Course Content

Programme: B. Sc (Hon's) Physics **Semester: II**

Course Name	**Electrochemistry**
Course Code	**CCS 5201**
Credit	4
Course Coordinator	Dr. Vivek Sheel & Dr. Shiwani Berry
Course Objectives	**1.** Develop fundamental understanding of electrolytic conductance and ionic mobility in solutions. **2.** Explain theoretical foundations such as Arrhenius theory, Ostwald dilution law, and Debye–Hückel theory of electrolytes. **3.** Provide knowledge of electrochemical cells, electrode potentials, and EMF measurements. **4.** Enable students to apply electrochemical principles in thermodynamic calculations (ΔG, ΔH, ΔS). **5.** Introduce practical electrochemical techniques such as conductometric and potentiometric titrations and pH determination.
Course Outcome (Cos)	After successful completion of this course, students will be able to: **CO1:** Explain conductivity, molar conductivity, ionic mobility, and transference number with experimental methods (Hittorf and moving boundary). **CO2:** Apply conductance measurements to determine degree of ionization, solubility product, hydrolysis constant and ionic product of water. **CO3:** Describe electrochemical cells, types of electrodes, electrochemical series, and calculate EMF of cells. **CO4:** Apply thermodynamic relations to calculate ΔG, ΔH, ΔS and equilibrium constant using EMF data. **CO5:** Use Nernst equation for electrode potential calculations and explain irreversible electrode processes such as polarization and overvoltage. **CO6:** Perform calculations related to potentiometric titrations and pH determination using hydrogen and quinhydrone electrodes.
Attendance	Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.
Evaluation Criteria	1. Mid Term Examination: 40 2. End Term Examination: 120 3. Continuous Internal Assessment: 40

Course contents:

Unit I

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility.

Unit II

Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base). Arrhenius Theory of Ionization. Factors affecting the degree of dissociation. Ostwald dilution law. Debye- Huckel Theory, Debye- Huckel Onsager equation.

Unit III

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Types of electrodes. Standard electrode potential. Electrochemical series. Applications of electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.

Unit IV

Nernst equation and its importance Calculation of equilibrium constant from EMF data. Irreversible electrode processes: Polarization, overpotential, decomposition potential, discharge potential, Hydrogen and oxygen overvoltage. Potentiometric titrations. pH determination using hydrogen electrode and quinhydrone electrode.

SUGGESTED BOOKS:

1. **B.R. Puri, L.R. Sharma & M.S. Pathania**, *Principles of Physical Chemistry*, Vishal Publishing Co..
2. **K.L. Kapoor**, *A Textbook of Physical Chemistry (Vol. III)*, Macmillan Publishers India.
3. **Gurdeep Raj**, *Advanced Physical Chemistry*, Goel Publishing House.
4. **R.C. Mukherjee**, *Physical Chemistry*, New Central Book Agency.
5. **P.W. Atkins & J. de Paula**, *Atkins' Physical Chemistry*, Oxford University Press.
6. **I.N. Levine**, *Physical Chemistry*, McGraw-Hill Education.
7. **S. Glasstone**, *An Introduction to Electrochemistry*, East-West Press.
8. **A.J. Bard & L.R. Faulkner**, *Electrochemical Methods: Fundamentals and Applications*, Wiley.

Mathematical Physics II

Course Code: PAS 5202 Course Type: Major
Credit: 04

Course Objectives: Mathematical physics and basic mathematics is an essential tool required for understanding physics. The main objective of the course is Introduce some techniques of ordinary differential equations Solve ordinary differential equations with constant and variable coefficients.
Solve partial differential equations arising in various topics of physics.

Learning Outcome: The student shall be able to Solve differential equation of various types arising in physics and mathematics. Develop techniques to solve complicated equations using the series solution method. Understand the importance of Fourier spaces and analyse functions accordingly.
Solve equations of mathematical physics in various coordinate systems.

