

DEPARTMENT OF PHYSICS

BSc. (Hons.) Physics

Category-I

DISCIPLINE SPECIFIC CORE COURSE – 1 (DSC-1) Mathematical Physics I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Mathematical Physics I	4	3	0	1	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

The emphasis of the course is on applications in solving problems of interest to physicists. The course will teach the students to model a physics problem mathematically and then solve those numerically using computational methods. The course will expose the students to fundamental computational physics skills enabling them to solve a wide range of physics problems. The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

Learning Outcomes

After completing this course, student will be able to,

- Draw and interpret graphs of various elementary functions and their combinations.
- Understand the vector quantities as entities with Cartesian components which satisfy appropriate rules of transformation under rotation of the axes.
- Use index notation to write the product of vectors in compact form easily applicable in computational work.
- Solve first and second order differential equations and apply these to physics problems.
- Understand the functions of more than one variable and concept of partial derivatives.
- Understand the concept of scalar field, vector field, gradient of scalar field and divergence and curl of vector fields.
- Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's theorems to compute these integrals and apply these to physics problems
- Understand the properties of discrete and continuous distribution functions.

In the laboratory course, the students will learn to,

- Prepare algorithms and flowcharts for solving a problem.
- Design, code and test simple programs in Python/C++ to solve various problems.

- Perform various operations of 1-d and 2-d arrays.
- Visualize data and functions graphically using Matplotlib/Gnuplot

SYLLABUS OF DSC – 1

THEORY COMPONENT

Unit 1 (18 Hours)

Functions: Plotting elementary functions and their combinations, Interpreting graphs of functions using the concepts of calculus, Taylor's series expansion for elementary functions.

Ordinary Differential Equations: First order differential equations of degree one and those reducible to this form, Exact and Inexact equations, Integrating Factor, Applications to physics problems

Higher order linear homogeneous differential equations with constant coefficients, Wronskian and linearly independent functions. Non-homogeneous second order linear differential equations with constant coefficients, complimentary function, particular integral and general solution, Determination of particular integral using method of undetermined coefficients and method of variation of parameters, Cauchy-Euler equation, Initial value problems. Applications to physics problems

Unit 2 (12 Hours)

Vector Algebra: Transformation of Cartesian components of vectors under rotation of the axes, Introduction to index notation and summation convention. Product of vectors - scalar and vector product of two, three and four vectors in index notation using δ_{ij} and ϵ_{ijk} (as symbols only – no rigorous proof of properties). Invariance of scalar product under rotation transformation.

Vector Differential Calculus: Functions of more than one variable, Partial derivatives, chain rule for partial derivatives. Scalar and vector fields, concept of directional derivative, the vector differential operator $\vec{\nabla}$, gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field and their physical interpretation. Laplacian operator. Vector identities.

Unit 3 (15 Hours)

Vector Integral Calculus: Integrals of vector-valued functions of single scalar variable. Multiple integrals, Jacobian, Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of vector fields. Flux of a vector field. Gauss divergence theorem, Green's and Stokes' Theorems (no proofs) and their applications

Probability D istributions: Discrete and continuous random variables, Probability distribution functions, Binomial, Poisson and Gaussian distributions, Mean and variance of these distributions.

PRACTICAL COMPONENT
Hours)

(30

The aim of this lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics. The course will consist of practical sessions and lectures on the related theoretical aspects of the laboratory. Assessment is to be done not only on the programming but also on the basis of formulating the problem.

- Every student must perform at least 6 programs covering each unit.
- The list of recommended programs is suggestive only. Students should be encouraged to do more practice. Emphasis should be given to assess student's ability to formulate a physics problem as mathematical one and solve by computational methods.
- The implementation can be either in Python or C++. Accordingly, the instructor can choose section A or B respectively from Unit 1 and 2. The list of programs is common for both sections. If C++ is used, then for all plotting programs, Gnuplot has to be used.

Basics of scientific computing (Mandatory):

- (a) Binary and decimal arithmetic, Floating point numbers, single and double precision arithmetic, underflow and overflow, numerical errors of elementary floating point operations, round off and truncation errors with examples.
- (b) Introduction to Algorithms and Flow charts. Branching with examples of conditional statements, for and while loops.

Unit 1

Section A:

Basic Elements of Python: The Python interpreter, the print statement, comments, Python as simple calculator, objects and expressions, variables (numeric, character and sequence types) and assignments, mathematical operators. Strings, Lists, Tuples and Dictionaries, type conversions, input statement, list methods. List mutability, Formatting in the print statement.

Control Structures: Conditional operations, if, if-else, if-elif-else, while and for loops, indentation, break and continue, List comprehension. Simple programs for practice like solving quadratic equations, temperature conversion etc.

Functions: Inbuilt functions, user-defined functions, local and global variables, passing functions, modules, importing modules, math module, making new modules. Writing functions to perform simple operations like finding largest of three numbers, listing prime numbers, etc., Generating pseudo random numbers.

OR

Section B:

Introduction to C++: Basic idea of Compilers. Structured programming. Idea of Headers, Data Types, Enumerated Data, Conversion and casting, constants and variables, Mathematical, Relational, Logical and Bit wise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables. Input and output statements. I/O

manipulations, iostream and cmath header files, using namespace.

Control Statements: The if-statement, if-else statement, Nested if Structure, If - Else if – else block, Ternary operator, Goto statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, For loop, nested loops, break and continue statements. Simple programs for practice like solving quadratic equations, temperature conversion etc.

Functions: Inbuilt functions. User-defined functions, function declaration, function definition, function prototype, void functions and function arguments, return statement. Local and global variables. The main function. Passing parameter by value and by reference. Inline functions. Function overloading. Writing functions to perform simple operations like finding largest of three numbers, listing prime numbers etc., Generating pseudo random numbers.

Recommended List of Programs (At least Two)

- (a) Make a function that takes a number N as input and returns the value of factorial of N. Use this function to print the number of ways a set of m red and n blue balls can be arranged.
- (b) Generate random numbers (integers and floats) in a given range and calculate area and volume of regular shapes with random dimensions.
- (c) Generate data for coordinates of a projectile and plot the trajectory. Determine the range, maximum height and time of flight for a projectile motion.

Unit 2

Section A:

NumPy Fundamentals: Importing Numpy, Difference between List and NumPy array, Adding, removing and sorting elements, creating arrays using ones(), zeros(), random(), arange(), linspace(). Basic array operations (sum, max, min, mean, variance), 2-d arrays, matrix operations, reshaping and transposing arrays, savetxt() and loadtxt().

Plotting with Matplotlib: matplotlib.pyplot functions, Plotting of functions given in closed form as well as in the form of discrete data and making histograms.

OR

Section B:

Arrays: Array definition, passing arrays to functions, Finding sum, maximum, minimum, mean and variance of given array. 2-d arrays, matrix operations (sum, product, transpose etc). Saving data generated by a C++ program in a file.

Gnuplot: Introduction to Gnuplot. Visualization of discrete data and plotting functions given in closed form and data for graphical visualization. Plotting data from the output file created by a C++ program, making histogram.

Recommended List of Programs (At least Three)

- (a) To plot the displacement-time and velocity-time graph for the un-damped, under-damped

critically damped and over-damped oscillator using matplotlib (or Gnuplot) using given formulae.

- (b) To compute the left, right and central approximations for derivative of a function given in closed form. Plot both the function and derivative on the same graph. Plot (using matplotlib/Gnuplot) the error as a function of step size on a log-log graph, study the behaviour of the plot as step size decreases and hence discuss the effect of round off error.
- (c) To generate array of N random numbers drawn from a given distribution (uniform, binomial, poisson and gaussian) and plot them using matplotlib/Gnuplot for increasing N to verify the distribution. Verify the central limit theorem.
- (d) To implement the transformation of physical observables under Galilean, Lorentz and Rotation transformation

Unit 3

Recommended List of Programs (At least one)

- (a) To find value of π and to integrate a given function using acceptance-rejection method.
- (b) To perform linear fitting of data using the inbuilt function `scipy.stats.linregress` in Python or using Gnuplot. Plot the data points and the fitted line on the same graph.

References (for Laboratory Work):

- 1) Documentation at the Python home page (<https://docs.python.org/3/>) and the tutorials there (<https://docs.python.org/3/tutorial/>).
- 2) Documentation of NumPy and Matplotlib : <https://numpy.org/doc/stable/user/> and <https://matplotlib.org/stable/tutorials/>
- 3) Schaum's Outline of Programming with C++, J. Hubbard, 2000, McGraw-Hill Education.
- 4) C++ How to Program, Paul J. Deitel and Harvey Deitel, Pearson (2016).
- 5) Computational Physics, Darren Walker, 1st Edn., Scientific International Pvt. Ltd (2015).
- 6) Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
- 7) An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).
- 8) Introduction to Numerical Analysis, S. S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- 9) Applied numerical analysis, Cutis F. Gerald and P. O. Wheatley, Pearson Education, India (2007).

Essential/Recommended Readings

REFERENCES FOR THEORY COMPONENT

- 1) An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning.
- 2) Differential Equations, George F. Simmons, 2007, McGraw Hill.
- 3) Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book.
- 4) Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning.

- 5) Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- 6) Probability and Statistics, Murray R Spiegel, John J Schiller and R Alu Srinivasan, 2018, McGraw Hill Education Private Limited.
- 7) Essential Mathematical Methods, K.F.Riley and M.P.Hobson, 2011, Cambridge Univ. Press.
- 8) Vector Analysis and Cartesian Tensors, D.E. Bourne and P.C. Kendall, 3 Ed. , 2017, CRC Press.
- 9) Vector Analysis, Murray Spiegel, 2 Ed., 2017, Schaum's outlines series.
- 10) John E. Freund's Mathematical Statistics with Applications, I. Miller and M. Miller, 7th Ed., 2003, Pearson Education, Asia.

.Suggestive readings:

- 1) Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 7 Ed., 2013, Elsevier.
- 2) Introduction to Electrodynamics, Chapter 1, David J. Griffiths, 4 Ed., 2017, Cambridge University Press.
- 3) The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, 2008, Narosa Publishing House.
- 4) Introduction to Vector Analysis, Davis and Snider, 6 Ed., 1990, McGraw Hill.
- 5) Differential Equations, R. Bronson and G.B. Costa, Schaum's outline series.
- 6) Mathematical Physics, A.K. Ghatak, I.C. Goyal and S.J. Chua, Laxmi Publications Private Limited (2017)
- 7) Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC - 2) MECHANICS

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Mechanics DSC – 2	4	3	0	1	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. The students will learn the collisions in the centre of mass frame, rotational motion and central forces. They will be able to apply the concepts learnt to several real world problems. In the laboratory part of the course, the students will learn to use various instruments, estimate the error for

every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.

Learning 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.

SYLLABUS OF DSC- 2

THEORY COMPONENT

Unit 1: (14 Hours)

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 between two spherical bodies. Kinematics of 2 → 2 scattering in centre of mass and laboratory frames.

Unit 2: (12 Hours)

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 3: (7 Hours)

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 the Kepler Problem, Kepler's Laws for planetary motion, orbit for artificial satellites

Unit 4: (12 Hours)

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.

PRACTICAL COMPONENT (30 Hours)

Introductory Concepts and related activities (Mandatory)

• **Use of Basic Instruments**

Determination of least count and use of instruments like meter scale, vernier callipers, screw gauge and travelling microscope for measuring lengths.

• **Errors**

(a) Types of errors in measurements (instrumental limitations, systematic errors and random errors), accuracy and precision of observations, significant figures.

(b) Introduction to error estimation, propagation of errors and reporting of results along with uncertainties with correct number of significant figures.

(c) Statistical analysis of random errors, need for making multiple observations, standard error in the mean as estimate of the error.

• **Graph Plotting**

Pictorial visualisation of relation between two physical quantities, Points to be kept in mind while plotting a graph manually.

• **Data Analysis**

Principle of least square fitting (LSF) and its application in plotting linear relations, estimation of LSF values of slope, intercept and uncertainties in slope and intercept.

Mandatory Activities

• Determine the least count of meter scale, vernier callipers, screw gauge and travelling microscope, use these instruments to measure the length of various objects multiple time, find the mean and report the result along with the uncertainty up to appropriate number of significant digits.

• Take multiple observations of the quantities like length, radius etc. for some spherical, cylindrical and cubic objects, find mean of these observations and use them to

determine the surface area and volume of these objects. Estimate the uncertainties in the outcome using law of propagation of errors. Report the result to appropriate number of significant figures.

- Given a data (x, y) corresponding to quantities x and y related by a relation $y = f(x)$ that can be linearised, plot the data points (manually) with appropriate choice of scale, perform least square fitting to determine the slope and intercept of the LSF line and use them to determine some unknown quantity in the relation. Determine the uncertainties in slope and intercept and use these to estimate the uncertainty in the value of unknown quantity.

Every student must perform at least 4 experiments from the following list.

- 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.

Suggested additional activities:

- 1) Virtual lab collision experiments on two dimensional elastic and inelastic collisions (for example available on following suggested links
 - a) <https://archive.cnx.org/specials/2c7acb3c-2fbd-11e5-b2d9-e7f92291703c/collision-lab/#sim-advanced-sim>
 - b) <https://phet.colorado.edu/en/simulations/collision-lab>
- 2) Amrita Virtual Mechanics Lab: <https://vlab.amrita.edu/?sub=1&brch=74>

References (for Laboratory Work):

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worshnop, 1971, Asia Publishing House.
- 2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- 3) Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
- 4) A Text Book of Practical Physics, Vol I, Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
- 5) An introduction to Error Analysis: The study of uncertainties in Physical Measurements, J.

R. Taylor, 1997, University Science Books

Essential readings:

FOR THEORY COMPONENT

- 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) Classical Mechanics by Peter Dourmashkin, 2013, John Wiley and Sons.
- 4) Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, 1977, McGraw Hill Education.
- 5) Introduction to Classical Mechanics With Problems and Solutions, David Morin, 2008, Cambridge University Press.
- 6) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
- 7) Introduction to Special Relativity, Robert Resnick, 2007, Wiley.

Suggestive Link:

[https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_\(Dourmashkin\)/](https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_(Dourmashkin)/)

Suggestive readings:

- 1) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- 2) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
- 3) Classical Mechanics, H. Goldstein, C. P. Poole, J. L. Safko, 3/e, 2002, Pearson Education.
- 4) Newtonian Mechanics, A.P. French, 2017, Viva Books.

DISCIPLINE SPECIFIC CORE COURSE– 3 (DSC – 3) WAVES AND OSCILLATIONS

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Waves and Oscillations DSC – 3	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

This course reviews the concepts of waves and oscillations learnt at school from a more advanced perspective and goes on to build new concepts. It begins with explaining ideas of free oscillations and superposition of harmonic motion leading to physics of damped and forced oscillations. The course will also introduce students to coupled oscillators, normal

modes of oscillations and free vibrations of stretched strings. Concurrently, in the laboratory component of the course students will perform experiments that expose them to different aspects of real oscillatory systems.

Learning Outcomes

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

- Understand simple harmonic motion
- Understand superposition of N collinear harmonic oscillations
- Understand superposition of two perpendicular harmonic oscillations
- Understand free, damped and forced oscillations
- Understand coupled oscillators and normal modes of oscillations
- Understand travelling and standing waves, stretched strings

SYLLABUS OF DSC – 3

THEORY COMPONENT

Unit 1: Simple Harmonic Motion (12 Hours)

Differential equation of simple harmonic oscillator, its solution and characteristics, energy in simple harmonic motion, linearity and superposition principle, rotating vector representation of simple harmonic oscillation, motion of simple and compound pendulum (Bar and Kater's pendulum), loaded spring.

Superposition of N collinear harmonic oscillations with (1) equal phase differences and (2) equal frequency differences, Beats

Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies, effect of variation of phase

Unit 2: Damped and Forced Oscillations (8 Hours)

Damped Oscillations: Equation of motion, dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor

Forced Oscillations: Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, power dissipation, quality factor

Unit 3: Coupled Oscillations (6 Hours)

Coupled oscillators, normal coordinates and normal modes, energy relation and energy transfer, di-atomic molecules, representation of a general solution as a linear sum of normal modes, normal modes of N coupled oscillators.

Unit 4: Wave Motion (4 Hours)

One dimensional plane wave, classical wave equation, standing wave on a stretched string (both ends fixed), normal modes. Travelling wave solution

PRACTICAL COMPONENT (60 Hours)

Every student must perform at least 5 experiments

- 1) Experiments using bar pendulum:
 - a) Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM.
 - b) Determine the value of g using bar pendulum.
 - c) To study damped oscillations using bar pendulum
 - d) Study the effect of area of the damper on damped oscillations. Plot amplitude as a function of time and determine the damping coefficient and Q factor for different dampers.
- 2) To determine the value of acceleration due to gravity using Kater's pendulum for both the cases (a) $T_1 \approx T_2$ and (b) $T_1 \neq T_2$ and discuss the relative merits of both cases by estimation of error in the two cases.
- 3) Understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO. And study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures)
- 4) Experiments with spring and mass system
 - a) To calculate g , spring constant and mass of a spring using static and dynamic methods.
 - b) To calculate spring constant of series and parallel combination of two springs.
- 5) To study normal modes and beats in coupled pendulums or coupled springs.
- 6) To determine the frequency of an electrically maintained tuning fork by Melde's experiment and to verify $\lambda^2 - T$ Law.
- 7) To determine the current amplitude and phase response of a driven series LCR circuit with driving frequency and resistance. Draw resonance curves and find quality factor for low and high damping.

References (For Laboratory Work):

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
 - 2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
 - 3) Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
 - 4) A Text Book of Practical Physics, Vol I and II, Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
 - 5) An Introduction to Error Analysis: The study of uncertainties in Physical Measurements, J. R. Taylor, 1997, University Science Books
- List of experiments

Essential Readings:

FOR THEORY COMPONENT

- 1) Vibrations and Waves by A. P. French. (CBS Pub. and Dist., 1987)

- 2) The Physics of Waves and Oscillations by N.K. Bajaj (Tata McGraw-Hill, 1988)
- 3) Fundamentals of Waves and Oscillations By K. Uno Ingard (Cambridge University Press, 1988)
- 4) An Introduction to Mechanics by Daniel Kleppner, Robert J. Kolenkow (McGraw-Hill, 1973)
- 5) Waves: BERKELEY PHYSICS COURSE by Franks Crawford (Tata McGrawHill, 2007).
- 6) Classical Mechanics by Peter Dourmashkin, John Wiley and Sons
- 7) [https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_\(Dourmashkin\)](https://phys.libretexts.org/Bookshelves/Classical_Mechanics/classical_Mechanics_(Dourmashkin))

Suggestive Readings:

- 1) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
- 2) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- 3) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.

BSc. Physical Sciences

Multidisciplinary

DISCIPLINE SPECIFIC CORE COURSE – 1 (PHYSICS DSC - 1) MECHANICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Mechanics Physics DSC 1	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with dynamics of a system of particles and ends with the special theory of relativity. Students will appreciate the concept of rotational motion, gravitation and oscillations. The students will be able to apply the concepts learnt to several real world problems.

Learning outcomes:

Upon completion of this course, students are expected to understand the following concepts.

- Laws of motion and their application to various dynamical situations.
- Conservation of momentum, angular momentum and energy. Their application to basic problems.
- Particle collision (elastic and in-elastic collisions)
- Motion of simple pendulum
- Postulates of special theory of relativity, inertial and non-inertial frame of reference and their transformation, relativistic effects on the mass and energy of a moving body.

In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, vernier calliper and travelling microscope) student shall embark on verifying various principles and associated measurable quantities.

SYLLABUS OF PHYSICS DSC – 1

THEORY COMPONENT

Unit 1: Review of vectors and ordinary differential equation (4 Hours)

Gradient of a scalar field, divergence and curl of vectors field, polar and axial vectors
Second order homogeneous ordinary differential equations with constant coefficients
(Operator Method Only).

