

**B.Sc. Physical Sciences
(Physics, Chemistry, Mathematics)
Choice Based Credit System (CBCS)**

Courses effective from academic year 2017-18

(Also applicable to B.Sc. 2016-2019 Batch)



**School of Vocational Studies and Applied Sciences
Gautam Buddha University, Greater Noida, UP-201312
India**

Preface

CHOICE BASED CREDIT SYSTEM (CBCS)

As per the UGC Guidelines the Gautam Buddha University (GBU) has adopted the CBCS for B.Sc. Physical Sciences Program. The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. This will benefit the students to move across institutions within India to begin with and across countries. GBU has also implemented Cumulative Grade Point Average (CGPA) in evaluation system. The computation of CGPA is based on student's performance in examinations in order to bring uniformity across the other universities.

Outline of Choice Based Credit System: (As per UGC)

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. Elective Course: Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

2.1 Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

2.2 Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. Ability Enhancement Courses (AEC)/Skill Development Courses: The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.

3.1 AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.

3.2 AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

B.Sc. (Physical Sciences)
(Physics, Chemistry, Mathematics)
Approved syllabus by BOS meeting on 29-07-2017

Course Structure

C: Core Course, AECC: Ability Enhancement Compulsory Course, SEC: Skill Enhancement Course, DSE: Discipline Specific Elective, GE: Generic Elective, L-lecture, T-Tutorial, P-Practical, Note:-Tutorial batches will contain maximum thirty students and the size of the practical group for practical papers is recommended to be 12-15 students. University/Institute can add/delete some experiments of similar nature in the Laboratory papers.

Semester I

S. No.	Course Code	Course	Category	Hours			Credit
				L	T	P	
1	EN-101	English Proficiency	AECC	2	0	0	2
2	PH105	Mechanics	C	4	0	0	4
3	PH107	Mechanics Lab	C	0	0	4	2
4	CH101	Atomic structure, Bonding, General organic chemistry, Aliphatic Hydrocarbons	C	4	0	0	4
5	CH103	Laboratory-I (Atomic structure, Bonding, General organic chemistry, Aliphatic Hydrocarbon)	C	0	0	4	2
6	MA115	Calculus	C	5	1	0	6
		Total Credit					20

Semester II

S.No.	Course Code	Course	Category	L	T	P	Credit
1	ES-101	Environmental Science	AECC	2	0	0	2
2	PH106	Electricity and Magnetism	C	4	0	0	4
3	PH108	Electricity and Magnetism Lab	C	0	0	4	2
4	CH102	Chemical Energetics, Phase equilibrium, Functional group organic Chemistry-I	C	4	0	0	4
5	CH104	Laboratory -II (Chemical Energetics, Phase equilibrium, Functional group organic Chemistry Practicals)	C	0	0	4	2
6	MA116	Algebra and Matrices	C	5	1	0	6
7	BS-101	Human Values & Buddhist Studies	GE	2	0	0	2
		Total					22

Semester III

S.No.	Course Code	Course	Category	L	T	P	Credit
1	PH201	Thermal Physics and Statistical Mechanics	C	4	0	0	4
2	PH203	Thermal Physics and Statistical Mechanics Lab	C	0	0	4	2
3	CH201	Solution, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry-II	C	4	0	0	4
4	CH203	Laboratory (Conductance, Electrochemistry & Functional Group Organic Chemistry-II)-III	C	0	0	4	2
5	MA211	Introduction to Real Analysis	C	5	1	0	6
6		SEC-1	SEC	-	-	-	2
		Total					20

Semester IV

S.No.	Course Code	Course	Category	L	T	P	Credit
1	PH202	Waves and Optics	C	4	0	0	4
2	PH204	Waves and Optics Lab	C	0	0	4	2
3	CH202	Transition Metal & Coordination Chemistry, States of matter & Chemical kinetics	C	4	0	0	4
4	CH204	Laboratory (Transition Metal & Coordination Chemistry, States of matter & Chemical kinetics)-IV	C	0	0	4	2
5	MA212	Differential Equations	C	4	0	0	4
6	MA212L	Differential Equations Lab		0	0	4	2
7		SEC-2	SEC	-	-	-	2
		Total					20

Semester V

S.No.	Course Code	Course	Category	L	T	P	Credit
1		SEC-3	SEC	-	-	-	2
2		DSE-1	DSE	-	-	-	6
3		DSE-2	DSE	-	-	-	6
4		DSE-3	DSE	-	-	-	6
		Total					20

Semester VI

S.No.	Course Code	Course	Category	L	T	P	Credit
1		SEC-4	SEC	-	-	-	2
2		DSE-4	DSE	-	-	-	6
3		DSE-5	DSE	-	-	-	6
4		DSE-6	DSE	-	-	-	6
		Total					20
Total Credits (All Semesters)							122

Optional: Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester

List of Discipline Specific Electives

	Code	Discipline Specific Electives (DSE-1)	Hours			Credits
			L	T	P	
1	PH301	Solid State Physics	4	0	0	4
	PH303	Solid State Physics Lab	0	0	4	2
2	PH305	Physics of Semiconductor Devices	4	0	0	4
	PH307	Physics of Semiconductor Devices Lab	0	0	4	2
3	PH309	Introductory Atmospheric Physics	3	0	0	3
	PH311	Basics of Nanoscience	3	0	0	3
		Discipline Specific Electives (DSE-2)				
1	CH301	Industrial Chemicals & Environment	4	0	0	4
	CH303	Laboratory (Industrial Chemicals & Environment)-V	0	0	4	2
2	CH305	Quantum Chemistry, Spectroscopy & Photochemistry	4	0	0	4
	CH307	Laboratory (Quantum Chemistry, Spectroscopy & Photochemistry)-V	0	0	4	2
		Discipline Specific Electives (DSE-4)				
1	PH302	Atomic, Molecular and Nuclear Physics	4	0	0	4
	PH304	Atomic, Molecular and Nuclear Physics Lab	0	0	4	2
2	PH306	Modern Physics and Quantum Mechanics	4	0	0	4
	PH308	Modern Physics and Quantum Mechanics Lab	0	0	4	2
		Discipline Specific Electives (DSE-5)				
1	CH302	Molecules of Life	4	0	0	4
	CH304	Laboratory(Molecules of Life)-VI	0	0	4	2
2	CH306	Chemistry of Main Group Elements, Theories of Acids and Bases	4	0	0	4
	CH308	Laboratory (Chemistry of Main Group Elements, Theories of Acids and Bases)-VI	0	0	4	2
		Discipline Specific Electives (DSE-3)/ (DSE-6)				
1	MA301	Numerical Methods and Computation	4	0	0	4
	MA301L	Numerical Methods and Computation Lab	0	0	4	2
2	MA303	Tensor & Geometry	5	1	0	6
3	MA305	Probability and Statistics	5	1	0	6
4	MA302	Theory of Complex Variable	4	0	0	4
	MA302L	Complex Variables Lab	0	0	4	2
5	MA304	Mathematical Methods	5	1	0	6
6	MA306	Introduction to Cryptography	4	0	0	4
	MA306L	Cryptography and Security Lab	0	0	4	2

Note: Departments may include more options or delete some from the list of DSE.

Skill Enhancement Course (SEC)			
	Physics Based	Math Based	Chemistry Based
SEC-I	PH205 Renewable Energy and Energy harvesting	MA221 Latex and HTML	CH -205 Intellectual Property Rights
SEC-II	PH206 Computational Physics	MA222 Programming in C/C++	CH206 Green Methods in Chemistry
SEC-III	PH313 Photolithography and Device fabrication	MA321 Mathematical Modelling	CH309 Pharmaceutical Chemistry
SEC-IV	PH310 Simulation Experiments in Physics	MA322 Experimental Statistics using R	CH310 Chemistry of Cosmetics & Perfumes

		MA324 Weather Forecasting	
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Mathematics

Course Name: Calculus
Course Code: MA115

Credits: 06

Functions of a real variable: Functions and their graphs, Inverse functions and logarithm, Limit of a function and Limit Laws, Precise definition of a limit ($\delta - \epsilon$), One sided limits, Continuity at a point, Limit involving infinity, Tangents and derivatives at a point, Derivative as a function, derivative as rate of change, chain rule, Linearization and Differentials, Monotonic functions and first derivative test, Concavity, Points of inflexion, Differentiability of Functions, Rolle's Theorem, Mean Value theorems, Successive Differentiation, Leibnitz's Theorem, Maclaurin series, Taylor's Theorem with Lagrange's and Cauchy's forms of remainder, Tangents, Normal, Curvature, Asymptotes, Singular Points, Tracing of Curves, Evaluating Definite Integral, Fundamental theorem of calculus.

Functions of several real variables: Functions of two and three variables, Limits for functions of two variables, Continuity, Partial derivatives, Partial derivatives and continuity, Total differential and Differentiability, Directional derivatives and gradient vectors, Tangent planes and differentials, Extreme values and saddle points, Euler's theorem, Lagrange's Multiplier Method, Taylor's series, Jacobians, Double Integrals, Double Integrals in Polar Form, Triple Integrals in Rectangular Coordinates, Triple Integrals in Cylindrical & Spherical Coordinates, Change of variable in Multiple Integrals, Change of order in multiple integral, applications of multiple integrals.

Books Recommended:

1. G.B. Thomas, J Hass and Maurice D. Weir, Thomas' Calculus, Pearson Education, 2009.
2. R.K. Jain and S.R.K. Iyengar, advanced Engineering Mathematics, Narosa publishing house, 2016
3. J. Stewart, Calculus: Early Transcendental, Cengage Learning, 2012
4. Tom Apostol, Calculus-I & II, Wiley, 2007

Course Name: Algebra and Matrices

Course Code: MA116

Credits: 06

Algebra: Groups, Subgroups and their examples, the group Z_n of integers under addition modulo n , The group $U(n)$ of units under multiplication modulo n , cyclic groups, complex roots of unity, circle group, the general linear group $GL_n(n, R)$, Dihedral group, The commutator subgroup, Examples of subgroups including the center of a group, Cosets, Index of subgroup, Lagrange's theorem, order of an element, Normal subgroups: their definition, examples, and characterizations, Quotient groups.

Matrices: Vector space over R and C , Concept of linear dependence and independence, basis, Subspaces, Translation, Dilation, Rotation, Reflection in a point, line and plane, Matrix form of basic geometric transformations, Interpretation of eigen values and eigen vectors for such transformations and eigen spaces as invariant subspaces, Types of matrices, Rank of a matrix, Invariance of rank under elementary transformations, Reduction to normal form, Solutions of linear homogeneous and non-homogeneous equations, Matrices in diagonal form, Computation of matrix inverses using elementary row operations.

