NEP and Learning Outcome-based Curriculum Framework (LOCF)

For

B.Sc. (Physical Science-Physics, Chemistry, Mathematics) Programme

Academic Session (w.e.f. 2024-2025)

I & II SEMESTERS

INSTITUTE OF BASIC SCIENCES

MAHARAJA SURAJMAL BRIJ UNIVERSITY BHARATPUR

Dr. Divyanshu Bhatnagar

Dr. Nisha Chanda

(Dr. Mahesh Kumar Jajoriya)

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Scheme of Examination

The examination pattern comprises 20% internal assessment and 80% external assessment.

External Assessment

Theory Papers:

1. Each theory paper in the end-of-semester examination (EoSE) carries 80% marks.

2. The EoSE will be of 3 hours duration.

3. The questions will be designed in alignment with Bloom's Taxonomy.

Part A of the question paper shall contain 10 very short answer type questions covering the entire syllabus. Each question carries equal marks.

Part B of the question paper shall contain 04 descriptive type questions one from each unit with internal choice. Each question carries equal marks.

Value-Added Papers

1. Each theory paper in the end-of-semester examination (EoSE) carries 80% marks.

2. The EoSE will be of 2 hours duration.

3. Question paper shall contain 40 multiple choice questions covering the entire syllabus. Each question carries 1 mark.

Practical:

Internal: continuous evaluation (20%).

External: end term practical record (20%), written exam (40%) and viva-voce (20%).

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SEMESTER-I

Course Title	Course Code	L (Hrs)	T (Hrs)	P (Hrs)	L Credits	T Credits	P Credits	Total Credits	MARKS TI	MARKS TE	MARKS PI	MARKS PE	MARKS Total
Core Course(s)													
Mechanics	UPSC-02	3	0	0	3	0	0	3	15	60	0	0	75
Mechanics Lab	UPSC-02L	0	0	2	0	0	1	1	0	0	5	20	25
Organic Chemistry-I	UCSC-02	3	0	0	3	0	0	3	15	60	0	0	75
Organic Chemistry-I Lab	UCSC-02L	0	0	2	0	0	1	1	0	0	5	20	25
Differential Calculus and Complex Analysis	UMSC-01	4	0	0	4	0	0	4	20	80	0	0	100
Elective Course(s)													
Basic of Drone Technology	UPGE-01	2	0	0	2	0	0	2	10	40	0	0	50
Introductory Astronomy-1	UPGE-02	2	0	0	2	0	0	2	10	40	0	0	50
Conductance and Electrochemistry	UCGE-01	2	0	0	2	0	0	2	10	40	0	0	50
Statistical Methods and Data Analysis-I	UCGE-02	2	0	0	2	0	0	2	10	40	0	0	50
Optimization Techniques	UMGE-01	1	0	0	1	0	0	1	5	20	0	0	25
Optimization Techniques Lab	UMGE-01L	0	0	2	0	0	1	1	0	0	5	20	25
Probability	UMGE-02	1	0	0	1	0	0	1	5	20	0	0	25

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Probability Lab	UMGE-02L	0	0	2	0	0	1	1	0	0	5	20	25
Ability Enhancement Course(s)													
Environmental Science and Sustainable Development-1	UAEC-01	2	0	0	2	0	0	2	10	40	0	0	50
Value-added Course(s)													
Science and Society	UVAC-01	2	0	0	2	0	0	2	10	40	0	0	50

Note:- Students are required to choose one course from each of the three elective categories: one from UPGE, one from UCGE and one from UMGE.

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UPSC-02: MECHANICS

Course Outcomes:

Upon completion of this course, students will be able to,

- Learn the Galilean invariance of Newton's laws of motion.
- Understand translational and rotational dynamics of a system of particles.
- Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
- Understand Einstein's postulates of special relativity.
- Apply Lorentz transformations to describe simultaneity, time dilation and length contraction.
- Use various instruments for measurements and perform experiments related to rotational dynamics, elastic properties, fluid dynamics, acceleration due to gravity, collisions, etc.
- Use propagation of errors to estimate uncertainty in the outcome of an experiment and perform the statistical analysis of the random errors in the observations.

Unit I

Fundamentals of Dynamics: Inertial and Non-inertial frames, Newton's Laws of Motion and their invariance under Galilean transformations. Momentum of variable mass system: motion of rocket. Dynamics of a system of particles, principle of conservation of momentum. Impulse. Determination of centre of mass of discrete and continuous objects having cylindrical and spherical symmetry, Differential Analysis of a static vertically hanging massive rope.

Work and Energy: Work and Kinetic Energy Theorem. Conservative forces and examples (Gravitational and electrostatic), non-conservative forces and examples (velocity dependent forces e.g. frictional force, magnetic force). Potential Energy. Energy diagram. Stable, unstable and neutral equilibrium. Force as gradient of the potential energy. Work done by non-conservative forces.

Collisions: Elastic and inelastic collisions. Kinematics of $2 \rightarrow 2$ scattering in centre of mass and laboratory frames.

Unit II

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Determination of moment of inertia of symmetric rigid bodies (rectangular, cylindrical and spherical) using parallel and perpendicular axes theorems. Kinetic energy of rotation. Motion involving both translation and rotation

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Centrifugal force. Coriolis force and its applications.

Unit III

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Central Force Motion: Central forces, Law of conservation of angular momentum for central forces, Two-body problem and its reduction to equivalent one-body problem and its solution. Concept of effective potential energy and stability of orbits for central potentials of the form kr^n for n = 2 and -1 using energy diagram, discussion on trajectories for $n = -2$. Solution of Kepler's problem, Kepler's laws for planetary motion, orbit for artificial satellites.

Unit IV

Relativity: Postulates of special theory of relativity, Lorentz transformations, simultaneity, length contraction, time dilation, proper length and proper time, Life time of a relativistic particle (for example muon decay time and decay length). Space-like, time-like and light-like separated events. Relativistic transformation of velocity and acceleration. Variation of mass with velocity, Mass-energy Equivalence. Transformation of Energy and Momentum.

References/Books:

1. An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
2. Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education
3. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education.
4. Classical Mechanics by Peter Dourmashkin, 2013, John Wiley and Sons.
5. https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_(Dour mashkin)/
6. Introduction to Classical Mechanics With Problems and Solutions, David Morin, 2008, Cambridge University Press.
7. Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
8. Introduction to Special Relativity, Robert Resnick, 2007, Wiley.

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UPSC-01L: MECHANICS LAB

Course Outcomes:

After successful completion of the course on Physics lab, a student will be able to:

• Develop skills in precision measurements and error analysis using mechanical systems.

• Demonstrate understanding of mechanical properties like moment of inertia, friction, viscosity, and elasticity through practical experiments.

• Apply principles of simple harmonic motion, damping, and resonance to analyse oscillatory systems.

Every student must perform at least 6 experiments:

List of Practical's

1) To study the random errors in observations. It is advisable to keep observables of the order of least count of the instruments.
2) To determine the moment of inertia of a symmetric as well as asymmetric flywheel
3) To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
4) To determine g and velocity for a freely falling body using Digital Timing Technique.
5) To determine the Young's Modulus of a Wire by Optical Lever Method.
6) To determine the vertical distance between two given points using sextant.
7) To determine the coefficients of sliding and rolling friction experienced by a trolley on an inclined plane.
8) To verify the law of conservation of linear momentum in collisions on air track.

Note: Any experiment can be introduced or deleted in the practical class on the basis of availability of instruments.

