SIKKIM UNIVERSITY

(A Central University established by an Act of Parliament in 2007 and accredited by NAAC in 2015)

SYLLABUS
FOR DEPARTMENTS IN
SCHOOL OF PHYSICAL SCIENCES

DEPARTMENT OF CHEMISTRY

DEPARTMENT OF COMPUTER APPLICATIONS

DEPARTMENT OF GEOLOGY

DEPARTMENT OF MATHEMATICS

DEPARTMENT OF PHYSICS

FOREWORD

Sikkim University, a central university established by an Act of Parliament, has completed twelve years of its establishment in July, 2019. The duration of course, is not a long period in the institution building process but certainly Sikkim University has become a new destination for higher learning in this short span.

One of the focused areas of the University since inception has been curriculum development. There has been a tradition of bringing in the best minds in academia from all over the country including people with lot of experiences for developing curriculum for the courses offered in Sikkim University.

Sikkim University has a standard policy of reviewing/ revising curriculum of all programmes after every three years. Such revision is to bring in fresh ideas and recent trends in learning process and, we believe, it opens up a new vista in learning and research. The last revision/review of curriculum of all the programmes took place in 2017 under the supervision of the Deans of School of Studies.

The idea to print syllabi of all departments under each School of Study is to document the syllabus of each course for future reference and to have an authentic version in circulation. This initiative received instant encouragement from Prof. Jyoti Prakash Tamang, Dean School of Life Sciences when he was officiating as the Vice-Chancellor and also from the present Vice-Chancellor Prof. Avinash Khare.

A lot of efforts have been put by Sh. Gagan Sen Chettri, UDC in Academic Section in compiling, editing and formatting under supervision of Dr. Suresh Kr. Gurung, Joint Registrar. All Deans of Schools and the Head(s)/In-charge(s) of all departments have taken pains in going through each and every word and making corrections in the draft versions and also going through the final version. Sometimes even their help was sought in making corrections. It was therefore, possible to bring out the print version of the syllabi.

(T.K Kaul)
Registrar

Contents

DEPARTMENT OF CHEMISTY

PG - M.Sc. Syllabus

Code	Name of Paper	Credits	Marks
1st Semester			
CHE-PG-C101	Chemistry I	4	100
CHE-PG-C102	Chemistry II	4	100
CHE-PG-C103	Mathematics and Biochemistry	4	100
CHE-PG-C104	Practicals I	4	100
2nd Semester			
CHE-PG-C201	Inorganic Chemistry	4	100
CHE-PG-C202	Organic Chemistry	4	100
CHE-PG-O203	Physical Chemistry	4	100
CHE-PG-C204	Practicals II	4	100
3rd Semester			
CHE-PG-O301	Instrumental Techniques	4	100
CHE-PG-E3XY	Elective I	4	100
CHE-PG-E3XY	Elective II	4	100
CHE-PG-C304	Practicals III	4	100
4th Semester			
CHE-PG-E4XY	Elective III	4	100
CHE-PG-E4XY	Elective IV	4	100
CHE-PG-E4XY	Elective Practical	4	100
CHE-PG-E404	Project	4	100
TOTAL		**36**	**1600**

Semester I

Chemistry I **4 credits**

CHE-PG-C101

Unit I: Stereochemistry and bonding in Main group compounds

Valence Shell Electron Pair Repulsion model, stereochemical rules and explanation of the shapes of molecules and ions of non-transition elements with 2-7 valence shell electron pairs. Walsh Diagram. Bent rule and energetics of hybridization.

HSAB: Classification of acids and bases as hard and soft; HSAB principle, theoretical basis of hardness and softness; Lewis-acid base reactivity approximation; Group Characteristic of Lewis Acids & Base (group 13, 14, 15, 16, 17 and s-block) donor and acceptor numbers, E and C equation; applications of HSAB concept.

Unit II: Group Theory and Symmetry of molecules

Group Theory: Definition of group, symmetry, point groups, representation of group, Abelian group, Group multiplication table, Groups, sub-groups and classes, Symmetry operations and symmetry elements, Point group, classification and symmetry number, Schoenflies symbols. orthogonality theorem, irreducible representation, character table, Point group symmetry and optical activity, dipole moment, vibrational spectroscopy and bonding.

Unit III: Aromaticity

Benzenoid and nonbenzenoid systems, antiaromaticity and non aromatic compounds.

Effects of Structure on Reactivity: Hammett equation, Linear free energy relationships (LFER) and substituent and reaction constants. Structure-activity relationship. Taft equation.

Aliphatic Nucleophilic Substitution at Saturated Carbon: Mechanism and Stereo-chemistry of SN1, SN2, SNi, SN1 and SN2 reactions. Neighboring group participation. Classical and non classical carbocations. The reactivity effects of substrate structure, solvent effects, competition between SN1 and SN2 mechanisms. Phase transfer catalysis ambident nucleophilicity , regioselectivity.

Aromatic Electrophilic Substitution: The Arenium ion mechanism, orientation and reactivity in monosubstituted benzene rings, ortho/ para ratio. Ipso substitution. Effect of substrates, leaving groups and solvent polarity on the reaction.

Aromatic Nucleophilic substitution: Aromatic SNAr, SN1, SN2 and benzyne mechanisms. Reactivity: effect of substrate structure, leaving group, and attacking nucleophile.

Unit IV: Addition to Carbon–Carbon Multiple Bonds

Electrophilic, free-radical and nucleophilic mechanisms-Mechanistic and Stereochemical aspects. Orientation and reactivity. Hydroboration and Michael reaction. mination reactions: The E1, E2 and E1cB mechanisms, Orientation of the double bond. Hofmann versus Saytzeff elimination, Pyrolytic syn-elimination- Chugaev and Cope eliminations, Competition between substitution and elimination reactions.

Nucleophilic Addition to Carbonyl Compounds

Hard and soft nucleophiles, addition to conjugated carbonyls; Competition between 1,2 and 1,4 addition, Meerwin-Pondorf Reaction, Cannizaro reaction, stetter reaction, Aldol condensation, Grignard reagent, alkyl lithium, Perkin reaction, Benzoin condensation, Benzilic acid rearrangement, Wittig reaction,

References

1. Cotton, F.A. and Wilkinson, G. 1999 Advanced Inorganic Chemistry, 6th Edn., John Wiley & Sons, New York.
2. Huheey, J. E., 1993 Inorganic Chemistry, 4th Ed., Addison-Wesley Pub. Co., New York.
3. Drago, R. S., 1971 Physical Methods in Inorganic Chemistry, International Edn., Affiliated East-West Press, New Delhi.
4. Shriver, D. F. and Atkins, P. W., 1999 Inorganic Chemistry, 3rd Edn., ELBS, London.
5. Cotton, F. A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry, 3rd Edition, John Wiley & Sons, New York.
6. Greenhood, 1976, Spectroscopic properties of inorganic and organometallic compounds, Royal Society of Chemistry.
7. Lee, J. D. 1999 Concise Inorganic Chemistry, Blackwell Science.
8. Purcell K. F. and Kotz J. C., 1987 Inorganic Chemistry, W. B. Sauders Com. , Hong Kong.
9. Cotton, F.A. 1990 Chemical Application of Group Theory, 3rd Ed, Wiley- Blackwell.
10. Smith M. B. and March, J. 2001 March's Advanced Organic Chemistry, 6th Edn, John Wiley & Sons, New York.
11. Sykes, P. 1997 A Guide book to Mechanism in Organic Chemistry, 6th Edition, Orient Longman Ltd., New Delhi.
12. Fryhle, S. Organic Chemistry, 8th Edition, John Wiley & Sons, New York.
13. Clayden, J., Greeves, N. , Warren, S. and Wothers, P., 2000 Organic chemistry, Oxford University Press
14. Bruice, Organic Chemistry, 5th Edition, Pearson Education
15. Carey F. A. and Sundburg R. J. 2007 Advance Organic Chemistry; 5th Ed. Springer
16. Mukherjee S. M. and Singh, S. P, 1990 Reaction Mechanism in Organic Chemistry, Ist Edition, Macmillan India Ltd., New Delhi.
17. Lowry T.H. and Richardson, K. S. 1998 Mechanism and Theory in Organic Chemistry, 3rd Edition, Addison – Wesley Longman Inc. (IS Edition)
18. Morrison R. T. and Boyd, R. N. 2003 Organic Chemistry, 6th Edition, Prentice- Hall of India, New Delhi.
19. Kalsi, P. S. 1996 Organic Reactions and Their Mechanisms, 1st Edition, New Age International Publication, New Delhi.

Chemistry II **4 credits**

CHE-PG-C102

Unit I: Metal-Ligand Bonding in Transition Metal Complexes

Crystal field splitting diagrams in complexes of low symmetry; Spectrochemical and Nephelauxetic series; thermodynamic and structural effects; site selection in spinels, Jahn-Teller distortions; experimental evidence for metal-ligand orbital overlap; ligand field theory, molecular orbital theory of octahedral complexes, brief introduction to Angular Overlap Model. Electronic spectra of Transition Metal Complexes: Spectroscopic ground states; Orgel energy level and Tanabe-Sugano diagrams for transition metal complexes; Charge transfer spectra; electronic spectra of octahedral and tetrahedral Co(II) and Ni (II) complexes and calculation of ligand-field parameters. Rusell-Saunders coupling for d^n states. Splitting of one-electron levels in an octahedral environment. Correlation diagram. The method of descending symmetry, selection rules. Spectral transition probability, vibronic coupling non-centrosymmetric complexes, polarization of allowed transitions.

Unit II: Thermodynamics

Review of Laws of Thermodynamics. Entropy, free energy and chemical potential. Partial molar properties and their significance. Fugacity: its concept and determination. Properties of ideal solutions; non-ideal systems-deviations (negative and positive) from ideal behavior, excess functions for non-ideal solutions, calculations of partial molar quantities, determination of partial molar volume and partial molar enthalpy.

Non equilibrium Thermodynamics Thermodynamic criteria for non-equilibrium process, Entropy production and entropy flow, Entropy balance equations for heat flow, chemical reactions etc., Transformations of the generalized fluxes and forces, Non equilibrium stationary states, Generalized flux and forces, Phenomenological equations, Onsager reciprocal relations, Principle of detailed balance, Electro kinetic phenomenon, Diffusion, Electric conduction, Transport number and electrochemical cells, Irreversible thermo dynamic for biological systems

Unit III: Electrochemistry

Theory of electrolytes, Ion-electron theory; Debye Huckel Limiting law, Activity Coefficients, Metal/Electrolyte interface: Outer Helmholtz Potential (OHP) and Inner Helmholtz Potential (IHP), potential profile across double layer region, potential difference across electrified interface; Structure of the double layer: Helmholtz-Perrin, Gouy-Chapman (Poisson-Boltzmann equation), and Stern models. Butler-Volmer equation under near equilibrium and non- equilibrium conditions, exchange current density, Tafel plot. Polarizable and non-polarizable interfaces. Electrochemical cells and Batteries.

Unit IV:

Micelles and Macromolecules: Surface active agents and their classification, micellization, hydrophobic interaction, critical micellar concentration (cmc), factors affecting cmc of surfactants, counter ion binding to micelles, thermodynamics of micellization-phase separation and mass action models, solubilization, micro emulsions, reverse micelles. Polymers-definition, types of polymers, liquid crystal polymers. Molecular mass-number and mass average molecular mass, determination of molecular mass (osmometry, viscosity, light scattering methods, Gel Permeation chromatography).

Colloids: Multimolecular, macromolecular and associated colloids. Stability of collids. The zeta potential. Kinetic, optical and electrical properties of colloids. Electrokinetic phenomena: Electrophoresis, electroosmosis, sedimentation potential and streaming potential. Donnan membrane equilibrium. Collodal quntum dots, Metal nanoparticles and magnetic nanoparticles. Size dependent optical and electrical properties. Supermagnetic limit.

References

1. Cotton, F.A. and Wilkinson, G. 1999 Advanced Inorganic Chemistry, 6th Edn., John Wiley & Sons, New York.
2. Huheey, J. E., 1993 Inorganic Chemistry, 4th Ed., Addison-Wesley Pub. Co., New York.
3. Drago, R. S., 1971 Physical Methods in Inorganic Chemistry, International Edn., Affiliated East-West Press, New Delhi.
4. Shriver, D. F. and Atkins, P. W., 1999 Inorganic Chemistry, 3rd Edn., ELBS, London.
5. Cotton, F. A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry, 3rd Edition, John Wiley & Sons, New York.
6. Greenhood, 1976, Spectroscopic properties of inorganic and organometallic compounds, Royal Society of Chemistry.
7. Lee, J. D. 1999 Concise Inorganic Chemistry, Blackwell Science.
8. Purcell K. F. and Kotz J. C., 1987 Inorganic Chemistry, W. B. Sauders Com. , Hong Kong.
9. Cotton, F.A. 1990 Chemical Application of Group Theory, 3rd Ed, Wiley- Blackwell.
10. Bockris J.O'M., and Reddy, A. K. N. 1998 Modern Electrochemistry, Vol. 1 & Vol. 2 AB, Second Edition, Plenum Press, New York.
11. Castellan G. W., Physical Chemistry, Addison-Wesley Publishing Company, Reading, MA.
12. Atkins, P. W. , 2002 Physical Chemistry, Seventh Edition, Oxford University Press, New York.
13. Levine, I. N. 2002 Physical Chemistry, 5^{th} Edition , Tata Mc Graw Hill Pub. Co. Ltd., New Delhi.
14. Ram J. Raja and Kuriacose, J.C. 1993 Kinetics and Mechanism of Chemical Transformations, MacMillan Indian Ltd., New Delhi.
15. Barrow, G.M. Physical chemistry, 3rd edn., international student edition, McGraw-Hill
16. Glasstone. S. 1940, Text - book of physical 1940. Publisher: Van Nostrand.
17. Pilling M. J. and Seakins, P. W. 1995 Reaction Kinetics, Oxford University Press, 1995
18. Moore, W. J. 1972, Physical Chemistry, Prentice Hall College Div; 4th edition.
19. Engel T. and Reid P., Physical Chemistry, Pearson Education

Mathematics and Biochemistry **4 credits**

CHE-PG-C103

Unit I: Functions: Linear, Quadratic, Cubic, Logarithmic, Exponential, Trigonometric, Hyperbolic. Differential and integral calculus, limits, derivative, physical significance, basic rules of differentiation, maxima and minima, applications in chemistry, exact and inexact differential, periodic function, Taylor and McLaurin series, curve sketching, partial differentiation, rules of integration, definite and indefinite integrals.

Differential equations Separation of variables, homogeneous, exact, linear equations, equations of second order, series solution method. Fourier series and analysis. Complex numbers. Laplace transformation.

Unit II: Permutations, combinations and theory of probability distributions Binomial, Gaussian and Poisson. Vectors, matrices and determinants: Vectors, dot, cross and triple products, introduction to matrix algebra, addition and multiplication of matrices, inverse, adjoint and transpose of matrices, unit and diagonal matrices. Complex Variables

Unit III: Carbohydrates: Glycosides, Oligosaccharides and polysaccharides. Role of sugar in molecular recognition. Nucleic Acids: RNA, DNA, base-pairing, double helical structure of DNA, Gene regulatory protein- Zinc finger protein.

Aminoacids and Proteins: Aminoacids, peptide links and oligopeptides. Proteins: primary, secondary, tertiary, and quaternary structure of proteins. Structure, purification and denaturation of proteins.

Lipids and membranes: Lipids, fatty acids, Classification of lipids, self-association of lipids- micelles, reverse micelles and membranes, transport of cations through membranes.

Unit IV: Metabolism and Energetics

Catabolic and anabolic processes, glycolysis, citric acid cycle and oxidative phosphorylation. Photosystems (PSI & PSII).

Enzyme Enzyme kinetics and applications of enzymes in organic synthesis. Enzyme inhibitors and co- enzymes in organics reactions. Drugs based on enzyme inhibition.

Metal ions in biological systems and their role in ion transport across the membranes (molecular mechanism) Oxygen-uptake proteins, cytochromes and ferredoxins. Oxygen uptake proteins: Hemoglobin, Myoglobin, hemerythrin and hemocyanin. Metal complexes in medicine. Chemotherapy.

References

1. Mortimer R. G., Mathematics for Physical Chemistry, Elsevier.
2. Steiner E. 1996The Chemical Maths Book, , Oxford University Press.
3. Daniels F. , 1972 Mathematical Preparation for Physical Chemistry, , McGraw Hill
4. Margenau, H and Murphy , G. M. 1956 The Mathematics of Chemistry and Physics- van Nostrand, Princeton, NJ.
5. Norris A. C. Computational Chemistry, John Wiley

6. Press, W. H. , Teukolsky, S. A. Vetterling, W. T. and Flannery B. P. 1996 Numerical Recipes in FORTRAN/ C by, Cambridge University Press, 2nd Ed.
7. Xavier , C. 2002 Fortran 77 and Numerical Methods b, New Age International,
8. Boas, M. L. Mathematical Methods in the Physical Sciences, Wiley; 2nd edition.
9. Stryer L., 2002 Biochemistry, 5th edition, Freeman & Co., New York.
10. Nelson D. L. and Cox M.M., 2002 Lehninger Principles of Biochemistry, 3rd edition McMillan North Publication.
11. Hughes M. N. , 1981 Inorganic Chemistry of Biological Processes, John Wiley.
12. Smith M.B., 1995 Organic Synthesis, McGraw Hill Inc., New York.
13. Ariga K. and Kunitake T. 2006 Supramolecular Chemistry – Fundamentals and Applications, Springer
14. Crabtree R. H., Organometallics in Organic synthesis Vol-II – Organometallics of Transition Metals in Organic Synthesis
15. Voet D., Voet J.G and Pratt C. W., 1999 Fundamentals of Biochemistry, John Wiley & Sons, New York

Practicals I **4 credits**

CHE-PG-C104

Inorganic Chemistry Experiments

A. Ore Alloy and Commercial Product Analysis: (Any two)

A.1 Determination of Silica and Manganese in pyrolusite

A.2 Determination of Copper and iron from chalcopyrite.

A.3 Determination of iron from hematite by complexometric titration.

A.4 Determination of tin & lead from solder.

A.5 Determination of iron & chromium from mild steel.

A.6 Determination of copper and nickel from cupronickel.

A.7 Determination of iron from hematite using UV-Vis spectrophotometer.

A.8 Determination of phosphoric acid in soft drinks

A.9 Analysis of Cement

A.10 Determination of Flouride in toothpaste.

B. Preparation and Characterization of the following compounds (Any seven preparations are to be completed):

B.1. Tris (oxalate) manganese (III)

B.2 Tetrapyridinesilver (II) peroxidisulphate

B.3. Tris (acetylacetonato) iron (III)

B.4 Bis (N,N-diethyldithiocarbamato) nitrosyliron (I)

B.5 Optical isomers of tris (ethylenediamine) cobalt (III) chloride

B.6 Linkage isomers of nitro and nitritopentamminecobalt (III) chloride

B.7 Ferrocene or dibenzene chromium

B.8 Hydridochlorocarbonyl tris (triphenylphosphine) ruthenium (II)

B.9 Tris(2,2’-bipyridine)ruthenium (II) perchlorate

B.10 $[(p\text{-}(cymene)RuCl_2]_2$

B.11. Tris (manganese (III)

B12. Copper(I) Thiourea complexes: $[Cu(Tu)_6\}SO_4.H_20$

Characterization includes microanalysis, magnetic susceptibility and conductance measurements and infrared, UV-Visible, NMR spectroscopy, XRD and cyclic voltammetry studies.

Books Recommended:

1. Elias, A. J., Collection of Interesting General Chemistry Experiments, Orient Longman.
2. A text book of Quantitative Inorganic Analysis – A. I. Vogel
3. Experimental Inorganic Chemistry - W. G. Palmer
4. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.
5. Chemistry experiments for Instrumental Methods by Donald T. Sawyer, William R. Heineman & Jalice M. Beebe , John Wiley & Sons 1984.
6. Experimental Physical Chemistry by G. Peter Matthews, Clarendon Press, 1985.
7. Modern Experiments for Introductory Chemistry, compiled by Neidig and Strattom 2nd Edition Reprinted from Journal of Chemical Education,1990.
8. Handbook of Inorganic Synthesis: G. Brauer
9. Inorganic Synthesis: R. B. King
10. Synthesis and Technique in Inorganic Chemistry: A Laboratory Manual, Gregory Girolami, Thomas B. Rauchfuss and Robert J. Angelici. University Science Books.

Semester II

Inorganic Chemistry **4 credits**

CHE-PG-C201

Unit I: Chemistry of non-transition elements: Non-transition metal chemistry. Synthesis, Properties, Structure and Bonding: Nitrogen, Phosphorous, Sulfur, Pseudohalogen, Interhalogen and Xenon Compounds; Boranes, Carboranes, Metallocarboranes, Borazines, Phosphazenes, Sulfur-Nitrogen compounds, silicates, silicones.

Isopoly and Heteropoly Acids and Salts

Synthesis, structural principles and application of V, Nb, Ta, Cr, Mo and W polyacids

Unit II: **Kinetics and Mechanism of transition metal complexes**

Energy profile of reactions, discussion on general reactivity of metal complexes, inert and labile complexs, different types of mechanisms (D,A,I_a and I_d). Techniques for experimental measurements of reaction rates, techniques for fast reaction Substitution reactions: Application of CFT, mechanism of ligand substitution in octahedral complexes, mechanism of isomerization and racemization, Twist mechanism of racemization, substitution reactions in square planar complexes. Cis- and trans- effects.

Unit III: Electron Transfer Reactions:

Mechanism of redox reactions with reference to metal complexes. Electron transfer reactions – outer sphere and inner sphere, atom transfer, induced electron transfer reactions, two electron transfer reactions, non complementary reactions, synthetic implications of electron transfer reactions, solid state electron transfer reactions. Electroprotic reactions, Marcus- Husch theory, correlation between thermal and optical electron transfer reactions; identification of intervalence transfer bands in solution

Unit IV: Metal Carbonyls

Metal carbonyls: Synthesis, structure and reactivity; bonding in metal carbonyls, variants of CO bridging, vibrational spectra of metal carbonyls, principal reaction types of metal carbonyls. Low nuclearity (M3-M4) and high nuclearity (M5-M10) carbonyl clusters. Metal-metal bonding(MO), skeletal electron counting. Wade-Mingos Lauher rule, isolobal analogy. Halide clusters of Nb, Ta, Mo, W, Re. Synthesis, structure and bonding. Interstitial Clusters- hydrides, carbides and nitrides.

References:

1. Huheey, J. 1993 E. Inorganic Chemistry, 4th Edn., Addison Wesley Pub. Co., New York.
2. Cotton F. A. and Wilkinson, G. 1999 Advanced Inorganic Chemistry, 6th Edn., John- Wiley

& Sons, New York.

3. Crabtree, R.H. 1988 The Organometallic Chemistry of the Transition Metals, 1st Edn., John- Wiley & Sons, New York.
4. Shriver , D. F. and Atkins, P. W. 1999 Inorganic Chemistry, 3rd Edn., ELBS, London.

5. Greenhood, 1976 Spectroscopic properties of inorganic and organometallic compounds, Royal Society of Chemistry.

6. Cleydon, J. , Greeves, N. , Warren, S. and Wolthers, P. , 2001 Organic Chemistry: Oxford

7. Collman, J. P. , Hegedus, L. S. , Norton J. R and Finke, Richard G. 1987 Principles and Applications of Organotransition Metal Chemistry, 1st Edn., University Science Books, Mill Valley, California.

8. Elschenbroich, Ch. and. Salzer, A, 1991 Organometallics: A Cosize Introduction, 2nd Edn.,VCH

Organic Chemistry **4 credits**

CHE-PG-C202

Unit I: Pericyclic Reactions

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reaction; conrotatory and disrotatory motions 4n, 4n+2 and allyl systems. Cycloaddition; antrafacial and suprafacial addition, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic Rearrangements; suprafacial and antrafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5- sigmatropic rearrangements, Claisen, Cope and Aza-Cope rearrangements. Ene reaction.

Unit II: Reagents in Organic Synthesis

Use of the following reagents in organic synthesis and functional group transformations; complex metal hydrides, Gilman's reagent, lithium dimethylcuprate, lithium diisopropylamide (LDA), dicyclohexylcarbodiimide, 1,3-dithiane (reactivity Umpoloung), trimethylsilyl iodide, tri-n-butyltin hydride, Woodward and pervost hydroxylation, osmium tetroxide, DDQ, selenium dioxide, Phase transfer catalysts, crown ethers and Merrifield resin, Peterson's synthesis, Wilkinson's catalyst, Baker yeast.

Unit III: Heterocyclic Chemistry

Synthesis and reactivity of furan, thiophene, pyrrole, pyridine, quinoline, isoquinoline and indole; Skraup synthesis, Fisher indole synthesis.

Chemistry of Natural Products: Structure elucidation and biosyntheses of Alkaliods, Terpenoids, Steroids.

effects. The AAc^1 and other pathways involving alkylto-oxygen bond cleavage. Introduct

and their treatments (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRK], RRKM theory) Experimental Methods: Enzyme kinetics, studies of fast reactions by flow method, relaxation method, flash photolysis and NMR. Techniques: Flow techniques.

General consideration of gas and solution phase fast reactions: Gas phase and solution phase reactions, Reactions at microsecond and nanosecond scale, ultrafast reactions: reactions at picoseconds and femtoseconds scale.

Unit IV: Etherification, Hydrolysis of Esters and Photo Chemistry

Evidence for tetrahedral intermediate in BAc^2 and AAc^2 mechanisms, steric and electronic effects. The AAc1 and other pathways involving alkylto-oxygen bond cleavage.

Introduction to various reactions in Photochemistry.

References

1. Fleming, I. 1976 Frontier Orbital and Organic Chemical Reactions John Wiley,.
2. Carruthers, W. 1990 Some modern Methods of Organic Synthesis Cambridge University Press.
3. Greene, T.W. 1999 Protective Groups in Organic Synthesis Wiley-VCH,.

4. Smith M.B. and March, J. 2001 March’s Advanced Organic Chemistry, 5th Edition, John Wiley & Sons, New York.
5. Joule J. A. and Mills, K. Heterocyclic Chemistry: (4th Ed) Wiley-Blackwell
6. Cleydon, J. , Greeves, N. , Warren, S. and Wolthers, P. 2001 Organic Chemistry: Oxford (2001)
7. Paquette L. A. and Benjamin W. A. 1968 Modern Heterocyclic Chemistry by W.A., Inc.,
8. Finar I. L. 1968 Organic Chemistry Vol II, ELBS.
9. Gilchrist, T. R. 1989 Heterocyclic Chemistry.

Physical Chemistry **4 credits**

CHE-PG-O203

Unit I: Statistical Thermodynamics

Concepts of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical and microcanonical ensembles, Boltzmann distribution of particles.

Partition function: translational, rotational and vibrational partition functions,thermodynamic properties of ideal gases in terms of partition function.

Unit II: Quantum Mechanics

Fundamentals: Review of essential mathematical concepts. Origin of the quantum theory. Postulates of quantum mechanics and Schrödinger equation; its application on some model systems viz., free- particle and particle in a box, tunneling, the harmonic oscillator, the rigid rotator, and the hydrogen atom. The variation theorem; linear variation principle;

Approximation Methods: Stationary perturbation theory for non-degenerate and degenerate systems with examples. Variation method. Ground state of He atom. Time-dependent perturbation theory. Radiative transitions. Einstein coefficients.

Atomic Structure: Many electron wave functions. Pauli Exclusion principle. Helium atom. Atomic term symbols. The self-consistent field method. Slater-type orbitals.

Group Theory Definition of group, symmetry, point groups, representation of group, orthogonality theorem, irreducible representation, character table, direct sum, direct product, derivation of projection operator.

Unit III: Rotation and Vibration of Diatomic Molecules

Selection rules. A review of MW and IR spectroscopy. Symmetry properties and nuclear spin effects. Raman effect: Rotational and vibration-rotational transitions. Polarization of Raman lines. Vibration of polyatomic molecules–normal coordinates.

Electronic Spectroscopy: Absorption and Emission of radiation. Selection rules. Line shapes and widths. Electronic spectroscopy of diatomic molecules. Franck-Condon factor. Dissociation and pre- dissociation. Rotational fine structure. Lasers and Laser spectroscopy.

Unit IV: Reaction Dynamics

Methods of determining rate laws, collision theory of reaction rates, Arrhenius equation and activated complex theory. Potential energy surfaces. Unimolecular reactions and their treatments (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRK], RRKM theory) Experimental Methods: Enzyme kinetics, studies of fast reactions by flow method, relaxation method, flash photolysis and NMR. Techniques: Flow techniques.

General consideration of gas and solution phase fast reactions: Gas phase and solution phase reactions, Reactions at microsecond and nanosecond scale, ultrafast reactions: reactions at picoseconds and femtoseconds scale.

References

1. Atkins, P. W. 2002 Physical Chemistry, 7th Edition, Oxford University Press, New York.
2. Maczek, A. Statistical Thermodynamics, Oxford University Press Inc., New
3. Reif, F, 1985 Fundamental of Statistical and Thermal Physics McGraw Hill, International edition.
4. Barrow, G. M. Introduction to Molecular Spectroscopy McGraw Hill
5. Pilar, F. L. 1990 Elementary Quantum Chemistry 2nd Edition, McGraw - Hill Publishing Company.
6. Atkins P. W. and Friedman, R. S, 1997, Molecular Quantum Mechanics 3rd Edition, Oxford Univ. Press.
7. Laidler, K. 1995 Chemical Kinetics Harper and Row.
8. Levine, I. N. 2002 Physical Chemistry, 5th Edition, Tata McGraw Hill Pub. Co. Ltd., New Delhi.
9. Brouard, M. 1998 Reaction Dynamics, Oxford University Press, Oxford.
10. Levine R.D. and Bernstein, R.B. 1987 Molecular Reaction Dynamics and Chemical
11. Reactivity, Oxford University Press, Oxford.

Practical II **4 credits**

CHE-PG-C204

Organic Chemistry Experiments

A. Extraction of Organic Compounds from Natural Source (Any three)

A.1. Isolation of caffeine, an alkaloid, from tea leaves.

A.2. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins)

A.3. Isolation of lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported.)

A.4. Isolation of nicotine dipicrate from tobacco.

A.5. Isolation of cinchonine from cinchona bark.

A.6. Isolation of piperine from black pepper.

A.7. Isolation of lycopene from tomatoes.

A.8. Isolation of -carotene from carrots.

A.9 Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid.

A10. Isolation of eugenol from cloves.

A.11. Isolation of limonine from citrus rinds.

A.12 Extraction and identification of DNA from green peas and onions

B. Spectro-photometric (UV/VIS) Estimations (Any Three)

B.1. Amino acids

B.2. Proteins

B.3. Carbohydrates

B.4. Cholesterol

B.5. Ascorbic acid

B.6 Aspirin

B.7. Caffeine

C. Synthesis of organic compounds, purification and characterization by chemical analysis, IR, UV-Vis, PL, NMR spectral analysis and mass spectral analysis: (Any three)

C.1. Synthesis of fluorescein, a classic fluorescent dye

C.2. Synthesis and chemiluminescence of luminol

C.3. Diels-Alder reaction of anthracene and maleic anhydride

C.4. Aspirin synthesis: Conventional and with microwave assistance

C.5. Sand Meyer's reaction: p-Chlorotoluene from p-chlorotoluidine.

C.6 Cannizzaro reaction using 4-chlorobenzaldehyde

C.7 Preparation of 1,3,5 tribromobenzene from analine

C.8 Acetoacetic ester condensation

Books Recommended:

1. Elias, A. J., Collection of Interesting General Chemistry Experiments, Orient Longman.
2. Addison Ault Techniques and Experiments for Organic Chemistry 6th Ed. University Science Books (1998).
3. Mann, F. G. & Saunders, B. C. Practical Organic Chemistry 4th Ed. Orient Longmans (1990).
4. Vogel, A. I. Vogel's Textbook of Practical Organic Chemistry 5th Ed. (revised by
5. A.R. Tatchell et al.) Wiley (1989) ISBN 0582-46236-3

Semester III

Instrumental Techniques **4 credits**

CHE-PG-O301

Unit I: Chemical Instrumentation

Elementary Electronics, Simple integrated circuit, Semiconductor, Power supply, transformer, operational amplifier, Lock-in amplifiers, Detectors (Oscilloscope and recorders), transducers, Rectifiers, Signal to noise ratio, Electronic components (Resistors, capacitors, inductors, transistors), Measuring instruments for pressure, temperature, pH, speed, flow, current and voltage. Fourier transformation.

Errors in Chemical Analysis and Statistical Evaluation of Data: Systematic and random errors, accuracy and precision, the correlation coefficient, Mean, Median and Modes, variance, standard deviation and significant figures.

Separation Methods: Principle of chromatography, Classifications of chromatography, Techniques of planar and column chromatography, Gas chromatography, High-performance liquid chromatography.

Unit II: UV-Visible Spectroscopy

Principles and Applications: dienes, polyenes, carbonyl compounds and á, â-unsaturated carbonyl compounds. Woodward Hoffman rule and its application in aromatic compounds. Infrared Spectroscopy: Vibration modes. Absorption frequency of common functional groups, electronic and steric effects, effects of Hydrogen bonding. Interpretation of IR spectra.

Raman Spectroscopy: Principles of Raman Spectroscopy and its comparison with IR

spectroscopy. Applications of vibrational spectroscopy: Symmetry and shapes AB_2, AB_3,AB_4, modes of bonding in ambidentate ligands.

Emission Spectroscopy: Principle and application of Fluorescence, phosphorescence, chemi- luminescence

Mössbauer Spectroscopy: Basic principle, conditions for Mössbauer spectroscopy, Spectral parameters (Isomer shift, electric quadrupole interactions, magnetic interactions), temperature- dependent effects, structural deductions for iron and tin complexes, miscellaneous applications.

Unit III: NMR Spectroscopy

Principle, instrumentation and different techniques (continuous wave and Fourier transformed) of NMR spectroscopy, factors influencing chemical shifts of the spectra, anisotropy, spin-spin interactions, coupling constant (J), spin-decoupling, Nuclear Overhauser Effect (NOE),

classification of AB, ABC, AMX and A_2B_2 type couplings, First order spectra, lanthanides shift reagent,

spin-spin and spin lattice relaxation processes. Applications. Introduction to ^{13}C NMR, principles of decoupling, Application of DEPT.^{1}H-^{1}HCOSY, HETCOR, NOESY, ROESY.

Basic introduction to ^{19}F ^{31}P NMR and heteronuclear coupling. Solid-state NMR:

Basic principles and applications. MRI basic. MRI Contrast agents.