Unit 2: Fundamentals of Dynamics (7 Hours)

Dynamics of a system of particles, centre of mass, determination of centre of mass for discrete and continuous systems having spherical symmetry
Conservation of momentum and energy, Conservative and non-Conservative forces, work – energy theorem for conservative forces, force as a gradient of potential energy.
Particle collision (Elastic and in-elastic collisions)

Unit 3: Rotational Dynamics and Oscillatory Motion (8 Hours)

Angular momentum, torque, conservation of angular momentum, Moment of inertia, Theorem of parallel and perpendicular axes (statements only). Calculation of moment of inertia of discrete and continuous objects (1-D and 2-D).
Idea of simple harmonic motion, differential equation of simple harmonic motion and its solution, Motion of simple pendulum, damped harmonic oscillator

Unit 4: Gravitation (3 Hours)

Newton's Law of Gravitation, Motion of a particle in a central force field, Kepler's Laws (statements only)

Unit 5: Special Theory of Relativity (8 Hours)

Frames of reference, Galilean transformations, inertial and non-inertial frames, Michelson Morley's Experiment, postulates of special theory of relativity, length contraction, time dilation, relativistic transformation of velocity, relativistic variation of mass.

References:

Essential Readings:

- 1) Vector Analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2nd Edn., 2009, McGraw- Hill Education.
- 2) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
- 3) Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education
- 4) Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.
- 5) Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.

Additional Readings:

- 1) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- 2) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- 3) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
- 4) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
- 5) Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.
- 6) Physics for Scientists and Engineers, Randall D Knight, 3/e, 2016, Pearson Education.

PRACTICAL COMPONENT (60 Hours)

The teacher is expected to give basic idea and working of various apparatus and instruments related to different experiments. Students should also be given knowledge of recording and analysing experimental data.

Every student should perform at least 06 experiments from the following list.

- 1) Measurement of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
- 2) Study the random error in observations.
- 3) Determination of height of a building using a sextant.
- 4) Study of motion of the spring and calculate (a) spring constant and, (b) acceleration due to gravity
- 5) Determination of moment of inertia of a flywheel.
- 6) Determination of g and velocity for a freely falling body using digital timing technique.
- 7) Determination of modulus of rigidity of a wire using Maxwell's needle.
- 8) Determination of elastic constants of a wire by Searle's method.
- 9) Determination of value of g using bar pendulum.
- 10) Determination of value of g using Kater's pendulum.

References (for Laboratory Work):

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- 2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- 3) Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
- 4) A Textbook of Practical Physics, I. Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
- 5) B. Sc. Practical Physics, Geeta Sanon, R. Chand and Co., 2016.

BSc. Physical Sciences with Electronics

Multidisciplinary

DISCIPLINE SPECIFIC CORE COURSE – 1 (PHYSICS DSC - 1) MECHANICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Mechanics Physics DSC 1	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with dynamics of a system of particles and ends with the special theory of relativity. Students will appreciate the concept of rotational motion, gravitation and oscillations. The students will be able to apply the concepts learnt to several real world problems.

Learning Outcomes

Upon completion of this course, students are expected to understand the following concepts.

- Laws of motion and their application to various dynamical situations.
- Conservation of momentum, angular momentum and energy. Their application to basic problems.
- Particle collision (elastic and in-elastic collisions)
- Motion of simple pendulum
- Postulates of special theory of relativity, inertial and non-inertial frame of reference and their transformation, relativistic effects on the mass and energy of a moving body.

In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, vernier calliper and travelling microscope) student shall embark on verifying various principles and associated measurable quantities.

SYLLABUS OF PHYSICS DSC-1

THEORY COMPONENT

Unit 1: Review of vectors and ordinary differential equation (04 Hours)

Gradient of a scalar field, divergence and curl of vectors field, polar and axial vectors
Second order homogeneous ordinary differential equations with constant coefficients (Operator Method Only).

Unit 2: Fundamentals of Dynamics (07 Hours)

Dynamics of a system of particles, centre of mass, determination of centre of mass for discrete and continuous systems having spherical symmetry
Conservation of momentum and energy, Conservative and non-Conservative forces, work – energy theorem for conservative forces, force as a gradient of potential energy.
Particle collision (Elastic and in-elastic collisions)

Unit 3: Rotational Dynamics and Oscillatory Motion (08 Hours)

Angular momentum, torque, conservation of angular momentum, Moment of inertia, Theorem of parallel and perpendicular axes (statements only). Calculation of moment of inertia of discrete and continuous objects (1-D and 2-D).
Idea of simple harmonic motion, differential equation of simple harmonic motion and its solution, Motion of simple pendulum, damped harmonic oscillator

Unit 4: Gravitation (03 Hours)

Newton's Law of Gravitation, Motion of a particle in a central force field, Kepler's Laws (statements only)

Unit 5: Special Theory of Relativity (08 Hours)

Frames of reference, Galilean transformations, inertial and non-inertial frames, Michelson Morley's Experiment, postulates of special theory of relativity, length contraction, time dilation, relativistic transformation of velocity, relativistic variation of mass.

References:

Essential Readings:

- 1) Vector Analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2nd Edn., 2009, McGraw- Hill Education.
- 2) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
- 3) Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education
- 4) Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.
- 5) Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.

Additional Readings:

- 1) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- 2) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- 3) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
- 4) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
- 5) Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.
- 6) Physics for Scientists and Engineers, Randall D Knight, 3/e, 2016, Pearson Education.

PRACTICAL COMPONENT (60 Hours)

The teacher is expected to give basic idea and working of various apparatus and instruments related to different experiments. Students should also be given knowledge of recording and analysing experimental data.

Every student should perform at least 06 experiments from the following list.

- 1) Measurement of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
- 2) Study the random error in observations.
- 3) Determination of height of a building using a sextant.
- 4) Study of motion of the spring and calculate (a) spring constant and, (b) acceleration due to gravity
- 5) Determination of moment of inertia of a flywheel.
- 6) Determination of g and velocity for a freely falling body using digital timing technique.
- 7) Determination of modulus of rigidity of a wire using Maxwell's needle.
- 8) Determination of elastic constants of a wire by Searle's method.
- 9) Determination of value of g using bar pendulum.
- 10) Determination of value of g using Kater's pendulum.

References (for Laboratory Work):

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- 2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- 3) Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
- 4) A Textbook of Practical Physics, I. Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
- 5) B. Sc. Practical Physics, Geeta Sanon, R. Chand and Co., 2016.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC - 2) Network Analysis and Analog Electronics

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Network Analysis and Analog Electronics Physics DSC 2	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

This course offers the basic knowledge to students to design and analyse the network circuit analysis and analog electronics. It gives the concept of voltage, current sources and various electrical network theorems, physics of semiconductor devices including junction diode, bipolar junction transistors, unipolar devices and their applications are discussed in detail. This also develops the understanding of amplifier and its applications.

Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes.

- To understand the concept of voltage and current sources, Network theorems, Mesh Analysis.
- To develop an understanding of the basic operation and characteristics of different type of diodes and familiarity with its working and applications.
- Become familiar with Half-wave, Full-wave centre tapped and bridge rectifiers. To be able to calculate ripple factor and efficiency.
- To be able to recognize and explain the characteristics of a PNP or NPN transistor.
- Become familiar with the load-line analysis of the BJT configurations and understand the hybrid model (h- parameters) of the BJT transistors.
- To be able to perform small signal analysis of Amplifier and understand its classification.
- To be able to perform analysis of two stage R-C coupled Amplifier.
- To understand the concept of positive and negative feedback along with applications in case of oscillators.
- To become familiar with construction, working and characteristics of JFET and UJT.

SYLLABUS OF PHYSICS DSC – 2

THEORY COMPONENT

Unit 1: (8 Hours)

Circuit Analysis: Concept of Voltage and Current Sources (ideal and practical). Kirchhoff's Laws. Mesh Analysis, Node Analysis. Star and Delta networks and their Conversion. Superposition Theorem. Thevenin's Theorem. Norton's Theorem. Reciprocity Theorem. Maximum Power Transfer Theorem.

Unit 2: (5 Hours)

Semiconductor Diode: PN junction diode (Ideal and practical), Diode equation (Qualitative only) and I-V characteristics. Idea of static and dynamic resistance, Zener diode working. Rectifiers: Half wave rectifier (Qualitative only), Full wave rectifiers (center tapped and bridge): circuit diagrams, working and waveforms, ripple factor and efficiency.

Filter circuits: Shunt capacitance and series Inductance filter (no derivation).

Regulation: Zener diode as voltage regulator for load and line regulation.

Unit 3: (7 Hours)

Bipolar Junction Transistor: Review of the characteristics of transistor in CE and CB configurations, Regions of operation (active, cut off and saturation), Current gains α and β . Relations between α and β . dc load line and Q point.

Amplifiers: Transistor biasing and Stabilization circuits - Voltage Divider Bias. Thermal runaway, stability (Qualitative only). Transistor as a two-port network, h-parameter equivalent circuit. Small signal analysis of single stage CE amplifier. Input and Output impedance, Current and Voltage gains. Class A, B and C Amplifiers.

Unit 4: (10 Hours)

Cascaded Amplifiers: Two stage RC Coupled Amplifier and its frequency response. Sinusoidal Oscillators: Concept of feedback (negative and positive feedback), Barkhausen criterion for sustained oscillations. Phase shift and Colpitt's oscillator. Determination of frequency and condition of oscillation
Unipolar Devices: JFET. Construction, working and I-V characteristics (output and transfer), Pinch-off voltage. UJT, basic construction, working, equivalent circuit and I-V characteristics. UJT Oscillator.

References:

Essential Readings:

- 1) Network, Lines and Fields, J. D. Ryder, Prentice Hall of India
- 2) Integrated Electronics, J. Millman and C.C. Halkias, Tata McGraw Hill (2001)
- 3) Electric Circuits, S. A. Nasar, Schaum Outline Series, Tata McGraw Hill (2004)
- 4) Electric Circuits, K.A. Smith and R. E. Alley, Cambridge University Press(2014)
- 5) 2000 Solved Problems in Electronics, J. J. Cathey, Schaum Outline Series, Tata McGraw Hill (1991)

Additional Readings:

- 1) Microelectronic Circuit, A. S. Sedra, K.C. Smith, A. N. Chandorkar, 6th Edition (2014), Oxford University Press
- 2) Electronic Circuits: Discrete and Integrated, D. L. Schilling and C. Belove, Tata McGraw Hill.
- 3) Electronic Devices and Circuits, David A. Bell, 5th Edition 2015, Oxford University Press.
- 4) Electrical Circuits, M. Nahvi and J. Edminister, Schaum Outline Series, Tata McGraw Hill (2005)

PRACTICAL COMPONENT (60 Hours)

At least 06 experiments from the following.

- 1) To familiarize with basic electronic components (R, L, C, diodes, transistors), digital Multimeter, Function Generator and Oscilloscope
- 2) Verification of
 - a. Thevenin's theorem and
 - b. Norton's theorem.
- 3) Verification of
 - a. Superposition Theorem and
 - b. Reciprocity Theorem
- 4) Verification of the Maximum Power Transfer Theorem.
- 5) Study of the I-V Characteristics of
 - a. p-n junction Diode, and
 - b. Zener diode.

- 6) Study of
 - a. Half wave rectifier and
 - b. Full wave rectifier (FWR).
- 7) Study the effect of
 - a. C- filter and L- filter and
 - b. Zener regulator.
- 8) Study of the I-V Characteristics of UJT and design relaxation oscillator.
- 9) Study of the output and transfer I-V characteristics of common source JFET.
- 10) Study of Voltage divider bias configuration for CE transistor.
- 11) Design of a Single Stage CE amplifier of given gain.
- 12) Study of the RC Phase Shift Oscillator.

References (For Laboratory Work):

- 1) Electronic Devices and Circuits, Allen Mottershead, Goodyear Publishing Corporation.
- 2) Electrical Circuits, M. Nahvi and J. Edminister, Schaum Outline Series, Tata McGraw Hill (2005)
- 3) Network, Lines and Fields, J. D. Ryder, Prentice Hall of India
- 4) Integrated Electronics, J. Millman and C.C. Halkias, Tata McGraw Hill (2001)

BSc. (HONOURS)
IN ANALYTICAL CHEMISTRY
&
IN INDUSTRIAL CHEMISTRY
Multidisciplinary

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Mechanics DSC - 1	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with a review of vector algebra and ordinary differential equations. The students will learn Newton's laws of motion, conservation of momentum, conservation of energy, concept of simple harmonic motion, Newton's laws of gravitation, elasticity and the Special Theory of Relativity. They will be able to apply the concepts learnt to several real world problems.

Learning Outcomes

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

- Learn the laws of motion and their application to various dynamical situations.
- Understand the concept of conservation of momentum, angular momentum and energy. Their application to basic problems.
- Understand the motion of simple pendulum
- Understand the laws of gravitation and basic idea of global positioning system
- Understand the elastic properties
- Postulates of special theory of relativity, inertial and non-inertial frame of reference and their transformation, relativistic effects on the mass and energy of a moving body.

SYLLABUS OF DSC – 1

Vectors: Review of vector algebra. Scalar and vector product

(2 Hours)

Ordinary Differential Equations: First order homogeneous differential equations, second order homogeneous differential equation with constant coefficients

(4 Hours)

Brief review of Newton's laws of motion, dynamics of a system of particles, centre of mass, determination of centre of mass for continuous systems having spherical symmetry. Conservation of momentum and energy, work – energy theorem for conservative forces,

force as a gradient of potential energy, angular momentum, torque, conservation of angular momentum

(9 Hours)

Idea of simple harmonic motion, differential equation of simple harmonic motion and its solution, kinetic energy and potential energy, total energy and their time average for a body executing simple harmonic motion

(4 Hours)

Newton's law of gravitation, motion of a particle in a central force field, Kepler's laws, weightlessness, geosynchronous orbit, basic idea of global positioning system

(4 Hours)

Elasticity: Concept of stress and strain, Hooke's law, elastic moduli, twisting torque on a wire, tensile strength, relation between elastic constants, Poisson's ratio, rigidity modulus

(3 Hours)

Postulates of special theory of relativity, Lorentz transformation relations, length contraction, time dilation, relativistic transformation of velocity

(4 Hours)

PRACTICAL COMPONENT (60 Hours)

Every student should perform at least 06 experiments from the following list.

- 1) Measurements of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
- 2) Determination of height of a building using a sextant.
- 3) Study of motion of the spring and calculate (a) spring constant and, (b) acceleration due to gravity (g)
- 4) Determination of moment of inertia of a flywheel.
- 5) Determination of Young's modulus of a wire by Optical Lever Method.
- 6) Determination of modulus of rigidity of a wire using Maxwell's needle.
- 7) Determination of elastic constants of a wire by Searle's method.
- 8) Determination of value of g using bar pendulum.
- 9) Determination of value of g using Kater's pendulum.

References (for Laboratory Work):

- 1) Advanced practical physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- 2) Engineering practical physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India
- 3) Practical physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
- 4) A text book of practical physics, I. Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
- 5) B. Sc. practical physics, Geeta Sanon, R. Chand, 2016

Essential Readings:

FOR THEORY COMPONENT

- 1) Schaum's Outline of Vector Analysis, 2nd Edn., Murray Spiegel, Seymour Lipschutz, Tata McGraw-Hill, (2009)
- 2) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
- 3) Mechanics Berkeley Physics Course, Vol. 1, 2/e, Charles Kittel, et. al., 2017, McGrawHill Education
- 4) Mechanics, D. S. Mathur and P. S. Hemne, 2012, S. Chand.

.Suggestive Readings:

- 1) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- 2) University Physics, H. D. Young and R. A. Freedman, 14/e, 2015, Pearson Education.
- 3) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.
- 4) Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES
Offered by Department of Physics
Category-IV

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

Note: Examination scheme and modes shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE – 1): MECHANICS

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Mechanics GE 1	4	3	0	1	Class XII pass	NIL	Physics and Astrophysics

Learning Objectives

This course reviews the concepts of mechanics learnt at school in a more advanced perspective and goes on to build new concepts. It begins with dynamics of a system of particles and ends with the special theory of relativity. Students will appreciate the concept of rotational motion, gravitation and oscillations. The students will be able to apply the concepts learnt to several real world problems. A brief recapitulation of vector algebra and differential equations is also done to familiarize students with basic mathematical concepts which are necessary for a course on mechanics.

Learning Outcomes

Upon completion of this course, students are expected to understand the following concepts.

- Laws of motion and their application to various dynamical situations. And their applications to conservation of momentum, angular momentum and energy.
- Motion of a simple and compound pendulum
- Application of Kepler's laws to describe the motion of satellites in circular orbit.
- The concept of geosynchronous orbits
- Concept of stress and strain and relation between elastic constants
- Postulates of Special Theory of Relativity, Lorentz transformation, relativistic effects on the mass and energy of a moving body.

In the laboratory course, after acquiring knowledge of how to handle measuring

instruments (like vernier calliper, screw gauge and travelling microscope) student shall embark on verifying various principles and associated measurable quantities.

SYLLABUS OF GE – 1

THEORY COMPONENT

Unit 1: Recapitulation of Vectors and Ordinary Differential Equation (8 Hours)

Vector algebra, scalar and vector product, gradient of a scalar field, divergence and curl of vectors field

Ordinary Differential Equations: First order homogeneous differential equations, second order homogeneous differential equation with constant coefficients

Unit 2: Fundamentals of Dynamics (10 Hours)

Review of Newton's laws of motion, dynamics of a system of particles, centre of mass, determination of centre of mass for discrete and continuous systems having spherical symmetry, Conservation of momentum and energy, Conservative and non-Conservative forces, work – energy theorem for conservative forces, force as a gradient of potential energy.

Unit 3: Rotational Dynamics and Oscillatory Motion (14 Hours)

Angular velocity, angular momentum, torque, conservation of angular momentum, Moment of inertia, Theorem of parallel and perpendicular axes, Calculation of moment of inertia of discrete and continuous objects (1-D and 2-D).

Idea of simple harmonic motion, Differential equation of simple harmonic motion and its solution, Motion of a simple pendulum and compound pendulum

Unit 4: Gravitation (5 Hours)

Newton's Law of Gravitation, Motion of a particle in a central force field, Kepler's Laws (statements only), Satellite in circular orbit and applications, geosynchronous orbits

Unit 5: Elasticity (3 Hours)

Concept of stress and strain, Hooke's law, elastic moduli, twisting torque on a wire, tensile strength, relation between elastic constants, Poisson's ratio, rigidity modulus

Unit 6: Special Theory of Relativity (5 Hours)

Postulates of Special Theory of Relativity, Lorentz transformation, length contraction, time dilation, relativistic transformation of velocity, relativistic variation of mass, mass-energy equivalence

PRACTICAL COMPONENT (30 Hours)

The teacher is expected to give basic idea and working of various apparatus and instruments related to different experiments. Students should also be given knowledge of recording and analyzing experimental data.

Every student should perform at least 06 experiments from the following list.

- 1) Measurement of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
- 2) Study the random error in observations.
- 3) Determination of height of a building using a sextant.
- 4) Study of motion of the spring and calculate (a) spring constant and, (b) acceleration due to gravity (g)
- 5) Determination of moment of inertia of a flywheel.
- 6) Determination of g and velocity for a freely falling body using digital timing technique.
- 7) Determination of modulus of rigidity of a wire using Maxwell's needle.
- 8) Determination of elastic constants of a wire by Searle's method.
- 9) Determination of value of g using bar pendulum.
- 10) Determination of value of g using Kater's pendulum.

References (for Laboratory Work):

- 1) Advanced practical physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- 2) Engineering practical physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
- 3) Practical physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
- 4) A text book of practical physics, I. Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
- 5) B. Sc. practical physics, Geeta Sanon, R. Chand and Co., 2016.

Essential readings:

FOR THEORY COMPONENT

- 1) Vector Analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2nd Edn., 2009, McGraw- Hill Education.
- 2) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
- 3) Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education
- 4) Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.
- 5) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.

Suggestive readings

- 1) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
- 2) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- 3) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
- 4) Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press
- 5) Physics for Scientists and Engineers, Randall D Knight, 3/e, 2016, Pearson Education.

GENERIC ELECTIVES (GE - 2): MATHEMATICAL PHYSICS

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Mathematical Physics GE – 2	4	3	1	0	Class XII pass	NIL

Learning Objectives

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. The course will expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.

Learning Outcomes

At the end of this course, the students will be able to,

- Understand functions of several variables.
- Represent a periodic function by a sum of harmonics using Fourier series and their applications in physical problems such as vibrating strings etc.
- Obtain power series solution of differential equation of second order with variable coefficient using Frobenius method.
- Understand properties and applications of special functions like Legendre polynomials, Bessel functions and their differential equations and apply these to various physical problems such as in quantum mechanics.
- Learn about gamma and beta functions and their applications.
- Solve linear partial differential equations of second order with separation of variable method.
- Understand the basic concepts of complex analysis and integration.
- During the tutorial classes, students' skill will be developed to solve more problems related to the concerned topics.