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UCSC-02: ORGANIC CHEMISTRY-1

(Basic Concepts and Aliphatic Hydrocarbons)

Course Outcomes:

On completion of the course, the student will be able to:

• Understand and explain the electronic displacements and reactive intermediates and their applications in basic concepts.

• Formulate the mechanistic route of organic reactions by recalling and correlating the fundamental concepts.

• Identify and comprehend mechanism for free radical substitution, electrophilic addition, nucleophilic substitution and elimination reactions.

• Understand the fundamental concepts of stereochemistry.

• Understand and suitably use the chemistry of hydrocarbons

Unit I: Basic Concepts of Organic Chemistry

Electronic displacements and their applications: inductive, electromeric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity.

Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions, carbenes and free radicals.

Electrophiles & nucleophiles, and introduction to types of organic reactions: addition, elimination and substitution reactions.

Unit II: Stereochemistry-I

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newman, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration. Racemic mixture and their resolution. Relative and absolute configuration: D/L and R/S designations (CIP rules).

Unit III: Stereochemistry-II

Geometrical isomerism: cis-trans, syn-anti and E/Z notations.Conformational Isomerism: Alkanes (Conformations, relative stability and energy diagrams of Ethane, Propane and butane). Relative stability of cycloalkanes (Baeyer strain theory), Cyclohexane conformations with energy diagram. Conformations of monosubstituted cyclohexanes.

Unit IV: Aliphatic Hydrocarbons

Alkanes: Preparation, Halogenation of alkanes, Concept of relative reactivity v/s selectivity.

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Alkenes and Alkynes: Methods of preparation of alkenes using Mechanisms of E_1, E_2, E_1cb reactions, Saytzeff and Hoffmann eliminations. Electrophilic additions, mechanism with suitable examples, (Markownikoff/Anti-markownikoff addition), *syn* and *anti*-addition; addition of H_2, X_2, oxymercuration- demercuration, hydroboration-oxidation, ozonolysis, hydroxylation, Reactions of alkynes; acidity, Alkylation of terminal alkynes, electrophilic addition: hydration to form carbonyl compounds, Relative reactivity of alkenes and alkynes, 1,2-and 1,4-addition reactions in conjugated dienes, Diels Alder reaction (excluding stereochemistry)

References:

1. Morrison, R.N., Boyd, R.N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

2. Finar, I.L. (2002), Organic Chemistry, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

3. Eliel, E.L., Wilen, S.H. (1994), Stereochemistry of Organic Compounds; Wiley: London.

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UCSC-02L: ORGANIC CHEMISTRY–I LAB

Course Outcomes:

• Calibrate laboratory thermometers and accurately determine melting and boiling points using standard techniques.

• Apply the concept of mixed melting point and recrystallization for the purification and identification of organic compounds.

• Perform separation and identification of compounds using paper and thin layer chromatography.

• Detect extra elements in organic compounds through systematic laboratory procedures.

List of Practical's

1) Calibration of a thermometer and determination of the melting points of the organic compounds using any one of the following methods-Kjeldahl method, electrically heated melting point apparatus and BODMEL).
2) Concept of melting point and mixed melting point.
3) Concept of recrystallisation using alcohol/water/alcohol-water systems (Any two).
4) Determination of boiling point of liquid compounds (boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL method)
5) Separation of a mixture of two amino acids/sugars by radial/ascending paper chromatography.
6) Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).
7) Detection of extra elements

Note: Any experiment can be introduced or deleted in the practical class on the basis of availability of instruments/chemicals.

References

1. Mann, F.G., Saunders, B.C. (2009), Practical Organic Chemistry, 4th Edition, Pearson Education.

2. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

3. Furniss, B.S., Hannaford, A.J., Smith, P.W.G.; Tatchell, A.R (2004), Vogel's Textbook of Practical Organic Chemistry, Pearson.

4. Leonard, J., Lygo, B., Procter, G. (2013) Advanced Practical Organic Chemistry, 3rd Edition, CRC Press.

5. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi.

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UMSC-01: DIFFERENTIAL CALCULUS AND COMPLEX ANALYSIS

Course Outcomes:

On successful completion of this course, the students will have the skill and knowledge to,

• Understand and analyse the behaviour, continuity, and differentiability of single and multivariable functions using graphical and analytical techniques.

• Apply concepts of curve tracing, polar coordinates, and envelopes to analyse geometric properties of standard curves.

• Evaluate convergence of infinite series using standard tests and apply Taylor and Maclaurin series for function approximation and geometric analysis.

• Demonstrate understanding of complex numbers and functions, including their geometric interpretation, analyticity, and mapping through Cauchy-Riemann equations and harmonic functions.

Unit I

Graphs of simple basic functions such as Polynomial, Trigonometric, Inverse trigonometric, Exponential, and logarithmic functions; Limits and continuity of a function, Properties of continuous functions including Intermediate value theorem; Differentiability, Successive differentiation, Leibnitz theorem, Recursion formulae for higher derivatives; Rolle's theorem, Lagrange's mean value theorem with geometrical interpretations and simple applications, Graphs and level curves of functions of two variables, Functions of two or more variables, Partial differential coefficients of a function of two or more variables, Total differentiation, Partial differentiation, Composite function, Euler's theorem on Homogeneous functions, Jacobian with properties, Maxima, Minima, and of functions of two & three variables, Lagrange's method of undetermined multipliers.

Unit II

Polar Coordinates Angles between radius vector and tangent, length of perpendicular from pole to the tangent, Pedal equation of Cartesian and polar curves. Envelope Family of curves. Definition of envelope. Envelope in Cartesian, Polar, and Parametric Curves. Asymptotes, Multiple points, Cure tracing of standard curves (Cartesian and polar Coordinates). Test of Concavity and Convexity.

Unit III

Infinite Series and Convergence Series, Tests for Convergence Series, Comparison Test, D'Alembert ratio Test, Cauchy's n^{th} root test, Rabee's Test, De-Morgen-Bertand's Test, Cauchy's Condensation test, Taylor's theorem, Maclaurin's series, Maclaurin's Theorem, Power series expansion of functions such as e^x, sin(x), cos(x), $log_e(1+x)$ and $(1+x)^m$, Derivatives of the length of an arc in Cartesian and polar forms, Curvature, Radius of Curvature and its formulae in various forms, Centre of curvature, circles of curvature, chord of curvature.

Unit IV

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Complex Numbers: Geometrical representation of complex numbers, addition, subtraction, multiplication and division of complex numbers; Lines, circles, and discs in terms of complex variables; Statement of the Fundamental Theorem of Algebra and its consequences; De Moivre's theorem and its application to solve simple equations in complex variables, Introduction of complex functions, Limit and continuity, Differentiation and Cauchy-Riemann equations, Analytic Functions, Elementary functions and their mapping properties, Harmonic functions.

References/Books:

1. J. P. Saini, S. K. Sharma & Rakesh Kumar, Calculus & Optimization Techniques, N.K. Publication Jaipur.
2. Andreescu, Titu & Andrica Dorin. (2014). Complex Numbers from A to...Z. (2nd ed.) Birkhäuser.
3. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). Calculus (10th ed.). John Wiley & Sons Singapore Pvt. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
4. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). Thomas' Calculus (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.
5. S.K. Sharma, Rakesh Kumar, K. K. Saini & R.S.A. Sharma, Calculus & Optimization Techniques N.K. Publication Jaipur.
6. Pranjali Sharma, Rakesh Kumar, D. Meena & M. Meena, Calculus, N.K. Publication Jaipur.
7. Malik and Arora Mathematical Analysis 5e New Age International Private Limited.