Electron Spin Resonance Spectroscopy: Basic principle, Hyperfine splittings (isotropic systems); the g-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); Anisotropic effects (the g-value and the hyperfine couplings); The EPR of triplet states; Structural applications to transition metal complexes.

Unit IV: Other Spectroscopic Techniques

UV photoelectron spectroscopy, X-ray photoelectron spectroscopy, ESCA and Auger, EDX. Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning tunnelling microscopy (STM) and Atomic force microscopy (AFM). Cyclic Voltammetry, Inductively coupled plasma emission spectroscopy (ICPE), TGA, DSC, DTA and thermometric titration.

Mass Spectrometry: Introduction, ion production, fragmentation, factors influencing ion abundance, single and multiple bond cleavage, rearrangements, cleavage associated with common functional groups, molecular ion peak, metastable ion peak, Nitrogen rule and interpretation of mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak; Ionization techniques (EI and FAB).

Optical Rotatory Dispersion and Circular Dichroism. Linearly and circularly polarized lights; optical rotatory power and circular birefringence, elipticity and circular dichroism; ORD and Cotton effect, Faraday and Kerr effects

References

1. Strobel, H.A. 1973 Chemical Instrumentation - A Systematic Approach, 2nd Edition, Addison Wesley, Mass.
2. Skoog D.A., Holler F.J. and Nieman, T.A. , 1998 Principles of Instrumental Analysis, 5th Edition, Harcourt Brace & Company, Florida.
3. Hollas, J. M. 2004 Modern Spectroscopy, 4th edition, John Wiley & Sons, Ltd., Chichester.
4. Harris, R. K. 1986 Nuclear magnetic resonance spectroscopy John Wiley and Sons Inc.,New York, NY .
5. R.J. Abraham and J. Fishe and P. Loftus, 1994, Introduction to NMR Spectroscopy John Wiley

& Sons.

6. Ladd M. F. C. and Palmer, R. A. 1985 Structure Determination by X-Ray Crystallography Plenum, NY, 2nd Ed.
7. Williams, D B. Carter, C. B. 2008 Transmission Electron Microscopy: A Textbook for Materials Science Springer.
8. Sarid, D. 1991 Scanning Force Microscopy With Applications to Electric, Magnetic and Atomic Forces New York, Oxford University Press
9. Chary, K. V. R. and Govil, G. 2008 NMR in biological systems: from molecules to human, Springer
10. Pecsok, R. P., Shields, L. D. , Cairns T. and William, L.C. Mc, 1976, 2nd Edition, John Wiley, New York.

Practical III **4 credits**

CHE-PG-C304

Physical Chemistry Experiments

A. Electrochemistry and Kinetics: (Any three)

1. Analysis of halide mixture by differential potentiometry
2. Degree of hydrolysis of urea hydrochloride by kinetics method.
3. Equilibrium constant of KI + I_2 ”!KI_3 by distribution method.
4. Kinetics of the iodide-hydrogen peroxide clock reaction
5. An experiment to determine the energy of activation, Ea
6. Determination of the amount of calcium in milk powder by EDTA complexometry
7. Estimation of iodine in iodized common salt using iodometry
8. Determination of phosphoric acid in soft drinks
9. Antioxidant property of Tea (DPPH method).

B. Physical and Analytical methods: (Any seven) Experiments based on

1 UV - Visible spectroscopy with application

2 Fluorescence Spectroscopy with application

3 Infrared Spectroscopy

4 EPR Spectroscopy

5 NMR Spectroscopy

6 Solvents effects in spectra

7 Differential Scanning Calorimetry

8 High Pressure Liquid Chromatography

9 Spectroscopy Instrumentation

10 Cyclic voltametry

11 Enzymetic reaction

12 Semiconductor materials (Quantum dots)

13 Metal Nanoparticles

14 Polymer

15 Magnetic nanoparticles

16 Ionic liquids

17 Liquid crystals

18 Optical materials

19 Carbon based nanomaterials

20 Paper and column chromatography of plant pigments

21 Acetylation of ferrocene and its purification by column chromatography

22 Ternary phase diagram

23 Determination of surface tension by differential capillary method.

24 Determination of molecular weight of a macromolecule by viscometry.

25 Determination of molecular weight by Victor Meyer's method.

26 Cryoscopy and determination of degree of dissociation.

27 Determination of g-value by ESR method.

28 Analysis of a UV spectrum, Raman spectrum, IR spectrum, NMR spectrum and EPR spectrum. Calculation of oscillator strength and transition moment.

29 Potentiometric titrations using the pH meter and determination of pI

30 Conductometric titrations and determination of dissociation constant

31 Determination of Phosphoric acid in soft drinks

Books Recommended:

1. Elias, A. J., Collection of Interesting General Chemistry Experiments, Orient Longman.
2. Daniels, F., Williams, J. W., Bender, P., Alberty, R. A., Cornwell, C. D. & Harriman, J. E. Experimental Physical Chemistry, McGraw-Hill (1962).
3. Das & R. C. & Behera, B., Experimental Physical Chemistry, Tata McGraw-Hill Publishing Co. Pvt. Ltd. (1993).
4. Shoemaker, D. P., Garland, C. W. & Nibler, J. W. Experiments in Physical Chemistry, McGraw- Hill: New York (1996).
5. Day, R. A., Jr. & Underwood, A. L. Quantitative Analysis 3rd Ed. Prentice-Hall India Pvt. Ltd.: New Delhi (1977).
6. Burns, D. T. & Rattenbury, E. M. Introductory Practical Physical Chemistry Pergamon Press (1966)
7. Harris, D. C. Quantitative Chemical Analysis 6th Ed. W. H. Freeman & Co. (2002).
8. Willard, H. H., Merritt, L. L., Dean, J. A. & Settle, F. A. (Eds.) Instrumental Methods of Analysis - 7th Ed., Wadsworth Publishing (February 1988) ISBN 0534081428
9. EDTA Titrations –F.Laschka
10. Experimental Physical Chemistry by A.M. Halpern, 2nd Ed., Prentice Hall, 1997.

Electives

Chemistry of Inorganic Materials **4 credits**

CHE-PG-E301

Inorganic Chemistry Elective I

Unit- I: Solid State Chemistry:

Bonding in solids and Crystal energetic. Crystal classifications, Madelung constant and Lattice energy. Electronic properties and Band theory of solids. Free electron model, Refinement to simple band theory- k-space and Brillouin Zones, Band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, Doped semiconductors, p-n junctions.

Unit- III: Structure of Solids

Crystal systems; Designation of crystal faces, lattice structures and unit cell; Bragg's law; X-ray diffraction by crystals; Close packing, radius ratio rules, calculation of some limiting radius ratio Structures of NaCL, KCL, ZnS, CsCL and $CaF_{2;}$ Stiochiometric and nonsstiochiometric defects, impurity defects, semi-conductors. Packing of solids, Crystal structure of representative systems, Pervoskites, Silicates and Zeolites, Cements, Glasses, Quasicrystals, Nanostructures.

Unit III: Supramolecular Chemistry

Origin of supramolecular chemistry-"Chemistry beyond the molecules". Concepts and terminology of supramolecular chemistry. Natural types of supramolecular interactions (Hydrogen bonding, van der Waal s interaction, ð-stacking, CH—ð interaction. supramolecular chemistry in inorganic perspective. Inorganic crystal engineering and design principle of metal organic framework (MOF). Application of MOFs in material science.

Unit IV: Metallomesogens and Inorganic Polymers

Basic concepts, types of meso-phases, synthetic strategies, characterization and applications. Inorganic Polymers: Classification, Types of Inorganic Polymerization, Comparison with organic polymers, Boron-oxygen and boron-nitrogen polymers, silicones, coordination polymers, sulfur-nitrogen, sulfur- nitrogen-fluorine compounds, chalcogenide clusters – binary and multi- component systems, homolytic inorganic systems.

References

1. Greenwood N. N. and. Earnshaw, A. 1997 Chemistry of the Elements, 2nd Edn., Butterworth Heinemann, London.
2. Lehn J. M., 1995 Supramolecular Chemistry, VCH, Weinheim.
3. Kahn O., 1993 Molecular Magnetism, VCH, Weinheim.
4. Cotton, F. A.Wilkinson, G., Murillo C. A. and Bochmann, M. , 2003, Advanced Inorganic Chemistry, 6th gh John Wiley & Sons (Asia), Singapore.
5. Mark, J. E., Allcock, H. R. and West, |R. 2004 Inorganic Polymers, 2nd Edition, Oxford University Press.
6. Huheey, J. 1993 Inorganic Chemistry, 4th Edn., Addison Wesley Pub. Co., New York
7. Miessler G. L. and Tarr, D. A. 1999 Inorganic Chemistry, 2nd Edn., Prentice Hall International Inc., London.
8. Serrano, J. L. 1996 Metallomesogens, VCH, Weinheim.

Organometallic Chemistry **4 credits**

CHE-PG-E302

Inorganic Chemistry Elective II

Unit I: Complexes of ó- donor ð-acceptor ligands:

(a) ó–bonded systems: metal-alkyls, -aryls and -hydrides, stability, preparation and reactivity, metal- carbonyls, metal-phosphines, metal-nitrosyls, metal-isocyanides: structures, reactivity and bonding, Metal-carbenes, metal-carbynes, Fischer carbenes, Schrock carbenes, complexes with N-heterocyclic carbenes, olefin metathesis

(b) ð-Complexes of Unsaturated Molecules: Structure, bonding and reactivity of alkene, alkyne, allyl, dienyl and trienyl complexes; reactions with special reference to organic synthesis.

Unit II: Metal Carbonyls and Metal Clusters

Metal carbonyls: Synthesis, structure and reactivity; bonding in metal carbonyls, variants of CO bridging, vibrational spectra of metal carbonyls, principal reaction types of metal carbonyls. Low nuclearity (M3-M4) and high nuclearity (M5-M10) carbonyl clusters. Metal-metal bonding(MO), skeletal electron counting. Wade-Mingos Lauher rule, isolobal analogy. Halide clusters of Nb, Ta, Mo, W, Re. Synthesis, structure and bonding. Interstitial Clusters-hydrides, carbides and nitrides.

Unit III: Organometallic reaction mechanism:

Ligand Exchange, Associative mechanism: Brookhart Polymerization Catalysts, 16 electron rule Dissociative meachanism: Oxidative addition;, Reductive elimination; transmetallation: Suzuki- Miyaura, Migratory Insertion / De-insertion, Agostic interaction, â-Hydride Elimination, Wacker Oxidation, Heck Arylation

Unit IV: Homogeneous & Heterogeneous Catalysis

Applications of organometallics in organic synthesis: C-C bond coupling reactions (Heck, Sonogashira, Suzuki), reduction using transition metal hydrides, asymmetric hydrogenation. Alkene isomerization; Hydrogenation; Hydroformylation; Monsanto acetic acid process; Alkene polymerization; Cross coupling reactions; Metathesis; C-H activation and functionalization; Buchwald-Hartwig Reaction and Metathesis reaction, Oxidation of olefins;

References:

1. Huheey, J. 1993 E. Inorganic Chemistry, 4th Edn., Addison Wesley Pub. Co., New York.
2. Cotton F. A. and Wilkinson, G. 1999 Advanced Inorganic Chemistry, 6th Edn., John- Wiley & Sons, New York.
3. Crabtree, R.H. 1988 The Organometallic Chemistry of the Transition Metals, 1st Edn., John- Wiley & Sons, New York.
4. Shriver , D. F. and Atkins, P. W. 1999 Inorganic Chemistry, 3rd Edn., ELBS, London.
5. Greenhood, 1976 Spectroscopic properties of inorganic and organometallic compounds, Royal Society of Chemistry.
6. Cleydon, J. , Greeves, N. , Warren, S. and Wolthers, P. , 2001 Organic Chemistry: Oxford
7. Collman, J. P. , Hegedus, L. S. , Norton J. R and Finke, Richard G. 1987 Principles and Applications of Organotransition Metal Chemistry, 1st Edn., University Science Books, Mill Valley, California.
8. Elschenbroich, Ch. and. Salzer, A, 1991 Organometallics: A Cosize Introduction, 2nd Edn.,VCH
9. Mehrotra, R. C. and Singh, A., 2004 Organometallic Chemistry: A Unified Approach, New age international limited, 2nd Edition.

Advanced topics in Organic Chemistry **4 credits**

CHE-PG-E311:

Organic Chemistry Elective I

Unit: 1 Special topic in stereochemistry:

General consideration of molecular asymmetry and dissymmetry, Determination of Special chiralities- axial, planner and helical chiralities, determination of their absolute configurations.

Topicities and relations, pseudo chirality, prochiral faces of carbonyl and alkenes. Meaning absolute and relative stereo chemistry of a molecule. chemical transformation,

Shape and stability of various conformations of molecules of different ring sizes and containing different functional groups, conformation and reactivity in cyclohexanes and decalin systems. quasiracemates, dynamic stereochemistry , atropisomerism of biphenyls.

Stereoselective synthesis: Different methods to introduce chirality or generate new chiral centres in a molecule. Asymmetric synthesis using chiral substrate, chiral auxiliaries, chiral reagents and chiral catalysts with various examples. Advantages and disadvantages of each of these techniques., Application of each of these techniques in synthesis of various natural products.

Unit II: Synthesis and mechanism of action of some new generation antibiotics.

New generation antibiotics/antibacterial agents: Synthesis and mechanism of action of (i) fluoroquinolones – norfloxacin, ciprofloxacin, O-floxacin, levofloxacin (ii) anti AIDS drugs – AZT, lamivadine (iii) antihypertensive agent – captopril (iv) calcium channel blocker – amlodipine (v) gastric secretion inhibitor – omeprazole and its mechanism of action (vi) drug for impotency – sildenafil and its mechanism of action.,

Unit III: Synthesis and application of organic materials

Organic Materials: Synthesis of Fullerenes, Carbon nanotubes, graphenes and various conducting polymers.

Conducting organics - Conducting polymers. Organic superconductors.

Liquid crystals: mesomorphic behaviour, optical properties of liquid crystals, display devices. Organic light emitting diodes.

Unit IV: Green Chemistry and solid phase reactions

Green Chemistry: Overview. Set of principles of green chemistry, green synthetic methods, catalysis, organics reactions in aqueous media, ionic liquids, supercritical fluids and under microwave radiations. Solvent from organics reactions, solid phase organics reaction and catalysis.

References:

1. Stereochemistry of Organic Compounds,.Eliel E.L. and Wilen, S.H., Wiley Interscience, New York, 1994
2. Stereochemistry of Organic Compounds. Principles and Applications. D. Nasipuri. John Wiley & sons, Chichester, 1991.

3. Classics in Stereoselective Synthesis, Wiley, Erick M. Carreira, Lisbet Kvaerno 2008
4. Stereoselective Synthesis in Organic Chemistry, Atta-ur-Rahman, Zahir Shah; Springer- Verlag New York, 1993
5. Stereoselective Synthesis: A Practical Approach, 2nd, Revised and Updated Edition; Mihály Nógrádi, Wiley; 1994
6. Antibiotics: Targets, Mechanisms and Resistance; Claudio O. Gualerzi, Letizia Brandi, Attilio Fabbretti, Cynthia L. Pon; Wiley-VCH; 2013
7. Antibiotics: Challenges, Mechanisms, Opportunities; Christopher J. Walsh, T. Wencewicz; 2016 ASM Press; 2016
8. Carbon Nanotubes and Related Structures: Synthesis, Characterization, Functionalization, and Applications Dirk M. Guldi, Nazario Martín ; WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim; Academic Press; 2010
9. Flat Panel Displays, Advanced Organic Materials; S.M. Kelly; RSC Materials Monographs; The Royal Society of Chemistry 2000
10. Conducting Polymers, Fundamentals and Applications: A Practical Approach; Prasanna Chandrasekhar; Springer Science & Business, 2013
11. Green Chemistry: An Introductory Text:, Lancaster, M. Royal Society of Chemistry; 2002

Instrumental Techniques for Organic Chemistry **4 credits**

CHE-PG-E312

Organic Chemistry Elective II

Unit I Further topics in ^{1}H NMR Spectroscopy and ^{13} CNMR Spectroscopy

^{1}H NMR Spectroscopy **:** Chemical exchange, effect of deuteration, spin-spin coupling, (n+1) rule, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), factors effecting coupling constant "J", classification of spin system like AB, AX, AX2, ABX, AMX, ABC, A2B2. Spin decoupling, Factors affecting coupling constant, simplification of complex spectra, nuclear magnetic 4 double resonance, spin decoupling, contact shift reagents, solvent effects, nuclear overhauser effect (NOE), resonance of other niclei like ^{31}P,^{19}F.

13 CNMR spectrometry: FT NMR, Types of 13 CNMR Spectra : un-decouled, Proton decoupled, Off resonance, APT, INEPT, DEPT, chemical shift, calculations of chemical shifts of aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbons, factors affecting chemical shifts, Homo nuclear (^{13}C-^{13}C) and Hetro nuclear (^{13}C-^{1}H) coupling constants

Unit II Mass spectrometry and 2D NMR Techniques:

Mass Spectrometry: Instrumentation, various methods of ionization (field ionization, field desorption, SIMS, FAB, MALDI), different detectors (magnetic analyzer, ion cyclotron analyzer, Quadrupoule mass filter, time of flight (TOF). Rules of fragmentation of different functional groups, factors influencing ion abundance, single and multiple bond cleavage, rearrangements, Nitrogen rule and interpretation of mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak;

2D NMR Techniques: General idea about two dimensional NMR spectroscopy, Correlation spectroscopy (COSY)- Homo COSY (1H-1H), TOCSY, Hetero COSY (HMQC, HMBC and Hetero nuclear 2D resolved spectroscopy, NOESY and 2D-INADEQUATE experiments and their applications.

Hetero nuclear 2D resolved spectroscopy, NOESY and 2D-INADEQUATE experiments and their applications.

Unit II Mass spectrometry and 2D NMR Techniques:

Mass Spectrometry: Instrumentation, various methods of ionization (field ionization, field desorption, SIMS, FAB, MALDI), different detectors (magnetic analyzer, ion cyclotron analyzer, Quadrupoule mass filter, time of flight (TOF). Rules of fragmentation of different functional groups, factors influencing ion abundance, single and multiple bond cleavage, rearrangements, Nitrogen rule and interpretation of mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak;

2D NMR Techniques: General idea about two dimensional NMR spectroscopy, Correlation spectroscopy (COSY)- Homo COSY (1H-1H), TOCSY, Hetero COSY (HMQC, HMBC and Hetero nuclear 2D resolved spectroscopy, NOESY and 2D-INADEQUATE experiments and their applications.

Hetero nuclear 2D resolved spectroscopy, NOESY and 2D-INADEQUATE experiments and their applications.

Unit III: Structure elucidation through the application of UV, IR, PMR, CMR, 2D NMR and Mass spectrometry.

(Including reaction sequences)

Unit IV: Molecular dyssemetry and chiroptical properties

Linear and circularly polarized lights, circular birefringence and circular dichroism, ORD and CD curves, Cotton effects, Faraday and Kerr effects. The axial halo-ketone rule, Octent diagrams, Helicity and Lowe's Rule. Application of ORD and CD to structural and stereochemical problems.

Separation techniques:

Fundamental principles, theory, instrumentation and application of Gas-liquid chromatography, HPLC, Size Exclusion chromatography, GC-MS, LC-MS, UPLC, HPTLC, Ion Pair & Ion Exchange Chromatography and Supercritical Fluid Chromatography.

References:

1. Introduction to Spectroscopy – D. L. Pavia, G.M. Lampman, G. S. Kriz, 4th Ed. Cengage Learning, 2008.
2. Spectrometric identification of organic compounds R. M. Silverstein, F. X. Webster,, David Kiemle David L. Bryce; 8th Edition. John Wiley and Sons 2014.
3. A Complete Introduction to Modern NMR Spectroscopy, Roger S. Macomber, Wiley, 1997
4. High-Resolution NMR Techniques in Organic Chemistry 3rd Edition Timothy D.W. Claridge Elsevier Science, 2016
5. Modern NMR Spectroscopy: A Guide for Chemists; Second Edition; Jeremy K. M. Sanders, Brian K. Hunter; Wiley, 1993
6. Solving Problems with NMR Spectroscopy, 2nd Edition; Atta-ur-Rahman Muhammad Choudhary Atia-tul-Wahab; Academic Press, 2015
7. Eberhard Breitmaier. Structure elucidation by NMR in organic chemistry. A practical guide. Wiley, Chichester, 2002
8. Guide to Fluorine NMR for Organic Chemists, 2nd Edition, William R. Dolbier, Jr.,Wiley, 2016
9. Organic Structures from Spectra, Fifth Edition, L D Field, S Sternhell, J R Kalman John Wiley and Sons Ltd. 2015
10. Organic Structures from 2D NMR Spectra, L. D. Field, H. L. Li, A. M. Magill
11. Phosphorus-31 NMR Spectroscopy A Concise Introduction for the Synthetic Organic and Organometallic Chemist, Olaf Kühl, Springer
12. Organic Structure Determination Using 2-D NMR Spectroscopy, A Problem-Based Approach Jeff rey H. Simpson, Academic Press, 2008
13. Introduction to Modern Liquid Chromatography, Third Edition; Lloyd R. Snyder, Joshep J. Kirkland, John W. Dolan, A John Wiley & Sons, Inc., Publication, 2010
14. Chiral Chromatography, Thomas E. Beesley, Raymond P.W. Scott, Wiley,
15. Mass Spectrometry, Principles and Applications, Third Edition, Edmond de Hoffmann

16. Mass Spectrometry in Medicinal Chemistry; Klaus T. Wanner, Georg Ho¨fner, Wiley, 2007

17. ManMohan Srivastava, High-Performance Thin Layer Chromatography (HPTLC) Springer Heidelberg Dordrecht London New York, 2011

18. LC/MS Applications in Drug Development, Mike S. Lee, Dominic M. Desiderio, Nico

M. Nibbering, Wiley Interscience, 2002

19. Ord and Cd in Chemistry and Biochemistry, 1st Edition, Pierre Crabbe, Academic Press, 1972

20. Basic Gas Chromatography, 2nd Edition, Harold M. McNair, James M. Miller, Wiley, 2009

21. Practical Gas Chromatography, A Comprehensive Reference Dettmer-Wilde, Katja, Engewald, Werner Springer 2014

22. Gas Chromatography and Mass Spectrometry: A Practical Guide, 2nd Edition, O. David Sparkman Zelda Penton Fulton Kitson, Academic Press, 2011

Nanochemistry **4 credits**

CHE-PG-E321

Physical/ Inorganic Chemistry Elective I

Unit I

Concept of length scale, de Broglie wavelength in a semiconductor, Exciton Bohr Radius, Quantum confinement, Density of states, The Fermi Energy, Fermi Velocity and Kubo gap, The Drude- Lorentz Model, Electron mean free path in metals. Super paramagnetic limit in magnetic nanoparticles. Wave particle duality in C_{60} Basic crystallography, unit cell, bravais lattice,Miller indices, planes, crystallographic directions, Single element crystals (SC, FCC, BCC), diamond structure, Zinc blende, Rock salt, Wurtzite, Spinel, Rutile, Perovskite, surface to volume ratio, calculation of density using unit cell approach. Debye Scherrer equation. Concept of concentration, Determination of molar extinction coefficient. Surface defects, Surface oxidation. Chemistry of small surfaces: Curvature and neighboring-charge effects on chemical reactivity and equilibria (pKa's, redox potentials), Effect on melting temperature.

Unit II Nucleation and growth:

Classical Theory, Monodispersity, Lamer Plot, Ostwald ripening, Digestive Ripening Homogeneous vs. heterogeneous nucleation and applications of nanomaterials, Anisotropic growth and shape control, Catalyzed (seeded) growth, Nanocrystal doping, solid solutions and Vegard's rule. Non-classical growth. Effect of precursor reactivity and stability on size. Unusual precursor kinetics in III-V semiconductor nanocrystal formation.

Unit III: Synthesis and characterization

Basics of CVD, sol-gel, microemulsion, template and hydrothermal methods. Hot injection (Bawendi and Murray method), heating up, Ion-exchange, Doping, Influence of Precursor reactivity.

Reaction kinetics and influence of reaction parameters on the synthesis of CdSe, InP, PbS, Au, Fe_3O_4, CH,NH_3PbCL_3. Synthesis and Finctionaisation of Carbon, Fullerenes and Graphenes.

Core/shell synthesis, SILAR. Purification techniques. Phase transfer: solid phase, solution phase. Surface functionliastion with small molecules, drugs, antibody, cell penetrating peptide, contrast agents. Role of Linkers.

Optical characterization: Absorption and photoluminescence (PL & PLE) spectroscopes, steady-state vs. fast spectroscopy, dynamic light scattering.

Structural characterization: XRD, TEM, AFM, Deviations between bulk and near-surface crystal structures

Unit IV: Properties and application

Quantum dots: Colloidal quantum dots, Optical properties of II-VI (CdSe, CdTe, ZnS), III-V (InP and InAs) and IV-VI (PbS and PbSe) colloidal quantum dots, Perovskites. Photostability of QDs in solution, thin film. Surface passivation, Core/shell nanocrystals. Determination of band gap. Application in solar cell, LED and bioimaging. Magnetic nanoaprticles: Single domain. Multiple domain. Superparamagnetism. Finite size effects in magnetic nanoparticles, superparamagnetic limit, Neel-Brown expression, Blocking temperature. Properties of FeO4 as MRI T2 contrast agent. Application on biology and magnetic recording.

Metal nanoparticles: Surface Plasmon resonance in Au nanoparticles. Surface Plasmon resonance, Mie theory of metal nanoparticles, Application in biology. Crystal structure of Co nanoparticles. Carbon based materials: Properties of C60, carbon nanotubes, fluorescence in carbon dots and fullerene. FRET

References

1. Kuno, M. Introductory Nanoscience, 2011, Taylor & Francis Group.
2. Rigach, A. L. (Editor), Semiconductor nanocrystal quantum dots: synthesis, assembly and applications
3. Klimov, V. I. Semiconductor and Metal Nanocrystals: Synthesis and Electronic and Optical Properties (Optical Science and Engineering)
4. Thanh, N.T. K. and Sayed, M. A. 2012 El Magnetic Nanoparticles: From Fabrication to Clinical Applications
5. Huck, W. T. and Huck, Wilhelm T. S. (Editor) Nanoscale Assembly: Chemical Techniques
6. Dresselhaus, M. S, Dresselhaus, G. and Avouris, P. Springer-Verlag. Carbon Nanotubes : Synthesis, Structure, Properties, and Applications
7. Acklin, B. and Lautens, E. Magnetic Nanoparticles: Properties, Synthesis and Applications
8. Taurozzi, J. S 2011 Nanoparticle-polymer composite membranes: Synthesis, characterization, and environmental applications.
9. Karn, B. Colvin, V. and Alivasatos, P. 2004 Nanotechnology and the Environment.
10. Zhou, B. Hermans, S., Somorjai, G. A. (Editors)Nanotechnology in Catalysis Volumes 1 and 2

Advanced Statistical Thermodynamics **4 credits**

CHE-PG-E322

Physical Chemistry Elective III

Unit I: Statistical Mechanical ensembles Grand Canonical and other ensembles.

Statistics of ideal classical and quantum systems: Ideal Bose system (Photons gas, Phonon gas, Helium Gas), superfluidity, Ideal Fermi system, Ideal Gas (Monoatomic, Diatomic gases), Chemical Equilibria in gases, Electrons in metals

Unit II: Statistical Mechanics of Interacting systems:

Classical and Quantum – Calculation of partition function for low densities, Alternative derivation of van der Waals equations, Cluster expansion for classical systems, Equation of state. Cluster expansion for quantum systems Virial expansion of equation of state, Imperfect Bose Gas

Unit III Statistical Thermodynamics of Solids and liquids:

Hard sphere fluid, Born Green equation, Integral equation. liquid crystal, Florry-Higgins polymer solution theory, Einstein's theory, Debye theory, Superconductivity in metals, Ginzberg-Landau theory of uperconductivity.

Unit IV: Phase transition and Non-equilibrium statistical thermodynamics

Ising model., Lattice gas, Mean field theory, Kaanoff transformation, Renormalization group theory, Langevin equation, Fluctuation-dissipation theorem, Fokker-planck equation, Onsager's regression hypothesis and time correlation functions, response function.

References:

1. Hill T. L., An Introduction to Statistical Thermodynamics: Dover Publications, New York
2. Chandler D. Introduction To Modern Statistcal Mechanics: Oxford University, Press, New York
3. Reif F., Fundamentals of Statistical and Thermal Physics, Levant Books, Kolkata
4. Sinha S. K., Introduction to Statistical Mechanics, Narosa Publishers

Semester IV

Magnetochemistry **4 credits**

CHE-PG-E401

Inorganic Chemistry Elective III

Unit I: Magnetochemistry-I:

Magnetic properties of substances, orbital and spin angular momentum of electrons, paramagnetic moment and magnetic susceptibility. Paramagnetic and diamagnetic materials, ferromagnetism, ferrimagnetism, antiferromagnetism, magnetic permeability, magnetic susceptibility, magnetization, classical theory of diamagnetism and paramagnetism, diamagnetism and Pascal s constants, zero-field splitting, spin-orbit coupling. Determination of magnetic susceptibility by these methods: Gouy, Faraday, NMR method and SQUID.

Unit II: Magnetochemistry-II:

Magnetic properties and temperature – The curie and Curie- Weiss law, derivation of Curie law. Microstates, hole formalism, multiplet, multiplet width, Lande interval rule, magnetic moments for different multiplet widths, crystal field diagram, quenching of orbital contribution, high spin/low spin equilibrium. Antiferromagnetic interactions in inorganic compounds: Mechanism like – direct interaction, superexchange interactions and elucidation with poly nuclear metal complexes as well as oxide and halide salts of transition metals.

Unit III: Magnetochemistry-III:

Ferromagnetism and Magnetic domains, Hysteresis, Molecular field theory, magnetic sublattice, Ferrimagnetism, Canting and Weak ferromagnetism Heisenberg and Ising model, Correlation of magnetic and structural properties.

Unit-IV: Magnetochemistry-IV

Magnetic materials, long range ordering, superparamagnetism, molecular magnets, metamagnetism, single chain magnet, magnetic ordering, magnetic behaviour of lanthanides and actinides, design of molecular magnets, physical investigations and applications.

References

1. Cotton, F.A. and Wilkinson, G. 1999 Advanced Inorganic Chemistry, 6th Edn., John Wiley & Sons, New York.
2. Huheey, J. E., 1993 Inorganic Chemistry, 4th Ed., Addison-Wesley Pub. Co., New York.
3. Drago, R. S., 1971 Physical Methods in Inorganic Chemistry, International 8th Edn., Affiliated East-West Press, New Delhi.
4. Shriver, D. F. and Atkins, P. W., 1999 Inorganic Chemistry, 3rd Edn., ELBS, London.
5. Cotton, F. A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry, 3rd Edition, John Wiley & Sons, New York.
6. Greenhood, 1976, Spectroscopic properties of inorganic and organometallic compounds, Royal Society of Chemistry.
7. Lee, J. D. 1999 Concise Inorganic Chemistry, Blackwell Science.
9. Purcell K. F. and Kotz J. C., 1987 Inorganic Chemistry, W. B. Sauders Com. , Hong Kong. Cotton, F.A. 1990 Chemical Application of Group Theory, 3rd Ed, Wiley-Blackwell.

Bio-Inorganic chemistry **4 credits**

CHE-PG-E402

Inorganic Chemistry Elective III

Unit I: Role of alkali and alkaline earth metal ions in biological systems

A. Role of alkali metals ions: Na^+-K^+ Pump, ionophores and crown ethers, Transport of Na^+-K^+ through membranes.

B. Catalysis of phosphate transfer by Mg^{2+} ion,

C. Regulatory role of Ca^{2+} - muscle contraction

Unit II: Heme Proteins

Hemoglobin, myoglobin, hemerythrin, hemocyanin Oxygen activation: Cytochrome P450, Cytochrome c oxidase.

Non-heme proteins: Copper Proteins: Type I, II and III. Copper in cytochrome c oxidase and in respiratory chain, blue copper proteins

Unit III: Proteins with reference to their oxygenation and oxidase activity

Anti-oxidative functions, Nitrate and nitrite reduction (NO3- and NO2- reductase), Synthetic models of iron-sulfur proteins, molybdo-enzymes – molybdenum cofactors (molybdenum-pterin complexes, nitrogen fixation through metal complexation, nitrogenase, Photosynthesis (PS-I and PS-II).

Unit IV: Metalloenzymes

Zinc enzymes- carboxypeptidase and carbonic anhydrase. Iron enzyme - catalases, peroxidase and cytochrome P-450. Copper enzyme-superoxide dismutase. Molybdenum oxo-transferase enzyme- xanthine oxidase. Urease and hydrogenase, and cyanocobalamine.

Metal ion storage and transport: Ferritin, transferritin, siderophores and metallothionein and hemosiderin.

Chemotherapeutic applications of metal complexes: Pt(II), Pt(IV) complexes and Ru(II), Ru(III) complexes as anticancer drugs, Au complexes as antiarthritis drugs

References

1. Hughes M. N., 1981 Inorganic Chemistry of Biological Processes, 2nd Ed., John-Wiley & Sons, New York.
2. Kaim W. and Schwederski B., 1995 Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide, Wiley, New York.
3. Lippard S. J. and Berg J. M., Principles of Bioinorganic Chemistry, University Science Books.
4. Bertini, I. , Grey H. B., Lippard S. J. and Valentine, J. S. , 1998 Bioinorganic Chemistry, Viva Books Pvt. Ltd., New Delhi.

Advances in Organic Synthesis **4 credits**

CHE-PG-E411

Organic Chemistry Elective III

Unit I Various synthetic approaches to drug discovery:

Combinatorial synthesis, Diversity oriented synthesis, Total synthesis, their importance, utilities, advantages and disadvantages.

Retrosynthetic analysis: Synthesis backwards, disconnections, synthons, choosing disconnections, functional group interconversion, two group disconnections, C–C disconnections, donor-acceptor synthons, natural reactivity and umpolung.

Synthesis: Illustrative synthesis of complex natural products with relevant examples.

Unit II Important reaction and synthetic tools in organic synthesis:

Multi-component reactions: Ugi, Passerini, Biginelli and Mannich reactions; Click chemistry: criterion for click reaction, Sharpless azides cycloadditions;

Coupling reactions: Suzuki, Heck, Sonogashira, Stille, Fukuyama, Kumada, Hiyama, Negishi, Buchwald-Hartwig, Noyori, Reppe, Oxo process

Metathesis: Grubbs 1st and 2nd generation catalyst, Olefin cross coupling (OCM), ring closing (RCM) and ring opening (ROM) metathesis, applications

Ring formation reactions: Pausan-Khand, Bergman and Nazerov cyclization, Various intramolecular cycloaddition reactions (INC)

Unit III Other important reactions:

Important named reactions: Wittig, Horner-Wordworth-Emmons, Shapiro, Bamford-Stevens, McMurry, Julia-Lythgoe and Peterson olefination reactions, Titanium-carbene mediated olefination: Tebbe, Petasis and Nysted reagent, Baylis Hilman, Eschenmoser-Tanabe fragmentation, Mitsunobu reaction.