SYLLABUS OF GE – 2

THEORY COMPONENT

Unit 1:

(6 Hours)

Fourier series: Periodic functions. Orthogonality of sine and cosine functions, Convergence of Fourier series and Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions (Fourier Cosine Series and Fourier Sine Series).

Unit 2: (10 Hours)

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 and Bessel Differential Equations.

Unit 3: (14 Hours)

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of integrals in terms of Gamma Functions.

Partial Differential Equations: Multivariable functions, Partial derivatives, Functions Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry, Solution of 1D wave equation.

Unit 4: (15 Hours)

Complex Analysis: Functions of complex variable, limit, continuity, Analytic function, Cauchy-Riemann equations, singular points, Cauchy Goursat Theorem, Cauchy's Integral Formula, Residues, Cauchy's Residue Theorem.

Essential readings:

- 1) Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- 2) Complex Variables and Applications, J. W. Brown and R. V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
- 3) Advanced Mathematics for Engineers and Scientists: Schaum Outline Series, M. R Spiegel, 2009, McGraw Hill Education.
- 4) Applied Mathematics for Engineers and Physicists, L.A. Pipes and L.R. Harvill, 2014, Dover Publications.
- 5) Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd Ed., 2006, Cambridge University Press.

Suggestive readings

- 1) Mathematical Physics, A. K. Ghatak, I. C. Goyal and S. J. Chua, 2017, Laxmi Publications Private Limited.
- 2) Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, 5 Ed., 2012, Jones and Bartlett Learning.
- 3) An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI Learning.
- 4) Differential Equations, George F. Simmons, 2007, McGraw Hill.
- 5) Mathematical methods for Scientists and Engineers, D. A. Mc Quarrie, 2003, Viva Books

GENERIC ELECTIVES (GE – 3): WAVES AND OPTICS

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Waves and Optics GE 3	4	3	0	1	Class XII pass	NIL

Learning Objectives

This coursework reviews the concept of waves and optics learnt at school level from a more advanced perspective and builds new concepts. This course is divided into two main parts. The first part deals with vibrations and waves. The second part pertains to optics and provides the details of interference, diffraction and polarization.

Learning Outcomes

After the completion of this course, the students will have learnt the following.

- Simple harmonic motion, superposition principle and its application to find the resultant of superposition of harmonic oscillations.
- Concepts of vibrations in strings.
- Interference as superposition of waves from coherent sources.
- Basic concepts of Diffraction: Fraunhofer and Fresnel Diffraction.
- Elementary concepts of the polarization of light.

SYLLABUS OF GE – 3

THEORY COMPONENT

Unit 1: (10 Hours)

Superposition of Harmonic Oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. Superposition of two collinear harmonic oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.

Unit 2: (5 Hours)

Waves Motion: Types of waves: Longitudinal and Transverse (General idea). Travelling waves in a string, wave equation. Energy density. Standing waves in a string - modes of vibration. Phase velocity.

Unit 3: (12 Hours)

Interference of Light: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Interference: Division of amplitude and division of wave front. Young's Double Slit experiment. Fresnel's Biprism. Phase change on reflection: Stoke's treatment. Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: measurement of wavelength and refractive index.

Unit 4: (12 Hours)

Diffraction: Fraunhofer diffraction - Single slit, Double slit and Diffraction grating. Fresnel Diffraction - Half-period zones, Zone plate, Fresnel Diffraction pattern of a straight edge using half-period zone analysis.

Unit 5: (6 Hours)

Polarization: Transverse nature of light waves. Plane polarized light. Production and detection of linearly polarized light. Malus's Law. Idea of circular and elliptical polarization.

PRACTICAL COMPONENT (30 Hours)

Every student must perform at least 05 experiments out of the list following experiments.

- 1) To determine the frequency of an electrically maintained tuning fork by Melde's experiment and to verify $\lambda^2 - T$ Law.
- 2) To study Lissajous Figures.
- 3) Familiarization with Schuster's focusing and determination of the angle of prism.
- 4) To determine the refractive index of the material of a prism using sodium light.
- 5) To determine the dispersive power of a prism using mercury light.
- 6) To determine wavelength of sodium light using Newton's rings.
- 7) To determine wavelength of sodium light using a plane diffraction grating.
- 8) To verify Malus's Law.
- 9) To determine the wavelength of Laser light using single slit diffraction. (Due care should be taken not to see Laser light source directly as it may cause injury to eyes.)

References (for Laboratory Work):

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, Asia Publishing House
- 2) A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal
- 3) An advanced course in practical physics, D. Chattopadhyay and P. C. Rakshit, New Central Book Agency

Essential readings:

FOR THEORY COMPONENT

- 1) The Physics of Waves and Oscillations: N K Bajaj, Tata Mcgraw Hill
- 2) Optics: Ajoy Ghatak, Seventh edition, Mcgraw Hill
- 3) Principle of Optics: B. K. Mathur and T. P. Pandya, Gopal Printing Press
- 4) Optics: Brij Lal and N. Subramanyam, S. Chand
- 5) The Fundamentals of Optics: A. Kumar, H. R. Gulati and D. R. Khanna, R. Chand

Suggestive readings:

- 1) Vibrations and Waves: A. P. French, CRC
- 2) The physics of Vibrations and Waves: H. J. Pain, Wiley
- 3) Fundamentals of Optics: Jenkins and White, McGraw Hill
- 4) Optics: E. Hecht and A R. Ganesan, Pearson, India
- 5) Introduction to Optics: F. Pedrotti, L. M. Pedrotti and L. S. Pedrotti, Pearson, India

GENERIC ELECTIVES (GE - 6): INTRODUCTORY ASTRONOMY**Credit distribution, Eligibility and Pre-requisites of the Course**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Introductory Astronomy GE 6	4	3	1	0	Class XII pass	NIL

Learning Objectives

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics, and more recently chemistry and biology. They will be introduced to the Indian contribution to astronomy starting from ancient times up to the modern era. They will learn about diverse set of astronomical phenomenon, from the daily and yearly motion of stars and planets in the night sky which they can observe themselves, to the expansion of the universe deduced from the latest observations and cosmological models. Students will also be introduced to internet astronomy and the citizen science research platform in astronomy. The course presupposes school level understanding of mathematics and physics.

Learning Outcomes

- After completing this course, student will gain an understanding of,
- 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
- Components of solar system and its evolution
- Current research in detection of exoplanets
- Basic structure of different galaxies and rotation of the Milky Way galaxy
- Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life
- Internet based astronomy and the collaborative citizen astronomy projects

- India's contribution to astronomy, both in ancient times and in modern era.

SYLLABUS OF GE – 6

Unit 1: (8 Hours)

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 2: (6 Hours)

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 3: (8 Hours)

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.

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

Unit 4: (8 Hours)

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

Exoplanets: Detection methods and characterization

Unit 5: (12 Hours)

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

Cosmology and Astrobiology: Standard Candles (Cepheids and SNe Type Ia), 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 6: (4 Hours)

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)

Essential readings:

- 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.
- 5) The Molecular Universe, A.G.G.M. Tielens (Sections I, II and III), Reviews of Modern Physics, Volume 85, July-September, 2013
- 6) Astronomy in India: A Historical Perspective, Thanu Padmanabhan, Springer

Useful websites for astronomy education and citizen science research platform

- 1) <https://aladin.u-strasbg.fr/>
- 2) <http://www.astrometrica.at/>
- 3) <https://www.sdss.org/>
- 4) <http://stellarium.org/>
- 5) <https://www.zooniverse.org/projects/zookeeper/galaxy-zoo/>
- 6) <https://setiathome.berkeley.edu/>
- 7) <https://www.radathomeindia.org/>

Suggestive readings:

- 1) Explorations: Introduction to Astronomy, Thomas Arny and Stephen Schneider, McGraw Hill
- 2) Astrophysics Stars and Galaxies K D Abhyankar, Universities Press
- 3) Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
- 4) Baidyanath Basu, An introduction to Astrophysics, Prentice Hall of India Private Limited.
- 5) The Physical Universe: An Introduction to Astronomy, F H Shu, University Science Books

DEPARTMENT OF CHEMISTRY

BSc. (Hons.) Chemistry

Category-I

DISCIPLINE SPECIFIC CORE COURSE -1 (DSC-1): Atomic Structure & Chemical Bonding

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Atomic Structure & Chemical Bonding (DSC-1: Inorganic Chemistry -I)	04	03	—	01	Physics, Chemistry, Mathematics	--

Learning Objectives

The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It provides basic knowledge about ionic and covalent bonding, and explains that chemical bonding is best regarded as a continuum between the two cases. It discusses the periodicity in properties with reference to the s and p block, which is necessary in understanding their group chemistry. The student will also learn about the fundamentals of acid-base and redox titrimetric analysis.

Learning outcomes

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

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization enthalpy and electron affinity of elements.
- Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
- Understand the concept of lattice energy using Born-Landé and Kapustinskii equation.
- Calibrate the apparatus used in titrimetric analysis and prepare standard solutions for titration
- Understand the theory and application of various acid-base and redox titrations.
- Comprehend the theory of acid-base indicators

SYLLABUS OF DSC-1

UNIT – I (15 Hours)

Unit 1: Atomic Structure

Recapitulation of concept of atom in ancient India, Bohr's theory & its limitations, atomic spectrum of hydrogen atom.

de Broglie equation, Heisenberg's Uncertainty Principle and its significance. Postulates of wave mechanics, Time independent Schrödinger's wave equation, well behaved wave function, significance of ψ and ψ^2 . Quantum mechanical treatment of H- atom, Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial function plots, radial probability distribution plots, angular distribution curves. Shapes of *s*, *p*, and *d* orbitals, Relative energies of orbitals.

Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity, Aufbau principle and its limitations.

UNIT – II (6 Hours)

Unit 2: Periodic properties of Elements & Periodic Trends

Brief discussion of the following properties of the elements, with reference to *s*- & *p*-block and their trends:

- Effective nuclear charge, shielding or screening effect and Slater's rules
- Atomic and ionic radii
- Ionization enthalpy (Successive ionization enthalpies)
- Electron gain enthalpy
- Electronegativity, Pauling's scale of electronegativity. Variation of electronegativity with bond order and hybridization.

UNIT – III (12 Hours)

Unit 3: Ionic bond

General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Landé equation with derivation, Madelung constant, importance of Kapustinskii equation for lattice energy. Born-Haber cycle and its applications.

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

UNIT – IV (12 Hours)

Unit 4: Covalent bond

Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H₂O, NH₃, PCl₃, PCl₅,

SF₆, ClF₃, I₃, BrF₂⁺, PCl₆⁻, ICl₂⁻, ICl₄⁻, and SO₄²⁻. Application of VSEPR theory in predicting trends in bond lengths and bond angles.

Valence Bond theory (*Heitler-London* approach). Hybridization, equivalent and non-equivalent hybrid orbitals, Bent's rule.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Molecular orbital diagrams of homo & hetero diatomic molecules [N₂, O₂, C₂, B₂, F₂, CO, NO] and their ions; HCl (idea of s-p mixing and orbital interaction to be given).

Practical component

Practicals: Inorganic Chemistry-I

(30 Hours)

(Laboratory periods: 15 classes of 2 hours each)

1. Titrimetric Analysis:

- (i) Calibration and use of apparatus
- (ii) Preparation of solutions of different Molarity/Normality.

2. Acid-Base Titrations: Principles of acid-base titrations to be discussed.

- (i) Estimation of oxalic acid using standardized NaOH solution
- (ii) Estimation of sodium carbonate using standardized HCl.
- (iii) Estimation of carbonate and hydroxide present together in a mixture.
- (iv) Estimation of carbonate and bicarbonate present together in a mixture.

3. Redox Titration: Principles of oxidation-reduction titrations to be discussed.

- (i) Estimation of oxalic acid using standardized KMnO₄ solution
- (ii) Estimation of water of crystallization in Mohr's salt by titrating with KMnO₄.
- (iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

Essential/recommended readings

References:

Theory :

1. Lee, J.D. (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter, R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
5. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry**. John Wiley & Sons.
6. Housecraft, C. E.; Sharpe, A. G., (2018), **Inorganic Chemistry**, 5th Edition, Pearson.
7. Wulfsberg, G (2002), **Inorganic Chemistry**, Viva Books Private Limited.
8. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, 5th Edition, Pearson.

- Shiver, D.; Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2014), **Inorganic Chemistry**, 6th Edition, Freeman & Company
- Das, A. K.; Das, M. (2014), **Fundamental Concepts of Inorganic Chemistry**, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd.

Practicals:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
- Harris, D. C.; Lucy, C. A. (2016), **Quantitative Chemical Analysis**, 9th Edition, Freeman and Company

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC-2): Basic Concepts and Aliphatic Hydrocarbons

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basic Concepts and Aliphatic Hydrocarbons (DSC-2: Organic Chemistry-I)	04	03	--	01	Physics, Chemistry, Mathematics	--

Learning Objectives

The core course Organic Chemistry I is designed in a manner that it forms a cardinal part of the learning of organic chemistry for the subsequent semesters. The course is infused with the recapitulation of fundamental concepts of organic chemistry and the introduction of the concept of visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts, the functional groups-alkanes, alkenes, alkynes are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Learning 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

SYLLABUS OF DSC- 2

UNIT – I (9 Hours)

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 (18 Hours)

Unit II: Stereochemistry

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).

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 – III (18)

Unit III: Aliphatic Hydrocarbons

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

Alkenes and Alkynes: Methods of preparation of alkenes using Mechanisms of E1, E2, E1cb reactions, Saytzeff and Hoffmann eliminations. Electrophilic additions, mechanism with suitable examples, (Markownikoff/Anti-markownikoff addition), *syn* and *anti*-addition; addition of H₂, X₂, oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, hydroxylation, reaction with NBS, 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)

Practical component

Practical (30 Hours)

Credits: 01

(Laboratory periods: 15 classes of 2 hour each)

Note: *Students should be provided with handouts prior to the practical class*

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

Essential/recommended readings

References:

Theory

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.

Practicals

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

Suggestive readings

Additional Resources:

1. Solomons, T.W.G., Fryhle, C.B., Snyder, S.A. (2017), **Organic Chemistry**, 12th Edition, Wiley.
2. Bruice, P.Y. (2020), **Organic Chemistry**, 8th Edition, Pearson.
3. Clayden, J., Greeves, N., Warren, S. (2014), **Organic Chemistry**, Oxford.
4. Nasipuri, D. (2018), **Stereochemistry of Organic Compounds: Principles and Applications**, 4th Edition, New Age International.
5. Gunstone, F.D. (1975), **Guidebook to Stereochemistry**, Prentice Hall Press.
6. Gupta, S.S. (2018), **Basic Stereochemistry of Organic Molecules**, 2nd Edition, Oxford University Press.

DISCIPLINE SPECIFIC CORE COURSE– 3 (DSC-3): Gaseous and Liquid

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Gaseous and Liquid State (DSC-3: Physical Chemistry-I)	04	02	--	02	Physics, Chemistry, Mathematics	--

Learning Objectives

The objective of this course is to develop basic and advance concepts regarding gases and liquids. It aims to study the similarity and differences between the two states of matter and reasons responsible for these. The objective of the practicals is to develop skills for working in physical chemistry laboratory. The student will perform experiments based on the concepts learnt in Physical chemistry-I course.

Learning outcomes

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

- Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
- Apply the concepts of gas equations and liquids while studying other chemistry courses and every-day life.
- Handle stalagmometer and Ostwald viscometer properly.
- Determine the density of aqueous solutions.
- Dilute the given solutions as per required concentrations.
- Data reduction using numerical and graphical methods.

SYLLABUS OF DSC-3

UNIT – I (24 Hours)

Gaseous state

Kinetic theory of gases- postulates and derivation of kinetic gas equation, Maxwell distribution of molecular velocities and its use in evaluating average, root mean square and most probable velocities and average kinetic energy. Definition, expression, applications and temperature and pressure dependence of each one of the following properties of ideal gases: Collision frequency, Collision diameter, Mean free path. Coefficient of viscosity, definition, units and origin of viscosity of gases, relation between mean free path and coefficient of viscosity, temperature and pressure dependence of viscosity of a gas, calculation of molecular diameter from viscosity

Barometric distribution law, its derivation and applications, alternative forms of barometric distribution law in terms of density and number of molecules per unit volume, effect of height, temperature and molecular mass of the gas on barometric distribution

Behaviour of real gases- Compressibility factor, Z , Variation of compressibility factor with pressure at constant temperature (*plot of Z vs P*) for different gases (H_2 , CO_2 , CH_4 and NH_3), Cause of deviations from ideal gas behaviour and explanation of the observed behaviour of real gases in the light of molecular interactions

van der Waals (vdW) equation of state, Limitations of ideal gas equation of state and its modifications in the form of derivation of van der Waals equation, Physical significance of van der Waals constants, application of van der Waals equation to explain the observed behaviour of real gases.

Isotherms of real gases- Critical state, relation between critical constants and van der Waals constants, correlation of critical temperature of gases with intermolecular forces of attraction, Continuity of states, Limitations of van der Waals equation, Reduced equation of state and law of corresponding states (statement only).

Virial equation of state-Physical significance of second and third virial coefficients, van der Waals equation expressed in virial form, Relations between virial coefficients and van der Waals constants

UNIT – II (6 Hours)

Liquid state

Nature of liquid state, qualitative treatment of the structure of the liquid state

Physical properties of liquids-vapour pressure, its origin and definition, Vapour pressure of liquids and intermolecular forces, and boiling point

Surface tension, its origin and definition, Capillary action in relation to cohesive and adhesive forces, determination of surface tension by (i) using stalagmometer (drop number and drop mass method both) and (ii) capillary rise method, Effects of addition of sodium chloride, ethanol and detergent on the surface tension of water and its interpretation in terms of molecular interactions, Role of surface tension in the cleansing action of detergents

Coefficient of viscosity and its origin in liquids, Interpretation of viscosity data of pure liquids (water, ethanol, ether and glycerol) in the light of molecular interactions, Effects of addition of sodium chloride, ethanol and polymer on the viscosity of water, relative viscosity, specific viscosity and reduced viscosity of a solution, comparison of the origin of viscosity of liquids and gases, effect of temperature on the viscosity of a liquid and its comparison with that of a gas.

Practical component

Practicals

60 Hours

(Laboratory periods: 15 classes of 4 hours each)

1. Gases

- a. To verify the Charles law using Charles law apparatus
- b. To determine the value of universal gas constant R using the reaction
$$\text{Mg(s)} + 2\text{HCl (aq)} \rightarrow \text{MgCl}_2 \text{ (aq)} + \text{H}_2 \text{ (g)}$$

2. Surface tension measurements using stalagmometer

- a. Determine the surface tension of a liquid by drop number method.
- b. Determine the surface tension of a liquid by drop weight method.
- c. Study the variation of surface tension with different concentration of detergent solutions. Determine CMC.
- d. Study the effect of the addition of solutes on the surface tension of water at room temperature and explain the observations in terms of molecular interactions:
 - (i) sugar
 - (ii) ethanol
 - (iii) sodium chloride
- e. Study the variation of surface tension with different concentration of sodium chloride solutions.

3. Viscosity measurement using Ostwald's viscometer

- a. Determination of co-efficient of viscosity of two unknown aqueous solution.
- b. Study the variation of viscosity with different concentration of sugar solutions.
- c. Study the effect of the addition of solutes such as (i) polymer (ii) ethanol (iii) sodium chloride on the viscosity of water at room temperature and explain the observations in terms of molecular interactions

- d. Study the variation of viscosity of water with the amounts of a solute and calculate the intrinsic viscosity at room temperature.
- e. Determine the viscosity average molecular mass of the polymer (PVA) using viscosity measurements.

Essential/recommended readings

References:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), **Atkin's Physical Chemistry Ed.**, 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), **Physical Chemistry**, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 1, 6th Edition, McGraw Hill Education.

Practical:

- Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
- Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
- Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.

Suggestive readings

Additional Resources:

1. Moore, W.J. (1972), **Physical Chemistry**, 5th Edition, Longmans Green & Co. Ltd.
- Glasstone, S. (1948), **Textbook of Physical Chemistry**, D. Van Nostrand company, New York.