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UPGE-01: BASICS OF DRONE TECHNOLOGY

Course Outcomes:

After completing this course, students will be able to:

• Explain the fundamentals, types, and key applications of drones.

• Describe the system architecture of drones, including mechanical, hardware, and software components.

• Analyze the physical structure, components, and integration methods used in drone systems.

• Interpret the role of sensors, computing systems, and control mechanisms in drone operations.

Unit I

Introduction to Drone Technology: Definition and history of drones, Types and classification: by structure, by autonomy, by altitude, by application, by wing type, Drone mission types: Combat, Logistics, Civil, Reconnaissance, Target & decoy, Research & development (R&D), Overview of drone parts: Airframe, Motors, Propellers, Payloads, Applications of drones: Military, Industrial (agriculture, inspection), Commercial.

Unit II

Drone System Architecture: design approach-Mechanical design elements: Industrial Design (ID) structure, Frame, Enclosure, Hardware components: PCBA (Printed Circuit Board Assembly), System-on-Chip (SOC) types, Subsystems: input, output, storage, and communication, Software architecture: Firmware, OS and drivers, Sensing, navigation, and control systems, Application-specific components.

Unit III

Physical and Functional Integration: Physical structure of drones and mechanical stack-up, Actuators: Types and roles in drones, Propeller types: Carbon fiber vs. plastic propellers, Motors and heat management in drone design, UAV Sensors and Degrees of Freedom (DOF).

Unit IV

Drone Computing Systems and Integration: UAV computing systems: Flight controllers, Inertial Measurement Units (IMUs), Single-Board Computers (SBCs), Autopilot systems, Functional block diagram of a drone, System integration techniques.

References/Books:

1. "Getting Started with Drones" by Terry Kilby & Belinda Kilby.
2. "The Drone Book: How Unmanned Aircraft Changed the World" by Jack Symes

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UPGE-02: INTRODUCTORY ASTRONOMY-1

Course Outcomes:

After completing this course, students will be able to:

• Different types of telescopes, diurnal and yearly motion of astronomical objects, astronomical coordinate systems and their transformations

• Brightness scale for stars, types of stars, their structure and evolution on HR diagram.

Unit I

Introduction to Astronomy and Astronomical Scales: History of astronomy, wonders of the Universe, overview of the night sky, diurnal and yearly motions of the Sun, size, mass, density and temperature of astronomical objects, basic concepts of positional astronomy: Celestial sphere, Astronomical coordinate systems, Horizon system and Equatorial system

Unit II

Basic Parameters of Stars: Stellar energy sources, determination of distance by parallax method, aberration, proper motion, brightness, radiant flux and luminosity, apparent and absolute magnitude scales, distance modulus, determination of stellar temperature and radius, basic results of Saha ionization formula and its applications for stellar astrophysics, stellar spectra, dependence of spectral types on temperature, luminosity classification, stellar evolutionary track on Hertzsprung-Russell diagram

Unit III

Astronomical Instruments: Observing through the atmosphere (Scintillation, Seeing, Atmospheric Windows and Extinction). Basic Optical Definitions for Telescopes: Magnification, Light Gathering Power, Limiting magnitude, Resolving Power, Diffraction Limit. Optical telescopes, radio telescopes, Hubble space telescope, James Web space telescope, Fermi Gamma ray space telescope.

Unit IV

Astronomy in the Internet Age: Overview of Aladin Sky Atlas, Astrometrica, Sloan Digital Sky Survey, Stellarium, virtual telescope

Citizen Science Initiatives: Galaxy Zoo, SETI@Home, RAD@Home India

References/Books:

1. Seven Wonders of the Cosmos, Jayant V Narlikar, Cambridge University Press
2. Fundamental of Astronomy, H. Karttunen et al. Springer
3. Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wesley Publishing Co.
4. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, Saunders College Publishing.

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UCGE-01: CONDUCTANCE AND ELECTROCHEMISTRY

Course Outcomes:

By the end of the course, the students will be able to:

- Understand factors influencing conductance and ionic mobility.
- Apply conductance measurements to determine physical and chemical properties.
- Explain electrochemical cells, electrode potentials, and EMF.
- Use EMF and potentiometric methods for titrations and pH determination.

Unit I: Fundamentals of Conductance

Quantitative aspects of Faraday's laws of electrolysis. Arrhenius theory of electrolytic dissociation. Conductivity: equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions. Wein Effect and Debye–Falkanhegan Effect.

Unit II: Applications of Conductance

Transference number and its experimental determination using Hittorf and moving boundary methods, Ionic mobility, applications of conductance measurements: determination of degree of ionization of weak electrolytes, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base).

Unit III: Basics of Electrochemistry

Reversible and irreversible cells with Examples, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes, standard electrode potential (reduction Potential) and its application to Gas–ion half-cell. Electrochemical series.

Unit IV: Applications of Electrochemistry

Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference, liquid junction potential; determination of activity coefficients and salt bridge, pH determination using hydrogen electrode. Potentiometric titrations qualitative treatment (acid-base and oxidation-reduction only).

References/Books:

1. Castellan, G.W. (2004), Physical Chemistry, Narosa.

2. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education.

3. Kapoor, K.L. (2013), A Textbook of Physical Chemistry, Vol 3, 3rd Edition, McGraw Hill Education.

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3. Kapoor, K.L. (2013), A Textbook of Physical Chemistry, Vol 3, 3rd Edition, McGraw Hill Education.

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UCGE-02: STATISTICAL METHODS AND DATA ANALYSIS-I

Course Outcomes:

By the end of the course, the students will be able to:

- Familiar with interpretation and use of analytical data collected by different techniques.
- Significance of different analytical techniques and their applications.
- Reliability and presentation of data for reporting to different forum.

Unit I: Basics of Chemical Analysis

Analytical Chemistry, Qualitative and quantitative analysis, Analytical methodology. Calibration of glass wares, recording laboratory data.

Unit II: Different Methods of Chemical Analysis

Titrimetric method: volumetric titremetry, standard solution, titrimetric curve, calculation;

Gravimetric method: precipitation gravimetry, calculation and applications of gravimetry; and

Spectrometric methods: introduction, principle and instrument, working quantitative aspects

absorbance, applications in chemical analysis

Unit III: Accuracy and Precision

Comparison of precision, Errors, Distribution of random errors, propagation of errors, measurement of errors, significant figure, inter laboratory error.

Unit IV: Statistical Method of Chemical Analysis

Methods of least square analysis of variance, Q test, Z test, T test, statistical treatment of finite sample, recommendations for treating outliers. Minimising errors in analytical procedure.

References/Books:

1. Dey, R. A. and Underwood, A. L., Quantitative Analysis, 6th Edition, Pearson.

2. Skoog, D. A., West, D. M., Holler, F. J., Crouch, S. R., Fundamental analytical chemistry, Thomson Asia Ltd.

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UMGE-01: OPTIMIZATION TECHNIQUES

Course Outcomes:

On successful completion of this course, the students will have the skill and knowledge to,

• Identify and analyze properties of convex sets and basic feasible solutions in optimization problems.

• Formulate real-world problems as linear programming problems using mathematical models.

• Apply the simplex method, including Big M and Two-Phase techniques, to solve LPPs and detect infeasibility or redundancy.

• Construct and interpret dual problems and apply the fundamental theorems of duality in linear programming.

Unit I

Convex sets and their properties, Basic solution, Some basic properties and theorems on convex sets.

Unit II

Introduction to Linear programming problems (LPP), Mathematical formulation.