Current trends in organic synthesis: Organocatalysis, Photoredox catalysis. C-H activation. **Unit IV Photochemistry:**

Quantum yields, intersystem crossing, photosensitization and energy transfer reactions.

Photochemistry of olefins and carbonyl compounds, photo oxygenation and photo fragmentation, Photochemistry of aromatic compounds: isomerisation, additions and substitutions. Singlet molecular oxygen reactions. Patterno-Buchi reaction, Di-pimethane rearrangement, Hofmann- Loffler-Freytag reaction, Bartons reaction and Photo-Fries rearrangement.,

References:

1. Combinatorial Chemistry: From Theory to Application, Volume 26, Second Revised Edition; Willi Bannwarth, Berthold Hinzen; Wiley-VCH Verlag GmbH & Co. KGaA, 2006
2. Combinatorial Chemistry: Synthesis Analysis, Screening; Günther Jung; WILEY-VCH Verlag GmbH, 1999

3. Diversity-Oriented Synthesis: Basics and Applications in Organic Synthesis, Drug Discovery, and Chemical Biology Andrea Trabocchi, Wiley, 2013
4. Diversity-oriented Synthesis of Alkaloids for Chemical Genetic Screening; Alexander Merton Taylor Harvard University, 2007
5. Organic chemistry; Clayden, J., Greeves, N. , Warren, S. and Wothers, P.; Oxford University Press, 2000
6. Multicomponent Reactions in Organic Synthesis; Jieping Zhu, Qian Wang, Mei-Xiang Wang; Wiley- VCH Verlag GmbH & Co. KGaA, 2015
7. Multicomponent Reactions: Concepts and Applications for Design and Synthesis; Raquel P. Herrera, Eugenia Marques-López; Wiley, 2015
8. Advance Organic Chemistry; 5th Ed. Carey F. A. and Sundburg R. J.; Springer, 2007
9. Strategic Applications of Named Reactions in Organic Synthesis; Laszlo Kurti Barbara Czako; Academic Press; 2005
10. Name Reactions and Reagents in Organic Synthesis, Second Edition; Bradford P. Mundy, Michael G. Ellerd, Frank G. Favaloro, Jr; John Wiley & Sons, Inc., 2013
11. C-H Bond Activation in Organic Synthesis; Jie Jack Li; CRC Press 2015
12. C-H Activation; Jin-Quan Yu, Zhangjie Shi; Springer; 2010
13. Photoredox Catalysis in Organic Chemistry, Megan H. Shaw, Jack Twilton, and David W. C. MacMillan J. Org. Chem., 2016, 81 (16), pp 6898–6926
14. Organic Photoredox Catalysis; Nathan A. Romero, David A. Nicewicz; Chem. Rev., 2016, 116 (17), pp 10075–10166

Natural Products and Bio-Organic chemistry **4 credits**

CHE-PG-E412

Organic Chemistry Elective IV

Unit I: Natural Products

Isoprene Rule, biogenesis and biosynthesis of representative examples. Retrosynthetic analysis of some typical natural products.

Alkaloids: Structure, synthesis, and stereochemistry of Narcotine and Quinine; synthesis and stereochemistry of Morphine, Lysergic acid and Reserpine.

Terpenoids: Camphor, Longifolene, Abietic acid, and Taxol. Steroids: Cholesterol, Aldosterone and Cortisone.

Prostaglandins and Thromboxanes: Introduction, nomenclature of prostaglandinsand thromboxanes; approaches to prostaglandin synthesis; cyclohexane precurors (Woodward synthesis of PGF2a), bicycloheptane precursors (Corey's synthesis of prostaglandins E and F) Oxygen Hetrocycles: Flavonoids, isoflavonoids and biosynthetic pathways. Antioxidant properties of flavonoids.

Unit II: Organotransition Metal Chemistry: Applications to Organic Synthesis

Electron counting, bonding, organometallic reaction mechanism; Homogeneous hydrogenation; Organometallics as electrophiles; Synthetic applications of transition metal alkene complexes: Wacker oxidation. Synthetic applications of complexes containing metal – carbon ó bonds: Heck and related reactions, carbonylation reactions; Synthetic applications of transition metal carbene complexes: Fischer carbene, Schrock carbene, metathesis processes, Tebbe's reagent, Zieglar – Natta reaction; Synthetic applications of transition metal alkyne complexes: Pauson – Khand reaction, cyclooligomerisation; Applications of transition metal complexes in the synthesis of: cyclic enediynes, estrone by Volhardt, clavicipitic acid by Hegedus.

Unit III: Enzymes and Mechanism of Enzyme Action

Classification, isolation and purification. Methods of Enzyme analysis. Two substrate reactions; Enzyme inhibition. Mechanism of action of chymotrypsin, aldolase, alcohol dehydrogenase, and lysozyme.

Co-enzyme Chemistry: Cofactors as derived from vitamins; coenzymes, prosthetic groups, and apoenzymes. Structure and biological functions of coenzyme A, thiamine Pyrophosphate, Pyridoxal

Phosphate, NAD^+,$NADP^+$, FMN, FAD, lipoic acid, and vitamin B_{12}

Unit IV: Chemistry of Medicinally Important Molecules

Bacterial and animal cells, antibacterial agents – mechanism with reference to â-lactam antibiotics; General method of synthesis of â-lactam ring: synthesis of penicillin, 6-APA, cephalosporin, 7-ACA; Morin – Jackson rearrangement; Structure-activity relationship of penicillin. New generation antibiotics / antibacterial agents: Synthesis and mechanism of action of (i) fluoroquinolones – norfloxacin, ciprofloxacin, levofloxacin (ii) anti AIDS drugs – AZT, lamivadine (iii) antihypertensive agent – captopril (iv) calcium channel blocker – amlodipine (v) gastric secret Vitamins: Structure and synthesis of Vitamins A, C, Thiamine (B_1), Riboflavin (B_2), Pyrdoxine (B_6), Cobalamin (B_{12}) and Vitamin D, Vitamin E, Biotin (H) and Vitamin K.ion inhibitor-omeprazole (vi) drug for Impotency-sidenafil etc.

References

1. Bruice T.C. and Bentkovic, S., 1996, Bioorganic Mechanisms, Vol. I & II, W. A. Benjamin, New York.
2. Voet D., Voet J.G. and Pratt CW, 1999 Fundamentals of Biochemistry, John Wiley & Sons, New York .
3. Dugas H. and Penney C., 1981, Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Springer-Verlag, New York.
4. Apsimon J.W., Total Synthesis of Natural Products, Vol. 1-6, Wiley-Interscience Publications, New York.
5. Clayden J. , Greeves N., Warren S., and Wothers P., 2001 Organic Chemistry, Chapter 30, Oxford University Press, Oxford.
6. Burger's Medicinal Chemistry and Drug Discovery, 2003 6th Edn. Donald J. Abraham (Editor), Wiley Interscience
7. Smith M. B., March J., 2000 March's Advanced Organic Chemistry. Reactions, Mechanisms, and Structure 5th Edition, Wiley-Interscience
8. Finar I.L., 1975 Organic Chemistry, Vol. II, 5th Edition Reprinted in 1996, ELBS and Longman Ltd., New Delhi.
9. Lehninger A.L., 1992 Principles of Biochemistry, CBS Publishers, Delhi
10. Mahler H.R. and Cordes E.H., 1971 Biological Chemistry, 2nd Edition, Harper and Row Pub., New York.

Solid-State Chemistry **4 credits**

CHE-PG-E421

Physical Chemistry Elective I

Unit I: Solid state Chemistry

Basic Principles and applications

Solid State Reactions: General Principles, Experimental procedure, Co-precipitation a a precursor to solid-state reactions, Kinetics of solid-state reactions, Crystallization of solutions, melts, glasses and gels. Preparation of thin films (chemical, electrochemical and physical methods), Hydrothermal methods, Growth of single crystals: Czochralski method, Bridgman and Stockbarger methods. Zone Melting. Reactions at solid surfaces.

Unit II: Phase transitions, electronic and magnetic properties

Phase Transitions: Thermodynamic and Burger's classification of phase transition, Kinetics of phase transition-nucleation and growth, T-T-T diagrams, Factors that influence kinetics of phase transition, Martensitic and order-disorder transitions.

Electronic Properties and Band Theory: Electronic structure of solids- band theory, Refinement to simple band theory-k-space and Brillouin Zones, Band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, Doped semiconductors, p- n junctions. Concepts of thin film devices. Field effect transistors, photovoltaics, Light emitting diodes.

Magnetic Properties: Classification of materials. Magnetism: Types, determination of magnetic susceptibility. Quantum theory of diamagnetism and paramagnetism. Cooperative phenomena. Magnetic domains. Hysteresis. Concepts of GMR, Solid State storage.

Unit III: Structural characterisation techniques

X- ray Diffraction: Diffraction of X-rays by crystals: The Laue equations and Bragg's law, Definitions related to crystal structure. X-ray diffraction experiments: The powder method and the single crystal method. Reciprocal lattice. Structure factor. Structure factor and intensity. Electron density maps.

Electron diffraction: Scattering intensity versus scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.

Neutron diffraction: Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques. Elucidation of structure of magnetically ordered unit cells.

Solid State NMR: Differences between solid and liquid state NMR, comparison with XRD, Magic Angle spinning, Chemical shielding, J-coupling, Dipolar coupling, Quadrupolar coupling.

Unit IV: High-Tc Oxide Superconductors

Structural features of cuprate superconductors. 1-2-3 and 2-1-4 cuprates; structure. Normal state properties: anisotropy and temperature dependence of electrical resistance.

Superconductingstate: heat capacity, coherence length, relation between Tc and hole concentration in cuprates; mechanism of superconductivity in cuprates. Applications of high Tc- cuprates.

Non-linear materials: Second and third order non-linear effects; molecular rectifiers and frequency doublers; unimolecular electronic devices. Photochromic materials; optical data storage, memory and switches.

References:

1. West A.R. 2003 Solid State Chemistry and its Applications, John Wiley and Sons, Singapore.
2. Azaroff L. V. 1977, Introduction to Solids, Tata McGraw-Hill, New Delhi
3. Massa, W. 2004 Crystal Structure Determination 2nd Ed. Springer.4. Warren, B. E., 1990 X-Ray Diffraction 1st Ed. Dover Publications (1990)
5. Sands, D.E 1994 Introduction to Crystallography , Reprint Dover Publiications.
6. Tinkham Michael, 2004 Introduction to Superconductivity 2nd Edition , Courier Dover Publications.
7. Rammakrishnan, T.V. and Rao C.N.R. 1999 Superconductivity Today Orient Blackswan.
8. Ashcroft N. W. and Mermin N. D., 1976 Solid State Physics, Brooks Cole, 1st Edition.
9. Keer H. V. 1993 Principles of the Solid State, New Age International.
10. Chakrabarty D.K., 2010 Solid State Chemistry, New Age Science ltd; 2nd Revised edition

Advanced Quantum Chemistry **4 credits**

CHE-PG-E422

Physical Chemistry Elective I

Unit I: Advanced Quantum Chemistry

Ab initio and Semi-empirical Methods for Closed Shell Systems:

Orbitals, Slater Determinants, The Hartree-Fock Self-Consistent Field Method: The generation of Optimized orbitals, Koopman's Theorem (The Physical Significance of Orbital Energies), The electron correlation energy, Density matrix analysis of the Hartree-Fock Approximation, Natural orbitals, The matrix solution of the Hartree- Fock Equations (Roothaan's equations). Density functional theory, Time- Dependent Density functional theory.

Semiempirical Molecular Orbital Methods I - PI Electron Systems: The Hückel Approximation for Conjugated Hydrocarbons, The Pariser-Parr-Pople Method.Semiempirical Molecular Orbital Methods II

- All valence - Electron systems: The Extended Hückel Method, The CNDO Method.

Unit II: Electronic Structure of Linear and non linear Molecule

The Born-Oppenheimer Approximation, The MO - LCAO Approximation, The Hydrogen Molecule Ion, H^+_2, The Hydrogen molecule, Molecular Configuration - Interactions, The Valence Bond Method, The stability of chemical bond, Hellmann-Feynman theorem, Molecular Perturbation Calculations. Electronic Structure of AH_n molecule: Methane, Ammonia and Water, Hybrid Orbitals: The Ethylene and Benzene Molecules.

The Virial Theorem and Chemical Bonding, The Hellmann-Feynman Theorem, The Electrostatic

Theorem.

Unit III: Atom-Radiation Interaction

Electromagnetic field and its interaction with one-electron atoms, Spontaneous emission, Electric dipole approximation, rotating-wave approximation (RWA), density matrix approach, Line intensities, widths and shapes, Rabi Oscillations, atomic coherence, Optical Bloch Equations, Photoionization, Scattering: Partial wave analysis, Phase shifts, The Born Approximation.

Unit IV: Quantum Computation & Information

Computer science, Quantum bits, The EPR Paradox, Bell's Theorem, Quantum algorithms, Quantum information theory, Quantum computers: Physical realization, Entropy and information.

References

1. Levine, I.N. 2000 Quantum Chemistry, 5th edition, Pearson Educ., Inc. New Delhi.
2. Karplus M. and Porter, R. N., 1970 Atoms and Molecules, Benjamin, London.
3. Atkins P.W. and Friedman, R.S., 1997 Molecular Quantum Mechanics, 3rd edition, Oxford University Press. Oxford.

4. Pilar, Frank L. 1990 Elementary Quantum Chemistry 2nd Edition, Mc Graw-Hill Publishing Company.
5. Mc Quarrie D.A. and Simon, J.D. , 1998, Physical Chemistry: A Molecular Approach, Viva Books, New Delhi.
6. Murrell, J.N. ,. Kettle S.F.A and Tedder, J. M. , 1965, Valence Theory,2nd edition, John Viley, New York.
7. Chandra, A.K. , 1994 Introductory Quantum Chemistry, 4th edition, Tata McGraw Hill, New Delhi.
8. Pualing L. and Wilson, E. B. , 1935 Introduction to Quantum Mechanics with Applications to Chemistry, McGraw Hill, New York.
9. B. H. Bransden and C. J. Joachain, 2003, Physics of atoms and molecules, 2nd edition, Pearson
10. R. Loudon, 2000, The Quantum Theory of Light, 3rd edition Oxford University Press.11. Nielsen and Chuang, 2000, Quantum Computation and Quantum Information, Cambridge University Press.

Elective Inorganic Chemistry Practical **4 credits**

CHE-PG-E403

1. Synthesis and characterization of the following (any five synthesis)

a. Pervoskite (bulk and nanoparticles)

b. Prussian blue

c. HKUST-1, $Cu_3(BTC)_2$ metal organic framework

d. Metallic nanoparticles (Ni,Co and Cu)

e. Polyoxometallate (V,Mo andW)

f. Layered materials (In_2O_3 and Fe_2O_3)

Characterization techniques to be used for each experiments (wherever applicable) are XRD, UV-vis, FT-IR, TGA/ DTA, Surface Area analysis (BET), Magnetic susceptibility measurements, Cyclic Voltammetry, ICP-MS and AAS.

2. Analysis of known compounds (any two)

a. Cyclic voltammetry, ^{1}H and ^{13}CNMR of Ferrocene

b. ^{13}C-NMR and FT-IR of iron carbonyls

c. TGA measurement of $CuSO_4.5H_2O$

d. Surface ligand analysis by TGA and FTIR of nanoparticles

e. Magnetic susceptibility measurements of $Fe(acax)_3$(Evans method)

f. Assignment of absolute configuration using circular dichroism (CD)

3. Chemistry Communication Skills:

a. How to draw chemical structures- Use of CHEMDRAW. How to write and draw equations (both chemical and mathematical).

b. How to find compound related data in the literature?

c. Use and management of mined data- End note.

d. Use of spectral databases and how to report compound data and procedures. Use of other specialized databases- CCDC, PDB, other nuclei NMR databases.

e. Data integrity and recording experiments in the lab notebook.

f. How to write new and views (reviews)? How to make presentation slides and present reviews to an audience?

References:

1 . Elias, A. J., Collection of Interesting General Chemistry Experiments, Orient Longman.

2. A text book of Quantitative Inorganic Analysis – A. I. Vogel

3. A Text Book of Quantitative Inorganic Analysis- A. I. Vogel

4. Experimental Inorganic Chemistry - W. G. Palmer

5. S ynthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.

6. Chemistry experiments for Instrumental Methods by Donald T. Sawyer, William R. Heineman & Jalice M. Beebe , John Wiley & Sons ,1984.

7. Experimental Physical Chemistry by G. Peter Matthews, Clarendon Press, 1985.

8. Handbook of Inorganic Synthesis: G. Brauer

9. Inorganic Synthesis: R. B. King

10. Synthesis and Technique in Inorganic Chemistry: A Laboratory Manual, Gregory S. Girolami, Thomas B. Rauchfuss and Robert J. Angelici. University Science Books.

Elective Organic Chemistry Practical **4 credits**

CHE-PG-E413

Organic Chemistry Experiments

B. Organic Special Practical: Part I

Preparation of organic compounds by typical organic reactions, purification and characterization of the product [by re-crystallization, TLC, PLC, determination of Rf value as required, m.p/b.p.].

Characterization of organic compounds by spectroscopic means.

B. Organic Special Practical: Part II

Multistep Organic Preparation. Extraction and Purification of Natural Products and Biomolecules

Books Recommended:

1. Elias, A. J., Collection of Interesting General Chemistry Experiments, Orient Longman.
2. Addison Ault Techniques and Experiments for Organic Chemistry 6th Ed. University Science Books (1998).
3. Mann, F. G. & Saunders, B. C. Practical Organic Chemistry 4th Ed. Orient Longmans (1990).
4. Vogel, A. I. Vogel's Textbook of Practical Organic Chemistry 5th Ed. (revised by A.R. Tatchell et al.) Wiley (1989) ISBN 0582-46236-3

Elective Physical Chemistry Practical **4 credits**

CHE-PG-E423

Experimental Solid state and Nanomaterials

1. Synthesis and Characterization of Nanoparticles (Metal, Spinel, Rutile, Zinc blende, Wurtzite Pervoskite)
2. Determination of Molar extinction coefficient of Nanoparticles.
3. Isolation and physical characterization of Fullerene C_{60} natural sources
4. Determination of size of nanoparticles using UV-Vis spectrophotometer and X-Ray Diffraction
5. Determination of quantum yield of quantum dots.
6. Solution and solid state ligand exchange in nanoparticles. Computational

Physical

1. Writing and executing computational codes for the following –Radioactive Decay, Other First-Order Reactions etc.
2. Use of quantum mechanical software – Gaussian, MPQC – calculation of energies of molecules.
3. Coding Minimization Algorithms: LBFGS etc.
4. Numerical Methods Roots of Polynomials, Solution of Linear simultaneous equations, matrix multiplication and inversion.
5. Numerical integration.
6. Statistical treatment of data, variance and correlations, Least square curve fitting.

Project for M.Sc. Thesis **4 credits**

CHE-PG-E404

Each student has to carry out innovative research on a topic chosen by the student.

Course Objectives:

a) Identification of the problem.

b) Literature review.

c) Exposure to analytical techniques/software

d) Communication skills: Scientific writing, presentation

e) Scientific ethics

DEPARTMENT OF CHEMISTRY

M.Phil/ Ph.D Coursework Syllabus

Code	Name of Paper	Credits	Marks
CHE-RS-C101	Research methodology	4	100
CHE-RS-C102	Research Proposal Preparation	4	100
CHE-RS-E103	Advanced Topics in Organic Chemistry	4	100
CHE-RS-E104	Bio-Inorganic Chemistry	4	100
CHE-RS-E105	Computational Chemistry	4	100
CHE-RS-E106	Food Chemistry	4	100
CHE-RS-E107	Nanoscience	4	100
CHE-RS-E108	Soil Chemistry	4	100
CHE-RS-E109	Strategies in Organic Synthesis	4	100
CHE-RS-E110	Supramolecular Chemistry	4	100

SEMESTER I

Research Methodology

CHE-RS-C101

Unit I: Basic principles, health and safety, working with liquids

Basic laboratory procedures, Principles of solution chemistry, pH and buffer solutions. Principles of Green Chemistry and its practices.

Making and recording measurements, SI units and their use, Scientific method and design of experiments, Project works.

Using graphs, presenting data in tables, Hintsfor solving numerical problems, Descriptive statistics, choosing and using statistical tests, drawing chemical structures, chemometrics, error analysis

– standard deviation, variance and various methods of error analysis

Unit II: The Internet and World Wide Web

Internet resources for chemistry, using spreadsheets, word processors, databases and other packages, finding and citing information.

General aspects of scientific writing, writing essays, writing articles, communications and reviews for journals, reporting practical and project work, writing literature surveys and reviews, organizing a poster display, giving an oral presentation examination.

Unit III: Meaning of research problems

Sources of research problems, criteria / characteristics of a good research problem, errors in selecting a research problem.

Format of research proposal, individual research proposal and institutional proposal. Format of the research report, style of writing the report, references and bibliography.

Unit IV: General safety and operational rules

Safety equipments, personal protective equipments, compressed gas safety, safety practices for disposal of broken glass wares, centrifuge safety, treated biomedical wastes. Emergency response, Chemical spills, radiation spills, biohazard spills, leaking compressed gas cylinders, fires, medical emergency accident reporting.

Ethics and Human Interface: Essence, determinants and consequences of Ethics in human actions; dimensions of ethics; ethics in private and public relationships. Scientific and Professional ethics.

References:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., and Jones, A. 2002 Practical Skills in Chemistry, Pearson Education Ltd. [Prentice Hall]
2. OSU safety Manual 1.01.
3. Kothari, C. R. Research Methodology. Methods and Techniques
4. Singh, A. K. Tests, Measurements and Research Methods in Behavioural Sciences:

Research Proposal Preparation

CHE-RS-C102

Unit I: Presentation of scientific papers

Presentation of the recently well cited scientific research studies from journals of high impact factor. Topics of the presentation to be decided by students in consultation with teachers. Students should be presenting more than once in different areas.

Unit II & III: Research proposal

The students will write a detailed proposal of their research including a thorough review of literature on a topic of their choice and present the same in a seminar at least 10 days before the End-Sem examination.

Unit IV: Presentation on Instrumentation techniques

This unit seeks to update student's knowledge about the various instrumentation techniques relevant to his/her research work.

CHE-RS-E101: Advanced Physical Chemistry Unit I: Irreversible Thermodynamics

Internal heat and entropy production; Relation of entropy production with Fluxes & Forces; Phenomenological equation; Onsager reciprocal relation; Prigogine's principle of minimum entropy production at non equilibrium stationary state.

Unit II: Molecular collisions

Scattering as a probe of collision dynamics, Potential energy surface, Experimental techniques in reaction dynamics: molecular beam and chemiluminescence techniques, trajectory calculations, state to state kinetics, some case studies.

Unit III: Lasers: its properties and applications in reaction kinetics

Techniques for the study of fast and ultrafast reactions: Flow and stooped flow technique, relaxation technique, pump-probe technique , single photon counting and fluorescence up- conversion techniques, femtochemistry.

Unit IV: Thermodynamics in Biochemistry (Fundamentals and Applications)

Biopolymers (Proteins, Enzymes, DNA, Carbohydrates); Biomembranes (Structure and Function); Active transport and passive transport, Multiple equilibria, Specific examples of multiple equilibria, Transport processes; General features of transport processes; Optical systems for the study of transport processes. Self organizing systems (Micelles, Lipids. Cyclodextrins, Liquid crystals, Reverse micelles, coacervates, Proteins etc) their interactions and solutions properties. Preparation, Characterization and Application of nanoparticles Surface and Biophysical Techniques: CD, SEM, TEM, EDAX, DLS, Gel Electrophoresis, Radioactivity, XPS.

References

1. Prigogine, I. Introduction to Thermodynamics of Irreversible Processes.
2. Levine, R.D. and Bernstein, Chemical kinetics and dynamics Molecular Reaction Dynamics and Chemical Reactivity, Oxford
3. Cantor, C. R. Schimmel, P. R. Biophysical Chemistry: Part I: The Conformation of Biological Macromolecules.
4. Cantor, C. R. Schimmel, P. R. Biophysical Chemistry: Part II: Techniques for the Study of Biological Structure and Function
5. Cantor, C. R. Schimmel, P. R. Biophysical Chemistry: Part III: The Behavior of Biological Macrolmolecules
6. Somorjai, G.A. Li, Y. Introduction to Surface Chemistry and Catalysis

Advance Topics in Organic Chemistry

CHE-RS-E102

Unit I: Advanced Analytical Techniques

All advanced analytical techniques for structure determinations.

Unit II: Preparative techniques

Pyrolytic methods; chemical strategies, chemical vapour deposition; preparation of nanomaterials, Langmuir- Blodgett Films. Fabrication of ordered nanostructuress.Composition and purity of materials. Conducting organics-Metals from molecules, charge transfer materials and conducting polymers. Organic superconductors. Fullerenes, Carbon nanotubes and graphene.Molecular ferromagnets and ferroelectrics. Liquid crystals: mesomorphicbehaviour, optical properties of liquid crystals, display devices. Organic light emitting diodes.

Unit III: Synthetic Medicinal chemistry

Methods of combinatorial chemistry, solid phase synthesis, different types of polymer supports, linkers, strategies of library synthesis, characterization, diversity oriented synthesis, examples.

Unit IV: Stereoselective Synthesis of Enantiomerically Pure Drugs

Biocatalyzed reactions, glycosidation reaction, antisense oligonucleotides

References

1. Silverstein, R. M. and Webster, F. X. Introduction to Spectrometric identification of organic compounds, 6th Ed. John Wiley and Sons.
2. Macomber, R. S. A Complete Introduction to Modern NMR Spectroscopy.
3. Urger’s Medicinal hemistr and Drug Discover 6 Volume Set
4. Williams, D. A., Foye, W. O. Lemke, T. L. Foye’s Principles of Medicinal Chemistry
5. Nadendla, R. R. Principles Of Organic Medicinal Chemistry
6. Wilson, C. O. Gisvold, O. Block, John, J. H., Beale, M.Wilson and Gisvold’s Textbook of Organic Medicinal and Pharmaceutical Chemistry

Bio-Inorganic Chemistry

CHE-RS-E103

Unit I: The storage of iron, zinc, copper, vanadium, chromium, molybdenum, cobalt, nickel, and manganese

Transport of Iron, Zinc, copper, vanadium, chromium, molybdenum, and cobalt. Iron Biomineralization

Unit II: Biological Redox Components

Energy Storage and Release, Coupling Electron Transfers and Substrate Activation. Electron- transfer rates: Self-Exchange and Cross Reactions, Marcus Theory, Cross reactions of blue copper proteins. Long-range electron transfer in proteins. Modified Metalloproteins

Transport through membranes, Anion and cation carriers; Coupled transport processes; Electron coupled transport; Proton coupled transport; Light driven transport; Transport via transmembrane channels.

Unit III: Biological Oxygen Carriers

Haemoglobin, hemocyanin, and hemerythrin. Redox chemistry of free molecular dioxygen. Geometry and electronic structure of coordinated dioxygen. General aspects of chemistry of dioxygenwith iron, copper and cobalt. Other Ligands for Biological Oxygen Carriers: carbon monoxide, nitric oxide, Isocyanide and nitroso species

Iron-sulfur proteins and models. Multi-site redox enzymes: Hydrogenase and Nitrogenase. Biological nitrogen fixation. FeMo cofactor

Unit IV: Coordination, Intercalation and hydrogen bonding

Fundamental Reactions with Nucleic Acids: redox and hydrolytic chemistry. A case study: tris (phenanthroline) metal complexes. Binding Interactions with DNA. Techniques to Monitor indingApplications of different metal complexes that bind nucleic acids Nature's use of

metal/nucleic-acid interactions.

Metal deficiency and disease. Toxic effects of metals, Metals used in diagnosis and chemotherapy. A case study of cis-Platin.

References

1. Hughes, M. N. 1981, Inorganic Chemistry of Biological Processes, 2nd Ed.John-Wiley

& Sons, New York

2. Kaim, W. and Schwederski, B. 1995 Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide, Wiley, New York
3. Lippard, S. J. and Berg, J. M. 1994 Principles of Bioinorganic Chemistry, University Science Books,
4. Bertini, I., Grey, H. B., Lippard, S. J. and Valentine, J. S. 1998 Bioinorganic Chemistry, Viva Books Pvt. Ltd., New Delhi
5. Mukherjee, G. N. and Das, A. Elements of Bioinorganic Chemistry

Computational Chemistry

CHE-RS-E104

Unit I: Monte Carlo, Molecular Dynamics simulationsand its applications to understanding of physical and chemical transformations.

Methods based on Hartree-Fock, Configuration Interaction, Deriving one and two electron properties, Semi-empirical methods, Coupled Cluster theory, Density functional theory, TDDFT. QM/MM methods

Unit II: Basic molecular biology

Basic principles of biochemistry, energy conversion, enzymatic catalysis, and active transport, enzyme models, drug design, computational modeling.

Unit III: Introduction to Classical Monte Carlo

Molecular Dynamics Simulation and Softwares - DLPOLY, GROMACS, TOWHEE, NAMD.Introduction to Quantum chemistry softwares – NwChem, Gaussian.Visualization softwares – VMD, Povray.

Unit IV: Computer programming languages

C++, FORTRAN. Python, Shell scripting. Writing Monte Carlo, Molecular Dynamics codes for chemistry problems. Parallel programming techniques like Open MP, MPI

References

1. Pople, J.A. and Beveridge, D.L. 1971 Approximate Molecular Orbital Theory, McGraw Hill, New York
2. Parr, R.G. and Yang, W. 1989 Density Functional Theory of Atoms and Molecules, Oxford University Press, Oxford
3.. Longman, A. L. 1996 Molecular Modelling, London.
4.. Hunt, R. and Shelley 1998 Computers and Common Sense, Prentice Hall, New Delhi
5. Rajaraman, V 1990 Computer Programming in Fortran-90 Prentice Hall, New Delhi
6. Dickson, T. R. 1968 Computer and Chemistry: introduction to programming and numerical methods
7. Detar, D. F. Benjamin, W. A. Computer programs for chemistry 1968-1969 New York Vol. 1- 3
8. Jensen, F. 1999 Introduction to Computational Chemistry, John Wiley, New York.
9. Cramer, D. Wiley, J. 2002 Computational Chemistry (Theories and Models), New York.
10. Frenkel, D. and Smit, B. Understanding Molecular Simulation: From Algorithms to Applications
11. Allen, M. P. and Tildsley, D. J. Computer Simulation of Liquids

Food Chemistry

CHE-RS-E105

Unit I: Review of Proteins, Lipids and Carbohydrates

Sources. Physical properties, Chemical properties

Vitamins and Minerals: Different types of vitamins and its sources, vitamins Stability and Degradation; Different kinds of minerals and its sources; Different Main elements, trace elements and some non essential elements; Minerals in Food Processing

Unit II: Food Additives

Importance of additives, food colors, bases, anti-oxidant, thickening agents, humectants in our everyday life.

Unit III: Food Contamination

Possibility of contamination of food with toxic compounds.

Classification of Toxic Compounds in Food; Food Safety and Regulations; Rules and Regulation Set for Food Contamination

Unit IV: Alcoholic Beverage

Composition, processing, and kinds of alcoholic beverage Fermented food; determine the composition, processing.

References

1. Belitz H.D. and Grosch, W. 1999 Food Chemistry, 2nd edition, Springer
2. Adams, M.R. and Moss, M.O. 2000 Food Microbiology Royal Society of Chemistry; 2nd edition
3. Damodaran, S., Parkin, K. L. and Fennema, O. R. Fennema's Food Chemistry, Fourth Edition (Food Science and Technology).
4. Lawley, R. and Curtis, L. and Davis. J. Food Safety Hazard Guidebook
6. Adams, M. Ensuring Safe Food: From Production to Consumption
7. Aguilera, J.M.; Simpson R.; Welti-Chanes, J.; Bermudez Aguirre, D.; Barbosa-Canovas, G. (Editors) Food Engineering Interfaces (Food Engineering Series).
8. Molecular Biological and Immunological Techniques and Applications for Food Chemists by Bert Popping, Carmen Diaz-Amigo and Katrin Hoenicke.

Nanoscience

CHE-RS-E106

Unit I: Introduction

Surface to volume ratio, crystal structures, basic properties. Length scale: de Broglie wavelength, Bohr radius, excitons, confinement regimes, The Fermi Energy, Kubo Gap, the mean free path in metals, charging energy. Size and shape-dependent electrical, magnetic and optical properties of metal, metal oxide and semiconductor nanoparticles. Quantum size effect, Superparamagnetism, Surface Plasmon resonance.

Unit II: Synthetic approaches

Top down and bottom up. Colloidal growth. Chemical synthesis, Classical Theory, Monodispersity, Lamer Plot, Ostwald ripening, Digestive Ripening Homogeneous vs. heterogeneous nucleation and applications of nanomaterials, Anisotropic growth and shape control, Catalyzed (seeded) growth, Nanocrystal doping, solid solutions and Vegard's rule. Non- classical growth. Effect of precursor reactivity and stability on size. Unusual precursor kinetics in III-V semiconductor nanocrystal formation.

Functionalisation and basic characterisation of metal, metal oxide and semiconductor nanoparticles. Core-shell / multishell nanoparticles. Properties and synthesis of Carbon nanotubes, grapheme, fullerene. Recent advances in synthesis of new materials and their synthetic strategies. Characterization of nanomaterials.

Unit III: Properties and Application

Electrochemistry of colloidal nanoparticles.Band gap engineering in semiconductor nanocrystals, Carbon based nanoparticles, self assembled nanostructures. Atom and molecule manipulation. Application of nanoparticles in drug delivery, biological imaging of cellular and subcellular structures, catalysis, sensor, tracer, cancer treatment, photovoltaics, single molecule detection and LED. Introduction to nanotoxicology.

Unit IV: Model problems for quantum wells, wires and dots

Density of states. Quantum mechanical review; wavefunction, Schrödinger equation, Bands; The Kronig- Penny Model, metals, semiconductor, insulators; Interband transition.

