

[4]

(b) Limit function : Boundedness, Repeated limits, Continuity, Integrability and differentiability of the limit function of sequence of functions in case of uniform convergence.

[5]

(c) Series of functions defined on a set : Pointwise and uniform convergence. Cauchy criterion of uniform convergence. Dini's theorem on uniform convergence (statement only), Tests of uniform convergence – Weierstrass' M-test. Statement of Abel's and

Dirichlet's test and their applications. Passage to the limit term by term.

[5]

(d) Sum function : boundedness, continuity, integrability, differentiability of a series of functions in case of uniform convergence.

[2]

(e) Power series: Cauchy-Hadamard theorem. Determination of radius of convergence. Uniform and absolute convergence of power series. Properties of sum function. Abel's limit theorems. Uniqueness of power series having sum function.

[8]

Module X

Group A (20 marks)

Linear Algebra II & Modern Algebra III

Section – I : Linear Algebra II (10 marks)

1. Linear Transformation (L.T.) on Vector Spaces : Definition of L.T., Null space, range space of an L.T., Rank and Nullity, Sylvester's Law of Nullity. [Rank (T) + Nullity (T) = dim (V)]. Determination of rank (T), Nullity (T) of linear transformation T : IRn → IRm. Inverse of Linear Transformation. Non-singular Linear Transformation.

2. Linear Transformation and Matrices : Matrix of a linear transformation relative to ordered bases of finite-dimensional vector spaces. Correspondence between Linear Transformations and Matrices. Linear Transformation is non-singular if its representative matrix be non-singular. Rank of L.T. = Rank of the corresponding matrix.

[5]

Section – II : Modern Algebra III (10 marks)

3. Normal sub-groups of a Group : Definition and examples. Intersection, union of normal sub-groups. Prefect of a normal sub-group and a subgroup. Quotient Group of a Group by a normal sub-group.

[5]

4. Homomorphism and Isomorphism of Groups. Kernel of a Homomorphism. First Isomorphism Theorem. Properties deducible from definition of morphism. An infinite cyclic group is isomorphic to (Z,+) and a finite cyclic group of order *n* is isomorphic to the group of residue classes modulo *n*. [5]

Group B (25 marks)

Tensor Calculus

A tensor as a generalized concept of a vector in an Euclidean space E3. To generalize the idea in an n-dimensional space. Definition of En. Transformation of co-ordinates in En (n = 2, 3 as example). Summation convention.

Contravariant and covariant vectors. Invariants. Contravariant, covariant and mixed tensors. The Kronecker delta. Algebra of tensors Symmetric and skew-symmetric tensors. Addition and scalar multiplication. Contraction. Outer and Inner products of tensors. Quotient law. Reciprocal Tensor. Riemannian space. Line element and metric tensor. Reciprocal metric tensor. Raising and lowering of indices with the help of metric tensor. Associated tensor. Magnitude of a vector. Inclination of two vectors. Orthogonal vectors. Christoffel symbols and their laws of transformations. Covariant differentiation of vectors and tensors.

[15]

Group C (15 marks)

Differential Equations II

1. Laplace Transformation and its application in ordinary differential equations : Laplace Transform and Inverse Laplace Transform. Statement of Existence theorem. Elementary properties of Laplace Transform and its Inverse. Laplace Transform of derivatives. Laplace transform of integrals. Convolution theorem (Statement only). Application to the solution of ordinary differential equations of second order with constant coefficients.

2. Series solution at an ordinary point : Power Series solution of ordinary differential equations. Simple problems only.

Or

Group C (15 marks)

Graph Theory

1. Graphs : Undirected graphs. Directed graphs. Basic properties. Walk. Path. Cycles. Connected graphs. Components of a graph. Complete graph. Complement of a graph. Bipartite graphs. Necessary and sufficient condition for a Bipartite graph. [7]

2. Euler graphs : Necessary and Sufficient condition for a Euler graph. Königsberg Bridge Problem.

[3]

3. Planar graphs : Face-size equation, Euler's formula for a planar graph. To show : the graphs K5 and K3, 3 are non-planar.

[3]

4. Tree : Basic properties, Spanning tree, Minimal Spanning tree, Kruskal's algorithm, Prim's algorithm, Rooted tree, Binary tree.