Unit III

Theory of Simplex Method, Simplex algorithm (Big M-method, Two Phase Method, Inconsistency and Redundancy in LPP).

Unit IV

Duality(Primal and Dual problem, Formulation of Dual problem, Fundamental properties of Dual problems), Fundamental Theorem of Duality.

References/Books:

1. G. Hadley, Linear Programming. Narosa Publishing House, New Delhi, 2002.
2. Hamdy A. Taha, Operations Research, An Introduction (9th edition), Prentice-Hall, 2010

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UMGE-01L: OPTIMIZATION TECHNIQUES LAB

Course Outcomes:

After successful completion of the course, a student will be able to:

- Apply the Simplex method to determine optimal solutions of linear programming problems (LPP).
- Formulate and solve the dual of an LPP using the Simplex method.
- Interpret optimality conditions and analyse solution feasibility in LPP models.
- Demonstrate proficiency in solving real-life optimization problems using LPP techniques.

List of Exercises

1. Find the optimum solution of LPP by using the Simplex method.
2. Find the Optimum Solution of Dual LPP by using the Simplex method.

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UMGE-02: PROBABILITY

Course Outcomes:

On successful completion of this course, the students will have the skill and knowledge to,

• Understand foundational probability concepts including sample space, events, and axioms of probability.

• Analyze and apply properties of discrete and continuous random variables and their distributions.

• Compute and interpret expectations, moments, and generating functions for various probability models.

• Evaluate joint distributions, conditional expectations, and independence of multiple random variables.

Unit I

Sample space and Event, Axioms of Probability, Random variables (discrete and continuous), Cumulative distribution function, Probability mass/density functions.

Unit II

Mathematical Expectation, Moments, Moment generating function, Characteristic function.

Unit III

Discrete distributions: Uniform, Binomial, Poisson, Continuous distributions: Uniform, Normal, Exponential.

Unit IV

Joint cumulative distribution function and its properties, Joint probability density functions, Marginal and Conditional distributions, Expectation of function of two random variables, Conditional expectations, and Independent random variables.

References/Books:

1. Robert V. Hogg, Joseph W. McKean, and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
2. Devore, J. L., Probability & Statistics for Engineering and the Sciences, 8th Edition, Cengage Learning, 2012.
3. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Application, 7th Ed., Pearson Education, Asia, 2006.
4. Sheldon Ross, Introduction to Probability Model, 9th Ed., Academic Press, Indian Reprint, 2007.

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UMGE-02L: PROBABILITY LAB

Course Outcomes:

After successful completion of the course, a student will be able to:

- Apply foundational concepts of probability to solve elementary problems.
- Analyze simple probability events using classical and empirical approaches.
- Understand and compute key characteristics of discrete and continuous distributions.
- Solve distribution-based problems involving mean, variance, and probability functions.

List of Exercises

1. Basic problem of Probability
2. Basic problem of Distribution

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UAEC-01: ENVIRONMENTAL SCIENCE AND SUSTAINABLE DEVELOPMENT-I

Course Outcomes:

After completing this course, students will be able to:

- Gain in-depth knowledge on natural processes and resources that sustain life and govern economy.
- Understand the consequences of human actions on the web of life, global economy, and quality of human life.
- Develop critical thinking for shaping strategies (scientific, social, economic, administrative, and legal) for environmental protection, conservation of biodiversity, environmental equity, and sustainable development.
- Acquire values and attitudes towards understanding complex environmental- economic-social challenges, and active participation in solving current environmental problems and preventing the future ones.

Unit I

Introduction to Environmental Studies: Multidisciplinary nature of environmental studies: components of environment: atmosphere, hydrosphere, lithosphere, and biosphere; Scope and importance; Concept of sustainability and sustainable development; Brief history of environmentalism.

Unit II

Ecosystems: Definition and concept, Structure of ecosystem (biotic and abiotic components); Functions of Ecosystem: Physical (energy flow), Biological (food chains, food web, ecological succession), and Biogeochemical (nutrient cycling) processes. Concepts of productivity, ecological pyramids and homeostasis, Types of Ecosystems: Tundra, Forest, Grassland, Desert, Aquatic (ponds, streams, lakes, rivers, oceans, estuaries); importance and threats with relevant examples from India, Ecosystem services (Provisioning, Regulating, Cultural, and Supporting); Ecosystem preservation and conservation strategies; Basics of Ecosystem restoration

Unit III

Natural Resources: Land resources- Minerals, soil, agricultural crops, natural forest products, medicinal plants, and forest-based industries and livelihoods; Land cover, land use change, land degradation, soil erosion , and desertification; Causes of deforestation; Impacts of mining and dam building on environment, forests, biodiversity, and tribal communities; Water resources-Natural and man-made sources; Uses of water; Over exploitation of surface and ground water resources; Floods, droughts, and international &interstate conflicts over water; Energy resources-Renewable and non-renewable energy sources; Use of alternate energy

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sources; Growing energy needs; Energy contents of coal, petroleum, natural gas and bio gas; Agro-residues as a biomass energy source.

Unit IV

Case studies: Contemporary Indian issues related to mining, dams, forests, energy, etc (e.g ., National Solar Mission, Cauvery river water conflict, Sardar Sarovar dam, Chipko movement, Appiko movement, Tarun Bharat Sangh, etc)

References/ Books:

1. Raven, P.H. Hassenzahl, D.M., Hager, M.C. Gift, N.Y., and Berg , L.R. (2015). Environment. 9th Edition. Wiley Publishing, USA.

2. Singh, J.S., Singh, S.P., and Gupta, S.R. (2017). Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.

3. Odum, E.P., Odum, H.T., and Andrews, J. (1971). Fundamentals of Ecology. Saunders, Philadelphia, USA.

4. Brusseau, M.L., Pepper, I.L. and Gerba, C.P. (2019). Environmental and Pollution Science, 3rd Edition. Academic Press, USA.

5. Carson, R. (2002). Silent Spring. Houghton Mifflin Harcourt, USA. Pp. 1-264.

6. Gadgil, M. and Guha, R. (1993). This Fissured Land: An Ecological History of India. University of California Press, Berkeley, USA.

7. McCully, P. (1996). Rivers no more: the environmental effects of dams, In: Silenced Rivers: The Ecology and Politics of Large Dams, Zed Books, New York, USA.

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UVAC-01: SCIENCE AND SOCIETY

Course Outcomes:

After successful completion of the course, a student will be able to:

• Understand and apply the principles of scientific thinking and the scientific method to differentiate facts from myths.

• Analyse contributions of ancient science and technology in water management, sustainable construction, and agriculture.

• Evaluate the role of modern science in addressing public health challenges and ensuring food security in society.

• Examine the impact of modern technologies, including IT, renewable energy, and space exploration, on environmental sustainability and governance.

Unit I

Philosophy of science, the scientific method, importance of observation, questions and experimental design, rational thinking, myths vs. Facts.

Unit II

Ancient Science and Technology in Society: Water harvesting structures and Practices; Construction, architecture and design - use of natural environment-friendly designs and materials; Agriculture including domestication of plants and animals.

Unit III

Modern Science in Society: Public Health: Nutrition, Hygiene, Physical and Mental Health, Vaccines and Antibiotics, Anti-microbial resistance; Food Security: Green Revolution, White Revolution.

Unit IV

Modern Technology in Society: IT Revolution, E-Governance; Clean Energy, Renewable Energy; Space Science and Exploration; Evolution, Ecology and Environment.