Books Recommended

1. S. H. Friedberg, A. L. Insel and L. E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
2. Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill, 1989.
3. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
4. Joseph A Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa, 1999.

Course Name: An Introduction to Real Analysis

Course Code: MA211

Credits: 06

Real number system: Algebraic and Order Properties of \mathbb{R} , delta-neighborhood of a point in \mathbb{R} , Idea of countable sets, uncountable sets and uncountability of \mathbb{R} , Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of \mathbb{R} , The Archimedean Property, Density of Rational (and Irrational) numbers in \mathbb{R} , Intervals, Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

Sequence and series: Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences, Cauchy sequence, Cauchy's Convergence Criterion, Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence, Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

Riemann integration: inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions, Intermediate Value theorem for Integrals; Fundamental theorem.

Books Recommended:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
 2. K.A. Ross, Elementary Analysis-The Theory of Calculus Series-Undergraduate Texts in Mathematics, Springer Verlag, 2003.
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Course Name: Differential Equations

Course Code: MA212

Credits: 6 (4-0-2)

Ordinary differential equations: Introduction to differential equation, Formulation of differential equation, Order and degree of differential equation, linear, nonlinear differential equation, First order exact differential equations. Integrating factors, First order higher degree equations solvable for x , y , p . Methods for solving higher-order differential equations, Basic theory of linear differential equations, Wronskian, and its properties, Solving a differential equation by reducing its order, Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations., Application of First order differential equations to acceleration- velocity model, Growth and Decay model.

Partial Differential Equation: Introduction to partial differential equation, origins of first order partial differential equation, Classification of first order PDE, Classification of Integrals, Order and degree of partial differential equation, Concept of linear and non-linear partial differential equations, Pfaffian differential forms and equations, Integral surfaces passing through a given curve, Linear partial differential equation of first order, method of characteristics and general solution of first order PDE, Canonical form of first order PDE, Lagrange's method, Charpit's method, Quasi-linear equation (Geometry of solutions), Non-linear partial differential equations of the first order. Method of separation of variables for first order PDE, Application (Derivation only): Mathematical modelling of vibrating string and conductions of heat in solid, Conservation laws and Burger's equation

Course Name: Differential Equations Lab

Course Code: MA212L

Credits: 2(0-0-4)

Practical based on above methods (Few example given below) using MATLAB/ Octave/ MATHEMATICA/ MAPLE/ Python

1. Solution of first order differential equation and plotting of their solutions.
2. Solution of second order differential equations with constant coefficients and plotting of their solutions.
3. Solution of second order differential equations with variable coefficients and plotting of their solutions.
4. Growth and Decay model.

5. Solution of Cauchy Problem for first order PDE
6. Finding the characteristics for the first order PDE and Plotting the characteristics for the first order PDE
7. Plotting of solutions of vibrating strings problem
8. Plotting of solutions of heat conduction
9. Plot the integral surfaces of a given first order PDE with initial data.
- 10.

(iii) Plot the integral surfaces of a given first order PDE with initial data.

(iv) Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions

(a) $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), x \in R, t > 0$

(b) $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u(0, t) = 0, x \in (0, \infty), t > 0$

(c) $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u_x(0, t) = 0, x \in (0, \infty), t > 0$

(d) $u(x, 0) = \phi(x), u_t(x, 0) = \psi(x), u(0, t) = 0, u(1, t) = 0, 0 < x < 1, t > 0$

(v) Solution of wave equation $\frac{\partial u}{\partial t} - k^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions

(a) $u(x, 0) = \phi(x), u(0, t) = a, u(l, t) = b, 0 < x < l, t > 0$

(b) $u(x, 0) = \phi(x), x \in R, 0 < t < T$

(c) $u(x, 0) = \phi(x), u(0, t) = a, x \in (0, \infty), t \geq 0$

Books Recommended:

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4th Ed., Springer, Indian reprint, 2006.
2. Shepley L. Ross, Differential equation, 3rd Ed., John Wiley & Sons.
3. William E. Boyce, Richard C. DiPrima, Elementry Differential Equations and Boundary value, Wiley, 2000.
4. Earl A. Coddington, Introduction to ordinary differential equations, PHI learning Pvt, Ltd. 2011.
5. I. N Sneddon, Elements of Partial Differential equations, Tata McGraw-Hill. problems, John Wiley & Sons.
6. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa.

Discipline Specific Electives (DSE-3)

Course Name: Numerical Methods and Computation

Course Code: MA301

Credits (L-T-P): 4 (4-0-0)

Errors in Computation: Floating representation of number, binary number, significant digits, errors due to rounding/chopping. The Taylor' Polynomial, Error in Polynomial, Polynomial evaluation. Errors in computation.

Numerical Solution of nonlinear equations: Bisection method, False position method, Fixed point iteration method, Newton-Raphson method, Secant method, Order of Convergence and Convergence of each method.

System of Linear equations: Gauss Elimination method, Gauss-Jordan method, LU decomposition, Jacobi Iterative methods, Gauss-Siedel Iterative method and condition convergence of above methods, Norms and condition numbers, Sparse matrices and Band Matrices.

Finite Differences: Finite difference operators, Interpolation: Lagrange and Newton interpolations, Newton's Divided difference interpolation, Numerical differentiation: forward difference, backward difference and Central Difference, round of errors in numerical differentiation, Quadrature formulae: Trapezoidal rule, Simpson's rule, Order of a method, Errors in quadrature formulae.

Recommended Books

1. K.E Atkinson, Elementary Numerical Analysis, John Wiley and Sons.
2. C.B. Moler, Numerical Computing with MATLAB, PHI
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5th Ed., New age International Publisher, India, 2007.
4. R. S. Gupta, Elements of Numerical Analysis, Macmillan, 2009.

Course Name: Numerical Methods and Computation Lab

Course Code: MA301L

Credits (L-T-P): 2 (0-

0-4)

Note: Practical based on above methods using MATLAB/MATHEMATICA/MAPLE/C++/Python

For any of the CAS, Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

Following experiment are to be implemented:

1. Calculate the sum $1/1 + 1/2 + 1/3 + 1/4 + \dots + 1/N$. Discuss error propagated.
2. To find the absolute value of an integer.
3. Enter 100 integers into an array and sort them in an ascending order.
4. Root finding methods, with desired accuracy.
 - a. Bisection Method.
 - b. Newton Raphson Method.
 - c. Secant Method.
 - d. Regulai Falsi Method.
5. LU decomposition Method.
6. Gauss-Jacobi Method.
7. Gauss-Siedel Method.
8. Lagrange Interpolation or Newton Interpolation.
9. Simpson's rules.
10. Other experiments may be added by concerned faculty.

Course Name: Tensor & Geometry

Course Code: MA303

Credits: 06

Tensor: Introduction, Summation Conventions, Kronecker symbols, Transformation of Coordinates in R^n Invariants, Contravariant and Covariant vectors, Tensors of second order, Contravariant and Covariant vectors of order two, Mixed tensors of order two, Mixed tensor of type (p,q), Zero tensor, Tensor Field, Algebra of tensors, Symmetric and Skew symmetric properties, Contraction of tensors, Inner multiplication, Quotient law, Christoffel Symbols, Tensor Calculus, Riemannian Space,

Analytical Solid Geometry: Projection and Direction Ratios, The plane, Straight Line, Change of axes, Sphere, Cone, Cylinder, Illustrations of graphing standard quadric surfaces like cone, ellipsoid, Paraboloids, Central Conicoids.

Recommended Books:

1. Barry Spain, Tensor Calculus, Radha Publ. House Calcutta,1988.

2. R.J.T. Bill, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan India Ltd., 1994
4. Shanti Narayan, Analytical Solid Geometry, S. Chand & Company, New Delhi.

Course Name: Probability & Statistics

Course Code: MA305

Credits: 06

Notion of Probability: Random experiments, Sample space, Probability axioms, equally likely outcome problems, Conditional probability, Bay's theorem.

Random variables: Concepts, discrete and continuous random variables, Cumulative distribution function, Probability mass/density functions, Mathematical expectation. Moments, Moment generating function, Characteristic function. Discrete distributions: uniform, binomial, Poisson, Geometric, Negative Binomial distributions. Continuous distributions: Uniform, Normal, Exponential, Gamma distributions

Joint cumulative distribution Function and its properties, Joint probability density functions – marginal and conditional distributions. Expectation of a function of two random variables, Conditional expectations, Independent random variables, Covariance and correlation coefficient.

Linear regression for two variables, The rank correlation coefficient. Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central Limit Theorem for independent and identically distributed random variables with finite variance.

Some Applications: list-model, a random graph, Polya's Urn Model

REFERENCES:

1. Robert V. Hogg, Joseph W. Mc Kean and Allen T. Craig. Introduction of Mathematical Statistics, Pearson Education, Asia, 2007
2. Irvin Miller and Marylees Miller, John E. Freund's Mathematical Statistics with Applications (7thEdn), Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Models (9th Edition), Academic Press, Indian Reprint, 2007

Discipline Specific Electives (DSE-6)

Course Name: Theory of Complex Variable

Course Code: MA302

Credits: 4(4-0-0)

Limits, Limits involving the point at infinity, continuity, Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings, Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability

Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions, Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals, Cauchy-Goursat theorem, Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra, Convergence of sequences and series, Taylor series and its examples, Laurent series and its examples, absolute and uniform convergence of power series.

Books Recommended

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.122
2. Joseph Bak and Donald J. Newman, Complex analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

Course Name: Theory of Complex Variable

Course Code: MA302L

Credits: 2(0-0-4)

List of Practicals (using any software)

- (i) Declaring a complex number e.g. $z_1 = 3 + 4i, z_2 = 4 - 7i$. Discussing their algebra $z_1 + z_2, z_1 - z_2, z_1 * z_2$ and z_1 / z_2 and then plotting them.
- (ii) Finding conjugate, modulus and phase angle of an array of complex numbers. e.g., $z = [2 + 3i, 4 - 2i, 6 + 11i, 2 - 5i]$.
- (iii) Compute the integral over a straight line path between the two specified end points e.g., $\int_C f(z) dz$, where C is the straight line path from $a + ib$ to $c + id$.
- (iv) Perform contour integration e.g. $\int_C f(z) dz$, where C is the contour given by $g(x, y) = 0$.
- (v) Plotting of the complex functions like $f(z) = z, f(z) = z^3, f(z) = (z^4 - 1)^{1/4}$, etc.
- (vi) Finding the residues of the complex function.
- (vii) Taylor series expansion of a given function $f(z)$ around a given point z, given the number of terms in the Taylor series expansion. Hence comparing the function and its Taylor series expansion by plotting the magnitude of each. For example
- (a) $f(z) = \exp(z)$ around $z = 0, n = 40$
- (b) $f(z) = \exp(z^2)$ around $z = 0, n = 160$, etc.
- (viii) To perform Laurentz series expansion of a given function $f(z)$ around a given point z, e.g., $f(z) = (\sin z - 1) / z^4$ around $z = 0, f(z) = \cot(z) / z^4$ around $z = 0$, etc.