[5]

Module XI

Group A (10 marks)

Vector Calculus II

Line integrals as integrals of vectors, circulation, irrotational vector, work done, conservative force, , potential orientation. Statements and verification of Green's theorem, Stokes' theorem and Divergence theorem.

[8]

Group B (20 marks)

Analytical Statics II

1. Centre of Gravity: General formula for the determination of C.G. Determination of position of C.G. of any arc, area of solid of known shape by method of integration. [3]

2. Virtual work: Principle of virtual work for a single particle. Deduction of the conditions of equilibrium of a particle under coplanar forces from the principle of virtual work. The principle of virtual work for a rigid body. Forces which

do not appear in the equation of virtual work. Forces which appear in the equation of virtual work. The principle of virtual work for any system of coplanar forces acting on a rigid body. Converse of the principle of virtual work. [8]

3. Stable and unstable equilibrium. Coordinates of a body and of a system of bodies. Field of forces. Conservative field. Potential energy of a system. The energy test of stability. Condition of stability of equilibrium of a perfectly rough heavy body lying on fixed body. Rocking stones.
[6]

4. Forces in the three dimensions. Moment of a force about a line. Axis of a couple. Resultant of any two couples acting on a body. Resultant of any number of couples acting on a rigid body. Reduction of a system of forces acting on a rigid body. Resultant force is an invariant of the system but the resultant couple is not an invariant.

Conditions of equilibrium of a system of forces acting on a body. Deductions of the conditions of equilibrium of a system of forces acting on a rigid body from the principle of virtual work. Poisnot's central axis. A given system of forces can have only one central axis. Wrench, Pitch, Intensity and Screw. Condition that a given system of forces may have a single resultant. Invariants of a given system of forces. Equation of the central axis of a given system of forces. [12]

Group C (20 marks)

Analytical Dynamics of A Particle II

1. Central forces and central orbits. Typical features of central orbits. Stability of nearly circular orbits.

2. Planetary motion and Kepler's laws. Time of describing an arc of the orbit. Orbital energy. Relationship between period and semi-major axis. Motion of an artificial satellite.

3. Motion of a smooth cure under resistance. Motion of a rough curve under gravity e.g., circle, parabola, ellipse, cycloid etc.

4. Varying mass problems. Examples of falling raindrops and projected rockets.

5. Linear dynamical systems, preliminary notions: solutions, phase portraits, fixed or critical points. Plane autonomous systems. Concept of Poincare phase plane. Simple examples of damped oscillator and a simple pendulum. The two-variable case of a linear plane autonomous system. Characteristic polynomial. Focal, nodal and saddle points.

[20]

Module XII

Group A (25 marks)

Hydrostatics

1. Definition of Fluid. Perfect Fluid, Pressure. To prove that the pressure at a point in fluid in equilibrium is the same in every direction. Transmissibility of liquid pressure. Pressure of heavy fluids. To prove

(i) In a fluid at rest under gravity the pressure is the same at all points in the same horizontal plane.

(ii) In a homogeneous fluid at rest under gravity the difference between the pressures at two points is proportional to the difference of their depths.

(iii) In a fluid at rest under gravity horizontal planes re surfaces of equal density.

(iv) When two fluids of different densities at rest under gravity do not mix, their surface of separation is a horizontal plane.

Pressure in heavy homogeneous liquid. Thrust of heavy homogeneous liquid on plane surface.

2. Definition of centre of pressure. Formula for the depth of the centre of pressure of a plane area. Position of the centre of pressure. Centre of pressure of a triangular area whose angular points are at different depths. Centre of pressure of a circular area. Position of the centre of pressure referred to coordinate axes through the centroid of the area. Centre of pressure of an elliptical area when its major axis is vertical or along the line of greatest slope. Effect of additional depth on centre of pressure.

3. Equilibrium of fluids in given fields of force : Definition of field of force, line

of force. Pressure derivative in terms of force. Surface of equi-pressure. To find the necessary and sufficient conditions of equilibrium of a fluid under the action of a force whose components are *X, Y, Z* along the co-ordinate axes. To prove (i) that surfaces of equal pressure are the surfaces intersecting orthogonally the lines of force, (ii) when the force system is conservative, the surfaces of equal pressure are equi-potential surfaces and are also surfaces of equal density. To find the differential equations of the surfaces of equal pressure and density.