References/Books:

1. Basu and Khan (2001). Marching Ahead with Science. National Book Trust
2. Gopalakrishnan (2006). Inventors who Revolutionised our Lives. National Book Trust
3. Yash Pal and Rahul Pal (2013) Random Curiosity. National Book Trust
4. Hakob Barseghyan, Nicholas Overgaard, and Gregory Rupik. Introduction to History and Philosophy of Science
5. John Avery {2005). Science and Society, 2nd Edition. H.C. Orsted Institute. Copenhagen.
6. Dharampal (2000). Indian Science and Technology in the Eighteenth Century, OIP.

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SEMESTER-II

Course Title	Course Code	L	T	P	L	T	P	Total Credits	MARKS				
		(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)													
Electricity and Magnetism	UPSC-05	3	0	0	3	0	0	3	15	60	0	0	75
Electricity and Magnetism Lab	UPSC-05L	0	0	2	0	0	1	1	0	0	5	20	25
Organic Chemistry-II	UCSC-05	3	0	0	3	0	0	3	15	60	0	0	75
Organic Chemistry-II Lab	UCSC-05L	0	0	2	0	0	1	1	0	0	5	20	25
Integral Calculus and Discrete Mathematics	UMSC-04	4	0	0	4	0	0	4	20	80	0	0	100
Elective Course(s)													
Engineering Materials	UPGE-03	2	0	0	2	0	0	2	10	40	0	0	50
Introductory Astronomy-2	UPGE-04	2	0	0	2	0	0	2	10	40	0	0	50
Coordination and Organometallic Compounds	UCGE-03	2	0	0	2	0	0	2	10	40	0	0	50
Statistical Methods and Data Analysis-II	UCGE-04	2	0	0	2	0	0	2	10	40	0	0	50
Vector Calculus	UMGE-01	1	0	0	1	0	0	1	5	20	0	0	25
Vector Calculus Lab	UMGE-01L	0	0	2	0	0	1	1	0	0	5	20	25
Statistics-I	UMGE-02	1	0	0	1	0	0	1	5	20	0	0	25

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Statistics-1 Lab	UMGE-02L	0	0	2	0	0	1	1	0	0	5	20	25
Ability Enhancement Course(s)													
Environmental Science and Sustainable Development-2	UAEC-02	2	0	0	2	0	0	2	10	40	0	0	50
Value-added Course(s)													
Indian Knowledge System	UVAC-02	2	0	0	2	0	0	2	10	40	0	0	50

Note:- Students are required to choose one course from each of the three elective categories: one from UPGE, one from UCGE and one from UMGE.

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UPSC-05: ELECTRICITY AND MAGNETISM

Course Outcomes:

After successful completion of the course on Electricity and Magnetism, a student will be able to:

- Apply Coulomb's law to line, surface, and volume distributions of charges.
- Apply Gauss's law of electrostatics to distribution of charges
- Solve boundary value problems using method of images
- Comprehend the genesis of multipole effects in arbitrary distribution of charges
- Understand the effects of electric polarization and concepts of bound charges in dielectric materials
- Understand and calculate the vector potential and magnetic field of arbitrary current distribution
- Understand the concept of bound currents and ferromagnetism in magnetic materials

UNIT-I

Electric Field and Electric Potential for continuous charge distributions: Electric field due to a line charge, surface charge and volume charge. Divergence of electric field using Dirac Delta function, Curl of electric field, electric field vector as negative gradient of scalar potential. Ambiguities of Electric potential, Differential and integral forms of Gauss's Law, Applications of Gauss's Law to various charge distributions with spherical, cylindrical and planar symmetries.

UNIT-II

Boundary Value Problems in Electrostatics: Formulation of Laplace's and Poisson equations. The first and second uniqueness theorems. Solutions of Laplace's and Poisson equations in one dimension using spherical and cylindrical coordinate systems and solutions in three-dimensional using Cartesian coordinates applying separable variable technique. Electrostatic boundary conditions for conductors and capacitors.

Special techniques for the calculation of Potential and Field: The Method of Images is applied to a system of a point charge and finite continuous charge distribution (line charge and surface charge) in the presence of (i) a Plane infinite sheet maintained at constant potential, and (ii) a Sphere maintained at constant potential.

UNIT-III

Multipole Expansion: Monopole, dipole and quadrupole potentials at large distances due to an arbitrary charge distribution expressed in terms of Legendre polynomials, negative Gradient of Dipole potential in spherical coordinates.

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Electric Field in Matter: Polarization in matter, Bound charges and their physical interpretation. Field inside a dielectric, Displacement vector D, Gauss' Law in the presence of dielectrics, Boundary conditions for D, Linear dielectrics, Electric Susceptibility and Dielectric Constant, idea of complex dielectric constant due to varying electric field. Boundary value problems with linear dielectrics.

UNIT-IV

Magnetic Field: Divergence and curl of magnetic field B, Magnetic field due to arbitrary current distribution using Biot-Savart law, Ampere's law, Integral and differential forms of Ampere's Law. Vector potential and its ambiguities. Coulomb gauge and possibility of making vector potential divergenceless. Vector potential due to line, surface and volume currents using Poisson equations for components of vector potential.

Magnetic Properties of Matter: Magnetization vector. Bound currents. Magnetic intensity. Differential and integral form of Ampere's Law in the presence of magnetised materials. Magnetic susceptibility and permeability. Ferromagnetism (Hund's rule).

Electrodynamics: Faraday's Law, Lenz's Law, inductance, electromotive force, Ohm's law ($\vec{j} = \sigma\vec{E}$), energy stored in a magnetic Field.

References/Books:

1. Introduction to Electrodynamics, D. J. Griffiths, 3rd Edn., 1998, Benjamin Cummings
2. Schaum's Outlines of Electromagnetics by J. A. Edminister and M. Nahvi
3. Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGraw-Hill.
4. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
5. Electricity and Magnetism, J. H. Fewkes and J. Yarwood, Vol. I, 1991, Oxford Univ. Press.

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UPSC-05L: ELECTRICITY AND MAGNETISM LAB

Course Outcomes:

After successful completion of the course on Physics lab, a student will be able to:

• Demonstrate the ability to measure electrical parameters such as current sensitivity, charge sensitivity, and high resistance using ballistic galvanometer techniques.

• Apply bridge methods like Carey Foster's, Anderson's, and Owen's to accurately determine unknown resistances, self-inductance, and mutual inductance in electrical circuits.

• Analyse the behaviour of RC, RL, LC, and LCR circuits in series and parallel configurations, including resonance phenomena.

• Measure and interpret magnetic fields and induction effects using solenoids, Helmholtz coils, and electromagnetic braking setups to validate laws of electromagnetism.

Every student must perform at least 06 experiments.

List of Practical's

1) Ballistic Galvanometer Experiments
   a. Measurement of current and charge sensitivity of a ballistic galvanometer
   b. Measurement of critical damping resistance of a ballistic galvanometer
   c. Determination of high resistance by the leakage method using a ballistic galvanometer
2) Measurement of Resistance Using Bridge Methods
   a. Determination of an unknown low resistance by Carey Foster's Bridge
   b. Calibration of bridge apparatus for precision measurements
3) RC, LC, RL and LCR Circuits
   a. Series and Parallel RC, LC, RL and LCR circuits
   b. Resonance in Series and Parallel RC, LC, RL and LCR circuits
4) Measurement of Self-Inductance
   a. Measurement of self-inductance of a coil using Anderson's Bridge
   b. Measurement of self-inductance of a coil using Owen's Bridge
5) Measurement of Mutual Inductance
   a. Determination of mutual inductance between two coils using the Absolute method
   b. Verification of coupling effect and dependence on coil separation
6) Field Mapping and Magnetic Measurements

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a. Measurement of magnetic field strength (B) and its variation along the axis of a solenoid (determine dB/dx)

b. Verification of linear variation and estimation of solenoid parameters from field distribution

7) The Magnetic Field from the Helmholtz Coil

a. Variation of the magnetic field due to a circular current-carrying coil on an axial point

b. Determination of Helmholtz Coil radius

c. Verification of Superposition principle using Helmholtz coil

8) Experiments on Electromagnetic Induction and Electromagnetic Braking

a. Study of the electromotive force (EMF) induced as a function of the velocity of the magnet

b. Study of the charge delivered due to induction

c. Study of electromagnetic (EM) damping

Note: Any experiment can be introduced or deleted in the practical class on the basis of availability of instruments.