Course Contents

Unit 1: Fourier expansion of functions Fourier Series: Periodic functions.
Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only).Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Even and odd functions and their Fourier expansions. Application, Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

(14 Lectures)

Unit 2: Differential equations with constant coefficients:
First Order Differential Equations and Integrating Factor. Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution.Statement of existence and Uniqueness Theorem for Initial Value Problems.Particular Integral.

(10 Lectures)

Unit 3: Frobenius Method and Special Functions:
Singular Points of Second Order Linear Differential Equations and their importance.Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality, Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality. (24 Lectures)

Unit 4: Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes.

(12 Lectures)

Text books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematical Physics by H. K. Dass, 2003 S Chand.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
- Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books
- Mathematical Physics by M. Das, P. K. Jena and B. K. Dash (2/e) 2006, Shrikrishna Prakashan.

Reference Books:

- Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press.
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India
- Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.

अनुलग्रक-ख

Course Content

Course Code: PAS 5203 **Course Name:** Nuclear Radiations and Safety

Credit: 2 **Course Coordinator:** Dr. Dalip Singh Verma

Objectives of the Course: The main aim of this course is to make you aware and understand the radiation hazards and safety.

Course Learning Outcome: After successful completion of this course one is able to understand the proper operating conditions of the nuclear radiation devices to prevent accidents or mitigate accident consequences, resulting in protection of radiation workers and public in general from undue radiation hazards. It enable us how to adhere to the approved operating and maintenance procedures.

Attendance: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:

1. Continuous Internal Assessment: 20%
2. Mid Term Examination: 20%
3. End Term Examination: 60%

Course contents:

UNIT - I: Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission. **(7 hours)**

UNIT - II: Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photoelectric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles-Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons-Collision, slowing down and Moderation. **(7 hours)**

UNIT - III: Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetery. **(10 hours)**

UNIT – IV: Radiation safety management: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management. **(6 hours)**

SUGGESTED BOOKS:

1. Introductory Nuclear Physics by Kenneth S. Krane
2. Elements of nuclear physics by Walter E. Meyerhof
3. Introduction To Radiological Physics And Radiation Dosimetry, by FRANK HERBERT Attlx

Reference Books:

1. Radiation Detection and Measurement by Glenn F. Knoll

Course Content

Course Code: **PAS 5201** **Course Name:** **Electricity and Magnetism**

Credit: 4 **Course Coordinator: Dr. D. S. Verma**

Objectives of the Course: The course aims to develop a comprehensive understanding of vector analysis and its application to classical electromagnetism. It seeks to build strong conceptual foundations in electrostatics, magnetostatics, electromagnetic induction, and Maxwell’s theory of electromagnetic fields. The course is designed to enable students to understand and apply fundamental principles such as Gauss's law, Biot-Savart law, Faraday's laws of electromagnetic induction, and Maxwell's equations in analyzing electric and magnetic fields in vacuum and material media. It further aims to cultivate analytical skills for solving field-related problems and to provide a theoretical foundation for advanced studies in physics and related disciplines.

Course Learning Outcome: Upon successful completion of the course, students will be able to apply vector algebra and vector calculus techniques to physical problems involving scalar and vector fields. They will be capable of analyzing electric and magnetic fields arising from various charge and current distributions, calculating electric potential, capacitance, and field energy, and explaining the behaviour of dielectric and magnetic materials. Students will understand electromagnetic induction, self and mutual inductance, and the conservation of charge through the continuity equation. They will be able to derive and interpret Maxwell’s equations and explain the propagation, transverse nature, and polarization of electromagnetic waves in vacuum and isotropic dielectric media, thereby demonstrating a coherent understanding of classical electromagnetic theory.

Attendance: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:

1. Continuous Internal Assessment: 20%
2. Mid Term Examination: 20%
3. End Term Examination: 60%

Course contents:

UNIT - I: Vector Analysis: Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only). **(12 Lectures)**

UNIT - II: Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric. **(22 Lectures)**

UNIT - III: Magnetism: Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials. **(10 Lectures)**

UNIT – IV: Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **(6 Lectures)**

UNIT – IV: Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization. **(10 Lectures)**

SUGGESTED BOOKS:

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
2. Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.