References

1. Kuno, M. Introductory Nanoscience, 2011, Taylor & Francis Group.
2. Rigach, A. L. (Editor), Semiconductor nanocrystal quantum dots: synthesis, assembly and applications
3. Klimov, V. I. Semiconductor and Metal Nanocrystals: Synthesis and Electronic and Optical Properties (Optical Science and Engineering)
4. Thanh, N.T. K. and Sayed, M. A. 2012 El Magnetic Nanoparticles: From Fabrication to Clinical Applications
5. Huck, W. T. and Huck, Wilhelm T. S. (Editor) Nanoscale Assembly: Chemical Techniques
6. Dresselhaus, M. S, Dresselhaus, G. and Avouris, P. Springer-Verlag. Carbon Nanotubes : Synthesis, Structure, Properties, and Applications
7. Acklin, B. and Lautens, E. Magnetic Nanoparticles: Properties, Synthesis and Applications
8. Taurozzi, J. S 2011 Nanoparticle-polymer composite membranes: Synthesis, characterization, and environmental applications.
9. Karn, B. Colvin, V. and Alivasatos, P. 2004 Nanotechnology and the Environment.
10. Zhou, B. Hermans, S., Somorjai, G. A. (Editors)Nanotechnology in Catalysis Volumes 1 and 2

Soil Chemistry

CHE-RS-E107

Unit I: Soil-definition

Chemical composition, method of separation of inorganic and organic components of soil.

Clay minerals: X-ray diffraction, Fourier synthesis. Arrangement of ions in a crystal lattice – correlation between ionic radii and coordination number.Different types of clay minerals, identification, their structures and structural formulas.Weathering: genesis of clay minerals, processes and products of weathering. Packing of coordinated units in a crystal lattice.Crystal structure of the silicates.

Unit II: Humic acid, Fulvic Acid

Their genesis. Structures – molecular weight of the organic components, determination of high molecular weights.Computer simulation of the structure of the organic components.

Surface charge, double layer theory.Adsorption/desorption: Langmuir adsorption isotherm. Derivation of the Langmuir equation for Ion-exchange Reactions in soils using statistical mechanics.Application and misapplication of the Langmuir equation to the soil adsorption phenomena.A general treatment and classification of the Solute Adsorption Isotherm.

Unit III: Cation exchange capacity

Causes of cation exchange capacity.Positions of exchangeable cations.Rate and environment of exchange reactions. Replaceability of exchangeable cations, Anion exchange

Soil redox potential - Some practical implications

Unit IV: Soil Fertility - An overview

A Quantity/Intensity approach to ion availability, Potassium Chemistry; Phosphorus Chemistry; Biogeochemistry of soil nitrogen; Biogeochemistry of soil sulfur; Evaluation of fertility status; Pollution problems

References

1. McBride, 1994 Environmental Chemistry of Soils, Oxford
2. Tan, Dekker, M. 1993 Principles of Soil Chemistry
3. Dixon and Weed, 1989 Minerals in Soil Environments, Soil Sci.
4. Sparks, 1989 Kinetics of Soil Chemical Processes, Academic Press
5. Wild and Longman, 1988 Russell’s Soil Conditions and Plant Growth
5. Davis and Hayes Geochemical Processes at Mineral Surfaces, American Chemical Soc.,
6. Harter, Van Nostrand Reinhold, 1986 Adsorption Phenomena,
7. Sparks, 1986. Soil Physical Chemistry, CRC Press,
8. Bohn, McNeal, & O’Connor 1985 Soil Chemistry, 2nd Ed, Wiley Interscience.
9. Sposito, 1984. The Surface Chemistry of Soils, Oxford Press.
10. Lindsay, 1979 Chemical Equilibria in Soils, Wiley Interscience,
11. Alexander, 1977 Soil Microbiology, Wiley Interscience.

Strategies in Organic Synthesis

CHE-RS-E108

Unit I: Umpolung

Reaction by Organometallic Reagents, Sigmatropic Rearrangements, Pericyclic reactions, reactions of carbenes, Benzyne, Coupling reactions – Heck, Suzuki, and related, Wittig, Tebbes, Petasis, Grubbs, Peterson reactions, Simmon-smith reactions, radical reaction,

Hetero-atom alkylation or acylation, Nucleophilc substitution or addition by hereoatom nucleophiles, Mitsunobu reaction, pericyclic reactions, nitrenes.

Unit II: Reagents for Oxidation

Reduction, elimination, addition, organo silicon, organotin reagents, organo boron, organo- phosprus, organosulfur, organoselenium, Titanium, Fluorinating agents, Important starting materials and intermediates

Unit III: Methods of determining atropisomerism

Biphenyls, quasiracemates, dynamic stereochemistry, Axial chirality, planar chirality, helical chirality, determination of absolute configuration, Conformational analysis based on physical properties and chemical reactivity, shape of small and medium ring, Steroselectivity Asymmetric synthesis using chiral pool, chiral auxiliaries, chiral reagents and chiral catalysts

Unit IV: Retrosynthetic strategies

Transform-Based Strategies, Structure-Goal Strategies, Topological Strategies, Stereochemical Strategies, Functional Group-Based Strategies. Choosing one path over other: Consideration of yield, availability of synthone, mildness of any reaction, Retrosynthesis and total synthesis of various natural products

References

1. Carey, F.A. and Sundberg, R.J. Advanced Organic Chemistry, Fourth Edition, Part A and B
2. Clayden, Greeves,Warren and Wothers, Organic Chemistry
3. March, J 6th Edition, Advanced Organic Chemistry
4. Carruthers, –W. Some modern methods of organic synthesis, Cambridge
5. Eliel, E. L. Stereochemistry of carbon compounds.
6. Fuhrhop, J.-H., Li, G., Corey, E. J. Organic Synthesis: Concepts and Methods.
7. Organic Synthesis: Concepts, Methods, Starting Materials, 2nd Edition, Jürgen-Hinrich Fuhrhop, Gustav Penzlin
8. Wyatt, P. Warren, S. Workbook for Organic Synthesis: The Disconnection Approach.

Supramolecular Chemistry

CHE-RS-E109

Unit I: Quantification of non-covalent forces and medium effects

Host design; Preorganization; Enthalpy and entropic contributions; Cooperativity and allosteric effects; Induced fit; Complexation selectivity.

Introduction, Proteins and Foldamers: Single Molecule Self-Assembly, Biochemical Self- Assembly, Self-Assembly in Synthetic Systems: Kinetic and Thermodynamic Considerations, Self-Assembling Coordination Compounds, Self-Assembly of Closed Complexes by Hydrogen Bonding, Catenanes and Rotaxanes, Helicates and Helical Assemblies, Molecular Knots

Unit II: Lariat ethers and podands

Crown ethers, cryptands, calyx[n]arenes, cucurbit[n]urils, spherands; Selectivity of cationcomplexation; Macrocyclic, macrobicyclic and template effects

Concepts in anion host design; Guanidinium-based receptors; Organometallic receptors; Neutral receptors; Hydride sponge; Anticrowns; Biological Anion receptors

Binding by cavitands, cyclodextrins, cucurbit[n]urils, dendrimers, molecular clefts and tweezers, cyclophane Hosts

Unit III: Catalysis by cation, anion and neutral receptors

Supramolecular metallocatalysis; Cocatalysis; Biomolecular and abiotic catalysis.

Biological Inspiration for Supramolecular Chemistry, Alkali Metal Cations in Biochemistry, Porphyrins and TetrapyrroleMacrocycles, Supramolecular Features of Plant Photosynthesis,

Uptake and Transport of Oxygen by Haemoglobin, Enzymes and Coenzymes, Neurotransmitters and Hormones, DNA.

Unit IV: Solid-State Host-Guest Compounds

Clathrate Hydrates, Urea and ThioureaClathrates, Other Channel Clathrates, Hydroquinone, Phenol, Dianin's ompound and the Hexahost Strategy, Tri-o-thymotide, Cyclotriveratrylene, Inclusion Compounds of the Calixarenes, Solid-Gas and Solid-Liquid Reactions in Molecular Crystals.

Introduction, Supramolecular Photochemistry, Information and Signals: Semiochemistry and Sensing, Molecule-Based Electronics, Molecular Analogues of Mechanical Machines, Nonlinear Optical Materials.

References

1. Steed, J. W. and Atwood, J. L. Supramolecular Chemistry John Wiley and Sons, Ltd.
2. Lehn, J.–M. Supramolecular Chemistry-Concepts and Perspectives, VCH.
3. Schnider. H.-J. and Yatsimirsky, A.K. Principles and Methods in Supramolecular Chemistry John Wiley and Sons, Ltd.

4. Bianchi, A., James, K. B. and Garcia-Espana, E. Supramolecular Chemistry of anions, Wiley- VCH.
5. Teikink, E. R. T. and Vittal, J. J. Frontiers in Crystal Engineering.
6. Steed, J. W. and Atwood, J. L. Encyclopedia of Supramolecular Chemistry.
7. Cragg, P. J. A Practical Guide to Supramolecular Chemistry.
8. Steed, J. W., Turner, D. R. and Wallace, K. J. Core Concepts in Supramolecular Chemistry and Nanochemistry

DEPARTMENT OF COMPUTER APPLICATIONS

SYLLABUS FOR MCA

SEMESTER I		
SUBJECT CODE	**SUBJECT NAME**	**CREDIT**
MCA-PG-C101	Mathematics I	4
MCA-PG-C102	Principles of Management	4
MCA-PG-C103	Digital Logic	4
MCA-PG-C104	Programming using C	4
MCA-PG-L105	Digital Logic Laboratory	4
MCA-PG-L106	C Laboratory	4
Total Credits: 24		

SEMESTER II		
SUBJECT CODE	**SUBJECT NAME**	**CREDIT**
MCA-PG-C201	Mathematics II	4
MCA-PG-C202	Computer Organization and Architecture	4
MCA-PG-C203	Operating System	4
MCA-PG-C204	Data Structure	4
MCA-PG-L205	Operating System Laboratory	4
MCA-PG-L206	Data Structure Laboratory	4
Total Credits: 24		

SEMESTER III		
SUBJECT CODE	**SUBJECT NAME**	**CREDIT**
MCA-PG-C301	Strategic Management	4
MCA-PG-C302	Formal Language and Automata Theory	4
MCA-PG-C303	Object Oriented Programming using Java	4
MCA-PG-C304	Microprocessor and Microcontroller	4
MCA-PG-L305	Object Oriented Programming using Java Laboratory	4
MCA-PG-L306	Hardware Design Laboratory	4
Total Credits: 24		

SEMESTER IV		
SUBJECT CODE	**SUBJECT NAME**	**CREDIT**
MCA-PG-C401	Intellectual Property Rights & Professional Ethics	4
MCA-PG-C402	Database Management System	4
MCA-PG-C403	Advanced Web Programming	4
MCA-PG-C404	Software Engineering	4
MCA-PG-L405	Database Management System Laboratory	4
MCA-PG-L406	Advanced Web Programming Laboratory	4
Total Credits: 24		

SEMESTER V		
SUBJECTCODE	**SUBJECTNAME**	**CREDIT**
MCA-PG-C501	Computer Networks	4
MCA-PG-D502	Minor Project	8
MCA-PG-I503	Internship Program	4
MCA-PG-E5XX	Elective I	4
MCA-PG-E5XX	Elective II	4
Total Credits: 24		

SEMESTER VI		
SUBJECT CODE	**SUBJECT NAME**	**CREDIT**
MCA-PG-D601	Major Project	24
Total Credits: 24		

LIST OF ELECTIVE I		
SUBJECT CODE	**SUBJECT NAME**	**CREDIT**
MCA-PG-E504	Cloud Computing	4
MCA-PG-E505	Operation Research	4
MCA-PG-E506	Wireless Sensor Network	4
MCA-PG-E507	Compiler Design	4
MCA-PG-E508	Big Data Analytics	4
MCA-PG-E509	Real-Time System	4
MCA-PG-E510	Android Application Development	4

LISTOFELECTIVEII		
SUBJECTCODE	**SUBJECTNAME**	**CREDIT**
MCA-PG-E511	Digital Image Processing	4
MCA-PG-E512	Cryptography and Network Security	4
MCA-PG-E513	Computer Graphics	4
MCA-PG-E514	Internet of Things	4
MCA-PG-E515	Embedded Systems	4
MCA-PG-E516	Mobile and Wireless Network	4
MCA-PG-E517	Programming with Python and R Language	4

Abbreviations: C-Core, L-laboratory, E-Elective, I-Internship

MCA-PG-D502 and MCA-PG-D601 (Minor Project and **Major Project)** are designed to advocate the needs of innovative technical contributions to the fields of computer science and applications. The students studying in semester 5^{th} and 6^{th} are required to work for a **Project** on a topic assigned/approved under the supervision of one or more SU faculty member

Minor Project might focus on critical reviews of recent advances on the assigned topic of computer science and applications or interdisciplinary background with some novel contribution by the student.

Major Project shall cater the implementation of the assigned topic on practical depending upon the work done so far by the student. The student may publish or communicate the findings of the work in journals or conferences. The evaluation of the **Major Project** should be monitored by the faculty time to time. The student has to defend his/her **Major Project** in an open seminar.

In special circumstances, Department may allow the students to carry out the **Major Project inside** the University. However, Minor Project should be carried within University and **Major Project and Minor Project** may not be related.

MCA-PG-I503 (Internship): Students studying semester 4^{th} shall be required to pursue at least 3 weeks internship program in terms of Summer School/ Academic Visit/ Short Term Course/ Industry Visit/ In House Project. The credit may be included in next semester in form of marks in the subject.

Note: Project mentioned under the particular curriculum shall be mandatory and may include divisional marks as per the decision made by the concerned faculty or Departmental committee.

Mathematics I **Credit: 4**

MCA-PG-C101

UNIT I (15 Hrs)

Differential Calculus: Method of differentiation, Differentiation for first principles, Differentiation of product, Successive differentiation, Differentiation of implicit and parametric functions, Logarithmic and Partial differentiation, Maxima and Minima.

UNIT II (15 Hrs)

Integral Calculus: Standard integration, Definite integral, Application of integration, Substitution and partial fraction, Integration by parts, Reduction, First order differential equation, Homogeneous differentiation, First order and second order differentiation, Partial differential equation.

UNIT III (15 Hrs)

Laplace Transform: Properties, Inverse LT, Solutions of differential equations using LT, Solutions of simultaneous differential equations using LT.

Fourier Series: Periodic functions of period 2Ï, Non-Periodic functions of period 2Ï, Even-odd function and half range Fourier series, complex or exponential form Fourier series.

UNIT IV (15 Hrs)

Interpolation and Polynomial Approximation: Lagrange Polynomial, Divided Differences, Hermite Interpolation Numerical integration and differentiation: Trapezoidal rule, etc., Gaussian quadrature and Euler-Maclaurin formula. Applied Linear Algebra: Direct methods for solving linear systems, numerical factorizations, Eigenvalue problems. IVP problems for ODE: Euler's, Taylor, Runge-Kutta, and multistep methods, Stability.

Text Books:

1. Bird J, 2010, Engineering Mathematics, Elsevier.
2. Grewal, B S, 2012, Higher Engineering Mathematics, Khanna publishers, 42 E.
3. Ramana, B V, 2006,Higher Engineering Mathematics, TMH.

Reference Books:

1. Sastry S S, 2012, Introductory Methods of Numerical Analysis, PHI, 5E.
2. Iyengar S R K, Jain M K, Jain R K, 2012, Numerical Methods for Scientific and Engineering Computation, 6E.

Principles of Management **Credit: 4**

MCA-PG-C102

UNIT I (15 Hrs)

Introduction: Management: Concept, Nature, Importance; Management: Art and Science, Management as a Profession, Management Vs Administration, Management Skills, Levels of Management, Characteristics of Quality Managers. Evolution of Management: Early contributions, Taylor and Scientific Management, Fayol's Administrative Management, Bureaucracy, Hawthorne Experiments and Human Relations, Social System Approach, Decision Theory Approach. Social Responsibility of Managers, Managerial Ethics.

UNIT II (15 Hrs)

Planning and Organizing: Introduction to Functions of Management Planning: Nature, Scope, Objectives and Significance of Planning, Types of Planning, Process of Planning, Barriers to Effective Planning, Planning Premises and Forecasting, Planning and Decision Making.

Organizing: Concept, Organization Theories, Forms of Organizational Structure, Combining Jobs: Departmentation, Span of Control, Delegation of Authority, Authority & Responsibility, Organizational Structure and Design- Vertical and Horizontal Dimensions

UNIT III (15 Hrs)

Staffing, Directing and Motivation: Staffing: Concept, System Approach, Manpower Planning, Job Analysis, Recruitment & Selection, Training & Development, Performance Appraisal

Directing: Concept, Direction and Supervision

Motivation: Concept, Motivation and Performance, Special Motivational techniques: Money, participation, reward systems, Quality of Work Life, Job Enrichment & Morale Building.

UNIT IV (15 Hrs)

Leadership and Control: Leadership: Concept and Functions, Process and models of Leadership Development, Contemporary views on Leadership: Transformational-Transactional, Charismatic-Visionary leadership.

Controlling: Concept, Types of Control, Process and Techniques of Controlling.

Text Books:

1. Stoner, Freeman, Gilbert Jr, 2009, Management, Prentice Hall of India, 6E.
2. Koontz Harold, Weihrich Heinz, 2008, Essentials of management, Tata McGraw Hill, 5E.
3. Robbins, Coulter, 2008, Management, Prentice Hall of India, 9E.

Reference Books:

1. Robbins S.P. and Decenzo David A., 2007, Fundamentals of Management: Essential Concepts and Applications Pearson Education, 6E.
2. Weihrich H, Koontz H., 2008, Management: A Global and Entrepreneurial Perspective (Mc Graw Hill, 12E.
3. Luthans, Fred, 2008, Organizational Behaviour, McGraw Hill, 7E.

Digital Logic **Credit: 4**

MCA-PG-C103

UNIT I (15 Hrs)

Data and number systems: Binary representation, Codes and their conversions: BCD, Octal, Hexadecimal, ASCII, EBDIC, Gray, Signed binary number representation with 1’s and 2’s complement methods, Binary arithmetic

UNIT II (15 Hrs)

Boolean algebra: Venn diagram, logic gates and circuits, Minimization of logic expressions by algebraic method, Kmap method and Quine Mc Clauskey method

Combinational circuits- adder, subtractor, encoder, decoder, comparator, multiplexer, de-multiplexer, parity generator, etc.

UNIT III (15 Hrs)

Design of combinational circuits: Programming logic devices and gate arrays

Sequential Circuits- Flip Flops, various types of Registers and counters and their design, Irregular counter, State table and state transition diagram, sequential circuits design methodology

UNIT IV (15 Hrs)

Memory devices: ROM, RAM, EPROM, EEPROM, etc.

Different types of A/D and D/A conversion techniques

Different Logic families- TTL, ECL, MOS and CMOS, their operation, design and specifications

Text Books:

1. Kohavi Z, 1978, Switching and Finite Automata Theory, 2nd ed., McGraw Hill, New York.
2. Mcclusky, E J, 1986, Logic Design Principles, Prentice Hall International, New York.
3. Biswas, N N, 1994, Logic Design Theory, Prentice-Hall of India, New Delhi.

Reference Books:

1. Freedman A D, Menon P R, 1975, Theory and Design of Switching Circuits, Computer Science Press, California.
2. Bartee, T C, 1985, Digital Computer Fundamentals, 6E, McGraw Hill, New York.
3. Hayes, J, 1988, Computer Architecture and Organization, 2E, McGraw Hill.
4. Choudhury, P P, 1994, Computer Organization and Design, Prentice Hall of India

Programming using C **Credit: 4**

MCA-PG-C104

UNIT I (15 Hrs)

'C' Fundamentals: Evolution of programming languages, Characteristics of C, Structure of C program, C character set, token in C, Data Types in C, Constants, Keywords, Identifiers, Variable and its declaration

Operators and Expressions: Arithmetic operators, Relational operators, logical operators, Increment and decrement operators, Conditional Operators, Bit-wise operators, Special Operators, Assignment operators. Arithmetic expressions and its evaluation, Precedence of operators and associatively, Type conversions.

UNIT II (15 Hrs)

Input and Output: Formatted input and Output: Decision making: Branching statements- if, if-else, else-if ladder, nested if, switch, conditional operator. Looping Statements- while, do while, for. Jumps in loop- break, continue, and goto.

Arrays: Arrays– One Dimensional and multidimensional arrays- Declaration, Initialization. Strings- Initialization, Display, String manipulation functions, array of strings.

UNIT III (15 Hrs)

Pointers: Pointers- declaration and initialization. Pointers and Arrays, Pointer and strings, array of pointers.

User defined functions: Basics of functions-function types, need for functions, elements and categories of functions, passing parameter to a function, passing array and string to a function, Recursion, Scope rules, function pointer.

UNIT IV (15 Hrs)

Structures, Unions and Dynamic Memory Allocation: Structures- definition, declaration and initialization, accessing structure member, operations on structure member and variables. Arrays of structures, array within structure. Structure within structure, Pointers to structures, Self-referential structures, Unions, Dynamic Memory Allocation and Linked List.

File management in C: Introduction, Defining and opening a file, Closing a file, I/O operations on files, Error handling during I/O operations, Random access to files, command line arguments.

Text Books:

1. Balagurusamy, E, 2004, Programming in ANSI C, Tata McGraw Hill.
2. Gottfried B S, 2006, Programming with C, Schaums' Outline Series.
3. Kernighan B W, Ritchie D M, 1998, The C Programming Language, Prentice Hall.

Reference Books:

1. Venugopal K R, Prasad S R, 2006, Mastering C, Tata McGraw Hill.
2. Kanetkar Y, 2010, Let us C, BPB Publications.
3. Kanetkar Y, 2010, Pointer in C, BPB Publications.

Digital Logic Laboratory **Credit: 4**

MCA-PG-L105

Introduction to basic gates (AND, OR, NOT, XOR, XNOR, NOR etc.), Combinational circuit design (Adder, Substractor, Comparator, Decoder, Encoder, Multiplexer, DeMultiplexer etc.), Sequential circuit design (various types of Flip Flops, various types of Counters, various types of Registers etc).

Introduction to CAD languages (VHDL, Verilog). Introduction to Programming of combinational and sequential logic.

C Laboratory **Credit: 4**

MCA-PG-L106

1. Write a C program to find the sum of individual digits of a positive integer.
2. A Fibonacci sequence is defined as follows: the first and second terms in the sequence are 0 and 1. Subsequent terms are found by adding the preceding two terms in the sequence. Write a C program to generate the first n terms of the sequence.
3. Write a C program to generate all the prime numbers between 1 and n, where n is a value supplied by the user.
4. Write a C program to calculate the following Sum: Sum=1-x2/2! +x4/4!-x6/6!+x8/8!-x10/10!
5. Write a C program to find the roots of a quadratic equation.
6. The total distance traveled by vehicle in 't' seconds is given by distance = ut+1/2at2 where 'u' and 'a' are the initial velocity (m/sec.) and acceleration (m/sec2).
7. Write C program to find the distance traveled at regular intervals of time given the values of 'u' and 'a'. The program should provide the flexibility to the user to select his own time intervals and repeat the calculations for different values of 'u' and 'a'.
8. Write a C program, which takes two integer operands and one operator form the user, performs the operation and then prints the result. (Consider the operators +,-,*, /, % and use Switch Statement)
9. Write C programs that use both recursive and non-recursive functions

a. To find the factorial of a given integer.

b. To find the GCD (greatest common divisor) of two given integers.

10. Write a C program to find both the largest and smallest number in a list of integers.
11. Write a C program that uses functions to perform the following:

c. Addition of Two Matrices

d. Multiplication of Two Matrices

12. Write a C program that uses functions to perform the following operations:

e. To insert a sub-string in to given main string from a given position.

f. To delete n Characters from a given position in a given string.

13. Write a C program to determine if the given string is a palindrome or not

14. Write a C program that displays the position or index in the string S where the string T begins, or – 1 if S doesn't contain T.

15. Write a C program to count the lines, words and characters in a given text.

16. Write a C program to generate Pascal's triangle.

17. Write a C program to construct a pyramid of numbers.

18. Write a C program to read in two numbers, x and n, and then compute the sum of this geometric progression:

i. 1+x+x2+x3+………….+xn

g. For example: if n is 3 and x is 5, then the program computes 1+5+25+125.

h. Print x, n, the sum

19. Perform error checking. For example, the formula does not make sense for negative exponents – if n is less than 0. Have your program print an error message if n<0, then go back and read in the next pair of numbers of without computing the sum. Are any values of x also illegal? If so, test for them too.

20. 2's complement of a number is obtained by scanning it from right to left and complementing all the bits after the first appearance of a 1. Thus 2's complement of 11100 is 00100. Write a C program to find the 2's complement of a binary number.

21. Write a C program to convert a Roman numeral to its decimal equivalent.

22. Write a C program that uses functions to perform the following operations:

i. Reading a complex number

j. Writing a complex number

k. Addition of two complex numbers

l. Multiplication of two complex numbers

m. (Note: represent complex number using a structure.)

23. Write a C program which copies one file to another.

24. Write a C program to reverse the first n characters in a file.

n. (Note: The file name and n are specified on the command line.)

25. Write a C program to display contents of a file.

26. Write a C program to merge two files into a third file(i.e., the contents of the first file followed by those of the second are put in the third file)

27. Write C programs that uses non recursive function to search for a key value in a given list of integers using Linear search
28. Write C programs that uses non recursive function to search for a key value in a given list of integers using Binary search
29. Write C programs that implements the Selection sort method to sort a given array of integers in ascending order.
30. Write C programs that implements the Bubble sort method to sort a given array of integers in ascending order.
31. Write C programs that uses functions to perform the following operations

o. Create a single linked list of integers elements.

p. Traverse the above list and display the elements.

32. Write C programs that implement Stack (its operations) using singly linked list to display a given list of integers in reverse order.

q. Ex. Input 10 23 4 6. Output 6 4 23 10

33. Write C programs that implement Queue (its operations) using singly linked list to display a given list of integers in same order.

r. Ex. Input 10 23 4 6. Output 10 23 4 6

34. Write C program to implement linear regression algorithm.
35. Write C program to implement the polynomial regression algorithm.
36. Write C program to implement the Lagrange interpolation.
37. Write C program to implement the Newton- Gregory forward interpolation.
38. Write C program to implement Trapezoidal method.
39. Write C programs to implement Simpson method.

Mathematics II **Credit: 4**

MCA-PG-C201

UNIT I (15 Hrs)

Mathematical reasoning; propositions; negation disjunction and conjuction; implication and equivalence; truth tables; predicates; quantifiers; natural deduction; rules of Inference; methods of proofs; use in program proving; resolution principle; application to PROLOG.

UNIT II (15 Hrs)

Set theory: Paradoxes in set theory; inductive definition of sets and proof by induction; Peono postulates; Relations; representation of relations by graphs; properties of relations; equivalence relations and partitions; Partial orderings; Posets; Linear and well-ordered sets.

UNIT III (15 Hrs)

Graph Theory: elements of graph theory, Euler graph, Hamiltonian path, trees, tree traversals, spanning trees; Functions; mappings; injection and surjections; composition of functions; inverse functions; special functions; Peono postulates; pigeonhole principle; recursive function theory.

UNIT IV (15 Hrs)

Definition and elementary properties of groups, semigroups, monoids, rings, fields, vector spaces and lattices; Elementary combinatorics; counting techniques; recurrence relation; generating functions.

Note: Students shall present solutions to the problems identified by the instructor.

Text Books:

1. Liu C L, 2000, Elements of Discrete Mathematics, 2E, McGraw-Hill.
2. Rosen K H, 2003, Discrete Mathematics and applications, 5E, TMH.
3. Mott J L, Kandel A, Baker T P, 1986, Discrete Mathematics for Computer Scientists and Mathematicians, 2E, PHI.

Reference Books:

1. Stephen A. Wiitala, 1987, Discrete Mathematics: A Unified Approach, McGraw-Hill.
2. Trembly J P, Manohar R, 2004, Discrete Mathematical Structure and applications to computer science, McGraw-Hill.

Computer Organization and Architecture **Credit: 4**

MCA-PG-C202

UNIT I (15 Hrs)

Processor Design: Addition of numbers – carry look-ahead and pre-carry vector approaches, carry propagation-free addition. Arithmetic: Multiplication- using ripple carry adders, carry save adders, redundant number system arithmetic, Booth's algorithm. Division- restoring and non-restoring techniques, using repeated multiplication. Floating-point arithmetic- IEEE 754-1985 format, multiplication and addition algorithms.

UNIT II (15 Hrs)

ALU design, instruction formats, addressing modes.

Control UNIT Design: Hardware control UNIT design, hardware programming language, microprogramming, horizontal, vertical and encoded-control microprogramming, microprogrammed control UNIT design.

UNIT III (15 Hrs)

Pipelining: Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards and structural hazards, techniques for handling hazards. Exception handling. Pipeline optimization techniques; Compiler techniques for improving performance.

Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super pipelined and VLIW processor architectures. Array and vector processors.

UNIT IV (15 Hrs)

Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies.

Multiprocessor architecture: taxonomy of parallel architectures; Centralized shared- memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. Cluster computers.

Text Books:

1. Patterson D A, Hennessy J L, 2012, Computer Organization and Design: The Hardware/Software Interface, Elsevier.
2. Hamachar C, Vranesic Z, Zaky S, 2002, Computer Organization, McGraw Hill.
3. Hayes J P, 1988, Computer Architecture and Organization, McGraw Hill.

Reference Books:

1. Stallings W, 2007, Computer Organization and Architecture: Designing for Performance, Pearson Education. Heuring V P, Jordan H F, 2008, Computer Systems Design and Architecture, Pearson Education.

Operating System **Credit: 4**

MCA-PG-C203

UNIT I (15 Hrs)

Introduction to Operating System: Basic concepts of OS, Evolution of OS; Type of OS: Simple Batch Systems, Multi-programming Systems, Time-Sharing Systems, and Characteristics of OS.

Processes and CPU scheduling: Process Concept, Process states, Process Control Block (PCB), Process scheduling : Long term, Medium term and Short term scheduler, Operation on Processes, System calls, Cooperating Processes, Inter process Communication (IPC).

UNIT II (15 Hrs)

Scheduling: Scheduling criteria, Scheduling algorithms: First Come First Serve (FCFS), Shortest Job First (SJF), Priority Scheduling, Shortest Remaining Time First (SRTF), and Round Robin scheduling (RR).

Memory Management: Logical versus Physical Address Space, Mapping of Logical to Physical address, Swapping, Contiguous Memory Allocation, Paging, Fragmentation: Internal and External and Memory allocation algorithms: First Fit, Best Fit and Worst Fit.

UNIT III (15 Hrs)

Virtual Memory: Demand paging, Page replacement, Page-replacement algorithms: First in First out (FIFO), Least Recently used (LRU), and Optimal Page Replacement.

Process Synchronization: Concurrent Execution, Precedence graph, Critical-Section problem (CSP), Criteria for CSP; Solutions to CSP: Peterson’s solution and Synchronization Hardware, Basics of Semaphores.

UNIT IV (15 Hrs)

Deadlocks: Deadlock characterization: Necessary conditions, Methods of Handling Deadlock, Deadlock Prevention, Deadlock Avoidance: Banker’s Algorithm, Deadlock Detection & Recovery from Deadlock.

Multiprocessor Operating System: The thread concept, Uses of threads, Lightweight processes, examples of threads (POSIX).

Case studies on various OS: UNIX, WINDOWS, RTOS, Distributed OS.

Text Books:

1. Silberschatz, Galvin, 1999, Operating System Concepts, Addition Wesley.
2. Diatel H M, 2000, an Introduction to Operating System, Addition Wiley. Andrew S. Tanenbaum, Modern Operating systems, PHI.

Reference Books:

1. Singhal M, Shivaratri N G, 2001, Advanced Concepts in Operating Systems, Tata McGraw- Hill.
2. Prasad P B, Operating Systems, Scitech Publication.
3. Stallings W, 2012, Operating Systems-Internals and Design Principles, Pearson Education.

Data Structure **Credit: 4**

MCA-PG-C204

UNIT I (15 Hrs)

Introduction and overview: Definition, Classification of data structures (Linear and Non-Linear), Operations on data structures.

Preliminaries: Mathematical notations and functions, Algorithmic notations, control structures, Complexity of algorithms, asymptotic notations for complexity of algorithms. String Processing: Definition, Storing Stings, String as ADT, String operations, word/text processing, Pattern Matching algorithms

UNIT II (15 Hrs)

Sorting and Searching Techniques: Bubble, Selection, Insertion, Shell sorts and Sequential, Binary, Indexed Sequential Searches, Interpolation, Binary Search Tree Sort, Heap sort, Radix sort.

Linked Lists: Representation of linked lists in memory-Operations on linked list (Insertion, Deletion, and Display): Circular linked lists (Insertion, Deletion, Display), doubly linked linear list (Insertion, Deletion, Display): Applications of linked linear lists.

UNIT III (15 Hrs)

Stacks and Queues: Concepts, Operations, sequential and linked implementation, Application of stacks: Towers of Hanoi, Infix, Prefix and Postfix expressions and Evaluation of postfix expression using stacks Queues Concepts, operations, sequential and linked implementation, Linear Queue (FIFO), Circular queues, and application of queues.

Trees: Binary trees, Complete Binary tree, AVL Tree, B Tree, B+ Tree, Binary Search Trees: Searching, Inserting and deleting in Binary Search Trees, Traversals on a BST (In-order, post-order, pre-order, DFS, BFS), Application of Trees.

UNIT IV (15 Hrs)

Hashing: Hashing Techniques: Hash function, Address calculation techniques, Common hashing functions, Collision resolution, Linear probing, Quadratic, Double hashing, Bucket hashing, Deletion and rehashing. Indexing.

Algorithm Design methods-Greedy method-applications-Kruskal's Algorithm for Minimum cost Spanning trees, Job Sequencing with deadlines, Single Source Shortest path problem, Dynamic Programming method-applications-Ordering matrix multiplications, Optimal Binary Search Trees, All Pairs Shortest Paths (APSP) problem.

Text Books:

1. Lipschutz S, Data Structures, 2006, McGraw Hill Education
2. Samanta D, Classic Data Structures, Second Edition,PHI.
3. T. H. Cormen, C. L. Leiserson, R. L. Rivest, and C. Stein, 2001, Introduction to Algorithms, MIT Press,
4. J. Kleinberg and E. Tardos, 2006, Algorithm Design, Addison-Wesley.

Reference Books:

1. Harry R. Lewis, Larry Denenberg, 1991, Data Structures and Their Algorithms, Harper Collins..
2. Gibbons, 1985, Algorithmic Graph Theory, Cambridge University Press.
3. Michael T. Goodrich and Roberto Tamassia, 2006, Algorithm Design: Foundations, Analysis, and InternetExamples, John Wiley. R. Sedgewick, 2001, Algorithms in C: Part 5, Addison Wesley.