4. Rotating fluids. To determine the pressure at any point and the surfaces of equal pressure when a mass of homogeneous liquid contained in a vessel, revolves uniformly about a vertical axis.

5. The stability of the equilibrium of floating bodies. Definition, stability of equilibrium of a floating body, metacentre, plane of floatation, surface of buoyancy. General propositions about small rotational displacements. To derive the condition for stability.

6. Pressure of gases. The atmosphere. Relation between pressure, density and temperature. Pressure in an isothermal atmosphere. Atmosphere in convective equilibrium.

[30]

Group B (25 marks)

Rigid Dynamics

1. Momental ellipsoid, Equimomental system. Principal axis. D'Alembert's principle. D'Alembert's equations of motion. Principles of moments. Principles of conservations of linear and angular momentum. Independence of the motion of centre of inertia and the motion relative to the centre of inertia. Principle of energy. Principle of conservation of energy.

2. Equation of motion of a rigid body about a fixed axis. Expression for kinetic energy and moment of momentum of a rigid body moving about a fixed axis. Compound pendulum. Interchangeability of the points of a suspension and centre of oscillation. Minimum time of oscillation.

3. Equations of motion of a rigid body moving in two dimensions. Expression for

kinetic energy and angular momentum about the origin of rigid body moving in two dimensions. Necessary and sufficient condition for pure rolling. Two dimensional motion of a solid of revolution moving on a rough horizontal plane.

4. Equations of motion under impulsive forces. Equation of motion about a fixed axis under impulsive forces. To show that (i) of there is a definite straight line such that the sum of the moments of the external impulses acting on a system of particles about it vanishes, then the total angular momentum of the system about that line remains unaltered, (ii) the change of K.E. of a system of particles moving in any manner under the application of impulsive forces is equal to the work done by the impulsive forces. [30]

Module XIII

Group A (20 marks)

Analysis IV

1. Improper Integral :

(a) Range of integration, finite or infinite. Necessary and sufficient condition for convergence of improper integral in both cases.

[2]

(b) Tests of convergence : Comparison and μ-test. Absolute and non-absolute convergence and interrelations. Abel's and Dirichlet's test for convergence of the integral of a product (statement only).

[3]

(c) Convergence and working knowledge of Beta and Gamma function and their interrelation (( ) (1) ,0 1,

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Γ Γ − = < < to be assumed).

Computation of the integrals

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/ 2 / 2 /2

0 0 0

sin*n xdx*, cos*n xdx*, tan*n xdx*

π π π

∫ ∫ ∫ when they

exist (using Beta and Gamma function).

[5]

2. Fourier series : Trigonometric series. Statement of sufficient condition for a trigonometric series to be a Fourier series. Fourier co-efficients for periodic functions defined on [−π ,π] . Statement of Dirichlet's conditions convergence. Statement of theorem of sum of Fourier series.

[5]

3. Multiple integral : Concept of upper sum, lower sum, upper integral, lower-integral and double integral (no rigorous treatment is needed). Statement of existence theorem for continuous functions. Change of order of integration. Triple integral. Transformation of double and triple integrals (Problem only). Determination of volume and surface area by multiple integrals (Problem only). [5]

Group B (15 marks)

Metric Space

1. Definition and examples of metric spaces. Open ball. Open set. Closed set defined as complement of open set. Interior point and interior of a set. Limit point, derived set and closure of a set. Boundary point and boundary of a set. Properties of interior, closure and boundary of a set. Diameter of a set and bounded set. Distance between a point and a set.

[7]

2. Subspace of a metric space. Convergent sequence. Cauchy sequence. Every Cauchy sequence is bounded. Every convergent sequence is Cauchy, not the converse. Completeness : definition and examples. Cantor intersection theorem. IR is a complete metric space. Q is not complete.