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UCSC-05: ORGANIC CHEMISTRY –II

(Haloalkanes, Arenes, Haloarenes, Alcohols, Phenols, Ethers and Epoxides)

Course outcomes:

On completion of the course, the student will be able to:

- Explain and use reactions of arenes, haloarenes and some oxygen containing functional groups for practical applications.
- Apply the concept of protection and deprotection in organic synthesis.
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Propose plausible mechanisms for the reactions under study.

Unit I: Haloalkanes

Alkyl halides: Methods of preparation and properties, nucleophilic substitution reactions – S_N1, S_N2, and S_Ni mechanisms with stereochemical aspects and effect of solvent; Nucleophilic substitution v/s elimination. Organometallic compounds of Mg (Grignard reagent) – Use in synthesis of organic compounds.

Unit II: Aromatic Hydrocarbons

Concept of Aromaticity and anti-aromaticity; Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/acylation with their mechanism. Directing effects of groups in electrophilic substitution.

Unit III: Aryl Halides

Preparation (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl, benzyl, vinyl, and aryl halides towards nucleophilic substitution reactions.

Unit IV: Alcohols, Phenols, Ethers & Epoxides

Alcohols: Relative reactivity of 1°, 2°, 3° alcohols, reactions of alcohols with sodium, HX (Lucas test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic dichromate, conc. HNO_3). Oppenauer oxidation; Diols: oxidation of diols by periodic acid and lead tetraacetate. Pinacol-Pinacolone rearrangement.

Phenols: Preparation using Cumene hydroperoxide, acidity and factors affecting it, Kolbe's Schmidt reactions, Riemer-Tiemann reaction, Houben–Hoesch condensation, Schotten–Baumann reaction, Fries and Claisen rearrangements and their mechanism.

Ethers and Epoxides: Acid and base-catalyzed cleavage reactions.

References:

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1. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

2. Finar, I.L. (2002), Organic Chemistry, Volume 1, 6th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.

3. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), Intermediate for Organic Synthesis, I.K. International.

4. Solomons, T.W.G., Fryhle, C.B., Snyder, S.A. (2017). Organic Chemistry. 12th Edition. Wiley.

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UCSC-05L: ORGANIC CHEMISTRY–II LAB

Course Outcomes

• Perform acetylation and benzoylation of amines and phenols using both conventional and green methods, demonstrating an understanding of reaction mechanisms and sustainable practices.

• Execute electrophilic aromatic substitution reactions such as bromination and nitration, using both traditional and green chemistry techniques.

• Carry out classic organic transformations including the haloform reaction and oxidation of alcohols to carboxylic acids, applying fundamental synthetic skills.

• Identify and estimate functional groups in organic compounds through qualitative tests and quantitative analysis methods like acetylation and bromate-bromide titration.

List of Practical's

1. Acetylation of any one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, salicylic acid) by any one method:

i. Using conventional method ii. Using green approach

2. Benzolyation of one of the following amines (aniline, o-, m-, p-toluidines and o, m-, p-anisidine) or one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.

3. Bromination of acetanilide/aniline/phenol by anyone of the following:

(a) Green method b) Conventional method

4. Nitration of nitrobenzene/chlorobenzene/phenols.

5. Haloform reaction of ethanol.

6. Oxidation of benzyl alcohol to benzoic acid

7. Estimation of the given sample of phenol/amine by:

a) Acetylation b) Bromate-Bromide method

8. Functional group tests for alcohols, phenols, carboxylic acids, phenols, carbonyl compounds, esters.

Note: Any experiment can be introduced or deleted in the practical class on the basis of availability of instruments/chemicals.

References:

1. Mann, F.G., Saunders, B.C. (2009), Practical Organic Chemistry, 4th Edition, Pearson Education.

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2. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2005), Vogel's Textbook of Practical Organic Chemistry, Pearson.

3. Ahluwalia. V.K.. Aggarwal. R. (2004). Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press.

4. Ahluwalia, V.K., Dhingra. S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

5. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi

6. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi.

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UMSC-04: INTEGRAL CALCULUS, AND DISCRETE MATHEMATICS

Course Outcomes:

After successful completion of the course, a student will be able to:

- Apply Gamma and Beta functions, and evaluate double and triple integrals for solving problems involving multiple integrals and special functions.
- Compute arc lengths, areas, volumes, and surface areas using rectification, quadrature, and integral calculus techniques.
- Analyze Boolean algebra structures, solve recurrence relations, and apply logic and generating functions in discrete mathematics.
- Demonstrate understanding of graph theory concepts and apply algorithms like Dijkstra's for solving shortest path and spanning tree problems.

Unit – I

Gamma and Beta functions – Definitions, Transformations of gamma functions. Relation Between Beta and Gamma function, Euler's functional equation, Double multiple formula. Double Integral-Evaluation of double integrals, change of order of integration. Triple integral – Evaluation of triple integrals. Dirichlet's formula for triple integrals.

Unit-II

Rectification Meaning, lengths of Cartesian and Polar curves. Quadrature – Areas Bounded by plane curves (Cartesian and polar), Use of double integrals to find areas. Volume and Surface of Solid of revolution Pappus theorem, Use of triple integral to find volumes.

Unit-III

Boolean Algebra- Definition, duality, properties of Boolean algebra, ordered relation in Boolean algebra, Lattices, Boolean functions and expressions, Conjunctive and Disjunctive normal forms. Generating functions-Discrete numeric function, ordinary generating function, Convolution of sequences, Summation using convolution, counting techniques, Recurrence Relation- First order relation, second order linear homogeneous relation. Third and higher order linear homogeneous relations, Linear non-homogenous relations of second and higher order, Solution of recurrence relations using generating functions. Logic and propositional calculus-propositions, basic logical operations, truth tables, tautologies, and contradictions.

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Unit-IV

Graph Theory-Introduction, the definition of graph, degree of a vertex, directed graphs, regular graphs, Bipartite Graph, Operations on graphs, Isomorphism, Connected and Disconnected graphs, Euler circuit, and Euler graphs. Hamiltonian cycles and Hamiltonian graphs, Weighted graphs, shortest path problems, Dijkstra algorithm. Planner and non-planner graphs, Euler's formula. Detection of planarity. Dual of planner graphs, Matrix representation of graphs, Trees, properties of trees, rooted tree, binary tree, spanning tree, spanning tree in weighted graphs.

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Reference Books:

1. J. P. Saini, S. K. Sharma & Rakesh Kumar, Discrete Mathematics & Vector Calculus, N.K. Publication Jaipur.
2. V. K. Bala Krishnan, Introductory Discrete Mathematics, Prentice-Hall, 1996.
3. N. Deo, Graph Theory with Applications to Computer Science, Prentice-Hall of India.
4. C.L. Liu, Elements of Discrete Mathematics, (Second Edition), McGraw Hill, International Edition. 1986.
5. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata Mc-Graw Hills, New Delhi, 2003.