BSc. IN ANALYTICAL CHEMISTRY
Multidisciplinary

DISCIPLINE SPECIFIC CORE COURSE (DSC1-AC1): Basic Principles and Laboratory Operations

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basic Principles and Laboratory Operations (DSC1-AC1)	04	02	00	02	Physics, Chemistry and Mathematics	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- make students aware about the SI Units, concentration terms, various analytical methods, and safe usage of chemicals and its waste.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to Understand SI units
- The students will be able to Learn the use of analytical equipment
- The students will be able to Know the types of errors in chemical analysis
- The students will be able to handle statistical tests of data

SYLLABUS OF DSC1-AC1

UNIT – I: Basic Concepts (6 Hours)

A. SI Units

- Definitions of the Seven Base Units
- Derived units
- Conversion between units
- Significant figures

B. Chemical concentrations

- Mole, molar mass (calculations in grams and moles)
- Solutions and their concentrations

- Molar concentration
- Analytical molarity
- Equilibrium molarity of a particular species
- Percent concentration
- Parts per million/billion (ppm, ppb)
- Volume ratios for dilution procedures
- p-functions.

UNIT – II: Introduction to Analytical Chemistry and Analytical Methods (4 Hours)

1. General steps in chemical analysis.
2. Introduction to methods of detecting analytes
 - a) Physical
 - b) Electromagnetic radiations
 - c) Electric charge.

UNIT – III: Errors in Chemical Analysis (20 Hours)

- Types of errors
- Accuracy and Precision, Absolute and relative uncertainty, propagation of uncertainty
- The Gaussian distribution
- Mean and standard deviation
- Confidence intervals
- Statistical tests of data (F test, t test, Q test for bad data)
- Method of least squares
- Calibration curve
- Safety with chemicals and waste

Practical component 60 Hours (Credits: 02; Laboratory Periods: 60; 15 Classes of 4 hours each)

1. Description, Use and Calibration of Common Laboratory Apparatus I: Glassware: Volumetric flasks, Burettes, Pipettes, Weighing bottles, Drying ovens.
2. Description, Use and Calibration of Common Laboratory Apparatus II: Different types of Funnels, Chromatographic columns, Chromatographic jars, Desiccators, Filter crucibles, Rubber policeman.
3. Preparing Solutions: Standard solutions (acids and bases), primary standards & secondary standards, and to find out their concentration by any suitable methods.
4. Determination of strength of given strong acid using strong base volumetrically
5. Estimation of sodium carbonate by titrating with hydrochloric acid.
6. Use and maintenance of pH meter. Determination of pH of given dilute solutions of shampoos, soaps, fruit juices, and different soft drinks.
7. Determination of cell constant of a conductometric cell using standard KCl solutions.
8. To check the conductivity of various water samples (*Collect at least four samples*).

Essential/recommended readings

- Higson, S. P.J. (2003), Analytical Chemistry, Oxford University Press.

- Skoog, D.A.; West, D.M. (2003), Fundamentals of Analytical Chemistry, Brooks/Cole.
- Christian, G.D. (2004), Analytical Chemistry, 6th Edition, John Wiley & Sons, New York.
- Fifield, F.W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
- Harris, D. C. (2007), Exploring Chemical Analysis, W.H. Freeman and Co.

Suggestive readings

- Day, R. A.; Underwood, A. L. (1991), Quantitative Analysis, Prentice Hall of India.
- Gordus, A. A. (1985), Schaum's Outline of Analytical Chemistry, Tala McGraw-Hill.
- Dean J. A. (1997), Analytical Chemistry Handbook, McGraw Hill.
- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Note: Examination scheme and modes shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC2-C1): Fundamentals of Organic Chemistry, Stereochemistry and Hydrocarbons

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Organic Chemistry, Stereochemistry and Hydrocarbons (DSC2-C1)	04	02	00	02	Physics, Chemistry and Mathematics	-

Learning Objectives

The Learning Objectives of this course are as follows:

- The course is infused with the recapitulation of fundamentals of organic chemistry and visualizing the organic molecules in a three-dimensional space.
- To establish the applications of these concepts different class of mechanism is included.
- The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Learning outcomes

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

- Understand and explain the differential behaviour of organic compounds based on fundamental concepts learnt.
- Understand the stereochemistry of aliphatic and aromatic hydrocarbons
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reaction mechanisms including electrophilic addition, nucleophilic addition, nucleophilic substitution, and electrophilic substitution.
- Understand the mechanism of reactions of hydrocarbons

SYLLABUS OF DSC2-C1

UNIT – I: Fundamentals of Organic Chemistry (4 Hours)

Introduction to carbon compounds, an overview of Fundamentals (Electronic displacement-Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect). Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbene.

Acidity and basicity in carbon compounds (comparison of carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivative).

UNIT – II: Stereochemistry (8 Hours)

Types of projection formulas of carbon compound - Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.

Stereoisomerism: the concept of chirality (upto two carbon atoms). Configurational Isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; cis-trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z nomenclature (for upto two C=C systems).

Conformational isomerism with respect to ethane, butane and cyclohexane.

UNIT – III: Aliphatic Hydrocarbons (12 Hours)

Functional group approach for the following reactions: preparations, physical property & chemical reactions to be studied with the mechanism in context to their structure.

Alkanes: Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, Grignard reagent. Reactions: Free radical substitution: Halogenation.

Alkenes: Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO_4) and trans-addition (bromine), the addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration oxidation.

Alkynes: Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides and acidity of alkynes, the addition of bromine and alkaline

KMnO₄, ozonolysis and oxidation with hot alk. KMnO₄. Hydration to form carbonyl compounds.

UNIT – IV: Aromatic Hydrocarbons (6 Hours)

Aromaticity: benzenoids and Hückel's rule. Structure and aromatic character of benzene.

Preparation: methods of preparation of benzene from phenol, benzoic acid, acetylene and benzene sulphonic acid. Reactions: electrophilic substitution reactions in benzene citing examples of nitration, halogenation, sulphonation and Friedel-Craft's alkylation and acylation with emphasis on carbocationic rearrangement, side-chain oxidation of alkylbenzenes.

Practical component (60 Hours) (Credits: 02; Laboratory Periods: 60; 15 C lasses of 4 hours each)

1. Purification of organic compounds by crystallization using the following solvents:
 - a. Water
 - b. Alcohol
 - c. Water + alcohol
2. Determination of the melting points of organic compounds using Kjeldahl method and electrically heated melting point apparatus.
3. To study the effect of impurities on the melting point.
4. To identify the organic compounds using mixed melting point experiment. (*Identify at least two organic compounds*).
5. Determination of boiling point of liquid organic compounds using both distillation and capillary method.
6. Detection of extra elements present in an organic compounds (*Upto two extra elements*).
7. Organic Preparations:
 - a. Bromination of acetanilide, phenol and aniline
 - b. Nitration of nitrobenzene and bromobenzene

Essential/recommended readings

- Sykes, P.(2005), A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- Eliel, E. L. (2000), Stereochemistry of Carbon Compounds, Tata McGraw Hill.
- Morrison, R. N.; Boyd, R. N. (2010) Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 7th Edition.
- Bahl, A; Bahl, B. S. (2012), Advanced Organic Chemistry, S. Chand.
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Pearson.
- Mann, F.G.; Saunders, B.C.(2009), Practical Organic Chemistry, Pearson Education.
- Dhingra, S; Ahluwalia V.K., (2017), Advanced Experimental Organic Chemistry, Manakin Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

BSc. In Industrial Chemistry
Multidisciplinary

**DISCIPLINE SPECIFIC CORE COURSE (DSC-IC 1): INDUSTRIAL
CHEMICALS AND ENVIRONMENT**

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE
COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Industrial Chemicals and Environment, DSC- IC 1	04	02	-	02	Chemistry+Physics +Maths	NA

Industrial Chemicals and Environment, DSC- IC 1

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to teach the Chemistry of the general industrial separation and purification techniques.
- Production, uses and hazards associated with different industrial gases and chemicals.
- Air pollution, air pollutants, pollutants control procedures, greenhouse effect, global warming,
- Water pollution, water pollutants, industrial effluents and their treatment.
- Water quality parameters and water purification techniques.

Learning outcomes

The Learning Outcomes of this course are as follows:

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

- Know the various separation and purification techniques used in industries like distillation, solvent extraction, absorption, adsorption etc.
- Know the production, uses and hazards of important gases like oxygen, helium, argon, hydrogen, acetylene, ammonia etc.

- Know the production, uses and hazards of important inorganic chemicals like hydrochloric acid, sulphuric acid, nitric acid, sodium hydroxide, potassium hydroxide etc.
- Learn about air pollution, air pollutants, their control procedure, global warming, ozone depletion, water pollution, water pollutants, effluents from different industries, their treatment, water quality parameters and water purification techniques like reverse osmosis, electro dialysis and ion exchange.

SYLLABUS OF DSC- IC-1

UNIT – I (06 Hours)

Unit 1: General industrial processes

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption

UNIT – II (12 Hours)

Unit 2: Industrial Gases and Inorganic Chemicals

(a) *Industrial Gases*: Production, uses and hazards in handling of the following gases: oxygen,

nitrogen, argon, neon, helium, hydrogen, acetylene, chlorine, fluorine and ammonia.

(b) *Inorganic Chemicals*: Production, uses and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, sodium hydroxide, potassium hydroxide, bleaching

powder, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

UNIT – III (12 Hours)

Unit 3: Environment

(a) *Air Pollution*: Pollutants and their sources, pollution by SO₂, CO, NO_x. Methods of estimation of CO, NO_x, SO_x and their control procedures. Greenhouse effect and global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, Particulate matter and its types.

(b) *Water Quality Standards and Water pollution*: Water quality parameters like pH, alkalinity, DO, BOD, COD, chloride, sulphate, available chlorine etc. Water treatment and purification processes (reverse osmosis, electro dialysis, ion exchange). Pollutants and their sources. Effluent treatment (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: textile, tannery, dairy and petrochemicals and agrochemicals.

Practical component (60 Hours)

Practical

(Credits: 02, Laboratory periods: 60)

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD).
3. Determination of Biological Oxygen Demand (BOD).

- Measurement of chloride and sulphate ions of water samples by simple titration method. (With AgNO₃ and potassium chromate).
- Measurement of salinity of water samples by simple titration method. (With AgNO₃ and potassium chromate).
- Estimation of total alkalinity of water samples (CO₃²⁻, HCO₃⁻) using double titration method.
- Determination of Percentage of available chlorine in bleaching powder.
- Isolation of compounds using solvent extraction method.

Essential/recommended readings

References (Theory):

- Stocchi, E. (1990), **Industrial Chemistry**, Vol-I, Ellis Horwood Ltd. UK.
- Kent, J. A. (ed.) (1997), **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
- Austin, G.T (2012), **Shreve's Chemical Process Industries**, Tata McGraw-Hill Education Private Limited.
- Girard, J.E, (2011), **Principles of Environmental Chemistry**, Jones & Bartlett India Pvt. Limited.
- Sodhi, G.S. ((2013), **Fundamental Concepts of Environmental Chemistry**, Narosa Publishing House.
- Vermani, O.P; Narula, A.K. (2012), **Industrial Chemistry**, Galgotia Publishing Pvt. Limited.
- Sharma, B.K. (2011), **Industrial Chemistry**, Goel Publishing House.
- Pani, B. (2017), **Textbook of Environmental Chemistry**, I.K. International Publishing House.
- De, A. K. (2015), **Environmental Chemistry**, New Age International Pvt, Ltd, New Delhi.
- Khopkar, S.M. (2012), **Environmental Pollution Analysis**, New Age International Publisher.

References (Practical):

- Bassett, J.; Denney, R.C.; Jeffery, G.H.; Mendham, J.(1996) **Vogel Textbook of quantitative inorganic analysis**, 7th edition, ELBS edition. Prentice Hall Publications.
- Furniss, B. S; Hannaford, A. J.; Smith, Peter W. G.; Tatchell, A. R; **Vogel's Text Book of Practical Organic Chemistry**, 5th Edition, Longman Scientific and Technical, Longman Group Ltd.
- Mittal, K.; Chandra, L.(2013) **Experiments in organic chemistry**, Anne Books Pvt. Limited.
- Gulati, S.; Sharma, J.L.; Manocha, S. (2017) **Practical Inorganic Chemistry**. CBS, Publications.
- Rogers, A. (2015) **Laboratory Guide of Industrial chemistry**, Palala Press.

Suggestive readings (if any)

**DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC-C 1):
Basic Concepts of Organic Chemistry**

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basic Concepts of Organic Chemistry, DSC- C1	04	02	-	02	NA	NA

Basic Concepts of Organic Chemistry, DSC- C1

Learning Objectives

The Learning Objectives of this course are as follows:

- The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of the concept of visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts, a study of diverse reactions through mechanisms is included.
- The constitution of the course strongly aids in the paramount learning of the basic concepts and their applications.

Learning outcomes

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

- Understand and explain the differential behaviour of organic compounds based on fundamental concepts learnt.
- Understand the fundamental concepts of stereochemistry.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reactions and their mechanisms including electrophilic addition, nucleophilic addition, nucleophilic substitution, electrophilic substitution and rearrangement reactions.

SYLLABUS OF DSC- C 1

UNIT – I (6 Hours)

Unit 1: Fundamentals of organic chemistry

Types of Electronic displacements: Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect. Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbenes.

Acidity and basicity in organic compounds (comparison of carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivatives)

UNIT – II (8 Hours)

Unit 2: Stereochemistry

Types of projection formulae: Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.

Stereoisomerism: Concept of chirality (upto two carbon atoms). Configurational isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; *Cis-trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and *E/Z* nomenclature (for upto two C=C systems).

Conformational isomerism with respect to ethane, butane and cyclohexane.

UNIT – III (16 Hours)

Unit 3: Types of Organic Reactions (Including reactions of alkenes, alkyl and aryl halides, alcohols, aldehydes, ketones) Lectures: 18

Electrophilic addition reactions

Electrophilic addition reaction (with respect to propene, propyne, 3,3-dimethyl-1-butene): Hydration,

Addition of HX in the absence and presence of peroxide, Hydroboration oxidation, Addition of bromine (with stereochemistry).

Nucleophilic addition reactions

Nucleophilic addition reaction of carbonyl compounds: Addition of HCN, ammonia derivatives

(Hydroxylamine, Hydrazine, Semicarbazide and 2,4-DNP), the addition of carbanion (Aldol condensation, Claisen Schmidt, Benzoin condensation, Perkin reaction, reactions involving Grignard reagent).

Elimination and Nucleophilic substitution reactions

Nucleophilic substitution reaction (SN1 and SN2) in alkyl halides (mechanisms with stereochemical aspect), alcohols (with nucleophiles like ammonia, halides, thiols, ambident nucleophiles (cyanide and nitrite ion)), ethers (Williamson ether synthesis), Elimination reaction (E1 & E2), elimination *vs* substitution (*w.r.t.* potassium t-butoxide and KOH); Nucleophilic aromatic substitution in aryl

halides-elimination addition reaction *w.r.t.* chlorobenzene, including the effect of nitro group (on the ring) on the reaction. relative reactivity and strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides towards substitution reactions

Electrophilic substitution reactions

Electrophilic Aromatic substitution with mechanism (benzene)- sulphonation, nitration, halogenation, Friedel craft acylation :*o*-, *m*- and *p*- directive influence giving examples of toluene/nitrobenzene/ phenol/ aniline/ chlorobenzene.

Reactive intermediates and Rearrangement Reactions

Free radicals (Birch Reduction); *Carbocations* (Pinacol-Pinacolone, Wagner-Meerwein, Rearrangement, and Beckmann rearrangement); *Carbanions* (Michael Addition); *Carbenes* (Reimer Tiemann)

Practical component (60 Hours)

Practical

(Credits: 02, Laboratory periods: 60)

1. Purification of an organic compound by crystallization (from water and alcohol) and distillation, Criteria of purity: Determination of M.P.
2. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
3. Detection of extra element
4. Preparations: (Mechanism of various reactions involved to be discussed).
 - a. Bromination of phenol/aniline.
 - b. 2,4-Dinitrophenylhydrazone of aldehydes and ketones
 - c. Semicarbazone of aldehydes/ ketones
 - d. Aldol condensation reaction using green method.
 - e. Bromination of Stilbene.
 - f. Acetanilide to p-Bromoacetanilide.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.

Essential/recommended readings

References (Theory):

1. Sykes, P.(2003), **A Guide Book to Mechanism in Organic Chemistry**, 6 th Edition Pearson Education.
2. Eliel, E. L. (2001), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Pearson Education.
4. Bahl, A; Bahl, B. S. (2019), **Advanced Organic Chemistry**, 22nd Edition, S. Chand.

References (Practical):

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of**

Practical Organic Chemistry, Pearson.

2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Dhingra, S; Ahluwalia V.K., (2017), **Advanced Experimental Organic Chemistry**, Manakin Press.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

DISCIPLINE SPECIFIC CORE COURSE – 3 (DSC-MP 1): Calculus

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Calculus, DSC-MP 1	04	02	-	02	NA	NA

Course Code: Mathematics DSC-MP 1

Course Title: Calculus

Learning Objectives

The Learning Objectives of this course are as follows:

Course Objectives: The primary objective of this course is to introduce the basic tools of calculus which are helpful in understanding their applications in many real-world problems. Students will be able to understand/create various mathematical models in everyday life.

Learning outcomes

The Learning Outcomes of this course are as follows:

This course will enable the students to:

- i) Understand continuity and differentiability in terms of limits and graphs of certain functions.
- ii) Describe asymptotic behaviour in terms of limits involving infinity.
- iii) Use of derivatives to explore the behaviour of a given function locating and classify its extrema and graphing the function.
- iv) Apply the concepts of asymptotes, and inflexion points in tracing of cartesian curves.
- v) Compute the reduction formulae of standard transcendental functions with applications.

SYLLABUS OF DSC- MP 1

UNIT – I (10 Hours)

Unit 1: Limits, Continuity and Differentiability

Limit of a function, ϵ - δ definition of a limit, Infinite limits, Continuity and types of discontinuities; Differentiability of a function, Successive differentiation: Calculation of the n th derivatives, Leibnitz theorem; Partial differentiation, Euler's theorem on homogeneous functions.

UNIT – II (10 Hours)

Unit 2: Mean Value Theorems and its Applications

Rolle's theorem, Mean value theorems and applications to monotonic functions and inequalities; Taylor's theorem, Taylor's series, Maclaurin's series expansions of e^x , $\sin x$, $\cos x$, $\log x$ and $\ln x$; Indeterminate forms.

UNIT – III (10 Hours)

Unit 3: Tracing of Curves and Reduction Formulae

Asymptotes (parallel to axes and oblique), Concavity and inflexion points, Singular points, Tangents at the origin and nature of singular points, Curve tracing (cartesian and polar equations). Reduction formulae for $\int \sin^m x \cos^n x dx$, $\int \cos^m x \sin^n x dx$, and $\int \sin^m x \cos^n x dx$ and their applications.

Essential/recommended readings

References:

1. Prasad, Gorakh (2016). *Differential Calculus* (19th ed.). Pothishala Pvt. Ltd. Allahabad.
2. Prasad, Gorakh (2015). *Integral Calculus*. Pothishala Pvt. Ltd. Allahabad.

Additional Readings:

- i. Apostol, T. M. (2007). *Calculus: One-Variable Calculus with An Introduction to Linear Algebra* (2nd ed.). Vol. 1. Wiley India Pvt. Ltd.
- ii. Ross, Kenneth. A.(2013). *Elementary Analysis: The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian reprint.

Note: Examination scheme and modes shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

BSc. Life Sciences
Multidisciplinary

DISCIPLINE SPECIFIC CORE COURSE (DSC-1): Basic Concepts of Organic

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basic Concepts of Organic Chemistry	04	02	-	02	12 th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of the concept of visualizing the organic molecules in a three-dimensional space.
- To establish the applications of these concepts, a study of diverse reactions through mechanisms is included.
- The constitution of the course strongly aids in the paramount learning of the basic concepts and their applications

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learned.
- Understand the fundamental concepts of stereochemistry.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reactions and their mechanisms including electrophilic addition, nucleophilic addition, nucleophilic substitution, electrophilic substitution and rearrangement reactions.

SYLLABUS OF DSC-1

UNIT – I Fundamentals of organic chemistry (6 Hours)

Types of Electronic displacements: Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect. Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbenes. Acidity and basicity in organic compounds (comparison of

carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivatives)

UNIT – II Stereochemistry (6 Hours)

Types of projection formulae: Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.

Stereoisomerism: Concept of chirality (upto two carbon atoms). Configurational isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; *Cis-trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and *E/Z* nomenclature (for upto two C=C systems).

Conformational isomerism with respect to ethane, butane and cyclohexane.