Course Name: Mathematical Methods

Course Code: MA3014

Credits: 06

Integral Transforms: Laplace Transformation, Laplace Transforms of derivatives and integrals, shifting theorems, differentiation and integration of transforms, convolution theorem, Inverse Laplace transform Application of Laplace transform in solution of ordinary differential equations, Fourier series expansion, Even and odd functions, periodic functions, Half range Fourier series, Fourier Transforms and boundary value problems, Finite Fourier transform, Z transform, solution of difference equation using Z transform, Application of Z transforms to find the sum of series.

Calculus of Variations:

Functionals, Deduction of Euler's equations for functionals of first order and higher order for fixed boundaries. Shortest distance between two non-intersecting curves. Isoperimetric problems. Jacobi and Legendre conditions (applications only).

Recommended Books:

1. R.K. Jain and S.R.K. Iyengar, advanced Engineering Mathematics, Narosa publishing house, 2016
 2. Francis B. Hildebrand, Methods of Applied Mathematics, Dover, New York, 20124.
 3. W. E. Boyce, R. C. DiPrima, Elementary Differential Equations and Boundary value, Wiley, 2000.
 4. F.B. Hilderbrand, Advanced Calculus for Applications, PHI, New Delhi, 1997.
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Course Name: Introduction to Cryptography

Course Code: MA306

Credits: 06

Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques- Substitution and transposition ciphers, Caesar cipher, Play fair cipher. Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES).

Polynomial and modular arithmetic, Introduction to finite field of the form $GF(p)$ and $GF(2^n)$, Fermat theorem and Euler's theorem(statement only), Chinese Remainder theorem, Discrete logarithm

Advanced Encryption Standard (AES), Stream ciphers. Introduction to public key cryptography, RSA algorithm and security of RSA, Introduction to elliptic curve cryptography.

Information/Computer Security: Basic security objectives, security attacks, security services, Network security model, Cryptographic Hash functions, Secure Hash algorithm, SHA-3.

Digital signature, El-Gamal signature, Digital signature standards, Digital signature algorithm

Books:

1. William Stallings, "Cryptography and Network Security", Principles and Practise, Fifth Edition, Pearson Education, 2012.
2. Douglas R. Stinson, "Cryptography theory and practice", CRC Press, Third edition, 2005.

Course Name: Cryptography and Security Lab

Course Code: MA306L

Credits: 2

Experiments based on course MA306.

Skill Enhancement Course (SEC)

Course Name: Latex and HTML

Course Code: MA221

Credits: 02

Elements of LaTeX; Hands-on-training of LaTeX; graphics in LaTeX; PSTricks; Beamer presentation; HTML, creating simple web pages, images and links, design of web pages. Practical: Six practical should be done by each student.

Book Recommended

1. Martin J. Erickson and Donald Bindner, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, Boca Raton, FL, 2011.
 2. L. Lamport, LATEX: A Document Preparation System, User's Guide and Reference Manual. Addison-Wesley, New York, second edition, 1994.
-

Course Name: Programming in C/C++

Course Code: MA222

Credits: 02

Introduction to C fundamentals, Constants, Variables, statements, iterative statements and Data types, Operators and expression, formatted input and output, Decision makings, Branching and Looping, Arrays, User defined functions, Passing arguments to procedure, procedures, Structures, Pointers, File handling, concept of recursion. Practical: Six practical should be done by each student.

Recommended Books:

1. B.W. Kernighan and D.M. Ritchie, The C Programming Language 2nd Edition, (ANSI features) Prentice Hall, 1989.
 2. V. Rajaraman, Programming in C, Prentice Hall of India, 1994.
 3. Byron S. Gotfried, Theory and Problems of Programming with C, Tata McGraw-Hill, 1998.
-

Course Name: Mathematical Modeling

Course Code: MA321

Credits: 02

Models, reality, properties of models, system characterization, steps in building in mathematical models, source of errors, dimensional analysis, model classification and illustration.

Applications of differential equations: Free damped motion, forced motion, resonance phenomena. Transport equation, Vibrating string, vibrating membrane, conduction of heat in solids, Conservation laws, Mathematical modeling in Biological process.

Books Recommended:

1. Shepley L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, 1984.
2. I. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, International Edition, 1967.
3. Y. Pinchover and J. Rubinstein, An introduction to Partial Differential Equations, Cambridge University Press.
4. "Mathematical Models in Biology", Leah Edelstein-Kesht, SIAM, 2005.
5. "Principles of Mathematical Modeling", Cliev L.Dym, Elsevier, 2004.

Frank R. Giordano, Maurice D. Weir and William P. Fox, A First Course in Mathematical Modeling, Thomson Learning, London and New York, 2003

Course Name: Experimental Statistics using R

Course Code: MA322

Credits: 02

Experimental Design: Principles, experimental designs, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, continuous distributions: uniform, normal.

Test of hypothesis: Chi-square test, t, F and Z tests and Turkey's Q test. Experimental Data Analysis: RBD, SPD, ANOVA, linear regression analysis using SPSS, Cluster analysis.

Books Recommended:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Application, 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Model, 9th Ed., Academic Press, Indian Reprint, 2007.
4. G.W. Snedecor and W.C. Cochran, Statistical Method, Oxford & IBH Pub.. Pvt. .Ltd. New-Delhi.

WEATHER FORECASTING

(Credits: 02)

Theory: 30 Lectures

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics. **(9 Periods)**

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

(4 Periods)

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

(3 Periods)

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate. **(6 Periods)**

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts. **(8 Periods)**

Demonstrations and Experiments: (Using Mesoscale Models)

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
 - (a) To calculate the sunniest time of the year.
 - (b) To study the variation of rainfall amount and intensity by wind direction.
 - (c) To observe the sunniest/driest day of the week.
 - (d) To examine the maximum and minimum temperature throughout the year.
 - (e) To evaluate the relative humidity of the day.
 - (f) To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non aviation)

Reference books:

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
 2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
 3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
 4. Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
 5. Why the weather, Charls Franklin Brooks, 1924, Chpraman & Hall, London.
 6. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.
 7. An Introduction to Dynamic Meteorology, James R. Holton, Academic Press; 5 edition
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CHEMISTRY

Core papers Chemistry (Credit: 06 each) :

Semester-I, CC-II

- (i) CH 101- Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons
- (ii) CH 103- Laboratory-I

Semester-II, CC-V

- (i) CH 102- Chemical Energetic, Equilibrium & Functional Group Organic Chemistry-I
- (ii) CH 104 Laboratory-II

Semester-III, CC-VIII

- (i) CH 201- Conductance, Electrochemistry & Functional Group Organic Chemistry-II
- (ii) CH 203 - Laboratory-III

Semester-IV, CC-XI

- (i) CH 202-Transition Metal & Coordination Chemistry, States of Matter and Chemical Kinetics
- (ii) CH 204- Laboratory-IV

Discipline Specific Elective papers (Credit: 06 each):

Semester-V, DSE-2 (Choose one)

- (i) CH 301-Industrial Chemicals & Environment
- (ii) CH 303- Laboratory(DSE)-V
- (iii) CH 305 Quantum Chemistry, Spectroscopy & Photochemistry
- (iv) CH 307- Laboratory(DSE)-V

Semester-VI, DSE-5 (Choose one)

- (i) CH 302-Molecules of Life
- (ii) CH 304- Laboratory(DSE)-VI
- (iii) CH 306- Chemistry of Main Group Elements, Theories of Acids and Bases
- (iv) CH 308- Laboratory(DSE)-VI

Skill Enhancement Course (Credit: 02 each)

Semester-III, SEC-I

CH 205-Intellectual Property Rights.

Semester-IV, SEC-II

CH 206-Green Methods in Chemistry.

Semester-V, SEC-III

CH 309-Pharmaceutical Chemistry.

Semester-VI, SEC-IV

CH 310-Chemistry of Cosmetics & Perfumes.

SEMESTER-1

CHEMISTRY- CC-II:

CH 101-ATOMIC STRUCTURE, BONDING, GENERALORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Section A: Inorganic Chemistry-1

(30 Lectures)

Atomic Structure: Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's uncertainty principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2 . Quantum numbers and their significance. Normal and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. (7 Lectures)

Periodicity of Elements: s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p- block,

Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy.

Electron gain enthalpy, trends of electron gain enthalpy.

Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio. (7 Lectures)

Chemical Bonding and Molecular Structure

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, Born-Haber cycle and its applications, 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 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 *s-s*, *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⁺. Comparison of VB and MO approaches. (16 Lectures)

Section B: Organic Chemistry-1

(30 Lectures)

Fundamentals of Organic Chemistry: Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free

radicals and Carbenes

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. **(8 Lectures)**

Stereochemistry: Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (up to two carbon atoms). Configuration: 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). **(10 Lectures)**

Chemistry of Aliphatic Hydrocarbons

Carbon-Carbon sigma bonds :Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.

Carbon-Carbon pi bonds :Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. **(12 Lectures)**

Reference Books:

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.
5. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
6. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. Eliel, E.L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
8. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
9. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010

CHEMISTRY LAB CC-I:

CH 103 – LABORATORY-I: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(60 Lectures)

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO_4 .
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .
4. Estimation of Fe (II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator
 - (i) N-phenyl anthranilic acid

- (ii) Diphenylamine
5. To determine calcium and magnesium hardness of given water sample separately.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements).
2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)
 - (a) Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
 - (b) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, .

SEMESTER-II

CHEMISTRY- CC-V:

CH 102- CHEMICAL ENERGETICS, EQUILIBRIA , FUNCTIONAL ORGANIC CHEMISTRY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Section A: Physical Chemistry-1 (30 Lectures)

Chemical Energetics: Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances. **(10 Lectures)**

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G₀, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases. **(8 Lectures)**

Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. **(12 Lectures)**

Section B: Organic Chemistry-2 (30 Lectures)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Aromatic hydrocarbons: Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene). **(8 Lectures)**

Alkyl and Aryl Halides:

Alkyl Halides Methods of preparation, nucleophilic substitution reactions – SN₁, SN₂ and SN_i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs elimination

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SN_{Ar}, Benzyne mechanism Relative reactivity of Alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li – Use in synthesis of organic compounds. **(8 Lectures)**

Alcohols, Phenols and Ethers (Upto 5 Carbons)

Grignard Reagent: Preparation, Properties and Reaction mechanism.