[4]

Group C (15 marks)

Complex Analysis

1. Extended complex plane. Stereographic projection.

[2]

2. Complex function : Limit , continuity and differentiability of complex functions. Cauchy-Riemann equations. Sufficient condition for differentiability of a complex function. Analytic functions. Harmonic functions. Conjugate harmonic functions. Relation between analytic function and harmonic function. [8]

Module XIV

Group A (30 marks)

Probability

Mathematical Theory of Probability :

Random experiments. Simple and compound events. Event space. Classical and frequency definitions of probability and their drawbacks. Axioms of Probability. Statistical regularity. Multiplication rule of probabilities. Bayes' theorem. Independent events. Independent random experiments. Independent trials. Bernouli trials and binomial law. Poisson trials. Random variables. Probability distribution. distribution function. Discrete and continuous distributions. Binomial, Poisson, Gamma, Uniform and Normal distribution. Poisson Process (only definition). Transformation of random variables. Two dimensional probability distributions. Discrete and continuous distributions in two dimensions. Uniform distribution and two dimensional normal distribution. Conditional distributions. transformation of random variables in two dimensions. Mathematical expectation. Mean, variance, moments, central moments. Measures of location, dispersion, skewness and kurtosis. Median, mode, quartiles. Momentgenerating function. Characteristic function. Two-dimensional expectation. Covariance, Correlation co-efficient, Joint characteristic function. Multiplication rule for expectations. Conditional expectation. Regression curves, least square regression lines and parabolas. Chi-square and *t*-distributions and their important properties (Statements only). Tchebycheff's inequality. Convergence in

probability. Statements of : Bernoulli's limit theorem. Law of large numbers. Poissons's approximation to binomial distribution and normal approximation to binomial distribution. Concepts of asymptotically normal distribution. Statement of central limit theorem in the case of equal components and of limit theorem for characteristic functions (Stress should be more on the distribution function theory than on combinatorial problems. Difficult combinatorial problems should be avoided).

[40]

Group B (20 marks)

Statistics

Random sample. Concept of sampling and various types of sampling. Sample and population. Collection, tabulation and graphical representation. Grouping of data. Sample characteristic and their computation. Sampling distribution of a statistic. Estimates of a population characteristic or parameter. Unbiased and consistent estimates. Sample characteristics as estimates of the corresponding population characteristics. Sampling distributions of the sample mean and variance. Exact sampling distributions for the normal populations.

Bivariate samples. Scatter diagram. Sample correlation co-efficient. Least square regression lines and parabolas. Estimation of parameters. Method of maximum likelihood. Applications to binomial, Poisson and normal population. Confidence intervals. Interval estimation for parameters of normal population. Statistical hypothesis. Simple and composite hypothesis. Best critical region of a test. Neyman-Pearson theorem (Statement only) and its application to normal population. Likelihood ratio testing and its application to normal population. Simple applications of hypothesis testing. [35]

Module XV

Group A (25 marks)

Numerical Analysis

What is Numerical Analysis ?

Errors in Numerical computation : Gross error, Round off error, Truncation error. Approximate numbers. Significant figures. Absolute, relative and percentage

error.

Operators : Δ, ∇ , E, μ, δ (Definitions and simple relations among them).

Interpolation : Problems of interpolation, Weierstrass' approximation theorem only statement). Polynomial interpolation. Equispaced arguments. Difference table. Deduction of Newton's forward and backward interpolation formulae. Statements of Stirling's and Bessel's interpolation formulae. error terms. General interpolation formulae : Deduction of Lagrange's interpolation formula. Divided difference. Newton's General Interpolation formula (only statement). Inverse interpolation.

Interpolation formulae using the values of both *f(x)* and its derivative *f(x)* :

Idea of Hermite interpolation formula (only the basic concepts).

Numerical Differentiation based on Newton's forward & backward and Lagrange's formulae.

Numerical Integration : Integration of Newton's interpolation formula. Newton-Cote's formula. Basic Trapezoidal and Simpson's ⅓rd. formulae. Their composite forms. Weddle's rule (only statement). Statement of the error terms associated with these formulae. Degree of precision (only definition).

Numerical solution of non-linear equations : Location of a real root by tabular method. Bisection method. Secant/Regula-Falsi and Newton-Raphson methods, their geometrical significance. Fixed point iteration method.

Numerical solution of a system of linear equations : Gauss elimination method. Iterative method – Gauss-Seidal method. Matrix inversion by Gauss elimination method (only problems – up to 3×3 order).