Operating System Laboratory **Credit: 4**

MCA-PG-L205

Operating System Laboratory comprises of following experiments:

Experiment 1

I. (a) Study of hardware and software requirements of different Operating Systems available such as Open source OS, Distributed OS, and Embedded OS etc.

Experiment 2

II. Write C program to

(a) Display process ID.

(b) Create process using fork () and return a parent ID.

Experiment 3 (CPU Scheduling Policies)

III. Implement CPU scheduling policies:

(a) FCFS (With same arrival time for all processes).

(b) FCFS (With different arrival time for all processes).

(c) SJF (With same arrival time for all processes).

(d) SJF (With different arrival time for all processes) i.e. SRTF.

(e) Priority scheduling.

(f) Round Robin (With same arrival time for all processes).

(g) Round Robin (With different arrival time for all processes).

Experiment 4 (Contiguous Allocation Techniques)

IV. Implementation of Contiguous allocation techniques:

(a) Best-Fit

(b) First-Fit

(c) Worst-Fit

Experiment 5 (Page Replacement Algorithm)

V. Implementation of Page Replacement techniques:

(a) FIFO page replacement.

(b) LRU page replacement.

(c) Optimal page replacement.

Experiment 6 (Bankers Algorithm)

VI. Implementation of Banker's Algorithm.

Experiment 7 (Semaphore)

VII. Implementation of Producer Consumer problem using Semaphore.

Experiment 8 (Readers Writers Problem, Dining Philosopher's Problem)

VIII. Implementation of problems such as:

(a) Readers Writers.

(b) Dining Philosopher's.

Experiment 9 (Orientation with different types of OS)

VIII. Implementation of problems such as:

(a) Real-time OS.

(b) Distributed OS.

Data Structure Laboratory **Credit: 4**

MCA-PG-L206

Laboratory Experiments

1. Write a program to calculate the factorial and Fibonacci series of given number using recursive function.
2. Write a program to use macros as an array and pointers.
3. Write a program to implement linear and binary search also find the location of its first occurrence
4. Write a program to sort the array in ascending/descending order using a) Quick sort b) Merge sort
5. Write a Program to perform the basic Matrix operations like add, subtract multiply, transpose.
6. Write a program to create a linked list and to perform insert and delete operations (insert at beginning, at last, at any position and same for delete function)
7. Write a program to add two polynomials using a linked list.
8. Write a program to perform insert and delete operations in a circular linked list.
9. Write a program to perform operations on a stack (linked list and array implementation)
10. Write a program to solve the problem of towers of Hanoi with 3 pegs and N discs.
11. Write a program to perform operations on a circular queue (linked list implementation).
12. Write a program to implement string functions.
13. Write a program to convert the given infix expression into its postfix form.
14. Write a program to evaluate the postfix expression with a set of values.
15. Write a program to devise an expression tree for any given arithmetic expression.
16. Write a menu driven program to create binary tree and to perform insert and delete operations.
17. Write a menu driven program to create a binary search tree and to perform inorder, preorder and postorder traversals (recursive and non-recursive)
18. Write a program sort the array of N elements using Heap Sort.
19. Write a program to implement sorting and searching techniques.
20. Write a program which reads the record of a new employee and inserts the record into the file.
21. Design a linked list data structure to represent the node of an m-way search tree. Write functions like Search_Mway, Insert_Mway and Delete_Mway to perform search, insert and delete operations.
22. Write a program to delete a given ITEM from the AVL search tree T.
23. Write a C program to implement all the functions of a dictionary (ADT) using hashing.
24. Write a c program to implement Kruskal's Algorithm.

Strategic Management **Credit: 4**

MCA-PG-C301

UNIT I (15 Hrs)

Introduction to Strategic Management: Define Strategy, Strategic Management Process, Levels of Strategies: Corporate, Business and Operational level, Types of Strategies: Functional Strategies, H. R Strategy, Marketing strategy, Financial Strategy, Operational Strategy.

Formulation of Strategy and Strategic Implementation: Business Environment, Components of Environment, Environmental Scanning, Analysis of Strategies and Choice of Strategy.

UNIT II (15 Hrs)

Business, Corporate and Global Strategies: Practices and Issues: Introduction to Corporate Restructuring, Need for corporate restructuring and forms of corporate restructuring.

Evaluation of Strategic Alternatives, Types of Strategic Alternatives like Portfolio, Analysis and its techniques, SWOT Analysis, Profit Impact of Market Strategy (PIMS).

UNIT III (15 Hrs)

Culture of Organization: Management of Strategies and Cultures, Strategies for Foreign Direct Investment and International Trade in India

New Emerging Strategies in Information Communication Technology (ICT): Concept of Outsourcing, Strategic Reasons of growing Outsourcing in India.

UNIT IV (15 Hrs)

MIS: Meaning of Management Information system (MIS), Strategic MIS, Characteristics of Strategic MIS System and Barriers to Successful Development of Strategic MIS System.

Business firms using Information Technology for creating Strategic Advantages: Reengineering Business Processes, Virtual Company Strategies, knowledge creating Company Emerging Strategies in Telecommunication Sector.

Text Books:

1. Carpenter M A, Sanders W G, Salwan P, 2004, Strategic Management, A Dynamic Perspective - Concepts and Cases, Dorling Kindersley (India) Pvt Ltd, Pearson Education.
2. Barney, J B, Hesterly W S, 2008, Strategic Management and Competitive Advantage-Concepts, PHI Learning Private Limited.
3. Michael V P, 2009, Globalization, Liberalization and Strategic Management.

Reference Books:

1. Lomash S, Mishra P K, 2005, Business Policy and Strategic Management, Vikas Publishing House Pvt. Ltd.
2. David F R, 2008, Strategic Management, Prentice Hall International.

Formal Language and Automata Theory **Credit: 4**

MCA-PG-C302

UNIT I (15 Hrs)

Introduction: Mathematical preliminaries, Alphabet, Grammars, Languages, Productions and Derivation, Transition functions, Transition graph, Transition table, Finite Automata: Deterministic Finite Automata (DFA) and Non-Deterministic Finite automata (NFA), Design of NFA and DFA, NFA and its equivalence with DFA, Minimization of FA, Regular set, Regular Expressions (RE), Regular Grammar, Regular Languages, FA and its equivalence with RE and its design, Properties of Regular Languages, Pumping Lemma for Regular Languages.

UNIT II (15 Hrs)

Context Free Languages (CFL) and Pushdown Automata (PDA): Context-free grammars (CFG) and languages (CFL), Simplification of CFG, Normalization and Normal Forms: Chomsky Normal Form (CNF) and Greibach Normal Form (GNF), Non-Deterministic Pushdown Automata (NPDA) and equivalence with CFG, Parsing, Parse trees, Ambiguity in CFG, Deterministic Pushdown Automata, and closure properties of CFLs, Parsing the CFG to generate parse tree using any parser.

UNIT III (15 Hrs)

Context Sensitive Languages: Context Sensitive Grammars (CSG) and Languages (CSL).

Turing Machines: The basic model for Turing machines (TM), Turing-recognizable (recursively enumerable) and Turing-decidable (recursive) languages and their closure properties, Variants of Turing machines.

UNIT IV (15 Hrs)

Undecidability: Church-Turing thesis, Universal Turing machine, the universal and diagonalization languages, reduction between languages and Rice’s theorem, undecidable problems about languages.

Text Books:

1. Lewis H R, Papadimitriou C H, 1988, Elements of the Theory of Computation, Pearson Education Asia.
2. Hopcroft J E, Motwani R, Ullman J D, 2008, Introduction to Automata Theory, Languages, and Computation, Pearson Education Asia.
3. Kozen D C, 1997, Automata and Computability, Undergraduate Texts in Computer Science, Springer.

Reference books:

1. Sipser M, 2012, Introduction to the Theory of Computation, PWS Publishing.
2. Martin J, 2010, Introduction to Languages and The Theory of Computation, Tata McGraw Hill.

Object Oriented Programming using Java **Credit: 4**

MCA-PG-C303

UNIT I (15 Hrs)

Introduction to UML: History; Goals; Tour of the Views, Diagrams, Model Elements and Mechanisms; Use case modeling (use case diagrams, actors, relationships); Modeling classes (class diagrams, associations, generalizations, dependencies, constraints).

Introduction to Java: Features of Java, Object Oriented Concepts, Lexical Issues, Data Types, Variables, Arrays, Operators, Control Statements.

UNIT II (15 Hrs)

Classes: Objects, Constructors, Overloading method: Static methods, Inner Classes, String Class, Inheritance, Overriding methods using super, Abstract class.

Packages and I/O: Access Protection, Importing Packages, Interfaces, Exception Handling: Throw and Throws, Thread, Synchronization, Runnable Interface, Deadlock: Suspending, Resuming and stopping threads, Multithreading.

UNIT III (15 Hrs)

The Java Library: String Handling, Exploring java.lang, java.util: The Collections Framework, Utility Classes, Input/Output: Exploring java.io, Exploring NIO, Networking, The Applet Class, Event Handling.

Introducing the AWT: Working with Windows, Graphics, and Text, AWT Controls, Layout Managers, and Menus, Images, The Concurrency Utilities, Regular Expressions.

UNIT IV (15 Hrs)

J2EE: Architectural overview, J2EE database, JDBC objects, Understanding Java Server Pages, Enterprise JavaBeans, containers and servers; entity vs. Session beans, XML deployment descriptors, Java Swing.

Sockets: Introduction to java sockets, Concurrent client-server, Iterative client-server.

Text Books:

1. Cornell G, Horstmann C S, 2012, Core Java: Advanced Features, Pearson, 9E.
2. Naughton R, Schildt H, 2007, Java The Complete Reference, TMH, 8E.
3. Balagurusamy E, 2009, Programming with Java: A Primer, TMH.

Reference Books:

1. Young B J, Maksimchuk R A, Engel M W, Houston K A, Booch G, Conallen J, 2008, Object-Oriented Analysis and Design with Applications, Pearson.
2. Keogh J. 2011, J2Ee: The Complete Reference, TMH, 1E.

Microprocessor and Microcontroller **Credit: 4**

MCA-PG-C304

UNIT I (15 Hrs)

Introduction: Historical background; organization and architectural features of microprocessor and microcontrollers; the instruction set: instruction format, addressing modes; assembly language programming with 8085. Analysis of timing diagram of various Opcodes.

UNIT II (15 Hrs)

8085: Interfacing of memory devices (R/W memory, ROM); Data transfer techniques; Memory mapped I/O, I/O mapped I/O; Interfacing with 8155 and 8255; interfacing of keyboard and display devices; Introduction to Programmable interrupts (TRAP, RST 7.5, RST 6.5, RST5.5, INTR) and DMA controllers.

UNIT III (15 Hrs)

Study and programming of advanced microcontroller: Arduino (AT Mega based), Raspberry Pi (ARM based) and Intel Galileo (Intel® Quark SoC X1000 based). Concepts of FPGA boards. Introduction to Embedded C language and programming.

UNIT IV (15 Hrs)

Accessories: Introduction to sensors and transducers, A/D and D/A Converters, data acquisition systems, standard interfaces - RS232, USB (A/B), RJ 45 etc.

Text Books:

1. Kumar N S, Saravanan M, Jeevananthan S, 2010, Microprocessors and Microcontrollers, Oxford University. Gaonkar R, 2002, Microprocessor Architecture, Programming, and Applications with the 8085, Penram. Banzi M, 2011, Getting Started with Arduino, Make, O’Reilly.

Reference Books:

1. Margolis M, 2011, Arduino Cookbook, O’Reilly. Richardson M, Wallace S, 2012, Getting Started with Raspberry Pi, O’Reilly.

2. Hohl W, 2009, ARM Assembly Language: Fundamentals and Techniques, CRC. Symes D, 2011, ARM System Developer’s Guide: Designing and Optimizing System Software, MK.

Object Oriented Programming using Java Laboratory **Credit: 4**

MCA-PG-L305

Laboratory Experiments

1. Write a Java Program to take and display the student's details to illustrate class, objects.
2. Write a Java Program to display multiplication table using arrays.
3. Write a Java Program to find the area, parameter of a circle and square using constructor.
4. Write a Java Program to calculate the percentage of the students mark and grade their points to implement method overriding.
5. Write a Java Program to add and display the book details in the library using inheritance.
6. Write a Java Program to make a calculator implementing the concept of Exception Handling.
7. Write a Java Program to run three threads.
8. Write a Java program for sorting a given list of names.
9. Write a Java program to calculate the length of the string, to append a string, delete a string and to find a string at a given position using String Buffer class and its methods.
10. Design an applet to display your Bio-data.
11. Write a Java Program using applet for configuring Applets by passing parameters.
12. Write a Java Program to create Arithmetic Math Calculator Using Applet Class and Event Handling.
13. Write an applet program to design a smiley.
14. Write a Java program to create frame that displays the student information.
15. Write a Java program using java controls to design a calculator.
16. Write a Java Program using Graphics class:

i. Display basic shapes and fill them with colors.

ii. Set background and foreground colors.

17. Write a Java Socket programming to perform addition of two numbers.
18. Write a Java Servlet program to download a file and display it on the screen (a link has to be provided in html when the link is clicked corresponding file has to be displayed on screen).
19. Write a JSP program to print even and odd number.
20. Write a JSP program to design a login page.

Hardware Design Laboratory **Credit: 4**

MCA-PG-L306

Microprocessor Laboratory: Assembly language programming using 8085. Exercises to be done based on Delay, Stack, Subroutine, Arithmetic, Interrupts etc. Assembly language programming based on 8085 may be studied

On simulators as well as kits.

Microcontroller Laboratory: Introduction and familiarization with AT Mega, ARM and Intel microcontrollers.

Project: Attention should be given on Arduino, Raspberry Pi, and Intel Galileo based application development like sensor (temperature, flex, gyro, light, etc.), actuator (lcd, dc motor, stepper motor, relay etc.). Priority should be given on web based application development. Android APP may also be included while developing a system.

Intellectual Property Rights & Professional Ethics **Credit: 4**

MCA-PG-C401

UNIT I (15 Hrs)

Introduction: Invention and Creativity, Intellectual Property (IP), Protection of IPR, Basic types of property: Movable Property, Immovable Property and Intellectual Property.

IP Patents: Copyrights and related rights, Trade Marks and rights arising from Trademark registration: Definitions, Industrial Designs and Integrated circuits: Protection of Geographical Indications at national and International levels, Application Procedures.

UNIT II (15 Hrs)

Indian Position Vs WTO and Strategies: Indian IPR legislations, commitments to WTO, Patent Ordinance and the Bill, Draft of a national Intellectual Property Policy, Present against unfair competition.

Case Studies on: Patents, Copyright and related rights, Trade Marks, Industrial design and Integrated circuit, Geographic indications, Protection against unfair competition.

UNIT III (15 Hrs)

Senses of 'Engineering Ethics': Variety of moral issues , Types of inquiry , Moral dilemmas , Moral Autonomy , Kohlberg's theory, Gilligan's theory, Consensus and Controversy , Professions and Professionalism, Professional Ideals and Virtues, Uses of Ethical Theories.

UNIT IV (15 Hrs)

Safety and Risk: Assessment of Safety and Risk – Risk Benefit Analysis, Reducing Risk, The Government

Regulator's Approach to Risk

Responsibilities and Rights: Collegiality and Loyalty, Respect for Authority, Collective Bargaining, Confidentiality, Conflicts of Interest, Occupational Crime, Professional Rights, Employee Rights, Intellectual Property Rights (IPR) Discrimination.

Note: Concern faculty shall provide the necessary information and demonstration if required to show how a Patent is

Filed in India or Abroad.

Text Books:

1. Subbaram N R, 1998, Handbook of Indian Patent Law and Practice, S. Viswanathan Printers and Publishers.
2. Martin M, Schinzinger R, 2005, Ethics in Engineering, McGraw Hill.
3. Harris C E, Pritchard M S, Rabins M J, 2000, Engineering Ethics–Concepts and Cases, Thompson Learning.

Reference Books:

1. Fleddermann C D, 1999, Engineering Ethics, Prentice Hall, New Mexico.
2. Boatright J R, 2003, Ethics and the Conduct of Business, Pearson Education.
3. Seebauer E G, Barry R L, 2001, Fundamentals of Ethics for Scientists and Engineers, Oxford University Press.

Database Management System **Credit: 4**

MCA-PG-C402

UNIT I (15 Hrs)

Introduction: Database, Database Management System (DBMS), Database system environment, data abstraction, instances and schemas, DBMS features, Advantages of DBMS over Traditional File Processing System, Data Definition Language (DDL), Data Manipulation Languages (DML), Actors on the scene, Workers behind the scene, Client-Server: Two-tier, Three-tier architecture, DBMS classifications.

Entity-Relationship model: Various components of ER diagram, mapping constraints, E-R diagram, reducing E-R diagrams to tables.

UNIT II (15 Hrs)

Relational model: Structure of a relational database, operation on relations, Salient feature of a query language, Structured Query Language (SQL): Features, Various DDL and DML commands.

Normalization: Pitfalls in RDBMS, Importance of Normalization, and Various Normal Forms based on Primary Key, Based on any Key: First Normal Form (1NF), Second Normal Form (2NF), Third Normal Form (3NF), Boyce-Codd Normal Form (BCNF).

UNIT III (15 Hrs)

Transaction: Transaction and System Concepts, Transaction states, Desirable properties of Transactions (ACID), Schedules and Recoverability, Lock-Based Protocols: Locks, Granting of Locks, and Two phase locking protocol and implementation of locking.

Importance of Database Tuning and Query Optimization: Index selection and clustering, Importance of query processing, equivalence of queries, cost Estimation for processing a query,

Brief Introduction to hierarchical and network model: Data description and tree structure diagram for hierarchical model, retrieval and update facilities, and limitations.

UNIT IV (15 Hrs)

Object oriented model: Nested relations, modeling nested relations as object model, extension of SQL, object definition and query language (ODL, OQL), and object relational database model, storage and access methods. Active databases, advanced trigger structures, SQL extensions.

Distributed Database: Basic Structure, Fragmentation algorithms, trade-offs for replication, query processing, recovery and concurrency control; Multi-database systems; Design of Web Databases.

Text Books:

1. Silberschatz A, Korth H, Sudarshan S, 2010, Database System Concepts, McGraw-Hill.
2. Ramakrishnan R, 2003, Database Management Systems, WCB/McGraw-Hill.
3. Ullman J D, 1989, Principles of Database Systems, Galgotia.

Reference Books:

1. Elmasri R, Navathe S, 2008, Fundamentals of Database Systems, Addison-Wesley.
2. Desai B, 1990, An Introduction to Database Systems, Galgotia.
3. Abiteboul S, Hull R, Vianu V, 1995, Foundations of Databases. Addison-Wesley.

Advanced Web Programming **Credit: 4**

MCA-PG-C403

UNIT I (15 Hrs)

Introduction: Overview and evolution of Internet programming and application tools.

Search Mechanisms: Search Engine, Crawler Technology, Filtering Technology Content based Searching, Agent Technology, Internet Robot.

Markup Languages and: HTML5, JavaScript, XML and related concepts.

UNIT II (15 Hrs)

Web Programming PHP: Features of PHP: String, Objects, File handling, Database connectivity, Graphics, AJAX, RSS feed.

UNIT III (15 Hrs)

Web Programming Python: Features of Python: HTML integration, String, Objects, , Functional Programming, File handling, Regular Expression, Client Programming, Multi thread Programming, GUI programming, Database connectivity.

UNIT IV (15 Hrs)

Advance Internet applications: Data and Web mining; e-commerce; Distributed Objects – component object model, common object request broker architecture, Web security.

Text Books:

1. Jackson, 2007.Web Technologies: A Computer Science Perspective, Pearson, 2007.
2. Holzner S, 2007. Php: The Complete Reference, TMH.
3. Murach J, 2008. Andrea Steelman, Murach's Java Servlets and JSP, Murach's, 2E.
4. Hoekman Jr. R, 2004. Java Servlet & JSP Cookbook, Schorr Pub.

Reference Books:

1. David L., Comer Douglas E., 2009. Internetworking With TCP/IP: Design, Implementation, And Internals, 3E, Prentice Hall.
2. Pascal H, Markus K, Sebastian R, 2009. Foundations of Semantic Web Technologies, Chapman and Hall/ CRC.
3. Jamsa K, 2002. Konrad King, HTML & Web Design, TMH Publications.
4. Hunter J, 2010. William Crawford, Servlet Programming, O'REILY.

Software Engineering **Credit: 4**

MCA-PG-C404

UNIT I (15 Hrs)

Introduction to Software Engineering: The software engineering discipline-evaluation and impact, Programs vs. software products, Why study of software engineering, Emergence of software engineering, Notable changes in software development practice, Computer system engineering.

Software life cycle: Life Cycle Models: Classical waterfall model, Iterative waterfall model, Prototype model, Evolutionary model, Spiral model, RAD model, comparison of different life cycle models.

UNIT II (15 Hrs)

Software Project Management: Responsibilities of project manager, Project planning, Metrics for project size estimation, Project estimation techniques-Empirical estimation and Heuristic estimation, Staffing Level Estimation, Putnam's Model.

Software Requirements Specification: Contents and Organization of the SRS Document, Functional Requirements, Traceability, Characteristics of a Good SRS Document. Case study on IEEE standard 830 for Software requirement specification (SRS).

UNIT III (15 Hrs)

Design Concepts: Cohesion and coupling, Control Hierarchy: Layering, Control Abstraction, Depth and width, Fan-out, Fan-in, Software design approaches, object oriented vs. function oriented design.

Function Oriented Design: Overview of SA/SD methodology, Structured analysis, Data flow diagram, Extending DFD technique to real life systems, Structured design, detailed design, Design review.

Object Oriented Design: Key Concepts Unified Modelling Language (UML), UML Diagrams, Use Case Diagram, Sequence Diagram, Activity Diagram, State Diagram and Class Diagram.

UNIT IV (15 Hrs)

Coding, Testing and Maintenance: Coding guidelines and standards, Block Box Testing, White Box Testing, Unit Testing, Integration testing, System testing. Software Maintenance Models, estimation of maintenance cost.

Software reliability and quality management: Software reliability, Statistical testing, Software quality, Software quality management system, ISO 9000, SEI capability maturity model, Personal software process (PSP), Six sigma, Software quality & Metrics

Note: Each student should be given about 3-4 assignments on SRS, design, testing and allied problems. Different students should be asked to use different tools.

Text Books:

1. Mall R, 2005, Fundamentals of Software Engineering, Prentice Hall of India.
2. Jalote P, 2005, An Integrated Approach to Software Engineering, 3E, Narosa Publishing House.
3. Fairley R, 2006, Software Engineering Concepts, Tata McGraw Hill.

Reference Books:

1. Pressman R S, 2005, Software Engineering: A practitioner's approach, McGraw Hill. Somerville, 2012, "Software Engineering", Pearson

Database Management System Laboratory **Credit: 4**

MCA-PG-L405

EXERCISE 1

Title of the Exercise: DATA DEFINITION LANGUAGE (DDL) COMMANDS

AIM OF THE EXPERIMENT: To practice and implement data definition language commands and constraints.

Q1. Create a table called EMP with the following structure.

Name	Type
EMPNO	NUMBER (6)
ENAME	VARCHAR2 (20)
JOB	VARCHAR2 (10)
DEPTNO	NUMBER (3)
SAL	NUMBER (7, 2)

Allow NULL for all columns except ename and job.

Q2: Add a column experience to the EMP table.

Q3: Modify the column width of the job field of EMP table.

Q4: Create dept table with the following structure.

Name	Type
DEPTNO	NUMBER (2)
DNAME	VARCHAR2 (10)
LOC	VARCHAR2 (10)

DEPTNO as the primary key

Q5: create the EMP1 table with ename and empno; add constraints to check the empno value while entering (i.e) empno > 100.

Q6: Drop a column experience from the EMP table.

Q7: Truncate the EMP table and drop the dept table

EXERCISE 2

Title of the Exercise: DATA MANIPULATION LANGUAGE (DML) COMMANDS

AIM OF THE EXPERIMENT: To study the various DML commands and implement them on the database.

Q1: Insert a single record into dept table.

Q2: Insert more than a record into EMP table using a single insert command.

Q3: Update the EMP table to set the salary of all employees to Rs15000/- who are working as ASP.

Q4: Create a pseudo table employee with the same structure as the table EMP and insert rows into the table using select clauses.

Q5: Select employee name, job from the EMP table

Q6: Delete only those who are working as lecturer

Q7: List the records in the EMP table order by salary in ascending order.

Q7: List the records in the EMP table order by salary in ascending order.

Q8: List the records in the EMP table order by salary in descending order.

Q9: Display only those employees whose deptno is 30.

Q10: Display deptno from the table employee avoiding the duplicated values.

EXERCISE 3

Title of the Exercise: DATA CONTROL LANGUAGE (DCL), TRANSACTION CONTROL LANGUAGE (TCL) COMMANDS

AIM OF THE EXPERIMENT: To study the various data language commands (DCL, TCL) and implements them on the database.

Q1: Develop a query to grant all privileges of employees table into departments table.

Q2: Develop a query to grant some privileges of employees table into departments table.

Q3: Develop a query to revoke all privileges of employees table from departments table.

Q4: Develop a query to revoke some privileges of employees table from departments table.

Q5: Write a query to implement the save point.

Q6: Write a query to implement the rollback.

Q6: Write a query to implement the commit.

EXERCISE 4

Title of the Exercise: IN BUILT FUNCTIONS

AIM OF THE EXPERIMENT: To perform nested Queries and joining Queries using DML command.

Q1: Display all the details of the records whose employee name starts with ‘A‘.

Q2: Display all the details of the records whose employee name does not starts with ‘A‘.

Q3: Display the rows whose salary ranges from 15000 to 30000.

Q4: Calculate the total and average salary amount of the EMP table.

Q5: Count the total records in the EMP table.

Q6: Determine the max and min salary and rename the column as max_salary and min_salary.

Q7: Display the month between 1-jun-10 and 1-aug-10 in full.

Q8: Display the last day of that month in 05-Oct-09.

Q9: Find how many job titles are available in employee table.

EXERCISE 5

Title of the Exercise: NESTED QUERIES AND JOIN QUERIES

AIM OF THE EXPERIMENT: To perform nested Queries and joining Queries using DML command.

Q1: Display all employee names and salary whose salary is greater than minimum salary of the company and job title starts with 'M'.

Q2: Issue a query to find all the employees who work in the same job as Arjun.

Q3: Issue a query to display information about employees who earn more than any employee in dept 1.

Q4: Display the employee details, departments that the departments are same in both the EMP and dept. [EQUIJOIN]

Q5: Display the employee details, departments that the departments are not same in both the EMP and dept. [NON-EQUIJOIN]

Q6: Display the Student name and grade by implementing a left outer join.

Q7: Display the Student name, register no, and result by implementing a right outer join.

Q8: Display the Student name register no by implementing a full outer join.

Q9: Write a query to display their employee names. [Self-Join]

Q10: Display the details of those who draw the salary greater than the average salary.

EXERCISE 6

Title of the Exercise: PL/SQL

AIM OF THE EXPERIMENT: To write various programs using PL/SQL.

EXERCISE 7

Title of the Exercise: Database connectivity using XAMPP server or any other.

AIM OF THE EXPERIMENT: To Write a program in PHP or any other programming language to establish database connectivity.

Advanced Web Programming Laboratory **Credit: 4**

MCA-PG-L406

Laboratory Experiments

1. Create a simple html file to demonstrate the use of different tags.
   a. Headings (h1 to h6)
   b. Paragraph.
   c. Line Break.
   d. Pre tag.
   e. Different logical style (<b>,<i>,<sub>,<sup>).
   f. Listing tags.
2. Create a HTML paragraph to illustrate the use of following commands
   a. Changing Direction of Text.
   b. Citation
   c. Abbreviations
   d. Mark
   e. Acronyms
   f. Strong Text
3. To create an html file to link to different html page which contains images, tables, and also link within a page.
4. Create a registration form having the following elements.
   a. Submit button.
   b. Radio element.
   c. Text element.
   d. Reset button.
   e. Password.
   f. Datalist.
   g. Select.
5. Create an html file by applying the different styles using inline, external & internal style sheets.
6. Write a javascript program to define user defined function for sorting the elements of an array.

7. Write a javascript program to display time on your page.
8. Create an HTML page to explain the use of various predefined functions in a string and math object in javascript.
9. Display calendar using javascript code by getting year from the user.
10. Create a html registration form and validate the form using javascript code.
11. Write an XML file which will display the Book information which includes the following:
    a) Title of the book
    b) Author Name
    c) ISBN number
    d) Publisher name
    e) 0Edition
    f) Price
12. Write a Document Type Definition (DTD) to validate the above XML file. Display the XML file as follows. The contents should be displayed in a table. The header of the table should be in color GREY. And the Author names column should be displayed in one color and should be capitalized and in bold. Use your own colors for remaining columns. Use XML schemas XSL and CSS
13. Show how to use PHP to validate form data.
14. Write a PHP program to store current date ,time in a COOKIE and display the 'last visited on' date and time on the webpage upon reopening of the same webpage.
15. Install a database (Mysql or Oracle). Create a table which should contain at least the following fields: name, password, email-id, phone number (these should hold the data from the registration form). Write a PHP program to connect to that database and extract data from the tables and display them. Experiment with various SQL queries. Insert the details of the users who register with the web site, whenever a new user clicks the submit button in the registration page.
16. Write a python program to merge mails.
17. Write a python program to find hash of file.
18. Write a python program to find the resolution of a image.
19. Demonstration of preprocessing on dataset.
20. Demonstration of association rule on dataset using apriori algorithm.
21. Demonstration of classification rule on dataset using naïve bayes algorithm.
22. Demonstration of clustering rule on dataset using simple k means .

Computer Networks **Credit: 4**

MCA-PG-C501

UNIT I (15 Hrs)

Introduction: Introduction of network, topology, Use of computer network, network hardware: LAN, WAN, MAN, Wireless Network, Reference Models: ISO-OSI model, TCP model.

Physical layer: Transmission media-Magnetic Media, Twisted Pair, Coaxial pair, Fiber Optics, Line coding and multiplexing.

UNIT II (15 Hrs)

Data link layer: Data link layer design Issue, Error Detection and correction, Elementary Data link protocol, Stop-and-Wait ARQ, Sliding Window, Go-back-n, Selective Repeat ARQ.

Mac sub layer: Multiple Access protocol: ALOHA, Slotted ALOHA, CSMA protocols, Introduction to MAC Protocols: 802.3, 802.4, 802.5, 802.11 b/g/n.

UNIT III (15 Hrs)

Network layer: Network Design Issue, Routing algorithm-introduction, optimality Principle, Shortest Path, Flooding, Distance Vector Routing. Congestion Control Routing: General principle of Congestion control, leaky bucket algorithm, Token Bucket Algorithm.

TCP/IP: TCP/IP architecture, the Internet Protocol, ARP, DHCP and mobile IP, Internet routing protocols:- RIP, OSPF, BGP. TCP/IP Implementation related case studies to be studied.

Transport layer: Transport Services, Element of transport protocols, TCP, UDP, TCP congestion control & Timer management.

UNIT IV (15 Hrs)

Application layer: DNS, SMTP, POP3, FTP, TELNET, HTTPS, SNMP.

Network Security: Introduction to Cryptography, Certificates, Firewalls.

Wireless and mobile communication: Wireless transmission, cellular radio, Gigabit and Terabit technology, CDMA, WCDMA.

Text Books:

1. Stallings W, 2007. Data and Computer Communication, Prentice Hall of India
2. Forouzan B A, 2007, Data Communication and Networking, McGraw-Hill.
3. Tanenbaum A S, 2008, Computer Networks, Prentice Hall.
4. Comer D, 2006, Internetworking with TCP/IP, Prentice Hall of India, Vol.1.

Reference Books:

1. Stevens W R, 2011, TCP/IP Illustrated: The Protocol, Volume 1, Addison-Wesley.
2. Stallings W, 2008, Cryptography and Network Security: Principles and Practice, PHI.
3. Koblitz N, 2008, A course in number theory and cryptography, Springer.

Elective I **Credit: 4**
MCA-PG-E5XX

Cloud Computing **Credit: 4**
MCA-PG-E504

UNIT I (15 Hrs)

Data Centre foot prints & Concepts.

Introduction To cloud: Virtualization Concepts: Types of Virtualization & its benefits, Introduction to Various Virtualization OS such as Vmware, KVM etc, HA/DR using Virtualization, Moving VMs, SAN backend concepts .

UNIT II (15 Hrs)

Cloud Fundamentals: Cloud Building Blocks, Understanding Public & Private cloud environments.

Cloud as IaaS: Private Cloud Environment: Basics of Private cloud infrastructure, QRM cloud demo.

UNIT III (15 Hrs)

Public Cloud Environment: Understanding & exploring Amazon Web services, Managing and Creating Amazon EC2 instances, Managing and Creating Amazon EBS volumes, Tata Cloud details & demo.

Managing Hybrid Cloud environment.

Big Data, IoT and Cloud.

UNIT IV (15 Hrs)

Setting up your own Cloud: How to build private cloud using open source tools, Understanding various cloud plugins, setting up your own cloud environment, Auto provisioning, Custom images, integrating tools like Nagio, Integration of Public and Private cloud.

Future directions: Cloud Domain and scope of work, Cloud as PaaS, SaaS, Cloud Computing Programming Introduction, Trends and market of cloud.

Note: Practice on available cloud platforms shall be done by the students. New architecture based cloud could be designed.

Text Books:

1. Kavis M J, 2014, Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, & IaaS), Wiley.
2. Gonzales D, 2010, Cloud Computing Bible: A Practical Approach To Cloud Computing Security, CloudProblems To Be Aware of and More, Kindle E.
3. Erl T, 2013, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall.

Reference Books:

1. Nielsen L, 2014, The Little Book of Cloud Computing, Kindle E.
2. Guy Bunker G, Thomson D, 2006, Delivering Utility Computing, John Wiley & Sons.
3. Reese G, 2009, Cloud Application Architectures, O'Reilly.
4. Gillam L, 2010, Cloud Computing: Principles, Systems and Applications, Springer.

Operation Research **Credit: 4**

MCA-PG-E505

UNIT I (15 Hrs)

Operations Research: Uses, Scope and Applications of Operation Research in managerial decision-making.

Decision-making environments: Decision-making under certainty, uncertainty and risk situations; Decision tree approach and its applications.

UNIT II (15 Hrs)

Linear programming: Mathematical formulations of LP Models for product-mix problems; graphical and simplex method of solving LP problems; sensitivity analysis; duality.

Transportation problem: Various methods of finding Initial basic feasible solution and optimal solution. Assignment model: Algorithm and its applications.