Alcohols: preparation, properties and relative reactivity of 1^o, 2^o, 3^o alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol- Pinacolone rearrangement;

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer – Tiemann and Kolbe's – Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH₄

Aldehydes and ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and from nitriles.

Reactions – Reaction with HCN, ROH, NaHSO₃, NH₂-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Ponndorf Verley reduction. **(14 Lectures)**

Reference Books:

1. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
4. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010
5. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
6. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
7. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
8. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009)

CHEMISTRY LAB CC-V:

CH 104- LABORATORY-I: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY (60 Lectures)

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3 , NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of H.

Ionic equilibria

1. pH measurements
 - a. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
 - b. Preparation of buffer solutions:
 - (i) Sodium acetate-acetic acid
 - (ii) Ammonium chloride-ammonium hydroxideMeasurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
 - a. Bromination of Phenol/Aniline
 - b. Benzoylation of amines/phenols
 - c. Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Reference Books

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
2. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
4. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

SEMESTER-III

CHEMISTRY- CC-VIII:

CH 201- SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Section A: Physical Chemistry-2 (30 Lectures)

Solutions: Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature- composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. **(8 Lectures)**

Phase Equilibrium: Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $\text{FeCl}_3\text{-H}_2\text{O}$ and Na-K only). **(8 Lectures)**

Conductance: Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base). **(6 Lectures)**

Electrochemistry: Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. 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 and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode.

Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only). **(8 Lectures)**

Section B: Organic Chemistry-3 (30 Lectures)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Carboxylic acids and their derivatives: Carboxylic acids (aliphatic and aromatic), Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlar - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation. **(6 Lectures)**

Amines and Diazonium Salts: Amines (Aliphatic and Aromatic): (Upto 5 carbons)

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2 , Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts:

Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes. **(6 Lectures)**

Amino Acids, Peptides and Proteins: Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of $-\text{COOH}$ group, acetylation of $-\text{NH}_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C-terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. **(10 Lectures)**

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Reference Books:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7thEd.,
7. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002

CHEMISTRY CC-VIII- LABORATORY

CH 203- LABORATORY-II: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-II (60 Lectures)

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

- i. $I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$
- ii. $Cu^{2+}(aq) + xNH_3(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$

Phase equilibria

1. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
2. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
3. Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Conductance

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

Potentiometry

1. Perform the following potentiometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base

- iii. Potassium dichromate vs. Mohr's salt
- 2. Determination of cell constant.
- 3. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- 4. Perform the following conductometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base
 - iii. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

1. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
2.
 - i. Separation of amino acids by paper chromatography
 - ii. Determination of the concentration of glycine solution by formulation method.
 - iii. Titration curve of glycine
 - iv. Action of salivary amylase on starch
 - v. Effect of temperature on the action of salivary amylase on starch.
 - vi. Differentiation between a reducing and a non-reducing sugar.

Reference Books:

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
2. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
4. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

SEMESTER-IV

CHEMISTRY- CC-XI:

CH 202-TRANSITION METAL & COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Transition Elements (3d series): General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only). **(12 Lectures)**

Coordination Chemistry: Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature. **(8 Lectures)**

Crystal Field Theory: Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of $10Dq$. Spectrochemical series. Application of CFSE, Comparison of CFSE for *Oh*

and Td complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination. **(10 Lectures)**

Section B: Physical Chemistry-3 **(30 Lectures)**

Kinetic Theory of Gases: 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 CO_2 . 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). **(8 Lectures)**

Liquids: 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). **(6 Lectures)**

Solids: 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. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals. **(8 Lectures)**

Chemical Kinetics: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only). **(8 Lectures)**

Reference Books:

1. Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
2. Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009)
4. Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry*, Wiley.
5. Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
6. Wulfsberg, G. *Inorganic Chemistry*, Viva Books Pvt. Ltd.
7. Rodgers, G.E. *Inorganic & Solid State Chemistry*, Cengage Learning India Ltd., 2008.

CHEMISTRY CC XI -LABORATORY

CH 204- LABORATORY-III: TRANSITION METAL & COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS **(60 Lectures)**

Section A: Inorganic Chemistry

Semi-micro qualitative analysis (using H₂S or other methods) of mixtures - not more than four ionic species (two anions and two cations, excluding insoluble salts) out of the following:

Cations : NH₄⁺, Pb²⁺, Bi³⁺, Cu²⁺, Cd²⁺, Fe³⁺, Al³⁺, Co²⁺, Ni²⁺, Mn²⁺, Zn²⁺, Ba²⁺, Sr²⁺, Ca²⁺, K⁺

Anions: CO₃²⁻, S²⁻, SO₃²⁻, S₂O₃²⁻, NO₃⁻, CH₃COO⁻, Cl⁻, Br⁻, I⁻, NO₃⁻, SO₄²⁻, PO₄³⁻, BO₃³⁻, C₂O₄²⁻, F⁻
(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis (dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Estimation of (i) Mg²⁺ or (ii) Zn²⁺ by complexometric titrations using EDTA.
3. Estimation of copper as cuprous thiocyanate

Section B: Physical Chemistry

1. Surface tension measurement (use of organic solvents excluded).
 - i. Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
 - ii. Study of the variation of surface tension of a detergent solution with concentration.
2. Viscosity measurement (use of organic solvents excluded).
 - i. Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
 - ii. Study of the variation of viscosity of an aqueous solution with concentration of solute.
3. Chemical Kinetics: Study the kinetics of the following reactions.
 - i. Initial rate method: Iodide-persulphate reaction
 - ii. Integrated rate method:
 - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
 - b. Saponification of ethyl acetate.
 - c. Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).

SEMESTER-V

Discipline Specific Electives (DSE-2)

CHEMISTRY-DSE - 2

CH-301: INDUSTRIAL CHEMICALS AND ENVIRONMENT

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Industrial Gases and Inorganic Chemicals: Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate. (10 Lectures)

Industrial Metallurgy: Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology. (4 Lectures)

Environment and its segments

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions

Atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by SO₂, CO₂, CO, NO_x, H₂S and other foul smelling gases. Methods of estimation of CO, NO_x, SO_x and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

Water Pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

(30 Lectures)

Energy & Environment: Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

(10 Lectures)

Biocatalysis: Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

(6 Lectures)

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, Environmental Chemistry, CRC Press (2005).
8. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
9. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

CHEMISTRY DSE-2 LABORATORY:

CH 303- LABORATORY-V: INDUSTRIAL CHEMICALS & ENVIRONMENT

(60 Lectures)

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO₃ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO₃²⁻, HCO₃⁻) using double titration method.
7. Measurement of dissolved CO₂.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.

10. Preparation of borax/ boric acid.

Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
3. J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt. Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi

CHEMISTRY DSE-2:

CH-305- QUANTUM CHEMISTRY, SPECTROSCOPY & PHOTOCHEMISTRY (Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.

Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+ . Bonding and antibonding orbitals. Qualitative extension to H_2 . Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2 , H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules. (24 Lectures)

Molecular Spectroscopy: Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental

frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

(24 Lectures)

Photochemistry: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence. (12 Lectures)

Reference Books:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).

CHEMISTRY DSE-2 LABORATORY:

CH-307- LABORATORY-V: QUANTUM CHEMISTRY, SPECTROSCOPY & PHOTOCHEMISTRY (60 Lectures)

UV/Visible spectroscopy

1. Study the 200-500 nm absorbance spectra of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1} , kJ mol^{-1} , cm^{-1} , eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $\text{K}_2\text{Cr}_2\text{O}_7$.
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colourimetry

1. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ in a solution of unknown concentration
2. Determine the concentrations of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.
4. Determine the amount of iron present in a sample using 1,10-phenanthroline.
5. Determine the dissociation constant of an indicator (phenolphthalein).
6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
7. Analyse the given vibration-rotation spectrum of HCl(g)

Reference Books

1. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).

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SEMESTER-VI

Discipline Specific Electives (DSE-4)

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CHEMISTRY DSE-5:

CH-302- MOLECULES OF LIFE

(Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Carbohydrates

Classification of carbohydrates, reducing and non-reducing sugars, General properties of glucose and fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof).

Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation. (10 Lectures)

Amino Acids, Peptides and Proteins

Classification of Amino Acids, Zwitterion structure and Isoelectric point.

Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis. (12 Lectures)

Enzymes and correlation with drug action

Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Non- competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure –activity relationships of drug molecules, binding role of –OH group, –NH₂ group, double bond and aromatic ring. (12 Lectures)

Nucleic Acids

Components of nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides (**nomenclature**), Structure of polynucleotides; Structure of DNA (Watson -Crickmodel) and RNA (**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation. (10 Lectures)

Lipids

Introduction to lipids, classification.

Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol). (8 Lectures)

Concept of Energy in Biosystems

Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of Carbohydrate-Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates. (8 Lectures)

Recommended Texts:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry (Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7thEd.*, W. H. Freeman.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

CHEMISTRY DSE-5 LABORATORY:

CH-304- LABORATORY-VI: MOLECULES OF LIFE

(60 Lectures)

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Study of titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Differentiate between a reducing/ nonreducing sugar.
9. Extraction of DNA from onion/cauliflower
10. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.

Recommended Texts:

1. Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. *Vogel's Textbook of Practical Organic Chemistry*, ELBS.
2. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry*, Universities Press.

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CHEMISTRY–DSE-5

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CH-306- CHEMISTRY OF MAIN GROUP ELEMENTS, THEORIES OF ACIDS AND BASES
(Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Acids and Bases: Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and

bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process. **(10 Lectures)**

General Principles of Metallurgy: Chief modes of occurrence of metals based on standard electrode potentials, Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agents.

Hydrometallurgy with reference to cyanide process for gold and silver. Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn, Au): electrolytic refining, zone refining, van Arkel-de Boer process, Parting Process, Mond's process and Kroll Process. **(8 Lectures)**

s- and p-Block Elements:Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, electronegativity (Pauling scale).

General characteristics of *s*-block metals like density, melting and boiling points, flame colour and reducing nature.

Oxidation states of *s*- and *p*-block elements, inert-pair effect, diagonal relationships and anomalous behaviour of first member of each group. Allotropy in C, P and S.