Eigenvalue Problems : Power method for numerically extreme eigenvalues.

Numerical solution or Ordinary Differential Equation : Basic ideas, nature of the problem. Picard, Euler and Runge-Kutta (4th order) methods (emphasis on the problems only).

[30]

Group B (25 marks)

Computer Programming

Fundamentals of Computer Science and Computer Programming :

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Computer fundamentals : Historical evolution, computer generations, functional description, operating system, hardware & software.

Positional number system : binary, octal, decimal, hexadecimal system. Binary arithmetic.

Storing of data in a computer : BIT, BYTE, Word. Coding of data – ASCII, EBCDIC, etc.

Algorithm and Glow Chart : Important features, Ideas about the complexities of algorithm. Application in simple problems.

Programming languages : General concepts, Machine language, Assembly Language, High Level Languages, Compiler and Interpreter. Object and Source Program. Ideas about some major HLL.

Students are required to opt for any one of the following two programming languages :

(i) Programming with FORTRAM 77/90.

Or

(ii) Introduction to ANSI C.

Programming with FORTRAN 77/90 :

Introduction, Keywords, Constants and Variables – integer, real, complex, logical, character, double precision, subscripted. Fortran expressions. I/O statements-formatted and unformatted. Program execution control-logical if, ifthen-else, etc. Arrays-Dimension statement. Repetitive computations – Do. Nested Do, etc. Sub-programs : Function sub program and Subroutine sub program. Application to simple problems : Evaluation of functional values, solution of quadratic equations, approximate sum of convergent infinite series, sorting of real numbers, numerical integration, numerical solution of non-linear equations, numerical solution of ordinary differential equations, etc.

Introduction to ANSI C :

Character set in ANSI C. Key words : if, while, do, for, int, char, float etc. Data type : character, integer, floating point, etc. Variables, Operators : =, = =, !!<, >, etc. (arithmetic, assignment, relational, logical, increment, etc.).

Expresions : e.g. (a = = b) !! (b = = c), Statements : e.g. if (a>b) small = a; else

small = b. Standard input/output. Use of while, if…. Else, for, do…while, switch, continue, etc. Arrays, strings. Function definition. Running simple C Programs. Header File. [30]

Boolean Algebra : Huntington Postulates for Boolean Algebra. Algebra of sets and Switching Algebra as examples of Boolean Algebra. Statement of principle of duality. Disjunctive normal and Conjunctive normal forms of Boolean Expressions. Design of simple switching circuits.

[10]

Module XVI

Practical

(Problem:30, Sessional Work:10, Viva:10)

(A) Using Calculator

(1) INTERPOLATION :

Newton's forward & Backward Interpolation.

Stirling & Bessel's Interpolation.

Lagrange's Interpolation & Newton's Divided Difference Interpolation.

Inverse Interpolation.

(2) Numerical Differentiation based on Newton's Forward & Backward Interpolation Formulae.

(3) Numerical Integration : Trapezoidal Rule, Simpson's ⅓ Rule and Weddle's Formula.

(4) Solution of Equations : Bisection Method, Regula Falsi, Fixed Point Iteration. Newton-Raphson formula (including modified form for repeated roots and complex roots).

(5) Solution of System of Linear Equations : Gauss' Elimination Method with partial pivoting, Gauss-Seidel/Jordon Iterative Method, Matrix Inversion.

(6) Dominant Eigenpair of a (4×4) real symmetric matrix and lease eigen value of a (3×3) real symmetric matrix by Power Method.

(7) Numerical Solution of first order ordinary Differential Equation (given the initial condition) by :

Picard's Method, Euler Method, Heun's Method,

Modified Euler's Method, 4th order Runge-Kutta Method.

(8) Problems of Curve Fitting : To fit curves of the form y=a+bx, y=a+bx+cx2, exponential curve of the form y=abx, geometric curve y=axb by Least Square Method.

(B) ON COMPUTER :

The following problems should be done on computer using either FORTRAN or C language :

(i) To find a real root of an equation by Newton-Raphson Method.

(ii) Dominant eigenpair by Power Method.

(iii) Numerical Integration by Simpson's ⅓ Rule.

(iv) To solve numerically Initial Value Problem by Euler's and RK4 Method.