UNIT – III Types of Organic Reactions (Including reactions of alkenes, alkyl and aryl halides, alcohols, aldehydes, ketones) (18 Hours)

Electrophilic addition reactions

Electrophilic addition reaction (with respect to propene, propyne, 3,3-dimethyl-1-butene): Hydration, Addition of HX in the absence and presence of peroxide, Hydroboration oxidation, Addition of bromine (with stereochemistry).

Nucleophilic addition reactions

Nucleophilic addition reaction of carbonyl compounds: Addition of HCN, ammonia derivatives (Hydroxylamine, Hydrazine, Semicarbazide and 2,4-DNP), the addition of carbanion (Aldol condensation, Claisen Schmidt, Benzoin condensation, Perkin reaction, reactions involving Grignard reagent).

Elimination and Nucleophilic substitution reactions

Nucleophilic substitution reaction (S_N1 and S_N2) in alkyl halides (mechanisms with stereochemical aspect), alcohols (with nucleophiles like ammonia, halides, thiols, ambident nucleophiles (cyanide and nitrite ion)), ethers (Williamson ether synthesis), Elimination reaction ($E1$ & $E2$), elimination *vs* substitution (*w.r.t.* potassium *t*-butoxide and KOH); Nucleophilic aromatic substitution in aryl halides-elimination addition reaction *w.r.t.* chlorobenzene, including the effect of nitro group (on the ring) on the reaction. relative reactivity and strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides towards substitution reactions

Electrophilic substitution reactions

Electrophilic Aromatic substitution with mechanism (benzene)- sulphonation, nitration, halogenation, Friedel craft acylation :*o*-, *m*- and *p*- directive influence giving examples of toluene/nitrobenzene/ phenol/ aniline/ chlorobenzene.

Reactive intermediates and Rearrangement Reactions

Free radicals (Birch Reduction); *Carbocations* (Pinacol-Pinacolone, Wagner-Meerwein, Rearrangement, and Beckmann rearrangement); *Carbanions* (Michael Addition); *Carbenes* (Reimer-Tiemann).

Practical component (60 Hours)

1. Purification of an organic compound by crystallization (from water and alcohol) and distillation, Criteria of purity: Determination of M.P.
2. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
3. Detection of extra element
4. Preparations: (Mechanism of various reactions involved to be discussed).
 - a. Bromination of phenol/aniline.
 - b. 2,4-Dinitrophenylhydrazone of aldehydes and ketones
 - c. Semicarbazone of aldehydes/ ketones
 - d. Aldol condensation reaction using green method.
 - e. Bromination of Stilbene.
 - f. Acetanilide to p-Bromoacetanilide.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.

Essential/recommended readings

Theory:

1. Sykes, P.(2003), **A Guide Book to Mechanism in Organic Chemistry**, 6th Edition Pearson Education.
2. Eliel, E. L. (2001), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Pearson Education.

Practical:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Dhingra, S; Ahluwalia V.K., (2017), **Advanced Experimental Organic Chemistry**, Manakin Press.

Suggestive readings

Theory:

1. Bahl, A; Bahl, B. S. (2019), **Advanced Organic Chemistry**, 22nd Edition, S. Chand.

Practical:

1. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and modes shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

BSc. Physical Sciences

DISCIPLINE SPECIFIC CORE COURSE (DSC-1): Basic Concepts of Organic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basic Concepts of Organic Chemistry	04	02	-	02	12 th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of the concept of visualizing the organic molecules in a three-dimensional space.
- To establish the applications of these concepts, a study of diverse reactions through mechanisms is included.
- The constitution of the course strongly aids in the paramount learning of the basic concepts and their applications

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learned.
- Understand the fundamental concepts of stereochemistry.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reactions and their mechanisms including electrophilic addition, nucleophilic addition, nucleophilic substitution, electrophilic substitution and rearrangement reactions.

SYLLABUS OF DSC-1

UNIT – I Fundamentals of organic chemistry (6 Hours)

Types of Electronic displacements: Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect. Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbenes.

Acidity and basicity in organic compounds (comparison of carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivatives)

UNIT – II Stereochemistry (6 Hours)

Types of projection formulae: Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.

Stereoisomerism: Concept of chirality (upto two carbon atoms). Configurational isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; *Cis-trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and *E/Z* nomenclature (for upto two C=C systems).

Conformational isomerism with respect to ethane, butane and cyclohexane.

UNIT – III Types of Organic Reactions (Including reactions of alkenes, alkyl and aryl halides, alcohols, aldehydes, ketones) (18 Hours)

Electrophilic addition reactions

Electrophilic addition reaction (with respect to propene, propyne, 3,3-dimethyl-1-butene): Hydration, Addition of HX in the absence and presence of peroxide, Hydroboration oxidation, Addition of bromine (with stereochemistry).

Nucleophilic addition reactions

Nucleophilic addition reaction of carbonyl compounds: Addition of HCN, ammonia derivatives (Hydroxylamine, Hydrazine, Semicarbazide and 2,4-DNP), the addition of carbanion (Aldol condensation, Claisen Schmidt, Benzoin condensation, Perkin reaction, reactions involving Grignard reagent).

Elimination and Nucleophilic substitution reactions

Nucleophilic substitution reaction (S_N1 and S_N2) in alkyl halides (mechanisms with stereochemical aspect), alcohols (with nucleophiles like ammonia, halides, thiols, ambident nucleophiles (cyanide and nitrite ion)), ethers (Williamson ether synthesis), Elimination reaction ($E1$ & $E2$), elimination *vs* substitution (*w.r.t.* potassium *t*-butoxide and KOH); Nucleophilic aromatic substitution in aryl halides-elimination addition reaction *w.r.t.* chlorobenzene, including the effect of nitro group (on the ring) on the reaction. relative reactivity and strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides towards substitution reactions

Electrophilic substitution reactions

Electrophilic Aromatic substitution with mechanism (benzene)- sulphonation, nitration, halogenation, Friedel craft acylation :*o*-, *m*- and *p*- directive influence giving examples of toluene/nitrobenzene/ phenol/ aniline/ chlorobenzene.

Reactive intermediates and Rearrangement Reactions

Free radicals (Birch Reduction); *Carbocations* (Pinacol-Pinacolone, Wagner-Meerwein, Rearrangement, and Beckmann rearrangement); *Carbanions* (Michael Addition); *Carbenes* (Reimer-Tiemann).

Practical component (60 Hours)

1. Purification of an organic compound by crystallization (from water and alcohol) and distillation, Criteria of purity: Determination of M.P.
2. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
3. Detection of extra element
4. Preparations: (Mechanism of various reactions involved to be discussed).
 - a. Bromination of phenol/aniline.
 - b. 2,4-Dinitrophenylhydrazone of aldehydes and ketones
 - c. Semicarbazone of aldehydes/ ketones
 - d. Aldol condensation reaction using green method.
 - e. Bromination of Stilbene.
 - f. Acetanilide to p-Bromoacetanilide.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.

Essential/recommended readings

Theory:

1. Sykes, P.(2003), **A Guide Book to Mechanism in Organic Chemistry**, 6th Edition Pearson Education.
2. Eliel, E. L. (2001), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Pearson Education.

Practical:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Dhingra, S; Ahluwalia V.K., (2017), **Advanced Experimental Organic Chemistry**, Manakin Press.

Suggestive readings

Theory:

1. Bahl, A; Bahl, B. S. (2019), **Advanced Organic Chemistry**, 22nd Edition, S. Chand.

Practical:

1. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and modes shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES
OFFERED BY DEPARTMENT OF CHEMISTRY FOR ODD SEMESTER

GE 1: Chemistry: Atomic Structure and Chemical Bonding

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Atomic Structure and Chemical Bonding (GE-1)	4	2		2		Basic knowledge of Chemistry

Learning Objectives

The Learning Objectives of this course are as follows:

- To discuss the structure of atom as a necessary pre-requisite in understanding the nature of chemical bonding in compounds.
- To provide basic knowledge about ionic and covalent bonding.

Learning Outcomes

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

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, and shapes of s, p, and d orbitals
- Understand the concept of lattice energy and solvation energy.
- Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).

SYLLABUS OF GE 1

Theory:

Unit – 1: Atomic Structure

(14 Hours)

Review of: Bohr's theory and its limitations, Heisenberg uncertainty principle, Dual behaviour of matter and radiation, De-Broglie's relation, Hydrogen atom spectra, need of a new approach to atomic structure. Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2 , Schrödinger equation for hydrogen atom, radial

and angular parts of the hydrogen wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation), radial and angular nodes and their significance, radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s . Shapes of s, p and d atomic orbitals, nodal planes, discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s). Rules for filling electrons in various orbitals, electronic configurations of the atoms, stability of half-filled and completely filled orbitals, concept of exchange energy, relative energies of atomic orbitals, anomalous electronic configurations.

Unit – 2: Chemical Bonding and Molecular Structure

(16 Hours)

Ionic Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, statement of Born-Landé equation for calculation of lattice energy (no derivation), Born Haber cycle and its applications, covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules. Ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. **Covalent bonding: VB Approach:** Shapes of some inorganic molecules and ions on the basis of VSEPR (H_2O , NH_3 , PCl_5 , SF_6 , ClF_3 , SF_4) and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. **MO Approach:** Rules for the LCAO method, bonding and antibonding MOs and their characteristics for ss, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+ .

Practicals:

(60 Hours)

(Laboratory Periods: 60)

1. Acid-Base Titrations: Principles of acid-base titrations to be discussed.

- (i) Estimation of sodium carbonate using standardized HCl.
- (ii) Estimation of carbonate and hydroxide present together in a mixture.
- (iii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iv) Estimation of free alkali present in different soaps/detergents

2. Redox Titrations: Principles of oxidation-reduction titrations (electrode potentials) to be discussed.

- (i) Estimation of oxalic acid by titrating it with $KMnO_4$.
- (ii) Estimation of Mohr's salt by titrating it with $KMnO_4$.
- (iii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iv) Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator (diphenylamine/ N-phenylanthranilic acid).

References:

Theory:

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.

Practicals:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Additional Resources:

1. Wulfsberg, G (2002), **Inorganic Chemistry**, Viva Books Private Limited.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, 5th Edition, Pearson.

GE 3: Chemistry: Bioinorganic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Bioinorganic Chemistry (GE-3)	4	2		2		Basic knowledge of Chemistry

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce students to bioinorganic chemistry, currently a frontier area of chemistry providing an interface between organic chemistry, inorganic chemistry and biology.
- To make students learn about the importance of inorganic chemical species, especially metals, in biological systems, through discussions on topics such as the sodium-potassium pump, the applications of iron in physiology, including iron transport and storage system, role of magnesium in energy production and chlorophyll, toxicity of heavy metal ions and their antidotes.

Learning Outcomes

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

- Classify metal ions in biological systems as essential, non-essential, trace & toxic.
- Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it
- Understand the role of metal ions such as Mg, Ca and Fe in biological systems.
- Understand the toxicity of heavy metal ions (Hg, Pb, Cd and As) in the physiological system
- Explain the use of chelating agents in medicine

SYLLABUS OF GE-3

Theory:

Unit 1: Introduction (6 Hours)

A brief introduction to bio-inorganic chemistry. Metal ions present in biological systems and their classification on the basis of action (essential, non-essential, trace & toxic). Classification of metallobiomolecules (enzymes, transport and storage proteins and non-proteins). Brief idea about membrane transport, channels, pumps.

Unit 2: Role of s-block Elements in Biological System (8 Hours)

Role of metal ions present in biological systems with special reference to Na^+ , K^+ and Mg^{2+} and Ca^{2+} ions: Na/K pump; Ca pump, role of Mg^{2+} ions in energy production and chlorophyll. Role of calcium in bone formation.

Unit 3: Role of iron in Biological System (8 Hours)

Role of iron in oxygen transport and storage (haemoglobin and myoglobin), Perutz mechanism, Cooperative effect, Bohr effect, comparison of oxygen saturation curves of haemoglobin and myoglobin, carbon monoxide. Storage and transport of iron in humans (ferritin and transferrin).

Unit 4: Toxicity of Heavy Metal Ions (8 Hours)

Toxicity of heavy metal ions (Hg, Pb, Cd and As), reasons for toxicity and their antidotes

Practicals: (60 Hours)

WEEKS)

(Laboratory Periods: 60)

1. Spectrophotometric estimation:

- Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7/\text{CoSO}_4$ in a solution of unknown concentration
- Spectrophotometric estimation of Fe^{2+} ions by using 1, 10-phenanthroline

(iii) Determination of the composition of the Fe^{3+} - salicylic acid complex in solution by Job's method.

2. Complexometric titrations using disodium salt of EDTA:

- Estimation of Zn^{2+} using EBT / Xylenol orange as indicator
- Estimation of Mg^{2+}
- Estimation of Ca^{2+} by substitution method
- To estimate the concentration of Ca in commercially available medicines.
- To estimate the Mg present in multivitamins.

References:

Theory:

- Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
- Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
- Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
- Crichton, R.R. (2008), **Biological Inorganic Chemistry: An Introduction**. Amsterdam, Elsevier.
- Kaim, W., B. Schwederski and A. Klein. (2014), **Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide**. 2nd Edition, Wiley.

Practical:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Additional Resources:

- Lippard, S.J.; Berg, J.M. (1994), **Principles of Bioinorganic Chemistry**, Panima Publishing Company.
- Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier

GE 4: Chemistry: Basic Concepts of Organic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Basic Concepts of Organic Chemistry (GE-4)	4	2		2		

Learning Objectives

The Learning Objectives of this course are as follows:

- To teach the fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three-dimensional space.
- To establish the applications of these concepts, different types of organic reactions are introduced.

Learning Outcomes

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

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reaction mechanisms including free radical substitution, electrophilic addition and electrophilic aromatic substitution.
- Differentiate between various types of organic reactions possible on the basis of reaction conditions

SYLLABUS OF GE-4

Theory:

Unit 1: Basic Concepts

(6 Hours)

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 and free radicals. Electrophiles and nucleophiles
Concept of Aromaticity: Huckel's rule

Unit 2: Stereochemistry

(10 Hours)

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newmann, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration.
CIP rules: Erythro/Threo, D/L and R/S designations.
Geometrical isomerism: *cis-trans*, *syn-anti* and *E/Z* notations.

Unit 3: Types of Organic Reactions

(14 Hours)

Introduction to substitution, addition, elimination, isomerization, rearrangement, oxidation and reduction reactions.
Free radical substitutions (Halogenation), concept of relative reactivity v/s selectivity. Free radical reactions in the biological reactions

Mechanisms of E1, E2, Saytzeff, Hoffmann eliminations and Cope elimination. Biological dehydration reactions

Electrophilic Additions reactions of alkenes and alkynes: mechanism with suitable examples, (Markownikoff/Antimarkownikoff addition), syn and anti-addition; addition of H₂, X₂, hydroboration-oxidation, ozonolysis, hydroxylation.

Nucleophilic substitution reactions – S_N1 and S_N2 mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution vs. elimination. Biological methylating agents
Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/ acylation with their mechanism. Directing effects of groups in electrophilic substitution.

Practicals:

(60 Hours)

(Laboratory Periods: 60)

1. Calibration of a thermometer and determination of the melting points of the organic compounds (Kjeldahl method, electrically heated melting point apparatus and BODMEL)
2. Purification of the organic compounds by crystallization using the following solvents:
3. a. Water b. Alcohol c. Alcohol-Water
4. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL)
5. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β -naphthol, salicylic acid) either by conventional or green method.
6. Bromination of acetanilide/aniline/phenol either by conventional or green method.
7. Nitration of chlorobenzene/nitrobenzene.

References:

Theory:

1. Sykes, P. (2005), **A Guide Book to Mechanism in Organic Chemistry**, Orient Longman.
2. Eliel, E. L. (2000), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. **Mehta B.; Mehta M. (2015)**, Organic Chemistry, **PHI Learning Private Limited**
5. **Bahl, A; Bahl, B. S. (2012)**, Advanced Organic Chemistry, **S. Chand.**

Practicals:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.

GE 7: Chemistry: States of Matter

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
States of Matter (GE-7)	4	2		2		

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students learn about the properties of ideal and real gases deviation from ideal behaviour, properties of liquid, types of solids with details about crystal structure.
- To make student learn about the reaction rate, order, activation energy and theories of reaction rates.

Learning Outcomes

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

- Derive ideal gas law from kinetic theory of gases and explain why the real gases deviate from ideal behaviour.
- Explain Maxwell-Boltzmann distribution, critical constants and viscosity of gases.
- Explain the properties of liquids especially surface tension and viscosity.
- Explain symmetry elements, crystal structure specially NaCl, KCl and CsCl
- Define rate of reactions and the factors that affect the rates of reaction.
- Understand the concept of rate laws e.g., order, molecularity, half-life and their determination
- Learn about various theories of reaction rates and how these account for experimental observations.

SYLLABUS OF GE-7

Theory:

Unit 1: Kinetic Theory of Gases

(12 Hours)

Postulates of kinetic theory of gases and derivation of the kinetic gas equation, deviation of real gases from ideal behaviour, compressibility factor, causes of deviation, van der Waals

equation of state for real gases. Boyle temperature (derivation not required), critical phenomena, critical constants and their calculation from van der Waals equation, Andrews isotherms of CO₂, Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions, most probable, average and root mean square velocities (no derivation), collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules, viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Unit 2: Liquids State

(6 Hours)

Surface tension and its determination using stalagmometer, Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer, effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only). Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents.

Unit 3: Solid State

(12 Hours)

Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of crystallography - law of constancy of interfacial angles. Law of rational indices, Miller indices. X-ray diffraction by crystals, Bragg's law and powder XRD. Powder diffraction patterns of NaCl, CsCl and KCl (qualitative treatment only), defects in crystals. Glasses and liquid crystals.

Practicals:

(60 Hours)

(Laboratory periods: 60)

1. Surface tension measurement (use of organic solvents excluded): Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
2. Viscosity measurement (use of organic solvents excluded):
 - a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.
 - b) Study of the variation of viscosity of an aqueous solution with concentration of solute.
3. Solid State: Powder XRD
 - c) Differentiate and classify the given set of the diffraction pattern as crystalline materials or amorphous (Glass) substance.
 - d) Carry out analysis of a given set of powder XRD and determine the type of the cubic crystal structure
 - e) Determination of approximate crystal size from a given set of powder XRD

References:

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkin's Inorganic Chemistry**, Oxford.
2. Miessler, G. L.; Tarr, D.A. (2014), **Inorganic Chemistry**, Pearson.
3. Castellan, G. W. (2004), **Physical Chemistry**, Narosa.

- Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
- Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.

Practicals:

- Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

GE 9: Chemistry: Conductance and Electrochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Conductance and Electrochemistry (GE-9)	4	2		2		Basic knowledge of Chemistry

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students learn about conductance, its measurement and applications.
- To make students learn the principles of electrochemical cells: Electrolytic and Galvanic cell, measurement of, measurement of emf and its applications.

Learning outcomes

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

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand different types of galvanic cells, their Nernst equations, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand applications of Emf measurements in relation to determination of activity coefficients, pH of a solution and Potentiometric titrations.

SYLLABUS OF GE-9

Theory:

Unit 1: Conductance

(10 Hours)

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. Wien Effect and Debye-Falkenhagen Effect.

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 2: Electrochemistry

(20 Hours)

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. 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).

Practicals:

(60 Hours)

(Laboratory periods: 60)

1. Conductance

- (i) Determination of cell constant.
- (ii) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- (iii) Perform the following conductometric titrations:
 - a) Strong acid vs strong base
 - b) Weak acid vs strong base.

2. Potentiometry

Perform the potentiometric titrations of (i) Strong acid vs strong base, (ii) Weak acid vs strong base and (iii) Mohr's salt vs KMnO_4 .

References:

Theory:

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.

Practicals:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

GE 11: Chemistry: Chemistry of Food Nutrients

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Chemistry of Food Nutrients (GE-11)	4	2		2		

Learning Objectives

The Learning Objective of this course is as follows:

- To help the students develop a basic understanding of the components of food, their source, properties and interactions as well as changes that occur during processing, storage, and utilization.

Learning Outcomes

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

- Build a strong understanding of chemistry of food: composition of food, role of each component.
- Understand some of the reactions and changes in individual food components which occur during processing, handling and storage

SYLLABUS OF GE-11

Theory:

Unit 1: Carbohydrates

(6 Hours)

Introduction, sources, functions, classification: monosaccharide, oligosaccharide and polysaccharide, structure and importance of polysaccharides in food chemistry (pectin, cellulose, starch, gums), chemical reactions of sugar: mutarotation, caramelisation; non enzymic browning and its prevention, role of carbohydrates as sweeteners in food.