UNIT III (15 Hrs)

Game Theory: Concept of game; Two-person zero-sum game; Pure and Mixed Strategy Games; Saddle Point; Odds

Method; Dominance Method and Graphical Method for solving Mixed Strategy Game.

Sequencing Problem: Johnsons Algorithm for n Jobs and Two machines, n Jobs and Three Machines, Two jobs and m - Machines Problems.

UNIT IV (15 Hrs)

Queuing Theory: Characteristics of M/M/I Queue model; Application of Poisson and Exponential distribution in estimating arrival rate and service rate; Applications of Queue model for better service to the customers.

Replacement Problem: Replacement of assets that deteriorate with time, replacement of assets which fail suddenly. Project Management. Rules for drawing the network diagram, Applications of CPM and PERT techniques in Project planning and control; crashing of operations.

Text Books:

1. Taha H, 2008, Operations Research - An Introduction, Prentice-Hall.
2. Panneerselvam R, 2006, Operations Research, EEE.

Reference Books:

1. Kothari, 2009, Quantitative Techniques, Vikas.
2. Kapoor V K, 2005, Operations Research, S. Chand.
3. Hiller F. and Leibermann G. J., 2001, Operation Research, Holder Day Inc.

Wireless Sensor Network **Credit: 4**

MCA-PG-E506

UNIT I (15 Hrs)

Motivation for a Network of Wireless Sensor Nodes and Its Applications

Definitions and background; sensing and sensors-sensor classification, wireless sensor networks; applications of wireless sensor networks; Difference between WSNs and Ad Hoc Wireless Networks challenges and constraints-energy, self-management, wireless networking, decentralized management, design, constraints, security, other challenges

Node Architecture and Operating System: sensing subsystem, the processor subsystem, communication interfaces, the IMote node architecture, operating systems - functional aspects, nonfunctional aspects; prototypes-TinyOS

UNIT II (15 hrs)

Physical Layer: Basic components, source encoding, channel encoding, modulation, signal propagation

Medium Access Control : overview, wireless MAC Protocols - Carrier Sense Multiple Access, Multiple Access with Collision Avoidance (MACA) and MACAW , MACA By Invitation, IEEE 802.11, IEEE 802.15.4 and ZigBee; Characteristics of MAC Protocols in Sensor Networks, Contention-Free MAC Protocols, Contention-Based MAC Protocols, Hybrid MAC Protocols

UNIT III (15 Hrs)

Network Layer: overview, categories of routing protocol, routing metrics, flooding and gossiping, data-centric routing- sensor protocols for information via negotiation, directed diffusion, rumor routing, gradient-based routing; proactive routing-destination sequenced distance vector, optimized link state routing; on-demand routing-ad hoc on-demand distance vector, dynamic source routing; hierarchical routing, location-based routing

Node and Network Management: power management- local power management, dynamic power management, architectural overview; time synchronization- clocks and the synchronization problem, time synchronization in wireless sensor networks, Sensor Database Challenges, In Network Aggregation, and Temporal Data.

UNIT IV (15 hrs)

Localization: overview, ranging techniques, range-based localization- triangulation, GPS-based localization; range-free localization- ad hoc positioning system (APS); event-driven localization

Security : Fundamentals of network security, challenges of security in wireless sensor networks, security attacks in sensor networks, protocols and mechanisms for security, IEEE 802.15.4 and ZigBee security

Text Books:

1. Dargie W, Poellabauer C, 2009, Fundamentals of Wireless Sensor Networks: Theory and Practice, Wiley.
2. Zheng J, Jamalipour A, 2008, Wireless Sensor Networks: A Networking Perspective, Wiley.
3. Zhao F, Guibas L, 2010, Wireless Sensor Networks: An Information Processing Approach, Elsevier.

Reference Books:

1. Karl H, Willig A, 2008, Protocols and Architectures for Wireless Sensor Networks, Wiley.
2. Faludi R, 2006, Building Wireless Sensor Networks, O’Reilly Publication.

Compiler Design **Credit: 4**

MCA-PG-E507UNIT I (15 Hrs)

Introduction: Phases of compilation and overview Lexical Analysis (scanner): Regular language, Finite Automata, Regular Expression, Regular Languages, Regular expression to Finite Automata, Normalization, Scanner generator (lex, flex).

UNIT II (15 Hrs)

Syntax Analysis (Parser): Context-Free Language and Grammar, Push-down Automata, LL (1) grammar and top down parsing, Operator grammar, LR (O), SLR (1), LR (1), LALR (1) grammars and bottom-up parsing, ambiguity and LR parsing, LALR (1) parser generator (yacc, bison).

Semantic Analysis: Attribute grammar, Syntax Directed Definition (SDD), Syntax Directed Translation (SDT), Evaluation and flow of attribute in a syntax tree using Top down and Bottom up parser.

UNIT III (15 Hrs)

Symbol Table: Its structure, symbol attributes and Scope management.

Run-time environment: Procedure activation, parameter passing, value return, memory allocation, and scope. Intermediate Code Generation: Translation of different language features, different types of intermediate forms.

UNIT IV (15 Hrs)

Code Improvement (optimization): Analysis: control-flow, data-flow dependence etc.; Code improvement local optimization, global optimization, loop optimization, peep-hole optimization etc. Architecture dependent code improvement: instruction scheduling (for pipeline), loop optimization (for cache memory) etc. Register allocation and target code generation

Text Books:

1. Aho A V, Sethi R, Ullman J D, 2007, Compilers: Principles, Techniques and Tools, Addison-Wesley.
2. Scott M L, 2009, Programming Language Pragmatics, Elsevier.
3. Appel A W, 2004, Modern Compiler Implementation in C/Java, Cambridge University Press.
4. Cooper K D, Torczon L, 2011, Engineering a Compiler, Elsevier.

Reference books:

1. Holob A I, 1994, Compiler Design in C, Prentice-Hall.
2. Muchnik S S, 1997, Advanced Compiler Design and Implementation, Elsevier.
3. Allen R, Kennedy K, 2007, Optimizing Compilers for Modern Architectures, Elsevier.

Big Data Analytics **Credit: 4**

MCA-PG-E508

UNIT I (15 Hrs)

Introduction to Big Data: Definition, Challenges in processing Big data, Technologies supported by Big data : Hadoop, Apache Pig, HIVE, HBase, Flume, Sqoop.

UNIT II (15 Hrs)

Hadoop: History, Use cases of Hadoop, RDBMS Vs. Hadoop, When to use and when not to use Hadoop.

UNIT III (15 Hrs)

HDFS (Hadoop Distributed File System) : Significance of HDFS in Hadoop, 5 daemons of Hadoop, Features of

HDFS, Data storage in HDFS, Accessing HDFS.

UNIT IV (15 Hrs)

Map Reduce: Map reduce architecture, How Map reduce works, Developing map reduce, Map reduce programming modules, creating input and output format in map reduce j

Note: Hands on experience on Amazon EC2/Cloudera/open source shall be done by the students. Algorithms need to be run on the cloud platforms.

Text Books:

1. Schonberger V M, Cukier K, 2013, Big Data: A Revolution That Will Transform How We Live, Work, and Think,   Kindle E.
2. Chellappan S, Acharya S, 2015, Big Data and Analytics (WIND), Wiley.
3. Kulkarni P, Joshi S, Brown M S, 2016, Big Data Analytics, PHI.

Reference Books:

1. EMC Education Services, 2015, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley.
2. Erl T, Kattak W, Buhler P, 2016, Big Data Fundamentals: Concepts Drivers: Concepts, Drivers and Techniques, PHI.

Real-Time System **Credit: 4**

MCA-PG-E509

UNIT I (15 Hrs)

Introduction: Definition and concepts of RTS, Issues in Real Time Computing, Broad categories and characteristics of Real Time (RT) systems, RT tasks classification, Modeling of Time constraints, Task Assignment and Scheduling, Mode changes and Fault Tolerant Scheduling.

Real Time task scheduling: Basics on RT task scheduling, RT task scheduling algorithms, Preemptive RT algorithms (Earliest deadline first, RMA), Static priority scheduling protocols, Resource sharing among RT Tasks, Priority inversion, Priority inheritance protocol (PIP), HLP, PCP, Different types of priority inversion under PCP, Scheduling RT tasks in multiprocessor and distributed systems.

UNIT II (15 Hrs)

Real Time Operating System: RTOS definition and characteristics, comparison with general-purpose OSs, light-weight vs. heavy-weight RTOSs, Commercial RTOS: UNIX V, UNIX based RTOS, RT POSIX, RT capabilities of Windows NT, Windows CE, Performance benchmarking of RTOS.

Real Time communication : Characteristics of RT traffic, Models for traffic characterization, Applications requiring RT communication, Soft and hard RT communication in a LAN, Network Topologies, Fault tolerant Routing, Fault Error containment Redundancy, Bounded access protocols for LANs, Performance comparison, QoS framework, QoS models.

UNIT III (15 Hrs)

Real Time databases: Definition, , Real time vs General Purpose Databases, Transaction priorities, Transaction Aborts, Concurrency control issues, Disk Scheduling Algorithms, Two phase Approach to improve Predictability, Maintaining Serialization Consistency, Commercial RT databases.

UNIT IV (15 hrs)

Evaluation Techniques and Clock Synchronization

Reliability Evaluation Techniques, Software error models, Clock Synchronization, Fault Tolerant Synchronization in hardware and software.

Programming languages and tools

Programming Languages and Tools, Desired language characteristics, Data typing, Control Structures, Facilitating Hierarchical Decomposition, Packages, Programming Environments, Run time support.

Text Books:

1. Mall R, 2007, Real Time Systems, Theory and Practice, Pearson Education, 2E.
2. Liu J W, 2004, Real Time systems, Pearson Education, 5E.
3. Laplante P, 2008, Real Time Systems Design and Analysis, Prentice Hall, 3E.
4. Klein M H, Ralya T, 1994, Practitioner's Handbook for Real-Time Analysis, Kluwers Academic Publishers, 2E.

Reference Books:

1. Gomaa H, 2007, Software Design Methods for Concurrent and Real-time Systems, Addison-Wesley.
2. Bennett S, 1998, Real Time Computer Control – An Introduction, Prentice Hall of India. Allworth S T, Zobel R N, 1987, Introduction to real time software design, Macmillan, 2E.

Android Application Development **Credit: 4**

MCA-PG-E510

UNIT I (15 Hrs)

Basics: What is Android, History and Version, Installing softwares, Setup Eclipse, Hello Android example, Internal Details, Dalvik VM, Software Stack, Android Core Building Blocks, Android Emulator, AndroidManifest.xml, R.java file, Hide Title Bar, Screen Orientation

UI Widgets: Working with Button, Toast, Custom Toast, Button, Toggle Button, Switch Button, Image Button, CheckBox, AlertDialo, Spinner, AutoComplete, TextView, RatingBar, DatePicker, TimePicker, ProgressBar, Quick Contact Budge, Analog Clock and Digital Clock , Working with hardware Button, File Download

Activity, Intent & Fragment: Activity Lifecycle, Activity Example, Implicit Intent, Explicit Intent, Fragment Lifecycle, Fragment Example, Dynamic Fragment, Android Menu, Option Menu, Context Menu, Popup Menu

UNIT II (15 Hrs)

Layout Manager: Relative Layout, Linear Layout, Table Layout, Grid Layout

Adaptor: Array Adaptor, ArrayList Adaptor, Base Adaptor

View: GridView, WebView, ScrollView, SearchView, TabHost, DynamicListView, ExpandedListView

Android Service: Android Service, Android Service API,Android Started Service, Android Bound Service, Android Service Life Cycle, Android Service Example

Data Storage: Shared Preferences, Internal Storage, External Storage

SQLit: SQLite API, SQLite Spinner, SQLite ListView

XML & JSO: XML Parsing SAX, XML Parsing DOM, XML Pull Parser, JSON Parsing

UNIT III (15 Hrs)

Cotent Provider: Content Proivider Fundamental, Contact Content Provider, Other Built-in Content Providers, Creating Custom Content Provider, Understanding Content URI, ContentResolver, Sharing Information from custom content provider

Android Notification: Notification API, Creating Notification Builder, Setting Notification Properties, Attaching Actions, Issuing Notification, NotificationCompat.Builder class, Android Notification Examples

Multimedia: Wallpapaer, Live Wallpaper, Multimedia API, Playing Audio, Creating Audio Player, Playing Video, Alarm Manager, Gallery

UNIT IV (15 Hrs)

API: Speech API, Telephony API, Location API, Android Animation API, Sensor API, Graphics API

Device Connectivity: Bluetooth Tutorial, List Paired Devices, Working with WiFi, Working with Camera

Android P2P Communication: Introducing Instant Messaging, Using the GTalk Service, Monitoring the Roste for

Change, Sending and Receiving Data Messages, Transmitting Data Messages, Receiving Data Messages

Android Web Services, Android Google Map

Text Books:

1. Burd B, 2015. Android application development all-in-one for dummies, Wiley, 2E.
2. Griffiths D, 2015. Griffiths D, Head First Android Development, O'Reilly.
3. Maclean D, Komatineni S, Allen G. 2015. Pro Android 5, Apress.

Reference Books:

4. DiMarzio J F, 2016. Beginning Android Programming with Android Studio, Wrox, 4E.
5. Yener M, Dundar O. 2016. Expert Android Studio, Wrox.

Digital Image Processing **Credit: 4**

MCA-PG-E511

UNIT I (15 Hrs)

Digital Image Fundamentals: A simple image model, Sampling and Quantization, Imaging Geometry, Digital Geometry, Image Acquisition Systems, Different types of digital images.

Bilevel Image Processing: Basic concepts of digital distances, distance transform, medial axis transform, component labeling, thinning, morphological processing, extension to grey scale morphology.

UNIT II (15 Hrs)

Binarization and Segmentation of Grey level images: Histogram of grey level images, Optimal thresholding using Bayesian classification, multilevel thresholding, Segmentation of grey level images, Water shade algorithm for segmenting grey level image.

Detection of edges and lines in 2D images: First order and second order edge operators, multi-scale edge detection, Canny's edge detection algorithm, Hough transform for detecting lines and curves, edge linking.

UNIT III (15 Hrs)

Images Enhancement: Point processing, Spatial Filtering, Frequency domain filtering, multi-spectral image enhancement, image restoration.

Color Image Processing: Color Representation, Laws of color matching, chromaticity diagram, color enhancement, color image segmentation, color edge detection, color demosaicing.

UNIT IV (15 Hrs)

Image Registration and depth estimation: Registration Algorithms, Setreo Imaging, Computation of disparity map. Image compression: Lossy and lossless compression schemes, prediction based compression schemes, vector quantization, sub-band encoding schemes, JPEG compression standard, Fractal compression scheme, Wavelet compression scheme.

Note: Study on various algorithms shall be devised and new algorithms shall be developed and simulated by the students.

Text Books:

1. Gonzalez, Woods, 2009, Digital Image Processing, Pearson, 3E.
2. Sridhar S, 2006, Digital Image Processing, Oxford University Press.
3. Castleman K R, 2007, Digital Image Processing, Pearson, 1E.

Reference Books:

1. Chanda B, Majumder D, 2011. Digital Image Processing and Analysis, Prentice Hall Publications.
2. Jayaraman, 2011. Digital Image Processing, McGraw Hill.
3. Shinghal R,2006, Pattern Recognition, Oxford Publications.

Cryptography and Network Security **Credit: 4**

MCA-PG-E512

UNIT I (15 Hrs)

Introduction: Basic objectives of cryptography, secret-key and public-key cryptography, one-way and trapdoor one-way functions, cryptanalysis, attack models, classical cryptography.

Block ciphers: Modes of operation, DES and its variants, RCS, IDEA, SAFER, FEAL, Blow Fish, AES, linear and differential cryptanalysis.

Stream ciphers: Stream ciphers based on linear feedback shift registers, SEAL, unconditional security.

UNIT II (15 Hrs)

Message digest: Properties of hash functions, MD2, MD5 and SHA-1, keyed hash functions, attacks on hash functions.

Public-key parameters: Modular arithmetic, GCD, Primality testing, Chinese remainder theorem, modular square roots, finite fields.

Intractable problems: Integer factorization problem, RSA problem, modular square root problem, discrete logarithm problem, Diffie-Hellman problem.

UNIT III (15 Hrs)

Public-key encryption: RSA, Rabin and EI Gamal schemes, side channel attacks.

Key exchange: Diffie-Hellman and MQV.

Digital signatures: RSA, DSA and NR signature schemes, blind and undeniable signatures.

UNIT IV (15 Hrs)

Entity authentication: Passwords, challenge-response algorithms, zero-knowledge protocols.

Standards: IEEE and ISO standards.

Network security: Certification, public-key infra-structure (PKI), secure socket layer (SSL), Kerberos.

Assignments: System Modeling assignment using Rhapsody; system Verification assignment using SPIN; performance analysis assignment using Chronos.

Text Books:

1. Menezes A J, Oorschot P C V, Vanstone S A, 201, Handbook of Applied Cryptography, CRC Press.
2. Stallings W, 2006, Cryptography and Network Security: Principles and Practice, Prentice Hall of India.
3. Koblitz N, 2007, A course in number theory and cryptography, Springer.

Reference Books:

1. Buchmann J A, 2000, Introduction to Cryptography, Undergraduate Text in Mathematics, Springer.
2. Stinson D, 2006, Cryptography Theory and Practice, CRC Press.
3. Das A, Madhavan C A V, 2009, Public-Key Cryptography: Theory and Practice, Pearson Education Asia.

Computer Graphics **Credit: 4**

MCA-PG-E513

UNIT I (15 Hrs)

Introduction: Objective, applications, GKS/PHIGS, normalized co-ordinate system, aspect ratio.

Graphics system: Vector and raster graphics, various graphics display devices, graphics interactive devices, segmented graphics, attribute table.

UNIT II (15 Hrs)

Raster scan Graphics: Line drawing algorithms, circle/ellipse drawing algorithms, polygon filling algorithms. Geometric transformation: Homogeneous co-ordinate system, 2D and 3D transformations, projection – orthographic and perspective.

Curve and Surfaces: Curve approximation and interpolation, Lagrange, Hermite, Bezier and B-Spline curves/surfaces and their properties, curves and surface drawing algorithms.

UNIT III (15 Hrs)

Geometric modeling: 3D object representation and its criteria, edge/vertex list, constructive solid geometry, wire-frame model, generalized cylinder, finite element methods.

Clipping: Window and viewport, 2D and 3D clipping algorithms.

Hidden line and hidden surfaces: Concept of object- and image-space methods, lines and surface removal algorithms.

UNIT IV (15 Hrs)

Intensify and color models: RGB, YIQ, HLS and HSV models and their conversions, gamma correction, halftoning.

Rendering: Illumination models, polygon mesh shading, transparency, shadow, texture.

Some advance topics/applications: (i) Animation and morphing, (ii) Virtual reality, (iii) User-interface design, (iv) Fractal graphics, (v) Multimedia authoring, (vi) 3D visualization.

Note: Students shall have hands on OpenGL based algorithms.

Text Books:

1. Hearn D D, Baker M P, 1997, Computer Graphics, C Version 2nd E (Paperback), Version C, Pearson
2. Education, 2E.
3. Giloi W K, 1978, Interactive Computer Graphics, Data Structure, Algorithms, Languages, Prentice Hall, Englewood Cliffs.

Reference Books:

1. Newman W M, Sproull R F, 1979, Principles of Interactive Computer Graphics, McGraw Hill, New Delhi.
2. Foley J D, 1993, Computer Graphics, Addison-Wesley, 2E.
3. Hearn D, Baker P M, 1987, Computer Graphics, Prentice Hall of India, New Delhi, 2E.
4. Hill F S, 1990, Computer Graphics, McMillan, New York.

Internet of Things **Credit: 4**

MCA-PG-E514

UNIT I (15 Hrs)

Internet in general and Internet of Things (IoT): layers, protocols, packets, services, performance parameters of a packet network as well as applications such as web, Peer-to-peer, sensor networks, and multimedia.

Transport services: TCP, UDP, socket programming.

Network layer: forwarding & routing algorithms (Link, DV), IP-addresses, DNS, NAT, and routers; Local Area Networks, MAC level, link protocols such as: point-to-point protocols, Ethernet, WiFi 802.11, cellular internet access, and Machine-to-machine.

UNIT II (15 Hrs)

Mobile Networking: roaming and handoffs, mobile IP, and ad hoc and infrastructure less networks.

Real-time networking: soft and real time, quality of service/information, resource reservation and scheduling, and performance measurements.

UNIT III (15 Hrs)

IoT definitions: overview, applications, potential & challenges, and architecture.

Domains of IoT, M2M vs IoT, Management of IoT, IoT Platforms, IoT Languages, IoT Physical systems.

UNIT IV (15 Hrs)

Application: Data Analytics using IoT.

IoT examples: Case studies, e.g. sensor body-area-network and control of a smart home.

Note: Students shall develop new architectures to enhance IoT and devise new paradigm to build new IoT based solutions.

Text Books:

1. McEwen A, Cassimally H, 2013, Designing the Internet of Things, Wiley.
2. Pfister C, 2013, Getting started with the Internet of Things, O'Reilly.
3. Ray P P, Rai R, 2013, Open Source Hardware: An Introductory Approach, 1E, Lambert Academic Publishing.

Reference Books:

1. Hersent O, Boswarthick D, Elloumi,O, 2915, The Internet of Things: Key Applications and Protocols, Wiley.
2. Cassimally H, Mcewen A, 2015, Designing The Internet of Things, Wiley.

Embedded Systems **Credit: 4**

MCA-PG-E515

UNIT I (15 Hrs)

Introduction to Embedded Systems: definitions and constraints. Hardware and processor requirements.

UNIT II (15 Hrs)

Special purpose processors.

Input-output design and I/O communication protocols. Design space exploration for constraint satisfaction, co-design approach, Example system design.

UNIT III (15 Hrs)

Formal approach to specification. Specification languages. Specification refinement and design.

UNIT IV (15 Hrs)

Design validation. Real Time operating system issues with respect to embedded system applications. Time constraints and performance analysis.

Note: Students shall learn how to design energy efficient, small size special purpose computing system.

Text Books:

1. Marwedel P, 2011, Embedded System Design, Kluwer.
2. Wolf W, 2008, Computers as Components: Principles of Embedded Computing Systems Design, Morgan Kaufmann.
3. Vahid F, Givargis T, 2006, Embedded System Design: A Unified Hardware/Software Introduction, John Wiley.

Reference Books:

1. Vahid G, Narayan, Gong, 2007, Specification And Design Of Embedded Systems, Pearson.
2. Ray P P, Rai R, 2013, Open Source Hardware: An Introductory Approach, Lap Lambert Pub.

Mobile and Wireless Network **Credit: 4**

MCA-PG-E516

UNIT I (15 Hrs)

The Cellular Concept-System Design Fundamentals: Introduction, Frequency Reuse, Channel Assignment Strategies, Handoff Strategies- Prioritizing Handoffs, Practical Handoff Considerations, Interference and system capacity – Co channel Interference and system capacity, Channel planning for Wireless Systems, Adjacent Channel interference , Power Control for Reducing interference, Trunking and Grade of Service, Improving Coverage & Capacity in Cellular Systems- Cell Splitting, Sectoring .

UNIT II (15 Hrs)

Mobile Radio Propagation: Large-Scale Path Loss: Introduction to Radio Wave Propagation, Free Space Propagation Model, Relating Power to Electric Field, The Three Basic Propagation Mechanisms, Reflection-Reflection from Dielectrics, Brewster Angle, Reflection from prefect conductors, Ground Reflection (Two-Ray) Model, Diffraction-Fresnel Zone Geometry, Knife-edge Diffraction Model, Multiple knife-edge Diffraction, Scattering, Outdoor Propagation Models- Longley- Ryce Model, Okumura Model, Hata Model, PCS Extension to Hata Model, Walfisch and Bertoni Model, Wideband PCS Microcell Model, Indoor Propagation Models-Partition losses (Same Floor), Partition losses between Floors, Log-distance path loss model, Ericsson Multiple Breakpoint Model, Attenuation Factor Model, Signal penetration into buildings, Ray Tracing and Site Specific Modeling.

UNIT III (15 Hrs)

Mobile Radio Propagation: Small Scale Fading and Multipath: Small Scale Multipath propagation-Factors influencing small scale fading, Doppler shift, Impulse Response Model of a multipath channel- Relationship between Bandwidth and Received power, Small-Scale Multipath Measurements-Direct RF Pulse System, Spread Spectrum Sliding Correlator Channel Sounding, Frequency Domain Channels Sounding, Parameters of Mobile Multipath Channels-Time Dispersion Parameters, Coherence Bandwidth, Doppler Spread and Coherence Time, Types of Small-Scale Fading-Fading effects Due to Multipath Time Delay Spread, Flat fading, Frequency selective fading, Fading effects Due to Doppler Spread-Fast fading, slow fading, Statistical Models for multipath Fading Channels-Clarke’s model for flat fading, spectral shape due to Doppler spread in Clarke’s model, Simulation of Clarke and Gans Fading Model, Level crossing and fading statistics, Two-ray Rayleigh Fading Model.

UNIT IV (15 Hrs)

Equalization and Diversity: Introduction, Fundamentals of Equalization, Training A Generic Adaptive Equalizer, Equalizers in a communication Receiver, Linear Equalizers, Non linear Equalization- Decision Feedback Equalization (DFE), Maximum Likelihood Sequence Estimation (MLSE) Equalizer, Algorithms for adaptive equalization-Zero Forcing Algorithm, Least Mean Square Algorithm, Recursive least squares algorithm. Diversity Techniques-Derivation of selection Diversity improvement, Derivation of Maximal Ratio Combining improvement, Practical Space Diversity Consideration- Selection Diversity, Feedback or Scanning Diversity, Maximal Ratio Combining, Equal Gain Combining, Polarization Diversity, Frequency Diversity, Time Diversity, RAKE Receiver.

Text Books:

1. Rappaport T S, 2002, Wireless Communications, Principles, Practice, PHI, 2E.
2. Goldsmith A, 2005, Wireless Communications, Cambridge University Press.
3. Rao G S, 2012, Mobile Cellular Communication, Pearson Education.

Reference Books:

1. Basagni S, Conti M, Giordano S, Stojmenovic I, 2012, Mobile Ad Hoc Networking, Wiley, 2E.
2. Sunilkumar S. Manvi, Mahabaleshwar S. Kakkasageri, 2014, Wireless and Mobile Networks, Wiley, 2E.

Programming with Python and R Language **Credit: 4**

MCA-PG-E517

UNIT I (15 Hrs)

Introduction: History,Features, Setting up path, Working with Python, Basic Syntax, Variable and Data Types, Operator

Conditional Statements: If, If- else, Nested if-else

Looping: For, While, Nested loops

Control Statements: Break, Continue, Pass

String Manipulation: Accessing Strings, Basic Operations, String slices, Function and Methods

Lists: Introduction, Accessing list, Operations, Working with lists, Function and Methods

Tuple: Introduction, Accessing tuples, Operations, Working, Functions and Methods

UNIT II (15 Hrs)

Dictionaries: Introduction, Accessing values in dictionaries, Working with dictionaries, Properties Functions

Functions: Defining a function, Calling a function, Types of functions, Function Arguments Anonymous functions, Global and local variables

Modules: Importing module, Math module, Random module, Packages, Composition

Input-Output: Printing on screen, Reading data from keyboard, Opening and closing file, Reading and writing files, Functions

Exception Handling: Exception, Exception Handling, Except clause, Try?, finally clause, User Defined Exceptions

UNIT III (15 Hrs)

Advance Python: OOPs concept, Class and object, Attributes, Inheritance, Overloading, Overriding, Data hiding

Regular expressions: Match function, Search function, Matching VS Searching, Modifiers, Patterns

CGI: Introduction, Architecture, CGI environment variabl, GET and POST methods, Cookies, File upload

Database: Introduction, Connections, Executing queries, Transactions, Handling error,

UNIT IV (15 Hrs)

Networking: Socket, Socket Module,Methods, Client and server, Internet modules

Multithreading: Thread, Starting a thread, Threading module, Synchronizing threads, Multithreaded Priority Queue

GUI Programming: Introduction, Tkinter programming, Tkinter widgets

R language: Overview of R, R data types and objects, reading and writing data, Control structures, functions, scoping rules, dates and times, Loop functions, debugging tools, Simulation, code profiling

Text Books:

1. Mueller J P, 2015. Beginning Programming with Python for Dummies, Wiley.
2. Dierbach C. 2015. Introduction to Computer Science Using Python : A Computational Problem - Solving Focus , Wiley.
3. Hall T, Stacey J P. 2009. Python 3 for Absolute Beginners, Apress.

Reference Books:

1. Rao R N, 2016. Core Python Programming, Dreamtech.
2. Lubanovic B. 2014. Introducing Python, O’Reilly.

DEPARTMENT OF COMPUTER APPLICATIONS

SYLLABUS FOR PH.D IN COMPUTER APPLICATIONS

SEMESTER 1						
SUBJECT CODE	**SUBJECT NAME**	**CORE/ OPTIONAL**	**CREDITS**	**MARKS**	**L**	**P**
PCA-RS-C101	Research Methodology	C	4	100	3	1
PCA-RS-C102	Research Proposal Preparation	C	4	100	0	4
PCA-RS-E103	Remote Sensing	E	4	100	4	0
PCA-RS-E104	Geographic Information System	E	4	100	4	0
PCA-RS-E105	Digital Image Processing	E	4	100	4	0
PCA-RS-E106	Advanced Computer Networks	E	4	100	4	0
PCA-RS-E107	Wireless Sensor Networks	E	4	100	4	0
PCA-RS-E108	Data Analytics	E	4	100	4	0
						Total credit: 12

Abbreviations:

PCA : PhD in Computer Applications

RS : Research

C : Core

E : Elective

L : Lecture

P : Practical

Research Methodology **L:3,P:1, Credit: 4**

PCA-RS-C101

Unit I [15 Hours]

Introduction to Computer Science Research: Meaning of research, aims, nature and scope of research, prerequisites of research, types of research- fundamental/ pure research, applied and action research. Research problem, meaning of research problem, sources of research problem, characteristics of research problem, techniques involved in defining research problems, hypothesis and types, preparation of research proposal or synopsis. Methods of research studies- qualitative and quantitative. Research design, need for research design and its features, different research designs.

Research Design: Definition, Need, Features, and Types of Research Design: Classification: Exploratory Research, Descriptive Research, Causal Research, Relationships

Literature Survey: review of related literature, purpose of the review, identification of related literature, organization of related literature.

Unit II [15 Hours]

Sampling design, measurement and scaling techniques: sampling, its need, sampling fundamentals, important sampling distributions, census and sample survey, implications of a sample design, steps in sample design, criteria of selection sampling procedures, characteristics of sample design, different types of sampling design. Measurement scales, sources of errors in measurement, tests of sound measurement. Scaling, classifications bases for scales, importance of scaling techniques, scale constructions techniques. Comparative and Non-comparative Scaling Techniques.

Data collection, processing and analysis: Collection of primary data and secondary data, different tools for collecting data. Processing operations, frequently encountered problems in processing, data analysis, statistics in research and statistical measures, analysis of variance and covariance.

Fieldwork: The Nature of Fieldwork, Fieldwork/Data Collection Process, Selection of Field Workers, Training of Field Workers.

Report Preparation and Presentation: Report Format, Report Writing, Guidelines for Tables, Guidelines for Graphs.

Unit III [15 Hours]

Correlation and Regression: Multiple and Partial Correlation, Method of Least Squares, Plane of Regression, Properties of Residuals, Coefficient of multiple correlation, Coefficient of partial correlation, Multiple correlation with total and partial correlations, Regression and Partial correlations in terms of lower order co-efficient.

Multivariate Analysis: Random vectors and Matrices, Mean vectors and Covariance matrices, Multivariate Normal density and its properties, Principal components: Population principal components, Principal components from standardized variables.

Unit IV [15 Hours]

Testing of hypothesis: hypothesis, concepts in hypothesis testing, procedure for hypothesis testing, flow diagram for hypothesis testing, parametric and non-parametric tests, types.

Scientific Writing: Introduction to the tools of scientific writing, Significance of scientific Writing, Different Steps in scientific Report, Layout of the scientific Reports, Oral Presentation, Mechanics of Writing a Research Proposal.

Text books:

1. Kothari, C. R., "Research Methodology: Methods and Techniques", New Age International Publishers, Second Edition, 2004.

2. Gupta, S.C., and Kapoor, V.K., "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, Eleventh Edition, 2002.

3. Taylor, B, Sinha, G., Ghoshal, T., "Research Methodology: A Guide for Researchers in Management and Social Sciences", Prentice-Hall of India Private Limited, New Delhi, 2006

4. Krishnaswamy, K. N., "Management Research Methodology : Integration of Principles, Methods and Techniques", Pearson, 2009

5. Kumar, R., "Research Methodology: A Step-By-Step Guide For Beginners", 4Th Edition, Sage Text, 2014

Reference Books:

1. Freund, J.E., "Mathematical Statistical", 5th Edition, Prentice Hall of India, 2001.

2. Devore, J.L., "Probability and statistics for Engineering and the Sciences", 5th Edition, Thomson and Duxbury, Singapore, 2002.

3. Creswell, J.W., "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches", 2nd Edition, SAGE Publications, 2002.

4. C.George Thomas, C.G.," Research Methodology and Scientific Writing", Ane Books Pvt. Ltd., 2015

Research Proposal Preparation **L:0,P:4, Credit: 4**

PCA-RS-C102

4 credits will be assigned to a non-lecture based paper in which the candidates review the literature and write a research proposal in the area of their research interest, and give a seminar at the end of the semester. There will be no sessional tests and no attendance requirement for this paper. They will be awarded marks out of 50 for the research proposal and 50 for the presentation and defense. At least one external member from within the School and two faculty members of the concerned department will constitute the evaluation committee for this paper.

Remote Sensing **L:4,P:0, Credit: 4**

PCA-RS-E103

Unit I [15 Hours]

Introduction to remote sensing and Basic Concepts: Remote sensing, Passive and active remote sensing, Basic concepts of remote sensing, different types of sensors, Electromagnetic spectrum, Energy sources and radiation principles, Effects of atmosphere Energy interaction with surface features, Spectral reflectance of vegetation, soil ,and water, atmospheric influence on spectral response patterns.

Unit II [15 Hours]

Remote Sensing Systems and Data Acquisition: Satellites and orbits, Polar orbiting satellites, Spectral, radiometric and spatial resolutions, Temporal resolution of satellites, Types of Platforms – different types of aircrafts-Manned and Unmanned spacecrafts, sun synchronous and geo synchronous satellites, Types and characteristics of different platforms, across track and along track scanners, multi spectral scanners and thermal scanners.