Complex forming tendency of *s* block elements and a preliminary idea of crown ethers and cryptates, structures of basic beryllium acetate, salicylaldehyde/ acetylacetonato complexes of Group 1 metals.

Solutions of alkali metals in liquid ammonia and their properties.

Common features, such as ease of formation, solubility and stability of oxides, peroxides, superoxides, sulphates and carbonates of *s*-block metals. **(14 Lectures)**

Structure, bonding and properties (acidic/ basic nature, oxidizing/ reducing nature and hydrolysis of the following compounds and their applications in industrial and environmental chemistry wherever applicable:

Diborane and concept of multicentre bonding, hydrides of Groups 13 (EH₃), 14, 15, 16 and 17.

Oxides of N and P, Oxoacids of P, S and Cl.

Halides and oxohalides of P and S (PCl₃, PCl₅, SOCl₂ and SO₂Cl₂)

Interhalogen compounds. A brief idea of pseudohalides **(14 Lectures)**

Noble gases: Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF₂, XeF₄ and XeF₆, bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory. **(5 Lectures)**

Inorganic Polymers:Types of inorganic polymers and comparison with organic polymers, structural features, classification and important applications of silicates. Synthesis, structural features and applications of silicones. Borazines and cyclophosphazenes – preparation, properties and reactions. Bonding in (NPCl₂)₃. **(9 Lectures)**

Recommended texts:

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
7. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

CHEMISTRY DSE-5 LABORATORY:

CH-308 - LABORATORY-VI: CHEMISTRY OF MAIN GROUP ELEMENTS, THEORIES OF ACIDS AND BASES (60 Lectures)

1. Iodometric estimation of potassium dichromate and copper sulphate
2. Iodimetric estimation of antimony in tartaremetic
3. Estimation of amount of available chlorine in bleaching powder and household bleaches
4. Estimation of iodine in iodized salts.
5. Iodimetric estimation of ascorbic acid in fruit juices.
6. Estimation of dissolved oxygen in water samples.
7. Gravimetric estimation of sulphate as barium sulphate.
8. Gravimetric estimation of aluminium as oximate complex
9. Preparation of the following: potash alum, chrome alum, tetraamminecopper (II) sulphate monohydrate, potassium trioxalatoferrate (III)
(any two, including one double salt and one complex).

Recommended Texts:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

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Skill Enhancement Course (any four)

(Credit: 02 each)
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SEMESTER-III

SEC-1

CH-205- INTELLECTUAL PROPERTY RIGHTS (IPR)

(Credits: 02)

Theory: 30 Lectures

In this era of liberalization and globalization, the perception about science and its practices has undergone dramatic change. The importance of protecting the scientific discoveries, with commercial potential or the intellectual property rights is being discussed at all levels – statutory, administrative, and judicial. With India ratifying the WTO agreement, it has become obligatory on its part to follow a minimum acceptable standard for protection and enforcement of intellectual property rights. The purpose of this course is to apprise the students about the multifaceted dimensions of this issue.

Introduction to Intellectual Property:

Historical Perspective, Different Types of IP, Importance of protecting IP.

Copyrights

Introduction, How to obtain, Differences from Patents.

Trade Marks

Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc.

Differences from Designs.

Patents

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their

importance for India.

Geographical Indications

Definition, rules for registration, prevention of illegal exploitation, importance to India.

Industrial Designs

Definition, How to obtain, features, International design registration.

Layout design of integrated circuits

Circuit Boards, Integrated Chips, Importance for electronic industry.

Trade Secrets

Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

Different International agreements

(a) World Trade Organization (WTO):

- (i) General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement
- (ii) General Agreement on Trade related Services (GATS)
- (iii) Madrid Protocol
- (iv) Berne Convention
- (v) Budapest Treaty

(b) Paris Convention

WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity

IP Infringement issue and enforcement – Role of Judiciary, Role of lawenforcement agencies – Police, Customs etc. Economic Value of Intellectual Property

– Intangible assets and their valuation, Intellectual Property in the Indian Context – Various laws in India
Licensing and technology transfer.

Reference Books:

1. N.K. Acharya: Textbook on intellectual property rights, Asia Law House (2001).
2. Manjula Guru & M.B. Rao, Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications (2003).
3. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill (2001).
4. Arthur Raphael Miller, MichealH.Davis; Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers (2000).
5. JayashreeWatal, Intellectual property rights in the WTO and developing countries, Oxford University Press, Oxford.

SEMESTER-IV

SEC-2

CH-206- GREEN METHODS IN CHEMISTRY (Credits: 02) Theory: 30 Lectures

Theory and Hand-on Experiments: Introduction: Definitions of Green Chemistry. Brief introduction of twelve principles of Green Chemistry, with examples, special emphasis on atom economy, reducing toxicity, green solvents, Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability

The following Real world Cases in Green Chemistry should be discussed:

1. Surfactants for carbon dioxide – Replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.

2. Designing of environmentally safe marine antifoulant.
3. Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
4. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

Practicals

1. Preparation and characterization of biodiesel from vegetable oil.
2. Extraction of D-limonene from orange peel using liquid CO₂ prepared from dry ice.
3. Mechano chemical solvent free synthesis of azomethine.
4. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).

Reference Books:

1. Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001).
2. Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
3. Ryan, M.A. & Tinnesand, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002).
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. Green Chemistry Experiments: A monograph I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore.
5. Lancaster, M. Green Chemistry: An introductory text RSC publishing, 2nd Edition.
6. Sidhwani, I.T., Saini, G., Chowdhury, S., Garg, D., Malovika, Garg, N. Wealth from waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated
7. "A Social Awareness Project", Delhi University Journal of Undergraduate Research and Innovation, **1(1)**: 2015.

SEMESTER-V

SEC-3

CH- 309- PHARMACEUTICAL CHEMISTRY (Credits: 02) Theory: 30 Lectures

Drugs & Pharmaceuticals

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), antilprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B₂, Vitamin B₁₂ and Vitamin C.

Practicals

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).

Reference Books:

1. G.L. Patrick: Introduction to *Medicinal Chemistry*, Oxford University Press, UK.
2. Hakishan, V.K. Kapoor: *Medicinal and Pharmaceutical Chemistry*, VallabhPrakashan, Pitampura, New Delhi.

3. William O. Foye, Thomas L., Lemke , David A. William: *Principles of Medicinal Chemistry*, B.I. Waverly Pvt. Ltd. New Delhi.

SEMESTER-VI

SEC-4

CHEMISTRY OF COSMETICS & PERFUMES (Credits: 02) (30 Lectures)

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Practicals

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol -I, Ellis Horwood Ltd. UK.
2. P.C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.

Physics

PH105: MECHANICS

4-Credits (4-0-0)

In this course, the brief description of vector calculus, the physics of motion and its relation with the applied forces will be discussed. The objective of this course is to review the geometrical description of motion in the context of one dimensional, multidimensional and circular motion. This course also reviews Newton's laws of motion, conservation theorems in linear and circular motion, Newton's law of gravitation, physics of simple harmonic motion and a detailed description of elasticity of materials. At the end, the mechanics at high speeds (comparable to speed of light) is covered in terms of special theory of relativity and a brief introduction to general theory of relativity. The students will also solve numerical problems based on the detailed theoretical description of the topics.

Vectors: Vector algebra, scalar and vector products, derivatives of a vector with respect to a parameter. **(6 Lectures)**

Laws of Motion: Frames of reference, Newton's laws of motion, dynamics of a system of particles, centre of mass. **(8 Lectures)**

Momentum and Energy: Conservation of momentum, work and energy, conservation of energy, motion of rockets. **(6 Lectures)**

Rotational Motion: Angular velocity and angular momentum, torque, conservation of angular momentum. **(6 Lectures)**

Gravitation: Newton's law of gravitation, motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant), Kepler's laws (statement only), satellite in circular orbit and applications, geosynchronous orbits, weightlessness, basic idea of global positioning system (GPS). **(7 Lectures)**

Oscillations: Simple harmonic motion, differential equation of SHM and its solutions, kinetic and potential energy, total energy and their time averages, damped oscillations. **(7 Lectures)**

Elasticity: Hooke's law, stress-strain diagram, elastic moduli, relation between elastic constants, Poisson's ratio, expression for Poisson's ratio in terms of elastic constants, work done in stretching and work done in twisting a wire, twisting couple on a cylinder, determination of rigidity modulus by static torsion, torsional pendulum, determination of rigidity modulus and moment of inertia - q , η and by Searles method. **(10 Lectures)**

Relativity: Constancy of speed of light, postulates of special theory of relativity, length contraction, time dilation, Doppler's effect, relativistic addition of velocities, introduction to general relativity, space-time, Minkowski space, gravitational red-shift, neutron star **(10 Lectures)**

Texts/References

1. An introduction to mechanics, Daniel Kleppner and Robert Kolenkov, 2/e, 2014, Cambridge University Press.
2. Concepts of Physics, H. C. Verma, 1/e, 1993 (second reprint 2011), Bharati Bhawan.
3. Mechanics Berkeley Physics course, Charles Kittel, et.al. 2007, Tata McGraw-Hill. University Physics. FW Sears, MW Zemansky & HD Young, 13/e, 1986, Addison Wesley.
4. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

PH107: MECHANICS LAB

2-Credits (0-0-3)

List of Experiments

1. Measurement of basic constant, length weight and time.
2. To determine the value of g with the help of a compound pendulum.
3. To determine the value of g by Katter's pendulum.
4. To study the coupled pendulum for in-phase, out-phase and beat oscillation.
5. To determine the Moment of Inertia of a Flywheel about its axis of rotation.
6. To determine the Moment of Inertia of an irregular body, about an axis passing through its gravity and perpendicular to its plane by dynamical method (Inertia Table).
7. To determine the modulus of rigidity of the material of wire with the help of a torsion pendulum
8. To determine the modulus of Rigidity of a wire by Maxwell's needle.
9. To determine the Young's modulus, modulus of Rigidity and Poisson ratio of the material of a wire by Searle's method.
10. To determine Young's Modulus of the given material in the form of a beam.
11. To determine the spring constant by Hooke's law.
12. To determine Poisson ratio of rubber.