Unit 2: Lipids

(8 Hours)

Introduction, sources, classification (fatty acids, phospholipids, fats & oils, waxes), common fatty acids present in oils and fats, Omega- 3&6 fatty acids, trans fats, chemical properties- Reichert Meissel value, Polenski value, iodine value, peroxide value, saponification value,

effect of frying on fats, changes in fats and oils- rancidity, lipolysis, flavor reversion, auto-oxidation and its prevention.

Unit 3: Proteins

(8 Hours)

Introduction, sources, classification (simple, conjugated, derived), structure of protein (primary, secondary and tertiary), physico-chemical & functional properties of proteins, protein denaturation.

Unit 4: Vitamins & Minerals

(8 Hours)

Vitamins: Introduction, classification: fat-soluble vitamins & water-soluble vitamins.

Minerals: Introduction, classification: macrominerals (Ca, P, Mg) & microminerals (Se, Fe, I, Co, Zn, Cu, Se, Cr).

Physiological importance of vitamins and minerals, effect of food processing on vitamins and minerals.

Practicals:

(60 Hours)

(Laboratory periods: 60)

1. Determination of moisture in food products by hot air oven-drying method.
2. Colorimetric determination of Iron in vitamin / dietary tablets.
4. 2, 6-Dichlorophenol indophenol method for estimation of vitamin C in a given solution/ lemon Juice/chillies.
5. Estimation of total soluble sugar content by ferricyanide method (volumetric analysis).
6. Determination of saponification value of the given fat/oil.
7. Determination of iodine value of the given fat/oil.
8. Qualitative tests for proteins and carbohydrates.
9. Qualitative estimation of cholesterol by Liebermann Burchard method.

References:

Theory:

1. deMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), **Principles of Food Chemistry**, 4th Edition, Springer.
2. Msagati, T.A.M. (2013), **Chemistry of Food Additives and Preservatives**, Wiley-Blackwell.
3. Fennema, O.R. (2017), **Food Chemistry**, 5th Edition, CRC Press.
4. Attokaran, M. (2017), **Natural Food Flavors and Colorants**, 2nd Ed., Wiley-Blackwell.
5. Potter, N.N., Hotchkiss, J.H, (1995) **Food Science**, 5th Ed., Chapman & Hall.

6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), **Food Additives**, 2nd Edition, CRC Press.
7. Coultate, T. (2016), **Food: The Chemistry of its Components**, 6th Edn., Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W. (2009), **Food Chemistry**, Springer.
10. Course: FOOD CHEMISTRY (iasri.res.in)

Practical:

1. Ranganna, S. (2017). **Handbook of analysis and quality control for fruits and vegetable products**, 2nd Edn., McGraw Hill Education
2. Sawhney, S.K., Singh, R. (2001), **Introductory Practical Biochemistry**, Narosa Publishing House

GE 12: Chemistry: Statistical Methods and Data Analysis

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Chemistry: Statistical Methods and Data Analysis (GE-12)	4	2		2		

Learning Objectives

The Learning Objectives of this course are as follows:

- To give the students insight about the statistical treatment on the chemical analysis data along with illustration about the analysis of collected analytical data that will help them to take up a job of technician, scientist and laboratory manager.
- To explain the presentation of data in different form such as “Table, Graph, Bar Diagram, Pie Chart, Venn diagram” along with their reliability and validity.

Learning Outcomes

At the end of this course student will be:

- 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.

SYLLABUS OF GE-12

Theory:

Unit 1: Basics of Chemical Analysis (4 Hours)

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

Unit 2: Different Methods of Chemical Analysis (8 Hours)

Titrimetric method: volumetric titrimetry, 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 3: Statistical Method of Chemical Analysis (8 Hours)

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

Unit 4: Data Analysis and Validation (4 Hours)

Confidence interval, Testing of hypothesis, plotting of data, least square method, 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 5: Sampling, Standardisation, Labelling and Calibration (6 Hours)

Analytical samples, sample size, constituent sample, real samples, sample, sample handling, preparing laboratory samples, automated sample handling, lab on chip and General laboratory principles, recording laboratory data, standards, comparison of standards, internal standard, external standards calibration, least square method, and multivariant calibration.

Practicals: (60 Hours)

(Laboratory periods: 60)

1. Calibrate the volume of laboratory glass wares i.e. volumetric flask, beaker, burette and calibration constant.
2. Demonstrate the good laboratory practices like effect of dilution, temperature, taking observation, personal and apparatus safety.
3. Determine the quantitative presence of heavy metals like copper, chromium and iron in natural and laboratory samples using volumetric and gravimetric titration.
4. Determine the presence of magnesium ion in heavy water by EDTA method and prepare calibration curve.
5. Evaluate the absolute and method errors in a set of data collected during determination of nitrogen in an organic compound.
6. Calculate the standard deviation and predict precision of analytical results.

- Determine the concentration of pollutant in natural sample after using external standards methods.
- Compare the inter laboratory error of a spectroscopic results.
- Evaluate the limit of detection for colorimetric analysis of dyes and coloured metals in wastes water samples.
- Demonstrate the control of interference by masking by complexation.
- Report the ten analytic results in significant numbers along with standard deviation.
- Determine the confidence limit and interval for a laboratory instrument like breath alcohol analyser
- Demonstrate the internal standard method for calibration of metal estimation.
- Estimate the comparative effectiveness of different types of graphs like line, pi chart and bar graph.
- Demonstrate the working of lab on chip like glucose sensor.

References:

- Dey, R. A. and Underwood, A. L., **Quantitative Analysis**, 6th Edition, Pearson.
- Skoog, D. A., West, D. M., Holler, F. J., Crouch, S. R., **Fundamental an alytical chemistry**, Thomson Asia Ltd.
- Encyclopaedia of analytical chemistry: Applications, Theory, and Instrumentation, R A Meyor (Eds) Wiley and Sons (2000).

GE 13: Chemistry: Medicines in Daily Life

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Medicines in Daily Life (GE-13)	4	2		2		

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students study the basic details about various medicines of general uses, which are crucial for the various diseases.
- To make students learn about the active pharmaceutical ingredient in some medicines, their synthesis; therapeutic effect and side effects on human physiology.

- To make students aware about the positive and negative effects of medicines those are essential for a healthy day-to-day life.

Learning Outcomes

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

- Understand the role of different medicines on human physiology.
- Gain the knowledge of active pharmaceutical ingredient and their roles in different disease.
- Learn the proper use of different medicines and their effect and side effects.
- Learn the techniques of administering blood group, pulse rate, blood pressure and may other general diagnostic applications.

SYLLABUS OF GE-13

Theory:

Unit 1: General Introduction

(8 Hours)

Introduction-Health, disease, drugs, chemotherapy, approaches in drug designing, classification of drugs and their origin.

Unit 2: Different class of medicines

(22 Hours)

Structure of active ingredients, uses, dosage, side effects and their natural remedies:

Analgesics and antipyretics- Aspirin, paracetamol, ibuprofen, morphine, codeine

Antibiotics- Amoxicillin, norfloxacin, ciprofloxacin

Antihistamines or antiallergics- Cetirizine and Levocetirizine (role of stereoisomers)

Antiparasitic- Albendazole

Antidiabetics- Insulin, Glipizide and metformin

Antihypertensive – Amlodipine and its natural remedies- Rauwolfia.

Diuretic- Lasix

Antidepressant-Zoloft and its natural treatment

Antifungal – fluconazole, Itraconazole

Antacids- Ideal properties of antacids, combinations of antacids, Sodium 40 Bicarbonate, rantidine, milk of magnesia, aluminium hydroxide gel

Anticoagulants/antiplatelet drugs- Warfarin, heparin and Ecosprin

Anaesthetics- Atracurium, Desflurane

Poison and Antidote: Sodium thiosulphate, Activated charcoal, Sodium nitrite

Astringents: Zinc Sulphate, Potash Alum

Supplements- zinc and calcium, vitamins

Synthesis of small molecule drugs like aspirin and paracetamol

Practicals:

(60 Hours)

(Laboratory periods: 60)

1. Determination of heart rate and pulse rate, blood pressure and discussion on medicines affecting them.
2. Identification test- Magnesium hydroxide, Sodium bicarbonate, Calcium gluconate.

3. Preparation of inorganic pharmaceuticals- Boric acid Potash alum
4. Determination of sugar content in the given solution.
5. Estimation of zinc and calcium in a given solution.
6. Qualitative analysis of carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose).
7. Qualitative tests for Proteins
8. Qualitative analysis of vitamin C.
9. Isolation of paracetamol (API) from a commercial tablet
10. Isolation of aspirin (API) from tablet and recording of melting point (synthesis needs discussion)

References:

Theory:

1. Patrick, G. L. (2001) **Introduction to Medicinal Chemistry**, Oxford University Press.
2. Lemke, T. L. & William, D. A. (2002), **Foye's Principles of Medicinal Chemistry**, 5th Ed., USA,
3. Singh H.; Kapoor V.K. (1996), **Medicinal and Pharmaceutical Chemistry**, Vallabh Prakashan.
4. Chatwal, G.R. (2010), **Pharmaceutical chemistry**, inorganic (vol. 1), Himalayan publishing house
5. <https://go.drugbank.com/>

Practicals:

1. Jeffery, G.H., Bassett, J., Mendham, J., Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Munwar, S., Ammaji, S.(2019), **Comprehensive Practical Manual of Pharmaceutical Chemistry**, Educreation Publishing.
4. Mondal, P., Mondal, S.(2019), **Handbook of Practical Pharmaceutical Organic, Inorganic and Medicinal chemistry**, Educreation Publishing.

GE 15: Chemistry and Society

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Chemistry and Society (GE-15)	4	2		2		

Learning Objectives

The Learning Objectives of this course are as follows:

- To expand the literacy of chemistry, and increase general awareness, background of chemistry and its importance among the non-chemistry student even arts as well as commerce.
- To make a common student understand the importance and role of chemistry in development of civilization, societal issues related to chemistry and their expected solutions.

Learning Outcomes

At the end of this course the student will be able to:

- Increase the literacy of chemistry even in non-science students
- Understand the basic concept, principle and importance of chemistry
- Realize the importance of chemistry in daily life and future requirement

SYLLABUS OF GE-15

Theory:

Unit 1: Basics of chemistry (4 Hours)

Periodic table, Atom and molecules, chemical bonding, properties and chemical reactions with simple examples and illustration.

Unit 2: Chemistry in Heritage (8 Hours)

Extraction and uses of metals like iron and stone in ancient times, metals in ornaments, medicines, weapons and chemistry for preservatives, basics of preservation and few examples of preservatives.

Unit 3: Chemistry in Life (10 Hours)

Edible and non-edible molecules, biochemistry of foods and medicine with examples: Aspirin, Paracetamol, Ibuprofen and Penicillin, Cephalosporin, Chemistry for industry: Artificial sweeteners, Soaps and detergents and cosmetics, Polymer and Plastics: Uses and environmental issues.

Unit 4: Chemical pollution and Toxicity (2 Hours)

Chemical source of water, air and soil pollution, biomagnification and metal toxicity with example and illustrations. monitoring of air pollution.

Unit 5: Testing of chemicals (2 Hours)

Flame test, solubility test, qualitative and quantitative identification of ions in natural samples like metal copper, iron and chromium ores and adulterant in foods.

Unit 6: Future of chemistry (4 Hours)

Basics of green chemistry, Reuse and recycling of by-products, zero waste chemistry and Alternate fuel and energy providing chemicals: biodiesel, natural gas and hydrogen.

Practicals/Hands-on Training:**(60 Hours)****(Laboratory periods: 60)**

1. Determine the calcium and magnesium contents in water samples using EDTA methods.
2. Determine the organic contents and pH of soil sample.
3. Estimate the food adulterants in edible items
4. Quantify the presence metals by flame test method
5. Demonstrate the conversion of PET into bottle into value added products.
6. Determine the quantitative presence of heavy metals like copper and chromium in natural sample like ore.
7. Demonstrate the exothermic and endothermic reaction in laboratory
8. Preparation aspirin and paracetamol as well as identify.
9. Compare the fuel efficiency of biodiesel and petrol.
10. Preparation of representative compound using microwave
11. Demonstrate the biodegradability of natural and synthetic plastics.
12. Demonstrate the protection of rusting of iron after surface spray coating.
13. Estimate the protein contents in edible samples using chemical methods.
14. Small working project on heritage chemistry like bio compatibility of metals and medicinal importance of metals like iron, gold and silver.

References:

1. Lee, J. D., **Concise Inorganic Chemistry**, Wiley India Pvt. Ltd.
2. Sharma, B. K., **Industrial chemistry**, Goel Publishing House, India
3. Christian, Gary D., Dasgupta, Purnendu K., Schug, Kevin A., **Analytical chemistry**, Wiley
4. V. Subramanian, **A text book of Environmental chemistry**, Wiley

GE 19: Radio-chemistry in Energy, Medicine and Environment**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Radio-chemistry in Energy, Medicine and Environment (GE-19)	4	3		1		

Learning Objectives

The Learning Objectives of this course is as follows:

- To give an introduction to nuclear and radiochemical concepts to the students.
- To help students gain fundamental knowledge about the radioisotopes and their real-world applications in medicine, diagnostic techniques, energy, research and environment.

Learning Outcomes

By the end of the course, the students will:

- Learn about radioisotopes, radioactive decay
- Use of radiochemistry in various fields
- Effect of radiations on health
- Learn about nuclear energy and nuclear pollution

SYLLABUS OF GE-19

Theory:

Unit 1: Introduction (9 Hours)

Atoms, composition of nucleus, mass number, isotopes, nuclear stability, radioactive decay, radioactivity in nature: natural and artificial radioisotopes, elementary particles, radioactive decay (α , β and γ decay), half-life period, types of nuclear reactions: nuclear fission and nuclear fusion.

Unit 2: Nuclear power generation (6 Hours)

Nuclear Power generation from uranium ore (energy production and nuclear waste), introduction to nuclear reactors for energy and nuclear weapons

Unit 3: Applications of radiochemistry (15 Hours)

C 14 decay and radioactive dating, irradiation of food, radiotracers for studying chemical reactions (photosynthesis, metabolic studies of drugs, metabolism of organisms, fundamental properties of genetic material), medicinal application of radio chemicals in radiotherapy (use in cancer, hyperthyroidism, blood disorders), radio-pharmaceuticals, diagnostic procedures: CT, PET

Unit 4: Environment radioactivity (6 Hours)

Natural radioactivity, natural process that release radioactive material in environment, man-made events like Chernobyl disaster, bomb test, use of radiotracers in environmental studies.

Unit 5: Nuclear pollution and safety management (9 Hours)

Radiation protection standards, basics of radiation hazards, international guidelines on radiation protection, disposal of nuclear waste, nuclear disaster and its managements, Effect of radiation on health: Biological effects of radiation, radiation monitors, dose limits for workers and public,

Practicals:

(30 Hours)

(Laboratory periods: 30)

1. Study the background radiation in different places and identify the probable source. (Data to be provided).
2. Survey the diagnostic procedures involving radio-chemistry in different diagnostic laboratories.
3. Write a report on the radio isotopes used in various diagnostic procedures.
4. Write a report on safety measures taken in diagnostic labs.
5. Write a report on any two nuclear and radiation accidents focusing on their impact on human life, environment and economy.

References:

1. Nuclear and radiochemistry, Konya J., Nagy N. 2nd Edition, Elsevier
2. Radiochemistry and Nuclear Chemistry, 4th Edition, Choppin G., Lilijenzin J-O, Rydberg J., Ekberg C. Elsevier.

GE 21: Chemistry in Indology and Physical & Mental Well Being

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Chemistry in Indology and Physical & Mental Well Being (GE-21)	4	3		1		

Learning Objectives

The Learning Objectives of this course is as follows:

- To illuminate the students about the scientific basis and approaches related to the practices that promote physical and mental health/balance, that includes meditation,

sports, Yoga and nutrition. The chemical/biochemical mechanisms that underscore the various states of the mind and body, which drives the general homeostasis or anomalies thereof, shall also be illustrated.

- To make students aware about role of metals in ancient and medieval India
- To make students aware of how Alchemists used metals, chemicals, compounds and ores in medicines
- To make students aware of the different types of instruments used in the ancient and medieval India
- To make students aware of the life and work of ancient and medieval scientists/chemists.

Learning Outcomes:

By the end of the course, the students will:

- Understand about the scientific basis and approaches that promote physical and mental health.
- Know about the chemical/biochemical mechanisms that underline the states of the mind and body
- Understand the role of metals in ancient and medieval India
- Understand how alchemists used metals and chemical compounds in medicines
- Know about the life and contributions of ancient scientists and chemists

SYLLABUS OF GE-21

Theory:

Unit 1: Physical Health Practices

(9 Hours)

Principles of Physical Education, Body composition with respect to health and fitness and different methods of body composition analysis, Calculation of energy expenditure (at rest and during exercise), VO_2 and calculation of VO_2 max, respiratory exchange ratio, blood pressure, Means of fitness development- aerobic and anaerobic exercises, yoga and physical fitness, Exercises and their intensities related to heart rate zone, Different fitness levels for different age groups and gender, Kinesiology, Physiology of Exercise

Unit 2: Mind-body Practices

(6 Hours)

States of mind and types of brain waves, mindfulness meditation in clinical psychology and psychiatry, Desbordes' recent studies on brain activities (Harvard's studies), MRI & functional MRI studies.

Types of meditations- focused attention meditation (FA), open monitoring meditation (OM), transcendental meditation (TM), loving-kindness meditation (LKM), mindfulness meditation (MM) and body-mind meditation (B-M).

Biochemical alterations, such as changes in activity/production of hormones, cytokines, chemokines, interferons, etc., oxygen saturation/desaturation, redox-condition and oxidative balance, progression/regression of certain diseases/health conditions, in response to various states of physical and mental well-being.

Unit 3: Nutrition for Mind/body Homeostasis (6 Hours)

Role of nutrition in physical and mental health. Nutrients: carbohydrates, Protein, Fat, Vitamins, Minerals, Water-their functions, role of hydration (water balance) during exercise, daily caloric requirement and expenditure.

Metabolism: An overview of ATP release in glycolysis, TCA cycle, electron transport chain. basic concept of balanced diet vs. fad diet (Atkins, ketogenic etc.), Concept of BMI (Body mass index) and BMR (Basal metabolic rate), Obesity and its hazard, Dieting versus exercise for weight control.

Unit 4: Concepts of Atoms, Molecules and Laws of Motion (3 Hours)

Concepts of atoms and molecules, properties and categories of atoms and molecules, Laws of motion.

Unit 5: Metallurgy (6 Hours)

Gold, Silver, Copper, Bronze and other alloys; Copper smelting blast furnace and copper extraction; Tron and Steel; Iron smelting blast furnaces from Southern India; Ironworks in Ancient and medieval India; Delhi Iron Pillar; Dhar and Kodachadri Iron pillars; Wootz steel; Zinc and its extraction.

Unit 6: Chemicals (3 Hours)

Drugs, dyes, pigments, glass, cosmetics and perfumes, etc.

Unit 7: Drugs (6 Hours)

Eight categories of Gandhasara; Compounds of mercury (Hg) made and used by the Indian Alchemists for medicinal purposes; Use of chemical, compounds and ores in medicines.

Unit 8: Life and work of Ancient Indian Scientists/Chemists (6 Hours)

(i) Maharshi Kanada (Ancient text and manuscripts), (ii) Nagarjuna (Ras Ratnakar, Kakshaputtantra, Arogya Manjari, Yog Saar, Yoasthak), (iii) Vaagbhatt (Rasratna Samuchchay), (iv) Govindacharya (Rasarnava), (v) Yashodhar (Ras Prakash Sudhakar), (vi) Ramachandra (Rasendra Chintamani), (vii) Somdev (Rasendra Chudamani)

Practicals: (30 Hours)

(Laboratory periods: 30)

1. Extraction of essential oil from rose petal.
2. Extraction of casein from milk.
3. Determination of pulse rate/blood pressure/oxygen saturation before and after exercise.
4. Determination of acid value of given oil sample.
5. Isolation of piperine from black pepper.
6. Determination of Copper in brass turnings.
7. Extraction of Butea monosperma (Palash) dye for its use in coloration of cloth.
8. Determination of mass loss in mild steel in acidic/basic media.