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UPGE-03: ENGINEERING MATERIALS

Course Outcomes:

After successful completion of the course on Engineering Materials, a student will be able to:

- Identify and classify key engineering materials including metals, ceramics, polymers, composites, and carbon-based nanomaterials.
- Explain the principles and techniques of top-down and bottom-up nanomaterial synthesis methods.
- Demonstrate an understanding of thermal and chemical processing techniques such as annealing, sintering, and green synthesis.
- Illustrate the applications and processes involved in thin-film fabrication techniques including PVD, CVD, and photolithography.

Unit I:

Engineering Materials: Introduction to engineering materials, Properties and applications of Metals and Alloys, Ceramics: types, properties, and uses, Polymers and Composites, Carbon-based nanomaterials (graphene, CNTs, fullerenes).

Unit II:

Nanomaterials Synthesis Techniques: Top-down vs. Bottom-up approaches, Mechanical milling: Ball milling, Wet chemical methods: Co-precipitation, Sol-gel synthesis, Green synthesis of nanomaterials.

Unit III:

Advanced Synthesis and Processing Techniques, Hydrothermal and Solvothermal synthesis, Thermal treatments: Annealing and sintering, Process parameters and their impact on material properties.

Unit IV:

Thin Film Deposition and Fabrication: Vacuum deposition and Thermal evaporation, Physical Vapor Deposition (PVD) and Chemical Vapor Deposition (CVD), Photolithography: Principles and applications in micro/nanofabrication.

References/Books:

1. "Materials Science and Engineering: An Introduction" by William D. Callister Jr. and David G. Rethwisch
2. "Nanostructures and Nanomaterials: Synthesis, Properties and Applications" by Guozhong Cao and Ying Wang
3. "Introduction to Nanoscience and Nanotechnology" by Gabor L. Hornyak et al.
4. "Thin Film Technology Handbook" by Aicha Elshabini and Fred D. Barlow III

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UPGE-04: INTRODUCTORY ASTROPHYSICS-2

Course Outcomes:

After successful completion of the course, a student will be able to:

• Explain the structure and activity of the Sun, the origin of the solar system, and planetary dynamics.

• Describe methods of exoplanet detection and explain their significance in astronomy.

• Analyse galactic structures, rotation curves, dark matter evidence, and the fundamental aspects of cosmology and astrobiology.

• Outline the historical and contemporary development of astronomy in India, including major observatories and space missions.

UNIT-I

Sun and the solar system: Solar parameters, Sun's internal structure, solar photosphere, solar atmosphere, chromosphere, corona, solar activity, origin of the solar system, the nebular model, tidal forces and planetary rings.

UNIT-II

Exoplanets: Detection methods and characterization.

Physics of Galaxies: Basic structure and properties of different types of Galaxies, Nature of rotation of the Milky Way (Differential rotation of the Galaxy), Idea of dark matter.

UNIT-III

Cosmology and Astrobiology: Standard Candles (Cepheids and SNe Type1a), Cosmic distance ladder, Olber's paradox, Hubble's expansion, History of the Universe, Chemistry of life, Origin of life, Chances of life in the solar system.

UNIT-IV

Astronomy in India: Astronomy in ancient, medieval and early telescopic era of India, current Indian observatories (Hanle-Indian Astronomical Observatory, Devasthal Observatory, Vainu Bappu Observatory, Mount Abu Infrared Observatory, Gauribidanur Radio Observatory, Giant Metre-wave Radio Telescope, Udaipur Solar Observatory, LIGO- India) (qualitative discussion), Indian astronomy missions (Astrosat, Aditya).

References/Books:

1. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, Saunders College Publishing.
2. The Molecular Universe, A.G.G.M. Tielens (Sections I, II and III), Reviews of Modern Physics, Volume 85, July-September, 2013
3. Astronomy in India: A Historical Perspective, Thanu Padmanabhan, Springer

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UCGE-03: COORDINATION AND ORGANOMETALLIC COMPOUNDS

Course Outcomes

By the end of the course, the students will be able to:

• Familiarize with different types of organometallic compounds, their structures and bonding involved.

• Apply 18-electron rule to rationalize the stability of metal carbonyls and related species

• Apply standard rules to name coordination compounds

• Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes

• Explain the meaning of the terms Δ_o, Δ_t, pairing energy, CFSE, high spin and low spin. Explain how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy and use it to explain behaviour of organometallics

Unit 1: Coordination Chemistry

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands.

Unit-2 Bonding in Coordination compounds

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes of Cr, Fe, Co and Ni. Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields. Crystal field stabilization energy (CFSE), concept of pairing energy. Factors affecting the magnitude of Δ_o. Spectrochemical series. Splitting of d orbitals in tetrahedral symmetry. Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry. Jahn-Teller distortion, square planar coordination.

Unit 3: Organometallic Compounds

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structure and bonding of methyl lithium and Zeise's salt. Structure and physical properties of ferrocene.

Unit 4: Metal Carbonyls

18-electron rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

References:

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1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010). Shriver and Atkins Inorganic Chemistry, W. H. Freeman and Company.

2. Miessler, G. L.; Fischer P.J.; Tarr, D.A. (2014), Inorganic Chemistry, Pearson.

3. Huheey, J.E.; Keiter, E.A., Keiter; R.L., Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.

4. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.

5. Cotton, F.A.; Wilkinson, G. (1999), Advanced Inorganic Chemistry Wiley-VCH.

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UCGE-04: STATISTICAL METHODS AND DATA ANALYSIS-II

Course Outcomes:

By the end of the course, the students will be able to:

- Understand key statistical tools such as confidence intervals and hypothesis testing for analytical data interpretation.
- Apply least square methods and evaluate figures of merit for data calibration and performance evaluation.
- Demonstrate proficiency in sampling techniques, sample handling, and laboratory data management.
- Analyse the role of standards, calibrations, and multivariate techniques in modern analytical methodologies.

Unit I: Statistical Foundations in Analytical Chemistry

Confidence interval, Testing of hypothesis, plotting of data, least square method.

Unit II: Analytical Performance Evaluation and Quality Control

Figures of merit: sensitivity, detection limit, linear dynamic range, control test, upper control limit and lower control limit, Validation, reporting analytical results and significant figures.

Unit III: Sampling Techniques and Sample Handling

Analytical samples, sample size, constituent sample, real samples, sample, sample handling, preparing laboratory samples, automated sample handling, lab on chip.

Unit IV: Laboratory Standards and Calibration Methods

General laboratory principles, recording laboratory data, standards, comparison of standards, internal standard, external standards calibration, least square method, and multivariant calibration.

References/Books:

1. Encyclopaedia of analytical chemistry: Applications, Theory, and Instrumentation, R A Meyor (Eds) Wiley and Sons (2000).

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UMGE-03: VECTOR CALCULUS

Course Outcomes:

On successful completion of this course, the students will have the skill and knowledge to,

- Understand and compute the gradient, divergence, and curl of vector and scalar point functions.
- Apply directional derivatives and derive vector equations of tangent planes, normal lines, and related geometric constructs.
- Utilize vector identities involving gradient, divergence, and curl in mathematical and physical contexts.
- Interpret and apply Gauss's, Stokes', and Green's theorems to solve integrals in vector calculus (without proofs).