Texts/References

1. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House.
2. B.Sc. Practical Physics, Geeta Sanon, R. Chand & Co. New Delhi, 2nd Ed. 2009.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengag Learning India Pvt. Ltd.
5. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

PH106: ELECTRICITY AND MAGNETISM

4-Credits (4-0-0)

Electricity and Magnetism course is designed with the following expected learning outcome:

- *Understanding, classification and identification of fundamental interactions in nature. The ability to identify and quantify electromagnetic interactions in real life.*
- *The origin of electric and magnetic character viz., why different materials show different electrical and magnetic behaviour.*
- *Historical evolution of electricity and magnetism from isolation to integration.*
- *Understanding electrification and magnetization of material objects and the skill to choose a material as per requirement e.g., electric cable, antenna, waveguide, magnetic storage etc.*
- *Understanding of Maxwell equations and their importance and applications in science, engineering and technology.*
- *Understanding the nature of light as electromagnetic radiation and the propagation in open and bound mediums.*
- *Imagination of the world and an individual without the gift of electricity and magnetism to the humanity.*

Vector Analysis: Review of vector algebra (scalar and vector product), gradient, divergence, curl and their significance, vector integration, line, surface and volume integrals of vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only). **(12 Lectures)**

Electrostatics: Electrostatic field, electric flux, Gauss's theorem of electrostatics, applications of Gauss theorem, electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor, electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere, calculation of electric field from potential, capacitance of an isolated spherical conductor, parallel plate, spherical and cylindrical condenser, energy per unit volume in electrostatic field, dielectric medium, polarisation, displacement vector. **(22 Lectures)**

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

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

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

Texts/References

1. Introduction to Electrodynamics, D. J. Griffith, Prentice Hall India (2009)
2. Electricity and Magnetism, E. M. Purcell, McGraw-Hill Education (1986)
3. Electricity and Magnetism, D. C. Tayal, Himalaya Publishing House, (1988)
4. University Physics, Ronald Lane Reese, Thomson Brooks/Cole, (2003)

PH108: ELECTRICITY & MAGNETISM LAB

2-Credits (0-0-3)

List of Experiments

1. To determine the capacitance of plate capacitor by charge measurement and dielectric constant of different dielectric materials. (Dielectric Constant)
2. To convert a Galvanometer into voltmeter/ammeter and to study resistance laws and a multi-meter.
3. To determine the specific resistance of a material of given wire using Carey foster's bridge.
4. To determine the specific resistance of a material of given wire using Wien's bridge.
5. Calibration of a voltmeter/ammeter with the help of a potentiometer.
6. To determine the magnetic field along the axis of current carrying coil and estimate the radius of the coil with the help of Tangent Galvanometer
7. To draw the Hysteresis curve of a given sample of ferromagnetic material and from this to determine magnetic susceptibility and permeability of the given specimen.
8. Faraday's law and induced E.M.F.
9. To determine the electro chemical equivalent of Copper using copper voltmeter
10. Magnetic field measurement with search coil & ballistic galvanometer.
11. To study the characteristics of a series R-C circuit.
12. To determine the internal resistance of a Leclanche's cell using potentiometer.

Texts/References

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.

2. B.Sc. Practical Physics, Geeta Sanon, R. Chand & Co., New Delhi, 2nd Ed. 2009.
3. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

PH201: THERMAL PHYSICS AND STATISTICAL MECHANICS

4-Credits (4-0-0)

The aim of this course is to provide a solid foundation in all aspects of thermodynamics and show a broad spectrum of modern trends in this area with a solid understanding of the fundamental laws of thermodynamics, thermodynamic potentials, and theory of radiation, kinetic theory and statistical physics. Statistical mechanics links the microscopic properties of physical systems to their macroscopic properties. Thermodynamics, which describes macroscopic properties, can then be derived from statistical mechanics with a few well motivated postulates. It leads to a microscopic interpretation of thermodynamic concepts, such as thermal equilibrium, temperature and entropy. In the course the basic principles of statistical mechanics will be introduced. Upon completion of this course, students should be able to:

- Describe the laws thermodynamics from both a macroscopic and microscopic point of view
- Apply the laws of thermodynamics to describe real physical systems and processes
- Describe the properties of ideal gases using kinetic theory
- Understand the theory of black body radiation and related phenomenon.
- Describe the differences between systems of bosons and fermions and how this arises from microscopic properties

Laws of Thermodynamics: Thermodynamic Description of system: Zeroth law of thermodynamics and temperature, first law of thermodynamics and internal energy, conversion of heat into work, various thermo-dynamical processes, applications of first law, general relation between C_p & C_v , work done during isothermal and adiabatic processes, compressibility & expansion coefficient, reversible & irreversible processes, second law & entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, entropy-temperature diagrams, third law of thermodynamics, unattainability of absolute zero. **(22 Lectures)**

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal energy functions, Maxwell's relations & applications, Joule-Thomson effect, Clausius-Clapeyron equation, expression for $(C_p - C_v)$, C_p/C_v , T-dS equations. **(10 Lectures)**

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, mean free path (Zeroth order), law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases. **(10 Lectures)**

Theory of Radiation: Blackbody radiation, spectral distribution, concept of energy density, derivation of Planck's law, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan Boltzmann law, and Wien's displacement law from Planck's law. **(6 Lectures)**

Statistical Mechanics: Phase space, macrostate and microstate, entropy and thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity -Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. **(12 Lectures)**

Texts/References

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. Heat and Thermodynamics: Brij Lal and N. Subramanyam, S. Chand.
3. Fundamentals of Statistical and Thermal Physics: F. Rief, Waveland Press.
4. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
5. Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill
6. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G. L. Salinger. 1988, Narosa.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PH203: THERMAL PHYSICS AND STATISTICAL MECHANICS LAB

2-Credits (0-0-4)

The Objectives of the laboratory is to develop experimental and data analysis skills through a wide range of experiments. And further to develop the experimental skills through a series of experiments which also illustrate major themes of the lecture courses.

List of Experiments

1. To determine the value of Stefan's constant.
2. To verify the Stefan's law by electric method.
3. To determine the coefficient of real expansion of a liquid (water) by up-thrust method.
4. To determine the coefficient of Linear Expansion of given Sample.
5. To determine the value of J, the mechanical equivalent of heat by Searle's friction cone apparatus.
6. To determine the mechanical equivalent of heat (J) with the help of Joule's calorimeter.
7. To determine the Coefficient of thermal conductivity of bad conductors by Lee's Disc method.
8. To determine the thermal conductivity of rubber in the form of tube.
9. To determine the critical temperature and critical pressure of a gas.
10. Determine of Temperature coefficient of resistance (α) for platinum wire by Callender and Griffith Bridge method.
11. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
12. To determine the value of Y (the ratio of two specific heats of gas) for air by Clement and Desorme's method.
13. To determine specific heat of a given liquid by method of cooling.

Texts/References

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.

PH202: WAVES AND OPTICS

4-Credits (4-0-0)

Optics, the study and manipulation of visible light, has always been an important sub-discipline in physics, and clearly, it contributes to the most important technologies of the 21st century. Understanding the nature of electromagnetic waves, its propagation and interaction with matter is essential to physics and hands-on experiences greatly enhance that understanding. The objective of the course is to familiarize the student to the wave phenomena in nature with special emphasis to optics. The course provides an extensive discussion of optical phenomena such as interference, diffraction, and polarization. It also familiarize the student with modern day application of optics in Lasers and Fiber optics.

Sound: Simple harmonic motion, forced vibrations and resonance, Fourier's Theorem, application to saw tooth wave and square wave, intensity and loudness of sound, Decibels, intensity levels. **(8 Lectures)**

Superposition of two harmonic oscillations: Linearity and Superposition Principle, superposition of two collinear oscillations having (a) equal frequencies and (b) different frequencies (Beats), Superposition of two perpendicular harmonic Oscillations: Graphical and analytical methods, Lissajous figures.

(8 Lectures)

Wave Motion: Transverse waves on a string, travelling and standing waves on a string, normal modes of a string, group velocity, phase velocity, plane waves, spherical waves, wave intensity. **(8 Lectures)**

Wave Optics: Electromagnetic nature of light, definition and properties of wave front, Huygens principle. **(2 Lectures)**

Interference: Interference by division of amplitude and division of wavefront, Young's double slit experiment. Lloyd's mirror and Fresnel's bi-prism, phase change on reflection, Stokes' treatment, interference in thin films: parallel and wedge-shaped films, Newton's rings: measurement of wavelength and refractive index. Michelson's Interferometer: Idea of formation of fringes, determination of wavelength, wavelength difference, refractive index. **(12 Lectures)**

Diffraction: Fraunhofer diffraction: Single slit; double slit, multiple slits & diffraction grating. Fresnel diffraction: half-period zones, zone plate, Fresnel diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **(9 Lectures)**

Polarization: Transverse nature of light waves, plane polarized light-production and analysis, circular and elliptical polarization. **(5 Lectures)**

Fiber Optics: Propagation of light in optical fiber, types of fiber and uses. **(3 Lectures)**

Lasers: Properties of lasers, Mechanism of laser oscillations, Three level and four level systems.

(5 Lectures)

Texts/References

1. N. K. Bajaj, Waves & Oscillations (Tata-McGraw-Hill)
2. A. K. Ghatak, Optics (Tata Mc Graw Hill)
3. D. P. Khandelwal, Optics & Atomic Physics, (Himalaya Publishing House)
4. Jenkins & White, Fundamentals of Optics (McGraw-Hill)
5. R. N. Chaudhary, Waves and Oscillations (New Age Publications)

PH204: WAVES & OPTICS LAB

2-Credits (0-0-3)

List of Experiments

1. To determine the wavelength of Sodium light by Newton ring method.
2. To determine the wavelength of Sodium light using Fresnel's Bi-prism.
3. To study interference and diffraction pattern with slits.
4. To determine the refractive index of the prism and its dispersive power with the help of spectrometer.

5. To determine the wavelength of different spectral light emitted by light sources with the Plane Transmission Grating.
6. To determine the specific rotation of cane sugar solution with the help of Polarimeter.
7. To verify the Malus's law.
8. To determine the plank's constant by photoelectric effect.
9. To verify Newton's formula for combination of two lenses.
10. Focal length of a combination of two lenses using Nodal slide assembly.
11. To determine frequency of AC mains using Sonometer.
12. To determine the surface tension by Searle's apparatus.
13. To determine the coefficient of viscosity by Poiseuille's/Stoke's method.
14. To determine the frequency of an electrically maintained tuning fork by Melde's experiment and to verify λ^2 -T law.
15. To study Lissajous' Figures.

Texts/References

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi

PH301: SOLID STATE PHYSICS

4-Credits (4-0-0)

The course will provide an overview of the fundamental applications of the physics of solids. This course includes theoretical description of crystal structure, lattice dynamics, electronic and dielectric properties of different material based on the classical and quantum physics principles. The materials include metals, semiconductors, dielectrics, magnetic materials and superconductors.