9. Project on (Do any one):

Ayurveda as alternate medicine system,

Homeopathy in India,

Yogic Practices for mental wellness

Ancient Chemists of India

Other titles can also be suggested by the teacher.

10. Visit to

Iron Pillar, the metallurgical marvel and prepare a brief report.

Industries like Dabur India Ltd.

References:

1. Baer cites Kabat-Zinn, J. (1994): **Wherever you go, there you are: Mindfulness meditation in everyday life**. New York: Hyperion, p.4.
2. Buchholz L (October 2015). "**Exploring the Promise of Mindfulness as Medicine**". JAMA. 314 (13): 1327–1329. doi:10.1001/jama.2015.7023. PMID 26441167.
3. Harrington A, Dunne JD (October 2015). "**When mindfulness is therapy: Ethical qualms, historical perspectives**". The American Psychologist. 70 (7): 621–631. doi:10.1037/a0039460. PMID 26436312.
4. Blanck P, Perleth S, Heidenreich T, Kröger P, Ditzen B, Bents H, Mander J (March 2018). "**Effects of mindfulness exercises as stand-alone intervention on symptoms of anxiety and depression: Systematic review and meta-analysis**". Behaviour Research and Therapy. 102: 25–35. doi:10.1007/s12671-014-0379-y. PMID 29291584.
5. Khoury B, Sharma M, Rush SE, Fournier C (June 2015). "**Mindfulness-based stress reduction for healthy individuals: A meta-analysis**". Journal of Psychosomatic Research. 78 (6): 519–528. doi:10.1016/j.jpsychores.2015.03.009. PMID 25818837.
6. Jain FA, Walsh RN, Eisendrath SJ, Christensen S, Rael Cahn B (2015). "**Critical analysis of the efficacy of meditation therapies for acute and subacute phase treatment of depressive disorders: a systematic review**". Psychosomatics. 56 (2): 140–152. doi:10.1016/j.psych.2014.10.007. PMC 4383597. PMID 25591492.
7. Reangsing C, Punsuwun S, Schneider JK (March 2021). "**Effects of mindfulness interventions on depressive symptoms in adolescents: A meta-analysis**". International Journal of Nursing Studies. 115: 103848. doi:10.1016/j.ijnurstu.2020.103848. PMID 33383273. S2CID 229940390.

8. Sharma M, Rush SE (October 2014). "**Mindfulness-based stress reduction as a stress management intervention for healthy individuals: a systematic review**". *Journal of Evidence-Based Complementary & Alternative Medicine*. 19 (4): 271–286. doi:10.1177/2156587214543143. PMID 25053754.
9. Hofmann SG, Sawyer AT, Witt AA, Oh D (April 2010). "**The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review**". *Journal of Consulting and Clinical Psychology*. 78 (2): 169–183. doi:10.1037/a0018555. PMC 2848393. PMID 20350028.
10. Chiesa A, Serretti A (April 2014). "**Are mindfulness-based interventions effective for substance use disorders? A systematic review of the evidence**". *Substance Use & Misuse*. 49 (5): 492–512. doi:10.3109/10826084.2013.770027. PMID 23461667. S2CID 34990668.
11. Garland EL, Froeliger B, Howard MO (January 2014). "**Mindfulness training targets neurocognitive mechanisms of addiction at the attention-appraisal emotion interface**". *Frontiers in Psychiatry*. 4: 173. doi:10.3389/fpsy.2013.00173. PMC 3887509. PMID 24454293.
12. Sancho M, De Gracia M, Rodríguez RC, Mallorquí-Bagué N, Sánchez-González J, Trujols J, et al. (2018). "**Mindfulness-Based Interventions for the Treatment of Substance and Behavioral Addictions: A Systematic Review**". *Frontiers in Psychiatry*. 9 (95): 95. doi:10.3389/fpsy.2018.00095. PMC 5884944. PMID 29651257.
13. Paulus MP (January 2016). "**Neural Basis of Mindfulness Interventions that Moderate the Impact of Stress on the Brain**". *Neuropsychopharmacology*. 41 (1): 373. doi:10.1038/npp.2015.239. PMC 4677133. PMID 26657952.
14. Dunning DL, Griffiths K, Kuyken W, Crane C, Foulkes L, Parker J, Dalgleish T (March 2019). "**Research Review: The effects of mindfulness-based interventions on cognition and mental health in children and adolescents - a metaanalysis of randomized controlled trials**". *Journal of Child Psychology and Psychiatry, and Allied Disciplines*. 60 (3): 244–258. doi:10.1111/jcpp.12980. PMC 6546608. PMID 30345511.
15. Sharman, J. R. (1964). **Introduction to physical education**. New York: A.S. Barnes & Co.
16. William, J. F. (1964). **The principles of physical education**. Philadelphia: W.B. Saunders Co
17. Bucher, C. A. (n.d.) **Foundation of physical education**. St. Louis: The C.V. Mosby Co.
18. Sharkey, B. J. (1990). **Physiology of fitness**, Human Kinetics Book
19. Giam, C.K & The, K.C. (1994). **Sport medicine exercise and fitness**. Singapore: P.G. Medical Book.
20. Kenney, W.L., Wilmore, J.H., Costill, D.L. (six edition) **Physiology of sport and exercise**.
21. Vedas: (i) Rig Veda, (ii) Yajur Veda, (iii) Atharva Veda, (iv) Sama Veda
22. Deb, B. M., **The Peacock in Splendour**, Visva Bharti University.
23. Ray, P. C., **A History of Hindu Chemistry: from the Earliest Times to the Middle of the Sixteenth Century A.D.**, Volume 1 – 1902, Volume 2 – 1908, The Bengal Chemical and Pharmaceutical Works Ltd

24. **“History of Chemistry in Ancient and Mideaval India”** (Edited volume of Acharya Ray’s “History of Hindu Chemistry”), Indian Chemical Society, Calcutta, 1956.
25. Harsha, N. M., Nagaraja, T. N., **The History of Hindu Chemistry**, *Ancient Science of Life*, 2010, 30, 58 – 61.
26. Ray, P. C., **Life and experiences of a Bengali chemist**, Two Volume Set. Calcutta: Chuckervertty, Chatterjee & Co. 1932 and 1935.
27. Ray, P. R., **Chemistry in Ancient India**, *Journal of Chemical Education*, 1948, 25 (6), 327.
28. Seal, B. N.(1915), **The Positive Sciences of the Ancient Hindus**, Longman Greens and Co., Kolkata.

BHASKARACHARYA COLLEGE OF APPLIED SCIENCE
B.Sc. (HONOURS) POLYMER SCIENCE

Category I

DISCIPLINE SPECIFIC CORE COURSE -1 (DSC-1) – :
INTRODUCTION TO POLYMER SCIENCE

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF
THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
INTRODUCTION TO POLYMER SCIENCE	4	3	0	1	PCM	PCM

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize with the structure of polymers.
- To acquaint students with knowledge of molecular weight determination and polymersolubility.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand physical state of polymers
- Develop fundamental knowledge of thermal transitions of temperature
- Understand structure-property relationship of polymers
- Apply mathematical formulae to depict polymer solution properties

SYLLABUS OF DSC-1

UNIT – I (9 hours)

INTRODUCTION TO POLYMER SCIENCES

Introduction and history of polymeric materials, classification of polymers, configuration and conformation of polymers, nature of molecular interaction in polymers, cumulative interaction, entanglement, random chain model and RMS end-to-end distance, Various structures of copolymers such as linear branched and cross-linked copolymers and their types.

UNIT – II (6 hours)***POLYMER CRYSTALS***

Crystal morphologies, extended chain crystals, chain folding, lamellae, spherulites, crystallization, crystallinity, crystallizability & orientation, crystalline melting point, crystallization kinetics, effect of orientation and crystallinity on polymer properties, determination of crystallinity.

UNIT – III (9 hours)***PROPERTIES OF POLYMERS***

Physical properties, introduction of mechanical properties (stress–strain curves, tensile, flexural, impact, fatigue, hardness, creep and abrasion), electrical properties (dielectric strength, volume resistivity and power factor)

UNIT – IV (9 hours)***POLYMER MOLECULAR WEIGHT***

Nature and structure of polymers: structure-property relationships, molecular weight of polymers (M_n , M_w , M_v and M_z), polydispersity, molecular weight distribution and determination of molecular weight by solution viscosity and end group analysis,

UNIT – V (6 hours)***SOLUTION PROPERTIES OF POLYMERS***

Polymer solutions, solubility parameter, athermal solvents, theta solvents, solution viscosity, thermodynamics of polymer solutions, Flory-Huggins theory

UNIT – VI (6 hours)***GLASS TRANSITION BEHAVIOUR OF POLYMERS***

Glass transition temperature (T_g) and measurement of T_g , factors affecting the glass transition temperature, WLF equation

Practical component – (30 hours)

1. Chemical identification of polymers- • Unsaturation • Testing of functional groups(associated with polymers).
2. Measurement of glass transition temperature (T_g).
3. To determine the melting point of crystalline polymers.
4. To check the solubility of the given polymeric sample in different solvents.
5. Determination of molecular weight by solution viscosity.
6. Determination of number average molecular weight by end group analysis.
7. To find out the acid number and hydroxyl number of a given polymer.
8. To measure volume resistivity of polymer samples.

Essential/recommended readings

1. Odian, G., (2004) Principles of Polymerization, Wiley-interscience.
2. Gowariker V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition.
3. Billmeyer F.W., (2007) Textbook of Polymer Science, Wiley, India.
4. Shah V., (1998) Handbook of Plastics Testing Technology, Wiley Interscience.

5. Seymour R.B., Carraher C.E., (2003) Polymer Chemistry, Marcel Dekker.
6. Teraoka, I. (2002). Polymer solutions: an introduction to physical properties.
7. Hiemenz, P. C., & Lodge, T. P. (2007). Polymer chemistry. CRC press.

Suggestive readings

1. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
2. Schultz J.M., (2001) Polymer Crystallization, American Chemical Society.
3. Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, Tata McGraw Hill.
4. Shah V., (2006) Handbook of Plastics Testing and Failure Analysis, John Wiley & Sons, Inc., 3rd Edition.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC-2): RAW MATERIALS FOR POLYMERS

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RAW MATERIALS FOR POLYMERS	4	3	0	1	PCM	

Learning Objectives

The Learning Objectives of this course are as follows:

- To learn about the resources of polymers
- To learn about basic concepts of polymer latex
- To gain knowledge of properties of monomers and their synthesis XXX

Learning outcomes

The Learning Outcomes of this course are as follows:

- Apply the knowledge of latex manufacturing and compounding
- Apply the knowledge of techniques used in monomer production

SYLLABUS OF DSC- 2

UNIT – I (6 hours)

INTRODUCTION TO CRUDE OIL AND IT'S REFINING

Petroleum oil, natural gas, coal: capabilities and limitations. general consideration of petrochemicals, an overview of petroleum refining, desalting, distillation, cracking and its types

UNIT – II (15 hours)

SYNTHESIS OF MONOMERS FROM PETROCHEMICALS

Ethylene, vinyl acetate, vinyl chloride, ethylene oxide and ethylene glycol, acrylonitrile, methyl methacrylate, isoprene, phenol, styrene, terephthalic acid, adipic acid, caprolactam, hexamethylenediamine

UNIT – III (6 hours)

LATEX

Natural rubber latex: collection process, composition, concentration and stabilization of latex

UNIT – IV (9 hours)

LATEX ADDITIVES AND IT'S COMPOUNDING

Vulcanizing agents, fillers, accelerator, coagulating agent, wetting, dispersing and emulsifying agents, stabilizers, thickening agents and other additives, compounding formulations for product manufacturing

UNIT –V (9 hours)

LATEX PRODUCT MANUFACTURING TECHNIQUES

Latex compound formulation, process of manufacturing, finishing and applications of spreading, casting and dipping (Dipping-principle and procedure of dipping process- different types of dipping –after treatment of latex deposits -Manufacture of dipped goods with formulation and flow chart-defects and remedies . latex casting – principle and procedure of casting-production of cast articles –mould preparation, latex thread and latex foam

Practical component- (30 hours)

1. Analysis of formalin/phenol/epichlorohydrin/Plasticizer
2. Determination of hydroxyl value/carboxyl value/ester value/epoxy value
3. Determination of colour and viscosity by gardner's tube method
4. Fractional distillation of crude oil.
5. To calculate dry rubber content (DRC) of latex.
6. To determine the coagulation strength of latex.
7. Preparation of balloon by dipping process.
8. Latex compounding for preparation of gloves & balloons.
9. Synthesis of adipic acid from cyclohexanol using Conc. HNO₃.
10. To prepare monomers from C₄ hydrocarbons.
11. Determination of percentage purity of phenol.

Essential/recommended readings

1. Kumar D., Chandra R., (2001) Latex Technology, Dhanpat Rai & Co.
2. Rao B.K.B., (2007) Textbook on Petrochemicals, Khanna Publishers.

- Blackley, D.C., "High Polymer Latices", Vol 1 and 2, Chapman and Hall, 1997
- Mausser, R.F., "The Vanderbilt Latex Hand book" 3rd edn. R.T. Vanderbilt Company, 1987.

Suggestive readings

- Rao B.K.B., (2007) Modern Petroleum Refining Processes, Oxford and IBH
- Maiti S., (2002) Introduction to Petrochemicals, Oxford & IBH Publ. Co.
- Speight J.G., (2006) Chemistry and Technology of Petroleum, CRC Press.
- Martin J. M., Smith W.K., (2007) Handbook of Rubber Technology, CBS Publishers.

DISCIPLINE SPECIFIC CORE COURSE– 3 (DSC-3): UNIT

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
UNIT OPERATIONS	4	3	0	1	PCM	PCM

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand concepts of unit operations and their importance in polymer industries
- To learn about the concepts of separation equipments used in the process industry
XXX

Learning outcomes

The Learning Outcomes of this course are as follows:

- Select suitable criteria for solving material and energy balance problems
- Illustrate energy and material balance equations for open and closed systems

SYLLABUS OF DSC-3

UNIT – I (6 hours)

INTRODUCTION TO UNIT OPERATIONS

Unit operations: concept and requirement, material and energy balances (with and without chemical reactions), energy transport in non-isothermal systems

UNIT – II (9 hours)

MECHANICAL OPERATIONS

Mechanical Operations: Size reduction and its equipment (ball mill, jack crusher, end and

edge roller mill), filtration: theory of filtration, filter aids, filter media, industrial filters including filter press, rotary filter, edge filter, etc., factors affecting filtration

UNIT – III (15 hours)

HEAT TRANSFER

Conduction (Fourier law, Reynolds number), convection, radiation, heat exchangers (tube shell, shell plate)

UNIT – IV (15 hours)

MASS TRANSFER MECHANISM

Mass diffusion, factors affecting diffusion, gas absorption (Henry's Law, Langmuir Absorption Isotherm, BET equation), types of distillation, drying

Practical component (30 hours)

1. Handling of jaw crusher, ball mill for crushing and grinding.
2. Calculate the rate of evaporations of different volatile liquids.
3. Distillation of various liquid mixtures.
4. To evaluate diffusion percentage of a plasticizer in a PVC.
5. Filtration of solids from slurry.
6. Calculation of pressure drop and pipe size.
7. Heat Transfer through different materials like glass and plastics.
8. Analysis of different adsorption isotherms.

Essential/recommended readings

1. McCabe W., Smith J., Harriott P., (2005) Unit Operations in Chemical Engg., McGraw-Hill Education.
2. Chattopadhaya P., (2003) Unit Operations in Chemical Engg., Vol. 1 & Vol. 2, KhannaPublishers.
3. Coulsan J.M., Richardson J.F., (2010) Chemical Engg., Vol. 1, Elsevier.

Suggestive readings

1. Kumar D. S., (2009) Heat and Mass Transfer, S K Kataria & Sons.
2. Rao G. K., (2002) Solved Example in Chemical Engg., Khanna Publishers.
3. Treybal R., (2012) Mass Transfer Operations, Tata McGraw Hill.

**COMMON POOL OF GENERIC ELECTIVE COURSES
OFFERED BY BHASKARACHARYA COLLEGE OF APPLIED
SCIENCES IN POLYMER SCIENCE**

**GENERIC ELECTIVES (GE-1): BASICS OF POLYMER
SCIENCE**

Category-IV

Credit distribution, Eligibility and Pre-requisites of the Course

Course title &Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
BASICS OF POLYMER SCIENCE	4	2	0	2	All Science Streams	NIL	Polymer Science

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize with the structure of polymers will be introduced to students.
- To acquaint students with knowledge of molecular weight determination and polymersolubility

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand concept of crystalline and amorphous states of polymers
- Correlate flexibility with the glass transition temperature
- Understand structure-property relationship of polymers
- Apply mathematical formulae to depict polymer solution properties

SYLLABUS OF GE-1

UNIT – I (10 hours)

INTRODUCTION TO POLYMERS

Introduction and classification of polymers, configuration and conformation of polymers,

nature of molecular interaction in polymers, entanglement, various structures of copolymers such as linear branched and cross-linked copolymers, Polymer solutions, solubility parameter, solution viscosity, polymer solubility, thermodynamics of polymersolutions

UNIT – II (10 hours)

PROPERTIES OF POLYMERS

Physical properties, stress–strain behaviour, mechanical properties (tensile, flexural, impact, fatigue, hardness, creep, abrasion), introduction to flow & glass transition temperature (T_g) and its measurement of T_g , factors affecting the glass transition temperature

UNIT – III (10 hours)

MOLECULAR WEIGHT OF POLYMERS

Nature and structure of polymers – structure-property relationships, Molecular weight of polymers (M_n , M_w etc.), polydispersity, molecular weight distribution and determination of molecular weight by viscosity, end group analysis, cryoscopy, ebulliometry, light scattering & ultracentrifugation methods

Practical component (60 hours)

1. Chemical identification of polymers: Functional groups (associated with polymers).
2. Determination of molecular weight by solution viscosity/end group analysis.
3. To check the solubility of the given polymeric sample in different solvents.
4. To determine the melting point of crystalline polymers.
5. Determination of heat deflection temperature & vicat softening point of polymers.
6. Acid value of acrylic acid
7. Estimation of hydroxyl value by PVA and Cyclohexanol
8. Determination of epoxy equivalent weight of the epoxy resin.
9. Determination of saponification value of oil.
10. Study of three component systems.

Essential/recommended readings

1. Brydson J.A., (2016) *Plastics Materials*, Butterworth Heinemann, 8th Edition.
2. Ghosh P., (2010) *Polymer Science and Technology: Plastics, Rubbers, Blends and Composites* Tata McGraw-Hill.
3. Gowarikar V.R., (2019) *Polymer Science*, New Age International Publishers Ltd, 3rd Edition
4. Billmeyer F.W., (2007) *Textbook of Polymer Science*, Wiley, India.
5. Shah V., (1998) *Handbook of Plastics Testing Technology*, Wiley interscience publications

Suggestive readings

1. Schultz J.M., (2001) *Polymer Crystallization*, American Chemical Society.
2. Seymour R.B., Carraher C.E., (2000) *Polymer Chemistry*, Marcel Dekker.

GENERIC ELECTIVES (GE-2): ADVANCED ANALYTICAL TECHNIQUES

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
ADVANCED ANALYTICAL TECHNIQUES	4	2	0	2	All Science Streams	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- To acquaint the students with the advanced instrumental techniques and their applications in characterization of polymeric materials

Learning outcomes

The Learning Outcomes of this course are as follows:

- Learn the electronic microscope for characterization of morphology of polymeric materials
- Elucidate crystallinity of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

SYLLABUS OF GE-2 UNIT – I (6 hours)

INTRODUCTION

Basic principle of spectroscopy, molecular and atomic spectra, Lambert-Beer's law, Frank-Condon principle, electromagnetic radiation and its properties, interaction of radiation with matter, statistical method of analysis

UNIT – II (6 hours)

SPECTROSCOPIC TECHNIQUES

Principles and applications in structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.): Infra-red spectroscopy, UV-Vis spectroscopy, electron spin resonance, raman, nuclear magnetic resonance spectrometer

UNIT – III (8 hours)

CHROMATOGRAPHY TECHNIQUES IN POLYMER

Thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography.