Unit I

Vector Calculus Differentiation and Integration of vector point function, Gradient of scalar point function.

Unit II

Directional derivatives, vector equation of Tangent plane and Normal, vector equation of Tangent line and Normal Plane.

Unit III

Divergence and Curl of vector point function, Identities on gradient, curl, divergence.

Unit IV

Gauss's theorem, Stoke's theorem, and Green's Theorem (proof is not required) and their applications.

References/Books:

1. M. R. Spiegel, S. Lipschutz, D. Spellman Schaum's Outlines Vector Analysis Mc Graw Hill (India) 2009.
2. Shanti Narayan and P.K. Mittal, A Textbook of Vector Calculus S. Chand (India) 2023.

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UMGE-03L: VECTOR CALCULUS LAB

Course Outcomes:

After successful completion of the course, a student will be able to:

• Apply Gauss's theorem to evaluate surface integrals and verify divergence theorems in vector fields.

• Use Stokes' theorem to relate surface integrals of curls to line integrals.

• Utilize Green's theorem to compute area integrals and understand circulation in plane regions.

• Analyse vector point functions through differentiation and integration, including divergence and curl operations.

List of Exercises

Section A:

1. Exercises on Gauss's theorem,
2. Exercises on Stoke's theorem
3. Exercises on Green's theorem

Section B:

4. Exercise on vector differentiation and integration of vector point functions.
5. Divergence and Curl of vector point function

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UMGE-04: STATISTICS-1

Course Outcomes:

On successful completion of this course, the students will have the skill and knowledge to,

• Apply descriptive statistics and estimation methods to summarize and analyze data sets.

• Understand and implement point estimation techniques such as method of moments and maximum likelihood estimation.

• Analyze sampling distributions and apply central limit theorem for interval estimation and hypothesis testing.

• Perform statistical inference including parameter estimation, correlation analysis, and hypothesis testing of means using Student's t-distribution.

Unit I

Descriptive Statistics and Estimation, Random sampling, Sample statistics.

Unit II

Point estimation, Method of moments & Maximum likelihood, Functions of random variables.

Unit III

Central limit theorem, Interval estimation of variability, Estimating the mean and Student-t distribution.

Unit IV

Hypothesis testing, Hypothesis tests on the mean, Model and parameter estimation, Correlation.

References/Books:

1. Milton, J. S. and Arnold, J. C.: Introduction to Probability and Statistics Principles and Applications for Engineering and the Computing Sciences, 4^th Edition, Tata McGraw-Hill, 2007.
2. Meyer, P. L.: Introduction to Probability & Statistics, 2^nd Edition, Oxford & IBH, 1970.
3. Ross, Sheldon M.: Introduction to Probability Models, 3^rd Edition, Elsevier, 2009.
4. Walpole, R. E., Myers, R. H., Myers, S. L., Ye, K.: Probability & Statistics for Engineers and Scientists, 8^th Edition, Pearson Education, 2007.
5. Johnson, R. A.: Miller Freund's Probability and Statistics, 7^th Edition, PHI, 2005.

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UMGE-04L: STATISTICS-1 LAB

Course Outcomes:

After successful completion of the course, a student will be able to:

- Apply descriptive statistical methods to summarize and interpret data sets.
- Perform estimation techniques to analyze population parameters using sample data.
- Demonstrate understanding of the Central Limit Theorem and its practical implications.
- Construct and interpret confidence intervals to estimate variability in data.

List of Exercises

1. Exercises on basic Descriptive Statistics and Estimation.
2. Exercises on basic Central limit theorem, Interval estimation of variability.

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UAEC-02: ENVIRONMENTAL SCIENCE AND SUSTAINABLE DEVELOPMENT-II

Course Outcomes:

After completing this course, students will be able to:

- Understand the causes and impacts of climate change on human health, biodiversity, and global economy.
- Analyse international environmental agreements and their relevance in addressing climate-related challenges.
- Assess the role of renewable energy sources in promoting sustainable development and environmental conservation.
- Evaluate the importance of environmental justice and movements in shaping national and global policies.

Unit I

Causes of Climate change, Global warming, Ozone layer depletion, and Acid rain; Impacts on human communities, biodiversity, global economy, and agriculture.

International agreements and programmes: Earth Summit, UNFCCC, Montreal and Kyoto protocols, Convention on Biological Diversity (CBD), Ramsar convention, The Chemical Weapons Convention (CWC), UNEP, CITES, etc.

Unit II

Sustainable Development Goals: India's National Action Plan on Climate Change and its major missions.

Human population growth: Impacts on environment, human health, and welfare; Carbon foot-print.

Unit III

Resettlement and rehabilitation of developmental project affected persons and communities; relevant case studies.

Environmental movements: Chipko movement, Appiko movement, Silent valley movement, Bishnois of Rajasthan, Narmada Bachao Andolan, etc.

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Unit IV

Environmental justice: National Green Tribunal and its importance.

Renewable Energy Sources: Solar Energy, Wind Energy, Hydropower, Biomass and Bioenergy, Tidal and Wave Energy, Hydrogen and Fuel Cells, Geothermal Energy.

References/ Books:

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1. Divan, S. and Rosencranz, A. Environmental Law and Policy in India: Cases, Material & Statutes.
2. Raven, P.H, Hassenzahl, D.M., Hager, M.C, Gift, N.Y. and Berg, L.R. Environment.
3. Singh, J.S., Singh, S.P. and Gupta, S.R. Ecology, Environmental Science and Conservation.

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UVAC-02: INDIAN KNOWLEDGE SYSTEM

Course Outcomes:

After successful completion of the course, a student will be able to:

- Understand the foundational concepts and scope of Indian Knowledge Systems (IKS).
- Examine the historical and cultural evolution of IKS from ancient to modern India.
- Explore the technological and scientific advancements of ancient India in fields such as aeronautics, metallurgy, and astronomy.
- Analyse archaeological and literary evidence supporting India's contributions to early science and engineering.

Unit I

Introduction to Indian Knowledge Systems (IKS): Definition, Concept and Scope of IKS, IKS-based approaches on Knowledge Paradigms, IKS in Ancient and Modern India, Genesis of the Land and Antiquity of Civilization, Traditional Knowledge System: Concept of Matter, Life and Universe.

Unit II

Scientific Thought and Technology in Ancient India: Sage Agastya's Model of Battery, Concept of Gravity and Velocity of Light, Vimāna: Aeronautics in Ancient Texts, Vedic Cosmology and Modern Concepts, Bhāratīya Kāla-gaṇanā (Indian Time Calculation).

Unit III

Astronomy and Cosmological Understanding: History and Culture of Astronomy, Sun, Earth, Moon, and Eclipses, Earth's Sphericity and Rotation, Archeoastronomy in Ancient India.

Unit IV

Material Sciences and Archaeological Insights: Laboratory Tools and Apparatus in Ancient India, Traditional Juices, Dyes, Paints, and Cements, Glass and Pottery Production, Metallurgy and Engineering in the Vedic & Post-Vedic Age Iron Pillar of Delhi, Rakhigarhi, Mehrgarh, Bet–Dwārkā Marine Technology and the Sindhu Valley Civilization.

References/Books:

1. The Knowledge System of Bhārata by Bhag Chand Chauhan.
2. Pride of India: A Glimpse of India's Scientific Heritage, edited by Pradeep Kohle
3. History of Science in India, Volume I and Volume VIII, edited by Sibaji Raha
4. India's Glorious Scientific Tradition by Suresh Soni.
5. Science and Technology in Ancient India by Debiprasad Chattopadhyaya.

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