Crystal Structure: Solids: Amorphous and crystalline materials, lattice translation vectors, lattice with a basis, unit Cell, Miller indices, reciprocal lattice, types of lattices, Brillouin zones, diffraction of X-rays by crystals, Bragg's law, atomic and geometrical factor. **(12 Lectures)**

Elementary Lattice Dynamics: Lattice vibrations and phonons: Linear monoatomic and diatomic chains, acoustical and optical phonons, qualitative description of the phonon spectrum in solids. Dulong and Petit's law, Einstein and Debye theories of specific heat of solids (qualitative only), T^3 law. **(10 Lectures)**

Magnetic Properties of Matter: Dia, Para, Ferri and Ferromagnetic materials, classical Langevin theory of dia and paramagnetic domains, quantum mechanical treatment of paramagnetism, Curie's law, Weiss's theory of Ferromagnetism and Ferromagnetic domains, discussion of B-H curve, hysteresis and energy loss. **(12 Lectures)**

Dielectric Properties of Materials: Polarization, local electric field at an atom, depolarization field, electric susceptibility, polarizability, Clausius-Mosotti equation, Classical theory of electric polarizability, normal and anomalous dispersion, Cauchy and Sellmeier relations, Langevin-Debye equation, complex dielectric constant, optical phenomena, applications: plasma oscillations, plasma frequency, plasmons. **(10 Lectures)**

Elementary Band Theory: Kronig Penny model, band gaps, conductors, semiconductors and insulators, p and n type semiconductors, conductivity of semiconductors, mobility, Hall Effect. **(8 Lectures)**

Superconductivity: Experimental results, critical temperature, critical magnetic field, Meissner effect, type-I, and type-II superconductors. **(8 Lectures)**
Piezo and Ferroelectric effect **(2 Lectures)**

Texts/References

1. Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
2. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
3. Solid State Physics, Neil W. Ashcroft and N. David Mermin, 1976, Cengage Learning
4. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PH303: SOLID STATE PHYSICS LAB

2-Credits (0-0-3)

List of Experiments

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method)
2. To measure the magnetic susceptibility of solids.
3. To determine the Coupling coefficient of a Piezoelectric crystal.
4. To measure the dielectric constant of a dielectric materials with frequency.
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR) technique.
6. To determine the refractive index of a dielectric layer using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of iron using a Solenoid and determine the energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150°C) by four-probe method and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Texts/References

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

PH 305: PHYSICS OF SEMICONDUCTOR DEVICES

Credits: 4 (4-0-0)

The objective of the course is to provide an in-depth introduction to electronic semiconductor devices and circuits intended for students who are taking their first course in electronics. The course provides the theoretical background of semiconductor devices in terms of band theory. It explains their structures and characteristics starting from simple p-n junction diode to advanced level MOSFETs. The course builds a detailed foundation for understanding the operation of electronic devices in circuits and their practical applications in terms of design and analysis.

Semiconductor Device Physics: Bonding in Solids, Energy Bands, Metals, Semiconductors, and Insulators, E-k diagram, Direct and Indirect bandgap Semiconductors, Density of states, Occupation probability, Fermi levels, Charge Carriers in Semiconductors, Effective Mass concept, Intrinsic and extrinsic Materials, Carrier concentration, Temperature dependence, Drift of Carriers in Electric and Magnetic Fields, Hall effect. **(15 Lectures)**

Semiconductor Diodes: p and n type semiconductors, Barrier Formation in PN Junction Diode, Current Flow Mechanism, junction characteristics, Static and Dynamic Resistance, Transition capacitance, Varactor diodes, junction breakdown, Zener diode and its characteristics, Tunnel Diode, Schottky Diodes, Principle and structure of Light Emitting Diodes (LED), Photodiode, Solar Cell. **(15 Lectures)**

Bipolar Junction transistors: n-p-n and p-n-p Transistors, Current flow mechanism, CB, CE and CC Configurations, Active, Cutoff, and Saturation Regions, Current gains α and β , Load Line and Q point, Biasing of Transistors, h-parameter model, Single-stage CE amplifier using Hybrid Model, Input and Output Impedance, Current, Voltage and Power Gains, Frequency response of transistors, pnpn diode, Silicon Controlled Rectifier (SCR). **(20 Lectures)**

Field Effect Transistors: Physical Description and Theory of JFET, Static characteristics, Small Signal Analysis, Equivalent circuit, Fundamental Concept of MOSFETs, Enhancement and Depletion Type. **(10 Lectures)**

Texts/References

1. Electronic Devices & Circuits, J. Millman and C.C. Halkias, Tata Mc-Graw Hill (1991).
2. Physics of Semiconductor Devices, S. M. Sze and K. K. Ng, Wiley Interscience (2007).
3. Solid State Electronic Devices: B. Streetman, S. Banerjee, PHI (2009).
4. Electronic Fundamentals and Applications, D. Chattopadhyay and P. C. Rakshit, New Age International (2008).

PH307 PHYSICS OF SEMICONDUCTOR DEVICES LAB

2-Credits (0-0-3)

List of Experiments

1. To measure of the band-gap of a semiconductor using four-probe method.
2. To study the Hall effect and determine the Hall Coefficient.
3. To study the **I-V** characteristics of pn junction diode and find the static and dynamic resistance.
4. To study the I-V characteristic of a Zener diode and use it as a voltage regulator.
5. To study the characteristics of (i) Light emitting diode and (ii) Photo-diode.
6. To study the characteristics of a Transistor in (i) CE, (ii) CB, (iii) CC configuration.
7. To design a CE amplifier of a given gain (mid-gain) using voltage divider bias.
8. To study the characteristics of a FET.

Texts/References

1. B.Sc Practical Physics, Geeta Sanon, R. Chand & Co. (2010).
2. B.Sc Practical Physics, Harnam Singh, S. Chand & Co. (2002).

PH309: INTRODUCTORY ATMOSPHERIC PHYSICS

3-Credits (3-0-0)

In this course, students will learn about the structure of earth's atmosphere and different atmospheric phenomena. The course will emphasize on the Physics of atmospheric waves and RADAR/LIDAR working principle. Moreover, students will learn about the role of radiation scattering e.g., Rayleigh and Mie scattering, on atmospheric conditions.

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze.

(8 Lectures)

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration

(8 Lectures)

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications.

(6 Lectures)

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Optical phenomena in atmosphere, Aerosol studies using Lidars.

(8 Lectures)

Texts/References

1. Fundamental of Atmospheric Physics-Murry L Salby; Academic Press, Vol 61, 1996.
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004.
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

PH311: BASICS OF NANOSCIENCE

3-Credits (3-0-0)

This course brings together relevant knowledge from the disciplines of physics and chemistry to give students a fundamental understanding of the integrated multidisciplinary nature of Nanotechnology. It will also be a forum for discussion on the possible consequences of such technological development. It will focus on introduction to Nanotechnology which aims to provide a broad overview of fundamental principles, chemical synthesis, characterization tools, and technological developments. This will provide students with a basic knowledge and grounding in cutting edge research being undertaken within this field.

Introduction to Nanoscience: Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires), band structure and density of states of materials at nanoscale, size effects in nano systems, **characteristic scale for quantum phenomena**, quantum confinement, applications of Schrodinger equation, infinite potential well, quantum confinement of carriers in quantum confined nanostructures and its consequences.

(8 Lectures)

Overview of Nano Fabrication Methods: Top-down and bottom-up approaches. Sol-Gel, Co-precipitation and Hydrothermal synthesis. Photolithography. Physical vapor deposition (PVD): Thermal evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). MBE

(10 Lectures)

Characterization Tools: X-Ray Diffraction. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy.. Profilometry. PL, UV Spectroscopy

(10 Lectures)

Optical Properties of nanostructural materials

(2 Lectures)

Applications: Applications of nanostructures for photonic devices (LED's and solar cells). Introduction to CNT based devices. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro

Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). Functionalized nanoparticles for biological application. Impact of nanotechnology on the environment. **(15 Lectures)**

Texts/References

1. Introduction to Nanotechnology by Charles P. Poole, Jr., Frank J. Owens, John Wiley & Sons, 2003.
2. Nanotechnology: Principles & Practices by S.K. Kulkarni, Springer, 3rd Edition, 2015.
3. Nanoscale science and technology, Robert Kelsall, Ian W. Hamley, Mark Geoghegan, John Wiley & Sons., 2005.
4. Nanomaterials: synthesis, properties and applications by A.S Edelstein, R.C Cammaratra, CRC Press, 1998
5. Electron Microscopy and Analysis, Peter J. Goodhew; John Humphreys; Richard Beanland, CRC Press, 3rd Edition, 2000.

PH302: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

4-Credits (4-0-0)

The objectives of this course are to study the fundamentals of atomic, molecular and nuclear structures. In addition to the basic concepts, this course will provide the students an understanding of the physics of atoms present in electric as well as magnetic fields. Applications of the concepts of Raman effect in Raman spectroscopy and principles with working of different lasers will be discussed. In the later part of the course, different concepts of nuclear physics including the basic characteristics of nucleus, radioactive decays, nuclear reactions, nuclear models, accelerators and detectors will be covered. The students will also solve numerical problems based on the detailed theoretical description of the topics covered in the course.

Basics of Atomic Physics: Quantum states of an electron in an atom, electron spin spectra of H, He, and alkali metals. **(5 Lectures)**

Atoms in Electric and Magnetic Fields: Electron Angular Momentum, Space Quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). **(14 Lectures)**

Raman Effect: Quantum Theory of Raman Effect, Characteristics of Raman Lines. Stoke's and Anti-Stoke's Lines. Complimentary Character of Raman and infrared Spectra. **(5 Lectures)**

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. **(6 Lectures)**

Basics of Nuclear Physics: Structure of nuclei: Basic Properties of Nuclei, Radioactivity: Law of Radioactive Decay. Half-life, Radioactive Series, Binding Energy, Mass Formula, α -decay: Range of α -particles, Geiger-Nuttal law and α -particle Spectra. Gamow Theory of Alpha Decay, β -decay: Energy Spectra and Neutrino Hypothesis, γ -decay: Origin of γ -rays, Nuclear Isomerism and Internal Conversion, Nuclear Reactions: Types of Reactions and Conservation Laws. Concept of Compound and Direct Reaction. Compound Nucleus. Scattering Problem in One Dimension : Reflection and Transmission by a Finite Potential Step, Attractive and Repulsive Potential Barriers. Scattering Cross-section. Reaction Rate. Q-value of Reaction. Fission and Fusion. Nuclear Models: Liquid Drop Model. Mass formula. Shell Model. Meson Theory of Nuclear Forces and Discovery of Pion. Accelerators, Detectors of Nuclear Radiations (Qualitative Discussion Only). **(30 Lectures)**

Texts/References

1. Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987)
2. Atomic physics by J. B. Rajam & foreword by Louis De Broglie.(S.Chand & Co., 2007).
3. Atomic Physics by J. H. Fewkes & John Yarwood. Vol. II (Oxford Univ. Press, 1991).
4. Nuclear physics by Irving Kaplan. (Oxford & IBH, 1962).
5. Introductory nuclear physics by Kenneth S. Krane.(John Wiley & Sons, 1988).
6. Concepts of nuclear physics by Bernard L.Cohen.(New Delhi: Tata McGraw Hill, (1998).