UNIT – IV (10 hours)

MICROSCOPIC AND X-RAY TECHNIQUES

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics and applications (size, morphology, crystallinity etc.) in polymers characterization

Practical component- (60 hours)

1. Study of UV stabilization of polymer samples by UV-visible spectrophotometer.
2. Calculate weight percentage of inorganic and organic ingredients in polymeric compounds.
3. Determination of K-value of PVC.
4. Quantitative determination of impurities by UV-Vis. spectrophotometer.
5. Characterization of Filler Content /Ash Content of common polymers by Thermogravimetric Analysis, (TGA).
6. Identification of additives in a processed polymer by chromatography.
7. Interpretation of FTIR, NMR and Raman spectra of polymers

Essential/recommended readings

1. Willard H.H., Merritt L.L., Dean J.A. (1988) Instrumental method of analysis, Wadsworth Publishing Company.
2. Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
3. Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.
4. Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.

Suggestive readings -

1. Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
2. Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
3. Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-interscience.

GENERIC ELECTIVES (GE-3): POLYMERS AND ENVIRONMENT

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS AND ENVIRONMENT	4	2	0	2	All Science Streams	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- To give understanding of basics of care to be taken while handling polymer products.
- To know the Safety and hazardous of their manufacturing processes.
- To impart Knowledge of the subject will help students to see the environmental impact of plastic and resin.
- To understand the current benefits and concerns surrounding the use of plastics and look to future priorities, challenges and opportunities.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand basics of environmental and safety issues in the chemical industry.
- Understand safety in handling monomer and resins
- Impact of final product of polymer on environment after use and its waste management

SYLLABUS OF GE-3

UNIT – I (8 hours)

ENVIRONMENTAL APPROACH OF PLASTIC WASTE

Health and safety, Plastics in the society, Plastics in the environment, Plastic waste management, Plastic waste in the marine and terrestrial environment, Plastic material degradation, regulations for hazardous chemicals in articles/plastic products, coated articles. Separation techniques of plastic wastes (density, float sink and froth floatation methods, optical, spectroscopic, sorting by melting temperature etc.).

UNIT – II (8 hours)

PLASTIC SEGREGATION

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle (mechanical and chemical), recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples.

UNIT – III (14 hours)

RECYCLING

Disposal processes and Various waste treatment methods – controlled tipping, pulverization, compositing, Energy from waste – (incinerators- pyrolysis, factors affecting incineration), new developments in thermal disposal of refuse, on-site disposal methods, compacting and baling. Recycling of Polyolefins, PVC, PET, Polystyrene, Polyamides (Nylon-6 and Nylon- 6,6). Recycling of Thermosets –reclaiming of rubber –pyrolysis, depolymerization of scrap rubber, tyre retreading, uses of recycled rubber.

Practical component- (60 hours)

1. Primary recycling of plastic waste collected from the environment.
2. Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
3. To study composting of natural/biopolymers.
4. Separation of polymer mixture by sink flotation technique.
5. Separation of polymer mixture by selective dissolution technique.
6. Recovery of BHET from PET by chemical recycling process
7. Recovery of Adipic Acid from Nylon 66 by chemical recycling technique
8. To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
9. Preparation of plasticizer from polyester waste.
10. Preparation of reclaim from tyre waste.

Essential/recommended readings

1. Chandra, R., & Adab, A. (1994). Rubber & Plastic Waste: Recycling, Reuse and Future Demand. CBD Publishers.
2. Scheirs, J., & Long, T. E. (Eds.). (2005). Modern polyesters: chemistry and technology of polyesters and copolyesters. John Wiley & Sons.

Suggestive readings

1. Blow, S. (1998). Handbook of Rubber Technology.
2. Brandrup, J., Bittner, M., Michaeli, W., & Menges, G. (1996). Recycling and Recovery of Plastics, Hanser. Gardner, München.
3. Goodship, V. (2007). Introduction to plastics recycling. iSmithers Rapra Publishing.
4. Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Sri Venkateswara College

COURSES OFFERED BY DEPARTMENT OF
BOTANY, BIOCHEMISTRY, ZOOLOGY, CHEMISTRY AND PHYSICS

B.Sc. (Hons.) Biological Science

Category-I

DISCIPLINE SPECIFIC CORE COURSE – 01: Basic concepts of Biomolecules

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Basic concepts of Biomolecules	DSC-101	2	0	2	10+2 from any recognized Board with Biology & Candidates must appear in CUET in the following subject combination: Physics+ Chemistry+ Biotechnology Biology/	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- to develop a basic understanding of the structure, bonding, stability, stereochemistry and reactivity of organic molecules with focus on biomolecules.
- This basic knowledge will empower the students to develop an understanding about chemistry and biology of biomolecules such as proteins and nucleic acids. This course also provides a basic understanding of the chemistry of carbohydrates and lipids.
- This knowledge will help students to better understand the biological applications of these biomolecules.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand and apply the fundamental principles of chemistry which include bonding, electronic effects, molecular forces and stability of reactive intermediates to biomolecules.
- Gain an insight into the influence of chemical bond polarization on a molecular structure and its reactivity.
- Identify the type of metabolic reaction and draw reaction mechanisms for key metabolic processes.
- Recognize stereochemistry of a biomolecule and give a rational explanation of its biological reactivity based on stereochemistry.
- Understand the chemistry and biological functions of carbohydrates and lipids

SYLLABUS OF DSC-1

Unit I: Basic Concepts

(6 hours)

Electronic displacements and their applications: Inductive, electromeric, resonance and hyperconjugation. Dipole moment, acidity and basicity. Types, shape and relative stability of carbocations, carbanions and free radicals. Electrophiles and nucleophiles, Intramolecular and intermolecular molecular forces including hydrophobic, hydrophilic interactions and hydrogen bond (emphasis on effect of these forces on the stability of biomolecules),

Unit II: Stereochemistry

(8 hours)

Stereochemistry and its importance to biological systems, Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. Mesomers, specific rotation; Resolution of racemic modification, Configuration and projection formulae: Newmann, Sawhorse, Fischer projections and their interconversion. Chirality in molecules with one and two stereocentres; CIP rules: Erythro/Threo, D/L and R/S designations.; Relative and absolute configuration; thalidomide case and chiral drugs; Geometrical isomerism: cis-trans, syn-anti and E/Z nomenclature.; Cis-trans isomerism in vision.

Unit III: Biologically significant chemical reactions

(6 hours)

Aldol condensation (Glucogenesis), Retro-aldol (Glycolysis), Benzoin condensation (umpolung-decarboxylation of pyruvate in the presence of TPP), Claisen condensation (Synthesis of fatty acids), Michael addition (Dehydrases), Cannizzaro (Sugar metabolism), Baeyer Villiger reaction (FAD dependent ketone synthesis), Pinacole-pinacolone rearrangement (1,2-carbon carbon shift), Isomerisation (Glycolysis), Redox reaction (Lactate dehydrogenase).

Unit IV: Carbohydrates

(6 hours)

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, linkage between monosaccharides, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, configuration, cyclic structure (exclude structure elucidation) and Haworth projection formulae of glucose and fructose: structure of disaccharides (sucrose, maltose, lactose); polysaccharides- classification, structure of important members, storage polysaccharides (Glycogen, Starch) and structural polysaccharides (Cellulose, chitin, peptidoglycans and glycosaminoglycans)

Unit V: Lipids

(8 hours)

Introduction, classification, biological importance of triglycerides, phospholipids, glycolipids, eicosanoids and steroids (cholesterol). Oils, Fats and Waxes: Common fatty acids present in oils and fats, essential fatty acids, characteristics of fatty acids and fats (saponification, iodine, acid, acetyl and peroxide values). Rancidity and reversion of fats; waxes, trans-fats and their biological significance.

Practical component: (60 hours)

1. Purification of organic compounds by recrystallization using the following solvents:
 - i. Water
 - ii. Water-Alcohol
 - iii. Alcohol
2. Criterion of purity of organic compound- melting point, mixed melting point and boiling point of organic compounds.
3. Estimation of saponification value of fat/oil.
4. Estimation of iodine value of fat/oil.
5. Qualitative tests for carbohydrates and lipids
6. Chromatography
 - a) To separate a mixture of sugars by circular paper chromatography
 - b) To separate a mixture of lipids in a sample by Thin Layer Chromatography.

Essential/recommended readings

- A Guidebook to mechanism in organic chemistry (2003) 6 th ed., Sykes, P. New York: John Wiley & Sons. Inc
- Organic Chemistry (2014) 7 th ed., Morrison, R.T., Boyd, R.N., Bhattacharjee, S. K., Pearson Education
- Stereochemistry of Organic Compounds (1994), Eliel, E. L., Wilen, S. H. John Wiley& Sons.
- Stereochemistry: Conformation and Mechanism (2015) 8 th ed., Kalsi, P. S. New Age International
- Organic Chemistry (2013), Madan, R. L. Tata McGraw Hill Education Private Limited, New Delhi
- Organic Chemistry (2020) 8th Edn., Bruice, P. Y., Pearson

Suggestive readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 2: Photobiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Photobiology	DSC-102	2	0	2	10+2 from any recognized Board with Biology & Candidates must appear in CUET in the following subject combination: Physics+ Chemistry+ Biotechnology Biology/	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- The course explores the physical properties of light and its interplay with living organisms. Light as a source of energy and information has shaped life on earth over the last 3.6 billion years. We see the world around us because the light reflected to the retina is processed to our brain (Photoreception), we breathe in oxygen because it has been evolved by the plants around us due to the light dependent Photosynthesis. Where there is no natural light, some organisms produce their own (Bioluminescence). Maintaining coordination with the changing light regime with changing seasons is fundamentally important to various aspects of living organisms across latitudes (Photoperiodism). Every part of the spectrum is used in one way or the other by different life forms. In this paper students will be able to appreciate the delicate processes of life that are dependent on light.

Learning outcomes

A student studying this course can:

- Understand and appreciate the dual nature of light.
- Comprehend the impact of light on biodiversity from pole to pole.
- Gain knowledge about the various photoreceptors in plants and animals and will appreciate and understand the mechanism of photosynthesis.
- Understand bioluminescence, photoperiodism and biological rhythms.
- Gain knowledge about the ecological and physiological responses to light.

SYLLABUS OF DSC-2

Unit 1: Introduction to Light and Life (6 hours)

Latitudinal Diversity gradient. Altitudinal and latitudinal variations in light intensity and photoperiod. Light as an ecological factor affecting distribution, physiological processes of plants and animals (Phyto and Zoo geography), in terrestrial and aquatic ecosystems.

Unit 2: Bioluminescence and Photoreception (6 hours)

Discovery, diversity and functions of Bioluminescence. Comparative account of chemistry and functional roles of photoreceptors in plants: chlorophylls, carotenoids, phycobiliproteins, bacteriochlorophylls, etc. Photoreception in animals, evolution of eyes, color vision and visual processing in the human eye.

Unit 3: Photosynthesis (6 hours)

History, Spectrum of autotrophs, Photosynthetic equation, Photosynthetic electron transport (cyclic and non-cyclic), photolysis of water, oxygen-evolving complex (OEC), concept of Reaction centers, Q-cycle, Dark Reactions in Photosynthesis, C₃, C₄, CAM cycle, photorespiration (C₂ cycle).

Unit 4: Photoperiodism (6 hours)

Phytochrome mediated responses in Plants, Animal responses to changing photoperiodism. Morphological, Anatomical, Physiological and behavioral adaptations to extreme light conditions in plants and animals.

Unit 5: Ecological and physiological responses to Light (6 hours)

Morphological and physiological color change in animals. Light as an inducer for biosynthesis/activation of biomolecules (Vitamin D, Melatonin, Thymine dimer formation, RuBisCo. Three rhythm domains, Biological clocks and circadian rhythms, night shift disorders and jet lag.

Practical component: (60 hours)

1. To study light penetration in water using Secchi disc.
2. To demonstrate the effect of light on soil fauna using Berlese funnel setup.
3. To study the effect of light and darkness on the chromatophores of fish.
4. To test / survey for color blindness using Ishihara charts.
5. To study various Bioluminescent organisms using photographs- *Photinus pyralis*, *Aequorea victoria*, Vampire squid, Anglerfish, Lanternfish, Viperfish, Black dragonfish, *Omphalotus nidiformes*
6. Diel vertical migration using photographs
7. Measurement of light using Luxmeter under various conditions
8. To study structure of chloroplast- through photographs
9. Separation of Chloroplast pigments by Paper Chromatography/ Chemical Separation of

Chloroplast pigments

10. To study the effect of Light intensity and CO₂ concentration on the rate of Photosynthesis
11. Demonstration of Hill's Reaction and study the effect of Light intensity (any 2 light conditions).
12. Demonstration of Etiolation and de-etiolation.

Essential/ recommended Readings:

- Björn, L. O. (2015) 3rd Ed. *Photobiology: Science of Light and Life*, L.O. Bjorn.,Springer
- Buchanan, B. B., Gruissem, W., and Jones, R. L. (2000). *Biochemistry and molecular biology of plants*. Rockville, Md.: American Society of Plant Physiologists.
- Huner, N. and Hopkins, W. (2013). *Introduction to Plant Physiology*. In: 4th ed. John Wiley & Sons, Inc.
- Kohen E., Santus R., Hirschberg J.G. (1995) 1st Ed., *Photobiology* Academic Press
- Randall D., Burggren W., & French k. (2001) 5th Ed. *Eckert, Animal Physiology Mechanisms and Adaptations*. W.H. Freeman and Co.

Suggested Readings:

- Gross M. (2003). *Light and Life*. Oxford University Press
- Shimomura O., (2012) *Bioluminescence: Chemical Principles and Methods*, World Scientific,
- Taiz, L., & Zeiger, E. (1991). *Plant physiology*. Redwood City, Calif: Benjamin/Cummings Pub. Co.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 3: Diversity in lifeforms I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Diversity in Life forms I	DSC-103	2	0	2	10+2 from any recognized Board with Biology & Candidates must appear in CUET in the following subject combination: Physics+ Chemistry+ Biotechnology Biology/	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- The course will acquaint students with variations and variability in the living world and the objectives of biological classification. The course covers important aspects of biodiversity and its components with emphasis on understanding the features of Kingdom Animalia and Plantae and systematic organization of the same based on their evolutionary relationships. Students will also understand the importance of taxonomy and structural organization of animals from Protista to Echinodermata to appreciate the diversity of non-chordates living in varied habitats. They will study about the general characteristics and significance of Algae, Fungi, Bryophytes and Pteridophytes

Learning outcomes

After studying this course the student will be able to:

- Understand characteristic features of different plant and animal life forms.
- Identify, classify and differentiate diverse non-chordates based on their morphological, anatomical and systemic organization.
- Understand similarities and differences in life functions among various non-chordates.
- Appreciate and understand the relevance of wild relatives of cultivated plants, their domestication and green revolution.
- Understand the general characteristics, classification, economic importance, morphology, asexual and sexual reproduction of Algae, Fungi, Bryophytes and Pteridophytes

SYLLABUS OF DSC-3

Please provide weekly distribution

Unit I: Algae and Fungi

(6 hours)

Importance of biodiversity in daily life. Biodiversity crisis and biodiversity loss,

Five kingdom classification and the position of Algae, Fungi, Bryophytes and Pteridophytes.

Algae: Study of general characteristics, Outline Classification, Economic Importance, Thallus Organization and Reproduction in Nostoc, Polysiphonia, Ectocarpus.

Fungi – General Characteristics, Outline Classification, Economic Importance, Thallus Organization and Reproduction in Rhizopus and Puccinia, Lichens (crustose, foliose and fruticose), Mycorrhiza (ectomycorrhiza and endomycorrhiza, VAM)

Unit II: Bryophytes and Pteridophytes

(8 hours)

Bryophytes: General Characteristics; Outline Classification; Ecological and Economic Importance; Morphology, Structure and Reproduction (comparative) in *Marchantia* and *Anthoceros*

Pteridophytes: General Characteristics; Outline Classification; Economic Importance; Morphology, Structure and Reproduction in *Selaginella*

Unit III Introduction to Animal Life Forms

(6 hours)

Introduction to animal diversity, Basic Taxonomy (Linnaean system of classification, Whittaker's five kingdom classification, ICZN Rules), General Characteristics of Non-Chordata and Chordata.

Unit IV: Non-Chordata Taxonomy and Diversity

(10 hours)

Study of General Characteristics and Classification up to classes (Protista, Porifera, Cnidaria, Platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata)

Practical component: (60 hours)

FLORA

1. Study of Vegetative and Reproductive Structures through Temporary Preparations and Permanent Slides- *Nostoc*, *Oedogonium*, *Polysiphonia*; *Chlamydomonas* (Through Photograph/Electron photomicrograph)
2. Study of Asexual Stage from Temporary/ Tease Mounts- *Rhizopus Albugo*; *Puccinia* - WM uredospores, teleutospores, Section of Leaf through pustules to show conidia
3. *Marchantia*-Morphology of Thallus, W.M. Rhizoids, V.S. Thallus through Gemma Cup, Antheridiophore (Permanent slide), Archegoniophore (Permanent Slide)), *Funaria*-Morphology of Gametophyte bearing Sporophyte, W.M. Rhizoids, W.M. Leaf, W.M. Operculum, W.M. Peristome, W.M. Spores (all Temporary Slides), L.S. Capsule (Permanent Slide).
4. *Selaginella*- Morphology, T.S. Stem, W.M. Strobilus, W.M. Microsporophyll and Megasporophyll (all Temporary Slides), L.S. Strobilus (Permanent Slide), *Pteris*-Morphology, V.S. Sporophyll, W.M. Sporangium, W.M. Spores (all Temporary Slides), W.M. Prothallus with Sex Organs (Permanent Slide).

FAUNA

5. **Study of following specimens:** *Euglena*, *Paramecium*, *Sycon*, , *Tubipora*, *Taenia solium*, *Ascaris Phertima*, *Hirudanaria*, *Peripatus*, *Scolopendra*, *Julus*, *Cancer*, *Daphnia*, *Apis*, *Pila*, *Dentalium*, *Octopus*, *Asterias*
6. **Dissections / Virtual demonstration:** Nervous system of Cockroach, Salivary apparatus and Ovary of Cockroach.
7. Study of adult *Fasciola hepatica*, *Taenia solium* and their life stages (Slides/micro-photographs).
8. Study of following permanent Slides.
 - a. T.S. and L.S. of *Sycon*.
 - b. Crustacean larvae (W.M. Mysis, W.M. Megalopa, W.M. Zoea).
9. To study faunal composition of water samples (Lucky drop method).
10. Field trip on: Biodiversity park/reserve/ NBPGR. (Botany + Zoology)

Essential/ recommended readings:

- Barnes, R.D. (1982). *Invertebrate Zoology*, 5th. Edition
- Campbell N. A., (2008). *Biology* 8th Edition, Pearson
- Barrington, E.J.W. (2012). *Invertebrate Structure and Functions*. II Edition, EWP Publishers
- Singh, V. (2010). *A text book of botany*. Rastogi Publications.
- Ennos, R., & Sheffield, E., (2000). *Plant Life*. UK: University Press, Cambridge.

Suggested readings:

- Ingrowille, M., (1992). *Diversity and Evolution of land plants*. Chapman and Hall
- Wilson, E. O., (1998). *Biodiversity*. National Academic Press.
- Barnes, R.D. (2006). *Invertebrate Zoology*, VII Edition, Cengage Learning, India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DEPARTMENT OF ANTHROPOLOGY

BSc (Hons.) Anthropology

Category-I

DISCIPLINE SPECIFIC CORE COURSE – 1: Introduction to Biological Anthropology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Biological Anthropology	4	3	0	1	Class X II pass with biology	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

1. In order to acquaint the students with the fundamental concepts of Biological Anthropology
2. To introduce the student a foundational understanding of human variation and evolution of human and non-human primates

Learning outcomes

The Learning Outcomes of this course are as follows:

1. The students will comprehensively learn the scope and focal theme of biological anthropology along with its implications.
2. They will also learn the emergence of mankind in the context of human evolution and variation.
3. Further, this paper will help them in learning the role of evolutionary forces in bio-cultural human adaptations in the context of changing environment.

SYLLABUS OF DSC-1

UNIT – I History, Concepts, Aims and Scope (9 hours)

1. History and development of Biological Anthropology
2. Basic concepts of human evolution and variation
3. Scope and relationship of biological anthropology with other disciplines

UNIT – II Theories of Evolution (12 hours)

1. Pre-Darwinian Theories of Evolution
2. Darwinism and Synthetic theory of evolution

UNIT – III The primates (12 hours)

1. Classification and characteristics of living primates, Primate radiation