Unit III [15 Hours]

Application of Digital Image Processing in Remote Sensing: Image Restoration, Image Enhancement and Information Extraction, Geometric corrections, Co-registration of Data, Ground Control Points (GCP), Atmospheric corrections, Solar illumination corrections. Concept of color, Color composites, Contrast stretching – linear and non-linear stretching, Filtering techniques, Edge enhancement, Density slicing, Thresholding, Intensity-Hue-Saturation (IHS) images. Multispectral classification, Ground truth collection, Supervised and unsupervised classification, Change detection analysis, Principal component analysis.

Thermal Radiation Principles and Thermal Imaging: Thermal remote sensing– thermal sensors, principles, thermal data processing, applications.

Unit IV [15 Hours]

Data Analysis: Resolution- Spatial, Spectral, Radiometric and temporal resolution- signal to noise ratio- data products and their characteristics.

Applications of Remote Sensing: Remote sensing of soils and geomorphology, Remote Sensing of vegetation, Remote sensing of water resources and Urban applications using remote sensing imagery.

Text Books:

1. Lillesand, T.M., and Kiefer. R.W, “Remote Sensing and Image interpretation”, VI edition of John Wiley & Sons-2000.
2. Elachi, C., Jakob J. van Zyl, “Introduction To The Physics and Techniques of Remote Sensing”, Wiley Series in Remote Sensing and Image Processing, 2006.
3. Paul Curran, P.J., “Principles of Remote Sensing”, ELBS; 1995.
4. Sabins, F.F. Jr, “Remote Sensing Principles and Image interpretation”, W.H.Freeman & Co, 1978.
5. Schowengerdt, R. A., “Remote Sensing: Models and Methods for Image Processing”, Academic Press, 2007.

Reference Books:

1. Jensen, J.R., “Introductory Digital Image Processing: A Remote Sensing Perspective”, 2nd Edition, 1995.
2. Richards, J.A., Springer –Verlag, “Remote Sensing Digital Image Analysis”, 1999.
3. Rees, W.G., “Physical Principles of Remote Sensing” 3rd Edition, Cambridge University Press, 2013
4. Campbell, J. B., Wynne, R. H., “Introduction to Remote Sensing”, Guilford Press, 2011
5. Kumar, S., “Basics of Remote Sensing and GIS”, Firewall Media, 2005

Geographic Information System **L:4,P:0, Credit: 4**

0987 PCA-RS-E104

Unit I [15 Hours]

Introduction: definition, historical perspective, components of GIS and types of GIS. Technology trends in GIS, relationship between geoinformatics, information technology and sensor technology, distributing computing (cloud GIS, SDI).Concept of data. geographic data sources (Remote Sensing, GPS, maps and Field Observations). Introduction to spatial decision problem, decision sport system, overview of internet GIS, location based services.

Unit II [15 Hours]

Models and database management: Data models: Concept and types, Raster data model, Vector data model. Data input: methods, data quality, data errors, data editing. Databases: Database concepts, development, implementation and design. Database management system (DBMS): Network DBMS, Hierarchical DBMS, Relational DBMS, object oriented DBMS.

Unit III [15 Hours]

Interpolations, geospatial analysis and Digital elevations model: Introduction to interpolation, types of interpolation, methods for interpolation: these in polygons, inverse distance, weighted splines and krigging. Geospatial analysis: introduction, vector-based analysis and raster-based analysis. Digital Elevation Model (DEM): definition, methods of development, and applications of DEM. Network analysis: concept and models.

Unit IV [15 Hours]

Global positioning system: Basic concepts of Global Positioning System (GPS), accuracy and error corrections in GPS. Fundamental of mobile mapping, application of GPS in resources surveys and mapping. Concept of absolute and differential global positioning system. Types of GPS receivers, GPS satellite signal, GPS data, error correction techniques in GPS. Introduction to IRNSS.

Applications of GIS: Utility mapping using GIS, land suitability analysis. GIS for environmental impact analysis (EIA).Disaster vulnerability analysis (landslide hazard zonation).geospatial modeling: introduction, importance and techniques, land degradation modelling.

Text Books:

1. Heywood, I., Cornelius, S., Carver, S., Raju, S., “An Introduction to Geographical Information Systems”, 2nd Edition, Pearson Education, 2010.
2. Bhatta, B., “Remote Sensing and GIS”, Oxford University Press, 2008.
3. Demers, M.N., “Fundamentals of Geographic Information Systems” John Wiley and Sons, Inc, 2008.
4. Burrough, P. A., McDonnell, R.A.,” Principles of Geographical Information Systems (Spatial Information Systems)”, Oxford University Press, 2015.
5. Clarke, K.C., Parks, B. O., Crane, M. P., Parks, B. E., “Geographic Information Systems and Environmental Modeling”, Prentice Hall, 2002.

Reference Books:

1. Burrough, P.A.,"Geographic Information Systems for Land Resources Assessment" Oxford: Oxford University Press, 1994.
2. Laurini, R., Thompson, D., "Fundamentals of Spatial Information Systems" Academic Press London, 1992.
3. Chou, Y. H.,"Exploring Spatial Analysis In Geographical Information Systems", Onward Press, New Mexico, US, 1997.
4. Chang, K.,T., "Introduction to Geographic Information Systems", McGraw Hill, 2015.
5. Pourabbas, E., "Geographical Information Systems: Trends and Technologies", CRC Press, 2014

Digital Image Processing **L:4,P:0, Credit: 4**

PCA-RS-E105

Unit I [15 Hours]

Introduction: Introduction: Digital Image, Fundamental steps in Image Processing, Elements of DIP systems, Simple Operations- Arithmetic, Logical, Geometric Operations.

Digital Image Fundamentals: Elements of Visual Perception, Sampling and Quantization, Relationships between pixels, Linear and Nonlinear operations.

Unit II [15 Hours]

Image Enhancement in Spatial domain: Enhancement by Point Processing, Histogram Processing, Spatial Filtering.

Image Enhancement in Frequency Domain: Introduction to the Fourier Transform, The discrete Fourier Transform, Properties of the two-dimensional Fourier Transform, Smoothing Frequency-domain filters, Sharpening Frequency domain filters.

Image restoration and construction: Image Restoration: Image Observation and Degradation Model, Circulant and Block Circulant Matrices and Its Application in Degradation Model, Algebraic Approach to Restoration, Inverse by Wiener Filtering, Generalized Inverse-SVD And Interactive Methods, Blind Deconvolution, Image reconstruction from projections.

Unit III [15Hours]

Image Compression: Fundamentals, Image Compression Models, Error Free Compression, Lossy Compression.

Image Segmentation: Edge Detection, Line Detection, Curve Detection, Edge Linking and Boundary Extraction, Boundary Representation, Region Representation and Segmentation, Morphology-Dilation, Erosion, Opening and Closing, Hit and Miss Algorithms feature analysis.

Unit IV [15 Hours]

Color and multispectral image processing: Color Image Processing Fundamentals, RGB Models, HSI Models, Relationship Between Different Models, Multispectral Image Analysis.

Object Recognition: Patterns and Pattern Classes, Recognition based on Decision-theoretic methods, structural methods.

Text Books:

1. Gonzalez, R. C., Woods, R. E., “Digital Image Processing”, Pearson, 2009.
2. Castleman, K. R., “Digital Image Processing”, Pearson Education, 1995.
3. Shinghal, R., “Pattern Recognition”, Oxford Publications, 1992.
4. Umbaugh, S.,E., “Digital Image Processing and Analysis: Human and Computer Vision Applications with CVIPtools”, CRC Press, 2010.

5. Solomon, C., Breckon, T., “Fundamentals of Digital Image Processing A Practical Approach with Examples in Matlab”, Wiley-Blackwell, 2011.

Reference Books:

1. Chanda, B., Majumder, D. D., “Digital Image Processing and Analysis”, Prentice Hall Publications, 2011.
2. Gonzalez, R. C., Woods, R. E., “Digital Image Processing with Matlab”, Pearson, 2013.
3. Sridhar, S., “Digital Image Processing”, Oxford University Press, 2011.
4. Jayaraman, S.,, “Digital Image Processing”, McGraw Hill, 2011.

Advanced Computer Networks **L:4,P:0, Credit: 4**

PCA-RS-E106

Unit I [15 Hours]

Network Layer: IP Protocol: Datagram-fragmentation, IP package, IP Addresses: Classful addressing, subnetting, supernetting, Classless addressing, Routing Protocols for Wired Network: Unicast Routing Protocols: Shortest Path, Flooding, DVR, Link State Routing, Multi Cast Routing Protocols, Interior Gateway Protocol :OSPF, Exterior Gateway Protocol : BGP, multi-path and type –of-service routing, quality-of-services routing –routing heuristics for GS, Internet QoS routing, fast routing/ switching

Unit II [15 Hours]

Mobile Network Layer: Mobile IP: IP packet deliver-Agent advertisement and discovery, Registration, Tunnelling and Encapsulation, Reverse tunnelling, Cellular Network, HAWAII, Mobile IPv4, Mobile IPv6, HMIPv6, MAP Discovery, Local Mobility Management in HMIPv6, dynamic host configuration protocol, Ad hoc networks: Routing- Destination sequence distance vector, Dynamic source routing, Hierarchical algorithms, Alternative metrics.

Unit III [15 Hours]

Transport Layer: Services- Congestion control, Reliable service, TCP features-TCP segment-TCP connection-flow control error control- congestion control-TCP variants –Tahoe- Reno- Vegas- new – Reno- SACK, Connectionless UDP: Use of UDP, Header Description, Real-time Transport Protocol (RTP), SCTP, Wireless TCP, SNOOP, Mobile Transport Layer: Traditional TCP: Congestion control, Implications on mobility: Mobile TCP, Transmission / time-out freezing, selective retransmission, Transaction oriented TCP.

Unit IV [15 Hours]

Application Layer: Domain Name Systems, E-mail system, WorldWide Web:-Architectural Overview, HTTP, SNMP, Performance Enhancements, multimedia and adaptive applications, voice and video over IP, real time transport protocols, scalable and QoS-aware servers, web proxy coaching Network Security: Cryptography, Symmetric Key Algorithms: - DES, Public Key Algorithms: - RSA. Digital Signatures: -Symmetric Key Signatures, Public Key Signatures, Message Digests.

Text Books:

1. Tanenbaum, A.S., “Computer Networks”, PHI, 2011.
2. Forouzan, B. A., “Introduction to Data Communication and Networking”, Mc Graw Hill, 2007.
3. Bagad, V.S., “Advanced Computer Networks” Technical Publications, 2010.
4. Jain,S., “Advanced Computer Networking: Concepts and Applications”, BPB Publications, 2006.
5. Peterson, L.L, Davie, B.S., “Computer Networks: A Systems Approach”, Morgan Kaufmann, 2011.

Reference Books:

1. Stalling, W., “Data and Computer Communications”, PHI, 2007.
2. Soliman, H., “Mobile IPv6 Mobility in a Wireless Internet”, Pearson Education, 2004.
3. Forouzan, B. A., Mosharraf, F., “Computer Networks: A Top-Down Approach”, Mc Graw Hill, 2011.
4. Ciubotaru, A., Muntean, G. M, “Advanced Network Programming - Principles and Techniques: Network Application Programming with Java”, Springer, 2013.
5. Kurose, J., Ross, K., “Computer Networking: A Top-Down Approach”, Pearson Education, 2010.

Wireless Sensor Networks **L:4,P:0, Credit: 4**

PCA-RS-E107

Unit I [15 Hours]

Introduction: Basics of Wireless Sensor Networks (WSNs) and its Applications, Design Issues: Energy, Self-Management, Wireless Networking, Decentralized Management, Security, Clustering of Sensors, Difference Between WSNs and Ad Hoc Wireless Networks.

Node Architecture and Operating System: Sensor Node Architecture, IMote node architecture, Operating System: TinyOS, Imperative Language: nesC, Dataflow Style Language: TinyGALS, Node-Level Simulators.

Unit II [15 Hours]

Communication Protocols: Physical Layer: Basic Components, Source Encoding, Channel Encoding, Medium Access Control: Wireless MAC Protocols, Contention-Free MAC Protocols, Contention-Based MAC Protocols, Hybrid MAC Protocols, Network Layer: Categories of Routing Protocol, Routing Metrics, Flooding and Gossiping, Data-Centric Routing, Proactive Routing, On-Demand Routing, Hierarchical Routing, Location-Based Routing.

In-Network Information Processing: Introduction, Communication Complexity Model, Comparing Functions over Wireless Networks; Special Reuse and Block Computation, Law of Sensor Network Lifetime and Its Applications.

Unit III [15 Hours]

Power Management and Time Synchronization: Local Power Management, Dynamic Power Management, Clocks and Synchronization Problem, Temporal Data.

Localization: Ranging Techniques, Range-Based Localization, GPS-Based Localization, Range-Free Localization, Event-Driven Localization.

Distributed Learning and Estimation: Introduction, Classical Learning, Fusion Center, Distributed Estimation under Bandwidth and Energy Constrains.

Unit IV [15 Hours]

Graphical Models and Fusion Sensor Networks: Introduction, Graphical Models, from Sensor Network Fusion to Graphical Models, Approximation and Impact on Fusion.

Security: Fundamentals of Network Security, Challenges of Security in Wireless Sensor Networks, Security Attacks in Sensor Networks, Protocols and Mechanisms for Security, IEEE 802.15.4 and Zigbee Security.

Text Books:

1. Dargie, W., Poellabauer, C., “Fundamentals of Wireless Sensor Networks: Theory and Practice”, Wiley Publication, 2010.
2. Zheng, J., Jamalipour, A., “Wireless Sensor Networks: A Networking Perspective”, Wiley Publication, 2009.
3. Swami, A., “Wireless Sensor Networks: Signal Processing and Communication Perspectives”, John Wiley, 2007.

Reference Books:

1. Zhao, F., Guibas, L., "Wireless Sensor Networks: An Information Processing Approach", Elsevier Publication, 2004.
2. Karl, H., Willig, A., "Protocols and Architectures for Wireless Sensor Networks", Wiley Publication, 2007.
3. Faludi, R., "Building Wireless Sensor Networks", O'Reilly Publication, 2010.
4. Farahani, S., "ZigBee Wireless Networks and Transceivers", Elsevier Publication, 2011.
5. Murthy, C., Murthy, B., "Adhoc Wireless Networks: Architectures and Protocols", Pearson Education, 2004
6. Hu, F., Cao, X., "Wireless Sensor Networks: Principles and Practice", An Auerbach Book, CRC Press, Taylor & Francis Group, 2010.

6\. Sarkar, S., "Wireless Ad hoc Mobile Wireless Networks: Principles, Protocols and Applications", Auerbach Publications, Taylor & Francis Group, 2007.

Data Analytics **L:4,P:0, Credit: 4**

PCA-RS-E108

Unit I [15 Hours]

Introduction: Introduction to data analytics (DA), data preparation, and data cleaning, Big Data Overview, What is data sciences, the rising and importance of data sciences, Big data analytics in industry.

Data Analytics Lifecycle and methodology: Understanding Business Data, Data Preparation, Data Modelling, Data Evaluation, Communicating results, Deployment of Data.

Unit II [15 Hours]

Statistical Analysis: Basic statistical concepts. Mean, standard deviation. Rank statistics and percentiles, Distributions, Covariance, correlation, analysis of variance, Statistical tests, confidence and hypothesis testing, Tools such as R.

Probabilistic Analysis: Dependence and Independence, Conditional Probability, Bayes's Theorem, Random Variables Continuous Distributions, The Normal Distribution, The Central Limit Theorem, For Further Exploration.

Unit III [15 Hours]

Data Analytics: Theory & Methods: Data features, Classification, Supervised and unsupervised learning, Supervised learning - Linear/Logistic regression, Decision trees, Naïve Bayes, Unsupervised learning - K-means clustering, Association rules, Clustering algorithms. Knowledge discovery. Anomaly detection.

Hypothesis and Inference: Statistical Hypothesis Testing, Example: Flipping a Coin, Confidence Intervals, P-hacking, Example: Running an A/B Test, Bayesian Inference.

Unit IV [15 Hours]

Tools for Data Analytics: Globally distributed data stores, Tools for big data, Introduction to Hadoop, HDFS, MapReduce, YARN, HBase, Hive, Pig, Sqoop, Zookeeper, Flume, NoSQL.

Data Representation and Analysis: Log Data Analysis – HDFS scenario: Write once & Read often, Data Warehouse, Fraud Detection, Risk Modeling, Social Sentiment Analysis, Image Classification, Graph Analysis.

Text Books:

1. Larose, D. T., Larose, C. D., "Discovering Knowledge in Data: An Introduction to Data Mining", Wiley 2nd Edition, 2005.
2. Klimberg, R., McCullough, B. D., "Fundamentals of Predictive Analytics with JMP", SAS Institute Publishers, 2013.

Reference Books:

1. EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data" Wiley Publications.
2. Grus, J., "Data Science from Scratch First Principles with Python", O'Reilly Media, 2015.

DEPARTMENT OF GEOLOGY

B. Sc. Geology Syllabus

Semester I		
GEOL-UG-O101	Geology-I (Earth System Science, Petrology and Mineralogy)	3L+1P
	Elective 1	4
	Elective 2	4
	Total	**12**
Semester II		
GEOL-UG-O201	Geology-II (Physical Geology and Sedimentology)	3L+1P
	Elective 3	4
	Elective 4	4
	Total	**12**
Semester III		
GEOL-UG-O301	Geology-III (Palaeontology and Stratigraphy)	3L+1P
	Elective 5	4
	Elective 6	4
	Total	**12**
Semester IV		
GEOL-UG-C401	Geology-IV(Igneous and Metamorphic Petrology)	3L+1P
GEOL-UG-C402	Geology-V (Geology of India)	2L+2F
	English	4
	Total	**12**
Semester V		
GEOL-UG-C501	Geology-VI (Structural and Engineering Geology)	3L+1P
GEOL-UG-C502	Geology-VII (Geochemistry and Hydrology)	3L+1P
HUR-UG-F106	Eastern Himalayan Studies	4
	Total	**12**
Semester VI		
GEOL-UG-C601	Geology-VIII (Economic Geology and Coal & Petroleum Geology)	3L+1P
GEOL-UG-C602	Geology-IX (Mini Project/Industrial Training)	4
HUR-UG-F105	Environmental Studies	4
	Total	**12**

- Minimum Credits for B.Sc. are Seventy Two (72)
- L – Lectures, P – Practical, F- Field Work

As at present very limited compatible UG elective courses are available for the students of the integrated courses at the University level. The department is required to offer options for the Elective Courses as well.

Elective Papers Department:

1. GEOL-UG-E102 Physical Sciences I (Physics)
2. GEOL-UG-E103 Physical Sciences II (Atmospheric, Oceanic and Planetary Sciences)
3. GEOL-UG-E202 Physical Sciences III (Chemistry)
4. GEOL-UG-E203 Computation I (Mathematics)
5. GEOL-UG-E302 Computation II (Computer Applications in Geosciences and Disaster Management)
6. GEOL-UG-E303 Computation III (Remote Sensing and GIS)

However the students are at liberty to choose any other available compatible elective courses.

Students of other department also can choose these courses, as these papers are open papers.

Semester I

GEOL-UG-O101

Geology-I (Earth System Science, Petrology and Mineralogy) **Credit: 3L+1P**

Module-I

Concept of earth system sciences and its branches.

Formation of various spheres of Earth.

Introduction to various branches of Earth Sciences.

Solar System, Age of the earth, origin of solar system. meteors and meteorites.

Introduction to Geological Time Scale.

Internal structure of Earth. Concept of Plate Tectonics and its elements.

Wilson Cycle, Orogeny, Earthquakes. Volcanoes, Tsunami

Introduction to Hydrology: Hydrologic cycle.

Introduction to Oceanography:

Module-II

Definition and classification of Rock and minerals.

Formation of Igneous, Sedimentary and Metamorphic rocks and their classification.

Rock Cycle. Common classification of minerals and their basis.

Physical Properties of the minerals.

Classification of major silicates and non silicate minerals:

Silicates: Ortho silicates, Ring & Di silicates, Chain silicates, Sheet silicates and Framework silicates. Nonsilicates: Carbonates, Sulfates, Phosphates, Tungstates, Molybdates, Borates, Oxides, Hydroxides, Halides, Sulfides and Native elements.

Module-III

Fundamentals of Crystallography.

Crystallographic axes, axial ratio, 32 crystal classes and classification in seven systems.

Fundamentals of Properties of Light, Polarizing petrographic microscope.

Optical properties of common rock forming silicate minerals.

Module-IV (Practical)

1. Field Based Practical for collection of samples and in-situ study.

2. Field Based Practical for identification of landforms and Earth processes.
3. Preparation of Thin and Polished sections of rock samples.
4. Study of Common Igneous, Sedimentary and Metamorphic Rocks.
5. Physical properties of common rock-forming and ore-forming minerals in hand specimen.
6. Study of common rock-forming minerals in thin section.
7. Study of optical properties of minerals under petrological microscope.
8. Study of crystal models of different classes.
9. Determination of Miller indices and zone axis calculations.

Suggested Readings

1. W. D. Nesse, (2000), Introduction to Mineralogy, Oxford University Press, ISBN 0-19-510691-1
2. Dana's New Mineralogy: The System of Mineralogy of James Dwight Dana and Edward Salisbury Dana by Richard V. Gaines , H. Catherine W. Skinner, Eugene E. Ford, Brian Mason,Abraham Rosenzweig, 1997, 1872 pages. Publisher: Wiley-Interscience; 8 edition, ISBN-10: 0471193100
3. P. F. Kerr Optical Mineralogy, 1959
4. Nesse W.D. , Introduction to Optical mineralogy, 2008
5. Deer, W. A. , Howie, R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication,1962-1963.
6. Rutleys Elements of Mineralogy, 1991, Publisher: Cbs Publishers & Distributors Pages: 482 ISBN10: 8123909160
7. Holme's Principles of Physical Geology. 1992. Chapman & Hall.
8. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

Elective-I **Credit: 4**

Elective-II **Credit: 4**

Semester II

GEOL-UG-O201

Geology-II (Physical Geology and Sedimentology) **Credit: 3L+1P**

Module-I

Nature and scope of geomorphology. Evolution of geomorphological thoughts.

Basic concepts of geomorphology.

Overview of landscape evolution models, weathering and cycle of erosion.

Drainage classification and morphometry.

Geomorphic Processes and associated Landforms: Fluvial, Glacial, Aeolian, Coastal and Karstic landforms.

Structural and lithological controls on landforms.

Overview of Indian geomorphology.

Module-II

Sediment Size Classification. Various Classifications of Siliciclastic Sedimentary Rocks.

Sedimentary Processes: Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs. turbulent flow, Reynolds number, Froude Number, Boundary layer effect, Particle entrainment, transport and deposition, sediment gravity flows.

Bouma’s Sequence.

Module-III

Introduction to Sedimentary environments and facies.

Sedimentary structure: Primary and secondary sedimentary structures.

Biogenic structures Paleocurrent analysis.

Siliciclastic rocks: Conglomerates, sandstones, mudrocks (texture, composition, classification, origin and occurrence).

Nonsiliciclastic rocks: Carbonate rocks, controls of carbonate deposition, components and classification of limestone, dolomite and dolomitisation, carbonate sedimentary environments. Chert and siliceous sediments, phosphorites, carbonaceous sediments, iron rich sediments and evaporites.

Digenetic processes and its effects on silicilastic and carbonate rocks.

Module-IV (Practical)

1. Field Based Practical for collection of samples/data and in-situ study.
2. Identification of various sedimentary rocks and their features.
3. Petrographic study of clastic and non-clastic rocks in thin sections.

4. Identification of sedimentary structures by diagrams and samples.

5. Particle size distribution and statistical treatment and paleocurrent analysis.

Suggested Readings

1. Bloom, A.L. 1998. Geomorphology: A systematic Analysis of Late Cenozoic Landforms (3rd Edition), Pearson Education, Inc.
2. Singh, S. 1998. Geomorphology. Prayag PustakBhavan, Allahabad.
3. Kale, VS. and Gupta, A. 2001. Introduction to Geomorphology. Orient Longman Ltd.
4. Easterbrook, D.J. 1992. Surface processes and landforms. McMillan Publ.
5. Prothoreo and Schwab, 2004, Sedimentary Geology, Freeman and Co. New York, 557p
6. Sam Boggs, 1995, Principles of Sedimentology and Stratigraphy, Printice Hall, New Jersey, 765p .
7. Maurice E. Tucker, 2006, Sedimentary Petrology, Blackwell Publishing, 262p.
8. Collinson, J.D. and Thompson, D.B. 1988, Sedimentary structures, Unwin-Hyman, London, 207p.
9. Lindholm, R.C., 1987, A practical approach to sedimenmtology, Allen and Unwin, London
10. Pettijohn, F.J. 1975, Sedimentary rocks, Harper and Row Publ. New Delhi

Elective-III **Credit: 4**

Elective-IV **Credit: 4**

Semester III

GEOL-UG-O301

Geology-III (Palaeontology and Stratigraphy) **Credit: 3L+1P**

Module-I

Introduction to fossils.

Fossilization processes (taphonomy), and modes of preservation.

Basic Concepts of organic evolution and Species concept.

Methods of description and naming of fossils, code of systematic nomenclature.

Application of Fossils in the study of Palaeoecology, Palaeobiogeography and Palaeoclimate.

Palaeobotany: Early plant life, colonization of land, important stages in plant evolution.

Role of plant fossils in palaeoclimatic reconstructions.

Significance of Gondwana flora. Introduction to palynology.

Module-II

Invertebrate Palaeontology: Brief introduction to various invertebrate groups. Significance of Mollusca, trilobites, brachiopods graptolites, foraminifera and ammonoids. Classification of trace fossils

Vertebrate Palaeontology: Evolution and Classification of vertebrates.

Major steps in vertebrate evolution.

Origin, evolution and extinction of dinosaurs.

Evolution of primates with special reference to human evolution.

Module-III

Stratigraphic principles and correlation.

Unconformities and principle of cross-cutting Relationship. Facies concept.

Evolution of Geological Time Scale.

Significant events in geological time.

Introduction to lithostratigraphy, biostratigraphy and chronostratigraphy, magnetostratigraphy and chemostratigraphy.

Seismic stratigraphy, sequence stratigraphy and its application in hydrocarbon exploration.

Intoduction to Quaternary Geology and its applications.

Pleistocene Glacial-Interglacial cycles.

Module-IV (Practical)

1. Field Based Practical for collection of samples/data and in-situ study.
2. Study of fossils showing various modes of fossilization.
3. Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils

Suggested Readings

1. Clarkson, E.N.K.1998. Invertebrate Palaeontology and Evolution, George Allen & Unwin.
2. Raup, D.M. and Stanley, S. M. 1971. Principles of Palaeontology, W.H. Freeman and Company.
3. Benton, M. 1997. Basic Palaeontology: An introductory text, D.Harker, Addision Wisely Longman.
4. Prothero, D.R. 1998. Bringing fossils to life – An introduction to Palaeobiology, McGraw Hill.
5. Benton, M.J. 2005. Vertebrate palaeontology (3rd edition). Blackwell Scientific, Oxford.
6. Brenchley, P. J., and Harper, D. A. T. 1998. Palaeoecology: Ecosystems, Environments and Evolution. By Chapman and Hall.
7. Schoch, R. M. 1989. Stratigraphy, principles and methods. Van Nostrand Reinhold.
8. Roy R. Lemon. 1990 Principles of Stratigraphy, 512 pages, Publisher: Longman Higher Education. ISBN-10: 0675205379
9. Condie. K.C., & Sloan, R. 1998, Origin and Evolution of Earth: Principles of Historical Geology. Prentice Hall; 1st edition 498 pages ISBN-10: 0134918207
10. Weller, J. Marvin 1960. Stratigraphic principles and practice. Harper's Geoscience series.

Elective-V **Credit: 4**

Elective-VI **Credit: 4**

Semester- IV

GEOL-UG-C401

Geology-IV (Igneous and Metamorphic Petrology) **Credit: 3L+1P**

Module-I

Introduction: Earth's interior structure.

Physical properties of magmas.

Volcanoes and types of volcanoes. Pyroclastic deposits.

Concept of intrusion and extrusion.

Forms and types of igneous bodies:- extrusive bodies-Flood basalts.

Intrusive bodies:- concept of concordant and discordant intrusion, Dikes and sills and types of dikes, breccia pipes, laccoliths, lopoliths, stocks and batholiths.

Module-II

Introduction: Definition of metamorphism. Factors controlling metamorphism.

Concept of metamorphic facies and grade.

Metamorphic zones and isograds.

Metamorphic facies series and paired metamorphic belts. Mineralogical phase rule of closed and open system.

Metamorphic mineral reactions (prograde and retrograde).

Relationship between metamorphism and deformation.

Module-III

Bowen's Reaction Series. Melting and crystallization.

Classification of igneous rocks.

Textures, structures and mineralogy of important igneous suites.

Types of metamorphism. Classification of metamorphic rocks.

Types of protoliths.

Textures, structures and mineralogy of metamorphic rocks.

Module-IV (**Practical)**

1. Field Based Practical for collection of samples/data and in-situ study.
2. Study of igneous and metamorphic rocks in hand specimens and thin sections.
3. Plotting of modal analysis data of igneous rocks.

4. Calculation of CIPW norm for important igneous rocks.

5. Exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams.

Suggested Readings

1. John D. Winter 2001. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall Inc
2. Loren A. Raymond 2002. Petrology: The study of Igneous, Sedimentary and Metamorphic rocks. Mc Graw Hill .New York
3. Cox, K.G. Bel, J.D. and Pankthrust, R.J. 2002. The interpretation of Igneous rocks. Allen and Unwin, London
4. Pankthrust, 2000. Igneous and Metamorphic rocks. Prentice Hall.
5. Phillpots, A.R., and Ague, S.J., 2009. Principles of igneous and metamorphic petrology (2nd Edn.) Cambridge.
6. Gill, Robin, Igneous rocks and processes-A practical guide. Wiley-Blackwell
7. Wilson, M. Igneous Petrogenesis, Wiley-Blackwell.
8. Yardley, B W D. 1990. An introduction to metamorphic petrology. ELBS publication.
9. Bucher K. and Martin F. 2002. Petrogenesis of Metamorphic rocks. Springer-Verlag Publication.
10. Best, M.G. 2002. Igneous and metamorphic petrology. Wiley publication.
11. Vernon R. H. and Clarke G. L. 2008. Principles of metamorphic Petrology. Cambridge publication.

GEOL-UG-C402

Geology-V (Geology of India) **Credit: 2L+2F**

Module-I Geology of Indian Peninsula

Physiographic and tectonic subdivisions of India.

Tectonic evolution of cratons and mobile belts in peninsular India.

Introduction to important Hadean, Archaean, Proterozoic, Palaeozoic, Mesozoic and Cenozoic Successions of Indian Peninsula.

Quaternary stratigraphy of India.

Concept of Gondwana and its significance.

Volcanic provinces of India.

Stratigraphic boundary problems with special reference to Precambrian / Cambrian boundary,

P / T and K / T boundaries in India.

Petroliferous basins of India.

Module-II Geology of Himalayas

Physiographic and lithotectonic subdivisions of the Himalaya.

Major thrusts and their boundaries.

India & Asia collision.

Lithological characteristics of subdivisions of the Himalaya.

Sedimentation and evolution of Himalayan foreland and intracratonic basins

Palaeozoic, Mesozoic and Cenozoic succession of the Himalayas.

Stratigraphy of the Siwalik Group.

Introduction to Geology of Eastern Himalaya.

Stratigraphy of the Sikkim – Darjeeling Himalaya.

Inverted metamorphic Sequence.

Quaternary geology and Neotectonics of Eastern Himalaya.

Module-III & Module-IV

Introduction to geological mapping techniques.

Field training to acquaint the students with geological characteristics of type outcrops of important geological formations of Indian peninsula and Himalayas.

Suggested Readings:

1. Krishnan, M.S. 1982. Geology of India and Burma, CBS Publishers, Delhi
2. Pascoe, E.H. 1968. A manual of the Geology of India and Burma (Vol.I-IV), Govt. Of India Press, Delhi.
3. Doyle, P. & Bennett, M.R. 1996. Unlocking the Stratigraphic Record. John Wiley
4. Ramakrishnan, M. & Vaidyanadhan, R. 2008. Geology of India Volumes 1 &

2, geological society of India, Bangalore.

5. Valdiya, K.S. 2010. The making of India, Macmillan India Pvt. Ltd.
6. Naqvi S.M. 2007: Geology and evolution of Indian Plate
7. Bigg, G., 1999 Ocean and Climate. Springer-Verlag
8. Bradley, F., 2000. Paleoclimatology: Reconstructing Climates of the Quaternary. Springer-Verlag
9. Maher and Thompson, 2000. Quaternary Climates, Environments and Magnetism. Cambridge University Press.
10. Williams, Durnkerley, Decker, Kershaw and Chhappell, 1998. Quaternary Environments. Wiley and Sons.

English

Unit I: Elementary Grammar

Articles

Tense

Direct and Indirect Speech

Prepositions

Unit: II: Composition

Essay Writing

Letter Writing

Comprehension

Precis/ Report writing

Unit III: Poetry

John Donne **-** " Death be not Proud"

Oliver Goldsmith - " The Village Schoolmaster"

Robert Frost - " Stopping by woods ona Snowy Evening"

Nsssim Ezekiel – " Night of the Scorpian"

Unit IV: Short Story

Leo Tolstoy – "How Much Land Does a Man Need"

Rabindranath Tagore - "Kabuliwala"

Ernest Hemingway- " In Another Country"

R.K Narayan – " A Horse and Two Goats"

Suggested Readings:

1. Eastwood, John . *Oxford Practice Grammar* (OUP)
2. Robert W. Bly. *Webster's New World Letter Writing Handbook*
3. Duigu,Gabi. *Essay Writing for English Test*

Semester-V **Credit: 4**

GEOL-UG-C501

Geology-VI (Structural Geology and Engineering Geology) **Credit: 3L+1P**

Module-I

Concept of rock deformation. Stress and Strain in rocks.

Strain ellipses of different types and their geological significance.

Importance of top-bottom criteria in structural geology.

Geometric and genetic classification of

i. Folds, ii. Boudins iii. Fractures iv. Faults, v. Joints, vi. Shear zones, vii. Cataclastic and Ductile deformation products.

Module-II

Mechanics of folding: Buckling, Bending, Flexural slip and flow folding etc.

Origin of foliations: axial plane cleavage. Origin of lineation.

Mechanics of Faulting, Mohr Circle of failure.

Effects of topography on structural features.

Rule of V. Effects of deformation on topography.

Stereographic projections and their use in structural analysis.

Module-III

Role of engineering geology in planning, design and construction of engineering structures. Geomechanical classification of rock mass (RMR, RQD, SMR).

Engineering classification of Soils.