PH-304: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS LAB

2-Credits (0-0-3)

List of Experiments

1. To study the absorption spectra of He and Na source.
2. To determine refractive index of the Material of a prism using sodium source.
3. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
4. To determine the absorption lines in the rotational spectrum of Iodine vapour.
5. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
6. To determine the wavelength of H-alpha emission line of Hydrogen atom.
7. To determine the ionization potential of mercury.
8. To setup the Millikan oil drop apparatus and determine the charge of an electron.
9. To determine the wavelength of laser source using diffraction of single slit.
10. To determine the wavelength of laser source using diffraction of double slits.
11. To determine angular spread of He-Ne laser using plane diffraction grating
12. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
13. Study of Zeeman effect: with external magnetic field; Hyperfine splitting

Texts/References

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11-th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

PH306: MODERN PHYSICS AND QUANTUM MECHANICS

4-Credits (4-0-0)

The course "Modern Physics and Quantum Mechanics" is designed in four sections. The objective of first section is to understand the dual nature of wave as well as particle through different theories and their experimental verification. The objective of second section is to understand the need and basics principles of quantum mechanics with its different applications. In the third section, the students will be able to understand the theory through important experiments in the atomic physics. The objective of fourth section is to make the students understand the important concepts and theories of nuclear physics. In this course, the students will develop an understanding of some of the fundamental laws of nature with their

mathematical representation and will also solve numerical problems based on the detailed theoretical description of the topics.

Dual nature of wave and particle: Origin of Planck's quantum theory, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering, de Broglie wavelength and matter waves; electron diffraction, Davisson-Germer experiment, Wave description of particles by wave packets, Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability amplitude and density, Wave amplitude and wave functions, Heisenberg uncertainty principle, Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. **(15 Lectures)**

Quantum mechanics: Matter waves and wave amplitude; time independent and dependent Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Applications of Schrodinger's equation: One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization, Quantum mechanical tunneling in one dimension-across a step potential and rectangular potential barrier. **(15 Lectures)**

Basics of Atomic Physics: Quantum states of an electron in an atom, atomic spectra of H, He, and alkali metals, Bohr atom, Quantum theory of H atom, Quantum numbers, Spectral Notations for Atomic States, electron spin, Pauli's Exclusion Principle, Stern-Gerlach experiment (Brief discussion), Symmetric and antisymmetric wavefunctions, Hund's rule, Spin orbit coupling, Total Angular Momentum, L-S and J-J couplings. **(15 Lectures)**

Basics of Nuclear Physics: Size and structure of atomic nucleus and its relation with atomic weight; Binding energy, Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, Nature of nuclear force, Liquid Drop model: semi-empirical mass formula and binding energy. energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion reactions (brief qualitative discussions). **(15 Lectures)**

Texts/References

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill.
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
5. A. Ghatak and S. Lokanathan, "Quantum Mechanics: Theory and Applications", Kluwer Academic Publishers (2004).
6. H. C. Verma, "Quantum Physics", Surya Publications (2006).

PH-308: MODERN PHYSICS AND QUANTUM MECHANICS LAB

2-Credits (0-0-3)

List of Experiments

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Measurement of Planck's constant using Photoelectric effect.
3. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
4. To determine work function of material of filament of directly heated vacuum diode.
5. To determine the Planck's constant using LEDs of at least 4 different colours.

6. To determine the wavelength of H-alpha emission line of Hydrogen atom.
7. To determine the ionization potential of mercury.
8. To determine the absorption lines in the rotational spectrum of Iodine vapour.
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.
11. To show the tunneling effect in tunnel diode using I-V characteristics.
12. To determine angular spread of He-Ne laser using plane diffraction grating.

Texts/References

1. Advanced Practical Physics for students, B.L. Flint and H.T.Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

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Physics: Skill Enhancement Courses (SEC)

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PH205: RENEWABLE ENERGY AND ENERGY HARVESTING

2-Credits (2-0-0)

In the course entitled, “Renewable energy and energy harvesting” students will get basic knowledge of energy harvesting technologies. Following outcomes are expected from the course:

- *Understanding, need, identification and classification of different sources of energy.*
- *Understanding, advantages and limitations of different energy harvesting approaches.*
- *Realizing the need of clean and green sources of energy.*
- *Motivation for exploring alternative sources of energy.*
- *Understanding energy scenario and industrialization in the global and Indian perspective.*
- *Understanding the vitality of energy for humanity.*

Conventional Energy Sources: Review of conventional energy sources and their limitations.

(2 Lectures)

Solar Energy: Solar energy and its importance, storage of solar energy, solar pond, non convective solar pond, applications of solar energy, photovoltaic (PV) systems, PV models and equivalent circuits, sun tracking systems.

(8 Lectures)

Wind Energy Harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

(4 Lectures)

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. **(3 Lectures)**

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. **(2 Lectures)**

Piezoelectric Energy harvesting: Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, piezoelectric parameters and modeling piezoelectric generators, applications. **(5 Lectures)**

Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications. **(4 Lectures)**

Environmental issues and sustainability. **(2 Lectures)**

Project and Plant Visit: One design project will be given. The project/model will be explained and demonstrated by the students. Students registered for the course will visit an energy plant/institution for learning the actual working of energy plants. *Sessional assessment marks will be awarded on the basis of project and the plant visit report.*

Texts/References

1. Non-conventional energy sources, B.H. Khan, Tata McGraw-Hill Education, 2006.
2. Solar Energy: Principles of Thermal Collection and Storage, K. Sukhatme, Suhas P. Sukhatme, Tata McGraw-Hill Education, 1996.
3. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., Oxford University Press, 2012.
4. Solar Energy Resource Assessment Handbook, Jayakumar, Renewable Energy Corporation Network for the Asia Pacific, 2009.

J. Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

PH-206: COMPUTATIONAL PHYSICS

2-Credits (2-0-0)

Computational physics is now widely accepted as a third, equally valid complement to the traditional experimental and theoretical approaches to physics. All modern scientific fields utilize computers extensively. Thus knowledge of a programming language and its application for problem solving has become essential for advanced level of studies. The objective of the course is two-fold. Primarily the course aims to provide an exposure to the students to MATLAB which is a technical computing language. Secondly the course aims to give a basic understanding of numerical methods of solving a problem in advanced level physics.

Basic programming techniques: Introduction to MATLAB, variables and arrays; scalar and array operations; built-in MATLAB functions; file input/output. Data visualisation and plotting in MATLAB; Revision of error analysis; propagation of errors; MATLAB functions for error analysis; **(10 Lectures)**

Basic programming techniques: User-defined functions in MATLAB, Numerical methods for solving ordinary differential equations; **(10 Lectures)**

Applications in physics: Numerical solution of some specific computational problems in Physics, Classical electrons in crossed electric and magnetic fields, Integral equations: Calculation of scattering cross section (a) quantum scattering with a spherically symmetric potential, Partial differential equations: Laplaces equation, wave equations, diffusion equation and Maxwell's equations .

(10 Lectures)

Texts/References

1. J Hasbun, P. Devries, A first course in computational physics.
2. Rudra Pratap, Getting started with Matlab 7: A quick introduction for Scientists and Engineers, Oxford University Press (2002).

PH313 : PHOTOLITHOGRAPHY AND DEVICE FABRICATION

2-Credits (2-0-0)

This course will provide a detailed overview of cleanroom-based processes for device fabrication. A cleanroom is a controlled environment in which micro and nano devices are manufactured. The course includes all the steps of device fabrication including photolithography process. The students will learn fabrication of multilayer devices like light emitting diodes and solar cells based on soft materials. The device characteristics required for commercialization will also be discussed in this course.

Fundamentals of Photolithography, Photo resists (PR), Positive and negative photo resists, Photo Resist Parameters, Developers, Key steps for doped Silicon photolithography, growth of oxide layer, surface preparation, coating of the Photo resist, Photo mask fabrication, Chromium etching, Optical exposure.

(12 Lectures)

Transparent conducting oxides films in device applications, Optical and electronic properties (absorption, resistivity, work function) of indium tin oxide (ITO) thin film. Introduction to Solar Cells and Light emitting diodes (LED) structure.

(8 Lectures)

Patterning of ITO, Surface treatment, evaporation or coating process, encapsulation, major challenges in device fabrication, optical out-coupling and approaches, Commercialization issues for solar cell and display devices: Efficiency, life time, size, weight & cost, Resolution, brightness, CIE, colour Gamut, aspect ratio, contrast ratio, power consumption.

(10 Lectures)

Texts/References/Resources

1. S.M.Sze, VLSI Technology, Tata McGraw Hill Edition (2003).
2. Franky So, 'Organic Electronics', CRC Press (2010).
3. Web: <http://www.nptel.ac.in>

PH-310: SIMULATION EXPERIMENTS IN PHYSICS

2-Credits (0-0-4)

In the course entitled, "simulation experiments in physics", students will perform science experiments through numerical computation. The students will learn physics concepts e.g., natural forces, planetary motion, relativity, wave propagation, heat transfer, atomic spectra, quantum concepts, through computer simulations.

1. Comparative study of gravitational, electromagnetic, and nuclear forces.
2. Planetary motion and satellite orbits.
3. Length contraction, time dilation, and mass energy equivalence.
4. Electric and magnetic field analysis for different charge and current distributions.
5. Electromagnetic wave propagation
6. Heat transfer
7. Blackbody radiation, ultraviolet catastrophe, and Planck's radiation law.
8. Calculating energy levels for hydrogen like atoms and analysis of their spectra.
9. Energy levels, wavefunctions and, probability densities for a particle in one dimensional infinitely rigid box.
10. Energy levels, wavefunctions and, probability densities for a harmonic oscillator.
11. Quantum mechanical scattering and tunneling.

12. I-V Characteristics of semiconductor devices.