Geotechnical components and classification of dams, reservoirs, spillways, tunnels, underground caverns, bridges, highways and shorelines.

Geological structures and discontinuities, engineering properties of rocks, engineering properties of jointed rocks.

Classification of construction materials and aggregates.

Geological hazards (landslides and earthquakes) their significance, causes and preventive/remedial measures.

Seismic zones of India, soil liquefaction.

Module-IV (Practical)

1. Field Based Practical for collection of samples/data and in-situ study.

2. Drawing profile sections and interpretation of geological maps of different complexities.
3. Study of 3D models of various geological structures.
4. Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.).
5. Solving problems related to stress and strain measurements.
6. Preparation and study of geological sections for feasibility and selection of sites for dams, tunnels, bridges, highways and similar civil structures.
7. Use of softwares for solving various geotechnical problems (Slope Stability etc).
8. Evaluation of mechanical properties of concrete aggregates.
9. Index Tests for soil, rocks and debris.
10. Evaluation of Atterberg limits and shear strength parameters.

Suggested Readings

1. Price, N.J, & Cosgrove, J.W.: Analysis of Geological Structures. 1990. Cambridge University Press.
2. R.G.Park: Fundamentals of Structural Geology.
3. Davis, GR. 1984. Structural Geology of Rocks and Region. John Wiley
4. Weijermars, R. 1997. Structural Geology and Map Interpretation, Alboran Science Publishing.
5. Billings, M.P. 1987. Structural Geology, 4th edition, Prentice-Hall.
6. Hatcher, Jr., R.D. 1995. Structural Geology - Principles, Concepts and Problems, Merrill Publishing Company.
7. Ghosh, SK. 1993. Structural geology: fundamentals and modern developments, Pergamon Press, London
8. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGrawHill (CBS Publ).
9. Johnson, R.B. and DeGraf, J.V. 1988. Principles of Engineering Geology, John Wiley & Sons, N.Y.
10. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. Jonh Wiley & Sons, N.Y.
11. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.

GEOL-UG-C502

Geology-VII (Geochemistry and Hydrology) **Credit: 3L+1P**

Module-I

Stellar evolution and origin of elements.

Different processes of nucleosynthesis.

Abundances of elements and Oddo-Harkin’s Law,

Meteorites, Chondrites and chondritic ratios.

Geochemical Distribution of elements in solar system.

Geochemical classification of elements.

Geochemical Structure of Earth

Geochemical Properties of elements (volatiles, semi-volatiles, alkalis, alkaline earths, REE, HFS, Transition metals and noble metals).

Trace elements: Raoult’s and Henry’s Law.

Introduction to Radioactive and Stable Isotopes and applications.

Module-II

Hydrologic cycle.

Vertical distribution of subsurface water.

Groundwater - Aquifer properties.

Geological classification of aquifers.

Darcy’s law and its validity, free and confined aquifers, phreatic and piezometric level, analysis of piezometric surface, groundwater level fluctuations.

Aquifer’s hydraulic parameters. Springs.

Groundwater occurrence in igneous, metamorphic and sedimentary rocks.

Physical and chemical properties of water.

Effect of geological environment on groundwater quality.

Surface and subsurface water interaction,

Sea water intrusion in coastal aquifers.

Groundwater provinces of India.

Module-III

Molarity and molality, solubility product and solubility.

Acids and bases, dissociation constant, pH, hydrolysis, ionic concentration.

CO_2-H_2O interaction to form carbonic acid, dissolution of calcite, weathering reactions.

Ground water quality and contamination.

Introduction to surface and subsurface exploration of groundwater.

Drilling and construction of wells.

Module-IV (Practical)

1. Field based practical for sample/Data collection and in-situ study.
2. Determination of morphometric parameters of watersheds.
3. Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams).
4. Numerical problems based on Darcy's Law
5. Preparation and interpretation of water table contour maps and depth to water level contour maps.
6. Water potential zones of India (map study) including saline water zones.
7. Plotting of Geochemical analyses on various geochemical discrimination plots.
8. Calculation of Half life and age of the samples by Isochron and Model age method.
9. Plotting of Normalised Trace element and Rare earth element plots.
10. Demonstration of Geochemical analytical methods.

Suggested Readings:

1. Walther John, V., 2009. Essentials of geochemistry, student edition. Jones and Bartlett Publishers.
2. Faure, Gunter. Inorganic Geochemistry.
3. Faure and Mensing: Early Earth Systems
4. Mason, B (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
5. Hugh Rollinson (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
6. Todd, D.K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
7. Davis, S.N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
8. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.
9. Raghunath, Hydrology
10. Fetter, C.W. 2001. Applied Hydrogeology, Prentice Hall Inc., N.J

EHS-UG-F106: Eastern Himalayan Studies **Credit: 4**

Unit I: Geography and Environment of the Eastern Himalayas [Sikkim, Darjeeling, Bhutan, Arunachal Pradesh]

Delineation of the Eastern Himalaya as a region

Physiography; Climate; Drainage; Biodiversity and overview of Natural Resources

Unit II: Historical background

Brief History of Sikkim and Darjeeling

Spatial relations (Trade and Religious linkages) of Sikkim with its Neighbours- Tibet, Bhutan and Nepal.

Unit III: Society, Economy and Polity

Society and Culture in Sikkim;

Economy and Livelihood in Sikkim with emphasis on Agriculture, Industry and Tourism; Social and Political dimensions of Sikkim and Darjeeling Himalaya

Unit IV: Critical Environmental Issues

Development Bottlenecks: Potentials, Prospects and Implications with special reference to Hydro- resources, Communication and Industrial Development.

Climate Change, Natural Hazards and Disaster Management, Degradation of Bio-Resources

Essential Readings:

1. Bose, S.C (1968). *Land and people of the Himalaya*. Indian Publications, Calcutta.
2. Karan, P.P and Jenkins, W.M (1963). *The Himalayan Kingdoms*. Princeton
3. 3.Risley, H.H., *The Gazetteer of Sikkim* (1989), B.R. Publishing Corporation
4. Rustumji, N (1971). *Enchanted Frontiers: Sikkim, Bhutan and India's North-Eastern Borderland*. Bombay: Oxford University Press.
5. Sarkar, RL and Mahendra P Lama (ed.1986). *The Eastern Himalayas: Environment and Economy*, Atma Ram, New Delhi.
6. Waddell, L.A (1979). *Among the Himalayas*. New Delhi: Mittal Publication

Suggested Readings and Documentaries

1. *Bulletin of Tibetology*, Namgyal Institute of Tibetology
2. Denjongpa, Anna Balikci and Mckay, Alex (2011*), Buddhist Himalaya: studies in Religion, History and Culture, Volume II: The Sikkim Papers*
3. *Grazing on the Border: the Yak Herders of North Sikkim*, (2017) ,Namgyal Institute of Tibetology

4. Mullard, S.(2009) *Opening of the Hidden, Land: State Formation and Construction of Sikkimese History,* University of Oxford

5. *Pang Lhabsol: Sikkim's national Ritual of the Land and its Guardian Deities,* (2015), Namgyal Institute of Tibetology

6. Satyajit(1971), *Sikkim*

7. *Tingvong: A Lepcha Village*, (2005), Namgyal Institute of Tibetology

Semester-VI

GEOL-UG-C601

Geology-VIII (Economic Geology, Coal and Petroleum Geology) **Credit: 3L+1P**

Module-I Economic Geology

Definition of Ore and gangue, tenor and grade, ore bodies and lodes.

Resources and reserves. Classification of economic deposits.

Introduction to processes of formation and enrichment of economic deposits.

Metallogeny and Plate tectonics.

Distribution of economic deposits in India.

Metallic ores: Native metals, oxides of Fe, Mn, Cr, W and sulphides of Cu, Pb, Zn, metallogenic provinces and epochs.

Atomic minerals.

Nonmetallic and industrial rocks and minerals, their nature and distribution in space and time in India:

Refractory, chemical, fertilizer, cement, chemical and gemstone industry including building stones.

Module-II Coal Geology:

Coal Classification and ranks of coal.

Coalification process and its causes;

Lithotypes, microlithotypes and macerals: their physical, chemical and optical properties.

Mineral and organic matter in coal.

Proximate and ultimate analyses.

Introduction to geology of different Tertiary and Gondwana coalfields of India.

Uses of coal for various industries e.g. carbonization, liquefaction, power generation, gasification and coal-bed methane production.

Module-III Petroleum Geology:

Origin of petroleum, Maturation of kerogen.

Classification of Crude oil.

Reservoir rocks: general attributes

Classification of reservoir rocks - fragmental reservoir rocks and chemical reservoir rocks; Migration of oil and gas: primary and secondary migration; geologic factors controlling hydrocarbon migration.

Classification of hydrocarbon traps - structural, stratigraphic and combination.

Cap rocks - definition and general properties.

Formation water characteristics.

Plate tectonics and global distribution of hydrocarbon reserves.

Introduction to petroleum geology of Assam, Bengal, Cauvery, Krishna-Godavari, Cambay and Bombay offshore basins.

Module-IV (Practical)

1. Field based practical for sample/Data collection and in-situ study.
2. Megascopic identification of different varieties of coal.
3. Interpretation of geologic structures from surface geological maps and bore hole data;
4. Construction of Panel and Fence diagram.
5. Preparation of structure contour and isopach maps of reservoir facies and drawing oil/water contact from bore hole data.
6. Problems on porosity and permeability
7. Calculation of oil reserves in defined structure.
8. Study of physical properties of ore forming minerals.
9. Study of optical properties of common ore forming minerals.
10. Study of association of ore forming and typical gangue minerals.
11. Preparation of maps showing distribution of important ores and other economic minerals in India.

Suggested Readings:

1. Evans, A.M. 1993. Ore Geology and Industrial Minerals. Blackwell ScLPubl.Guilbert, J.M. and Park Jr., C.F. 1986. The Geology of Ore deposits. Freeman & Co.
2. Bateman, A.M. and Jensen, M.L. 1990. Economic Mineral Deposits. John Wiley.Gokhale, K.V.G.K. and Rao, T.C. 1978. Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.Deb, S. 1980. Industrial minerals and rocks of India. Allied Publishers
3. Mukherjee Ashok
4. Coal Geology: Larry Thomas, 2002, Wiley and Sons.
5. Coal: it’s composition, analysis, utilisation and valuation.: E.E.Somermier 2008, Mc GrawHill
6. Petroleum Geology: F.K.North, 1986, Allen and Unwin
7. Petroleum Formation and Occurrence: B.P.Tissot and D.H.Welte 1978, Publisher: Springer-Verlag
8. Elements of petroleum Geology: R.C.Shelley 1998, Academic press
9. Petroleum Development Geology: P.A.Dickie, 1986, Publisher: Pennwell Publishing, Tulsa, Oklahoma
10. Petroliferous basins of India: Publisher: KDMIPE, ONGC, 1986.

GEOL-UG-C602

Geology-IX (Mini Project/Industrial Training) **Credit: 4**

For Mini Project the student may carry out a study of geological interest (petrology, landslides, hydrological, environmental problems etc) in consultation with the course supervisor and submit a project report and make presentations.

For industrial training the student may undergo a short training at DST & CSIR labs or in organizations such GSI, NHPC, CGWB etc and submit a report and make presentations.

Syllabus of Elective Papers

1. GEOL-UG-E102 Physical Sciences-I (Physics)
2. GEOL-UG-E103 Physical Sciences-II (Atmospheric, Oceanic and Planetary Sciences)
3. GEOL-UG-E202 Physical Sciences-III (Chemistry)
4. GEOL-UG-E203 Computation-I (Mathematics)
5. GEOL-UG-E302 Computation-II (Computer Application in Geosciences and Disaster Management)
6. GEOL-UG-E303 Computation-III (Remote Sensing and GIS)

GEOL-UG-E102

Physical Sciences-I: Physics **Credit: 3L+1P**

Module I: Introduction to Mechanics

Scalar and vector fields, Scalar and vector products, polar and axial vectors, triple products, directional derivative, Gradient, Curl, Divergence, Laplacian, line and surface integrals, theorems of Green, Gauss and Stokes, line integrals independent of path.

Newton's laws of motion, conservation of linear momentum, centre of mass, work energy theorem, Rotational motion, torque and angular momentum, kinetic energy of rotation, rigid body rotation dynamics, moment of inertia, conservation of angular momentum, comparison of linear and angular momentum, Simple harmonic motions.

Concept of Gravitational force and acceleration, Keplers' Laws, Gravitational Potential energy, Earth satellites,

Mechanical properties of solids (Elasticity, stress and Strain, Hooke's Law, Stress strain Curve, elastic moduli) and liquids (pressure, streamline flow, Bernoulli's principle, viscosity, Reynolds, Surface tension).

Module II: Optics

Geometrical Optics: Reflection and refraction from plane and curved surface.

Wave optics: Interference, division of amplitudes, Young's double slit, Fresnel's biprism, and interference in thin films, Fraunhoffer diffraction, single slit, double slit, plane transmission grating, Rayleigh's criteria of resolution, resolving power of a telescope and a microscope, resolving and dispersive power of a plane transmission grating.

Polarization: Polarization by reflection and refraction, Brewster's law, double refraction, nicol prism, quarter and half-wave plates, Production and analysis of circularly and elliptically polarized light.

Photoelectric Effect, Wave particle Duality.

Module III: Electromagnetism and Electronics

Electric Charge, Coulombs law, Electric field, potential due to a charge distribution and due to a dipole, electrical potential energy, flux, Gauss's law, electric field in a dielectric, polarization, energy stored in an electric field.

Conductors and insulators, Electric current, ohms law, resistivity and resistance.

Magnetic Field, Biot-Savart law, magnetic force on a current, Lorentz force, electromagnetic induction, Lenz's law, magnetic properties of matter, para- dia- and ferromagnetism, magnetic dipole.

Electromagnetic Radiation and Introduction to Maxwell's equations.

Introduction to electronic devices e.g. Capacitor, Resistance, Diode, transistor and ICs, Number systems (binary, BCD, octal and hexadecimal), 1's and 2's complements. Logic gates, AND, OR, NAND, NOR, XOR and NXOR. Boolean algebra (Boolean laws and simple expressions), binary adders, half adder, half subtractor, full adder and full subtractor.

Module-IV (Practical)

1. Determination of spring constant of a spring by (i) static, and (ii) dynamic methods.
2. Determination of g by Simple Pedulum.
3. Determination of g by Kater's pendulum or Bar pendulum.
4. Measurement of Resistance by Meter Bridge.
5. Sereis and Parallel Combination of Resistances by PO box
6. To determine resistance per unit length of a given wire by plotting a graph of potential difference versus current.
7. Determination of Viscosity of a liquid using Stokes Law.
8. Determination of Youngs Modulus of a solid.
9. To find the focal length of a convex lens by plotting graphs between u and v or between 1/u and 1/v.
10. To find the focal length of a concave mirror.
11. Determination of wavelength of light by Fresnel's biprism.
12. Determination of wavelength of sodium light using a plane transmission grating and resolving power of a diffraction grating.
13. Determination of specific rotation of cane sugar solution using a polarimeter
14. To verify experimentally OR, NAD, NOT, NOR, NAND gates.
15. Study of Half-Adder/ Subtractor.

Suggested Readings:

1. Spiegel, M. R. Vector Analysis Schaum's Outline Series. McGraw-Hill Book Co.: Singapore (1974)
2. Beiser, A. Concepts of Modern Physics McGraw-Hill Education (2002).
3. Resnick, R., Halliday, D. & Krane, K. S. Physics Vol. I and II 5th Ed. John Wiley & Sons (2004)
4. Serway, R. A. & Jewett, J. W. Physics for Scientists and Engineers 6th Ed.
5. Ghosh, N.N. Introductory Physics, Part-I & II. Bharati Bhawan, 1997.
6. Griffiths, D. J. Introduction to Electromagnetism 3rd Ed. Prentice-Hall (1999).
7. Malvino, A.P. & Leach, D. P. Digital Principles and Applications, Tata McGraw-Hill (2008).
8. Ryder, J. D. Electronic Fundamentals and Applications: Integrated and Discrete Systems. 5th Ed. Prentice-Hall, Inc. (2007).

9. Floyd, T. L. & Buchla, D. M. Electronics Fundamentals: Circuits,Devices and Applications (8th Ed.) Prentice-Hall (2009).21

GEOL-UG-E103

Physical Sciences-II

Atmospheric, Oceanic and Planetary Sciences **Credit 4L**

Module-I: Planetary Sciences

General characteristics and Origin of the Universe.

Solar System its planets and satellites.

Meteorites, Asteroids and Comets.

Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.

Earth and Moon System: Origin and Characteristics.

Initiation of plate tectonics movements and origin of Earth's early atmosphere.

Artificial satellites – Polar orbiting and geostationary satellites.

Module-II: Atmospheric Sciences

Thermal structure of the atmosphere and its composition.

Insolation, solar constant, albedo, radiation windows, radiative transfer, Greenhouse effect, net radiation budget, Rayleigh and Mie scattering, multiple scattering.

Latitudinal and seasonal variation of insolation, and different meteorological parameters.

Thermodynamics of dry and moist air: specific gas constant.

Adiabatic and isoentropic processes, Vertical stability of the atmosphere.

Module-III: Climatology

Classification of Cloud, Condensation and Precipitation.

Air masses, monsoon, Jet streams, tropical cyclones, and ENSO.

Classification of climates – Koppen's and Thornthwaite's scheme of classification.

Basic equations and fundamental forces: Pressure, gravity, centripetal and Corolis forces, continuity equation in Cartesian and isobaric coordinates.

Geostrophic, gradient winds and thermal wind.

Module-IV: Oceanic Sciences

Introduction to Oceanography.

Major Oceans of the world. Major physical divisions of the ocean basin.

Properties of Sea Water

Temperature and salinity distribution in surface of the ocean.

Dissolved gases in seawater. Carbon dioxide and carbonate cycle.

Major currents of the world's ocean.

The Ocean Conveyor belt and its role in controlling world's climate.

Surface circulation, concept of mixed layer, thermocline and pycnocline, Coriolis Force and Ekman Spiral and Upwelling.

Deep-sea sediments and Calcite and Aragonite Compensation depth and significance.

Mineral resources of the ocean including polymetallic nodules. Marine Gas Hydrates and their economic potential.

Suggested Readings:

1. Fischer, G. and Wefer, G., 1999. Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer.
2. Gross, M.G., 1977. Oceanography: A view of the Earth, Prentice Hall.

3. Haq and Boersma, 1978. Introduction to Marine Micropaleontology, Elsevier.

4. Tolmazin, D., 1985. Elements of Dynamic Oceanography, Allen and Unwin.

GEOL-UG-E202 Physical Sciences-III

Chemistry **Credit: 3L+1P**

Module I

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, Schrodinger's wave equation, significance of ø and ø2. Quantum numbers and their significance. Radial and angular wave functions. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Periodicity of Elements: s, p, d, f block elements and it general physical properties e.g Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.Atomic radii (van der Waals), Ionic and crystal radii, Covalent radii (octahedral and tetrahedral), Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy, Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity.

Pauling's and Mulliken's electronegativity scales. Introduction of chemical bonding.

Module II

Chemical Thermodynamics. State of a system, state variables, intensive and extensive variables, concept of heat and work, thermodynamic equilibrium, thermodynamic properties, various types of systems and processes.

First Law of thermodynamics. Calculation of work (w), heat (q), changes in internal energy (NU) and enthalpy (NH) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w, q, NU and NH for processes involving changes in physical states.

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.

Various statements of Second Law of thermodynamics, concept of entropy, Gibbs free energy and Helmholtz energy, Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity. Gibbs – Helmholtz equation. Maxwell's relations.

Introduction to Chemical kinetics Ist order, IInd order reactions. Rate law, molecularity & order. Arrhenius Equation.

Module III

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.

Ionic Equilibrium: 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 31 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.

Phase Equilibrium: Ehrenapst classification of Phases, Solid –Liquid, Soild-Solid and Liquid-Liquid Mixtures. One Component and Two Component System, Eutectic and Peritectic system, classical Nucleation Theory.

Module IV (Practical)

1. Physical & Chemical parameters of Water
2. Estimation of Fe content in Haematite.
3. Mg & Ca ions Hard water
4. Estimation of Cu in Chalcopyrite
5. Estimation of Ca & Mg in Dolomite
6. Estimation of Fe in cement
7. Estimation of Fe using UV-VIS spectrophotometer.
8. Preparation of solutions of different Molarity/Normality of titrants
9. Estimation of carbonate and hydroxide present together in mixture.
10. Estimation of carbonate and bicarbonate present together in a mixture.
11. Estimation of oxalic acid and sodium oxalate in a given mixture.
12. Determination of heat capacity of calorimeter for different volumes.
13. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
14. Determination of enthalpy of ionization of acetic acid.
15. Determination of integral enthalpy of solution of salts (KNO3, NH4Cl).
16. Determination of enthalpy of hydration of copper sulphate.
17. Study of the solubility of benzoic acid in water and determination of pH
18. Introduction to different analytical Instruments like UV-VIS, FTIR and P-XRD.

Suggested Readings:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
3. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

5. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.
6. Barrow, G. M. Physical Chemistry Tata McGraw Hill (2007).
7. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
8. Mahan, B. H. University Chemistry 3rd Ed. Narosa (1998).

GEOL-UG-E203 Computation-I

Mathematics **Credit: 4L**

Module I

Variables, Functions and Mapping: Variables and functions, Inverse functions, Common functions, Curves and Parameters, Exponential, Hyperbolic and Logarithmic Functions.

Functions and their graphs: polynomial, sine, cosine, exponential and logarithmic functions.

Motivation and illustration for these functions through projectile motion and simple pendulum, Simple observations about these functions like increasing, decreasing and, periodicity.

Sequences, Limits and Continuity: Sequences, Limits of sequences and functions, Functions of several variables – limits, continuity.

Module II

Differentiation of Functions: The derivative, rules of differentiation, Higher derivatives, Parital differentiation, change of variable, implicit functions, higher order partial derivatives. Use of methods of differentiation like Chain rule, Product rule and Quotient rule. Second order derivatives of above functions

Integration as reverse process of differentiation. Integrals of the functions introduced above. Fundamental theorem of integral calculus, mean value theorems, evaluation of definite integrals, Convergence of improper integrals, tests of convergence, Differentiation of an integral containing a parameter, differentiation of integrals with variable limits - Leibnitz rule. Rectification, double and triple integrals, computations of area, surfaces and volumes. Integration by substitution, Integration by parts, Reduction formulae.

Module III

Differential Equations: Classification of differential equations, Arbitrary constants and the order of differential equations, Ordinary first order differential equations, Ordinary differential equations of the second and higher orders, Transforms of basic functions, Inversion, Solution of differential equations, Partial differential equations.

Matrices and Linear Algebra: Algebra of matrices, Determinants, linear transformations, rank and inverse of a matrix, solution of algebraic equations, Eigenvalues and eigenvectors, Tensors.

Points in plane and space and coordinate form.

Module IV

Elementary understanding of data, Measures of central tendency and dispersion. Curve fitting and method of least-squares, regression analysis, Correlation theory, simple linear regression, multiple regression, Co-variance and correlation co-efficient.

Introduction to set theory, Permutations and combinations, Elementary probability theory, Conditional probability, Expectation.

Random variables, probability distribution of finite random variables, discrete and continuous random variables, Normal distribution, Central limit theorem, Binomial distribution, Poisson distribution, t-Distribution, Chi-square distribution.

Suggested Readings:

1. H. S. Bear: Understanding Calculus, John Wiley and Sons (Second Edition); 2003.
2. E. Batschelet : Introduction to Mathematics for Life Scientists,Springer Verlag, International Student Edition, Narosa Publishing House, New Delhi (1971, 1975).
3. Introduction to probability and statistics. Schumm's Outlines.
4. Davis, JC Statistics and data analysis in geology. John Wiley & Sons. 2002.

5. H. S. Bear: Understanding Calculus, John Wiley and Sons (Second Edition); 2003.

6. E. Batschelet : Introduction to Mathematics for Life Scientists,Springer Verlag, International Student Edition, Narosa Publishing House, New Delhi (1971, 1975)

GEOL-UG-E302 Computation-II

Computer Application in Geosciences and Disaster Management **Credit: 3L+1P**

Module-I Computer Applications in Geosciences

Introduction to computer applications in geosciences.

Geological Data compilation, processing and presentation.

Introduction to Computer programming. Basic programming codes.

Statistical analysis using various statistical softwares including Excel, Origin and SPSS.

Introduction to MATLAB.

Introduction to Rockworks, Slope Stability and hydrological modeling softwares.

Module-II Computer Applications in Hazard Assessment

Concept of Disaster and Hazard.

Types, Causes, Factors and Consequences of i. Geological ii. Hydro-meteorological iii. Biological, iv Technological and v. Man-made Hazards. Global and National distribution of different Hazards

Computer Applications in Disaster Risk Management.

Pre-disaster phase – Hazard, Vulnerability and Risk Zonation; Monitoring, Warning and Alert System; Awareness, Preparedness, Planning and Capacity Development.

During Disaster phase – Incident Command System (ICS) and Emergency Operations Centre (EOC), Emergency communication, transportation, rescue, relief, damage and needs assessment, rehabilitation, and restoration of basic facilities and infrastructure.

Post-disaster phase – Reconstruction, Relocation, Recovery and Redevelopment.

Module-III Geohazards and risk assessment

Lithospheric Hazards: Earthquakes and Faults, Measures of an Earthquake, Earthquake Hazards, Earthquake Control and Prediction. Seismic zonation map of India.

Landslides, Types of slope failure, Slope Mass Rating (SMR) classification, Causative factors, Landslide Hazard Zonation, Factor of Safety analysis, Slope stabilization measures.

Volcanic Hazard: Origin and Types, Products and Hazards, Monitoring, Risk Evaluation, Prediciton, Tectonics and Climate, Meteorite Impacts.

Atmospheric Hazards: Cyclones and Anticyclones, Thunderstorms and Lightning, Hail, Flash Flooding GLOF. Drought.

Hydrospheric Hazards: Fluvial hazards: Flooding, channel migration, bank erosion, catchment erosion. Snow avalanches – snow packages and density, avalanche types, characteristics of avalanche, avalanche prone areas and their mitigation

Coastal Hazards: Tsunamis, Sea Level fluctuation

Module-IV (Practical)

1. Application of listed softwares for Hazard assessment and Risk Management.
2. Case Studies related various Disasters.

Suggested Readings:

1. Bell, F.G., 1999. Geological Hazards, Routledge, London.
2. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
3. Patwardhan, A.M., 1999. The Dynamic Earth System. Prentice Hall.
4. Smith, K., 1992. Environmental Hazards. Routledge, London.

5. Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International

6. Merriam D.F., (Ed.) 2000. Computer methods in the Geosciences, Elsevier.

7. Chapman, S.J., 2008 Fortran for Scientists and Engineers (3rd Edn.) McGraw-Hill.

GEOL-UG-E303 Computation-III

Remote Sensing and GIS **Credit: 3L+1P**

Module I Concept and Foundation of Remote Sensing & Photogrammetry:

Electromagnetic radiations, Radiation Principles.

Interaction of energy with Atmosphere and Earth Surface features.

Different component of Remote sensing (Source of Energy, Data acquisition, Data interpretation and Reference Data).

An Ideal Remote Sensing System.

Characteristics of Real Remote sensing System.

Introduction to Global Positioning System and DGPS.

Application of Remote Sensing.

Characteristics and applications of imageries of LANDSAT1 to 7, SPOT missions,

Indian Remote Sensing Satellite mission.

Basic idea of hyperspectral image.

Elements of photo interpretation,

Basic characteristics of aerial photographs and camera.

Photographic scales, ground coverage of aerial photographs. Area Measurements, Relief displacement, vertical exaggeration and, distortion of aerial photographs, Image parallax.

Module II Visual image interpretation and Digital Image processing

Fundamental of visual image interpretation,

Land use land cover mapping,

Geologic and soil mapping

Introduction to Digital Image processing.

Image rectification and restoration

Image Enhancement

Contrast manipulation

Spatial Feature Manipulation

Multi Image Manipulation

Image Classification

Module-III: GIS and Surveying

Introduction to GIS, Spatial data types

Principles and use of the vocabulary of GIS,

Nature of geographic phenomena and their representation in the context of geo-informatics; Principal data models for spatial and non-spatial data used in GIS databases;

Basic data preparation

Geo-referencing and Data entry into a GIS.

Significance and Principles of Surveying,

Geodetic survey, Datum, Projection and Coordinate System.

Different type of maps: base maps, thematic maps.

Main categories of thematic maps used in earth sciences;

Techniques for legend and symbols in the maps;

Scale & Representative Fraction of maps,

Classification of maps according to the scale, effect of the scale on the level of details of the information;

Introduction to Survey methods and application of Compass, Tape, Chain, Plain Table, Theodolite, Electronic Distance Meter, Total Station.

Contouring and Plotting, Measurement of slope heights, aspects and gradients; Use of abney level, pedometer,

Module-IV (Practical)

1. Application of RS & GIS softwares : i. ArcGIS, ii. ERDAS, iii. ILWIS, iv. ENVIS
2. Hand on Practice on Remote Sensing and GIS softwares as mentioned in different Modules
3. Field Survey by using : Compass and Tape Survey, Plain Table Survey, and Total Station

Suggested Readings:

1. Avery, T.U. and Berlin, G.L. 1992 Fundamentals of remote sensing and air photo interpretation, McMillion Publishing Co., New York.
2. Campbell, J. B. (1996) Introduction to Remote Sensing.622pp.
3. Drury, S.A. 1987. Image interpretation in Geology. Chapman and Hall.
4. Gupta, R.P. (1991) Remote Sensing Geology. Springer-Verlag. 356pp.
5. Miller, V.C. & Miller, C.F. 1961. Photogeology. McGraw Hill, New York.
6. Pandey, S.N. 1987. Principles and applications of photogeology. Wiley Eastern, New Delhi.
7. Ray, R.G. 1969 Aerial photographs in geologic interpretation. USGS Professional Paper 373.

8. Punmia, b. C. , Jain, A.K. & Jain, A.K., Surveying (Volume - 1), 2005, Laxmi Publication Ltd.
9. Basak N N., Surveying and Levelling , 2001 (1st Edition) Tata Mcgraw Hill Education Private Limited
10. Bannister, A., Raymond, S. & Baker, R. Surveying 7th Edition, 2006, Pearson Education Singapore Pte Ltd

ENV-UG-F105: Environmental Studies

Unit I: Environment and Ecosystem

Introduction, Importance and Scope of Environmental Studies

Components of Environment; Atmosphere, Hydrosphere, Lithosphere and Biosphere

Ecosystems: Concept, Structure and Function of an Ecosystem; Energy Flow, Food Chains, Food Webs, Ecological Pyramids, Ecological Niche and Keystone Species.

Unit II: Resources and Conservation

Introduction and Classification of Resources

Problems Associated with Resources and Conservation; Forest resources, Water Resources, Energy Resources, Land Resources

Biodiversity: Introduction, Issues and Conservation

Unit III: Environmental Pollution and Issues

Introduction to Environmental Pollution

Causes, Effects and Control Measures of: Air Pollution, Water Pollution, Soil Pollution, Noise Pollution, Nuclear Pollution

Environmental Issues; Climate Change, Global Warming, Acid Rain, Ozone Layer Depletion etc. Firecracker and Associated Issues

Unit IV: Human and Environment

Human-Environment Relationship, Sustainable Development: Concept and Issues

Role of Information Technology in Environmental Management

Solid Waste Management Environmental Refugees

Environmental Ethics: Issues and possible solutions

DEPARTMENT OF GEOLOGY
M.Sc. Geology Syllabus

- **Structure:**

Total 20 Papers (4 Credit Each) of 80 credits and 200 Marks

A. Core Theory Paper: 8 Papers
B. Core Practical Paper: 4 Papers
C. Core Field Training: 2 Papers
D. Open Paper: 2 Papers
E. Elective (Special) Paper 3 Papers
F. Dissertation: 1 Paper

- **Distribution of Papers of M.Sc.**

Semester	**I**	**II**	**III**	**IV**
	Theory I (Core)	Theory V (Core)	Theory IX (Core)	Theory XIII (Elective)
	Theory II (Core)	Theory VI (Core)	Theory X (Core)	Theory XIV (Elective)
	Theory III (Core)	Theory VIII (Open)	Theory XI (Open)	Theory XVI (Dissertation)
	Theory IV (Core)	Practical II	Theory XII (Elective)	Practical IV
	Practical I	Field Training I	Practical III	Field Training II
Total Credits	20	20	20	20
Total Marks	500	500	500	500

- **Course Details:**

Paper	Paper Title	Credit	Marks
Semester I			
GEOL-PG-C101	Mineralogy and Igneous Petrology	4	100
GEOL-PG-C102	Sedimentary Geology	4	100
GEOL-PG-C103	Atmospheric and Oceanic Sciences	4	100
GEOL-PG-C104	Structural Geology	4	100
GEOL-PG-P109	Practical I	4	100
Total		**20**	**500**
Semester II			
GEOL-PG-C201	Stratigraphy of India and Palaeontology	4	100
GEOL-PG-C202	Metamorphic Petrology	4	100
GEOL-PG-O203	Remote sensing and GIS	4	100
GEOL-PG-P209	Practical II	4	100
GEOL-PG-F210	Field Training I	4	100
Total		**20**	**500**
Semester III			
GEOL-PG-C301	Ore Geology	4	100
GEOL-PG-C302	Fuel Geology	4	100
GEOL-PG-O303	Hydrogeology	4	100
GEOL-PG-E304	Geophysics and Geodynamics	4	100
GEOL-PG-E305	Applied River Science	4	100
GEOL-PG-E306	Isotope Geology	4	100
GEOL-PG-P309	Practical III	4	100
Total		**20**	**500**
Semester IV			
GEOL-PG-E401	Exploration Geology	4	100
GEOL-PG-E402	Sequence Stratigraphy and Basin Evolution	4	100
GEOL-PG-E403	Environmental and Engineering Geology	4	100
GEOL-PG-E404	Cryospheric Science	4	100
GEOL-PG-E405	Micropaleontology	4	100
GEOL-PG-E406	Oceanography	4	100
GEOL-PG-E407	Geology of Hydrocarbon Reservoirs	4	100
GEOL-PG-E408	Atmospheric Processes	4	100
GEOL-PG-P409	Practical IV	4	100
GEOL-PG-F410	Field Training II	4	100
GEOL-PG-D411	Dissertation	4	100
Total		**20**	**500**

· **Detailed Syllabus**

Semester I

Core Theory Paper:

Mineralogy and Igneous Petrology

GEOL-PG-C101

Unit I: Origin and abundance of elements

Origin and abundance of elements in the solar system and in the Earth Geochemistry of atmosphere, hydrosphere and lithosphere.Geochemical classification of elements.

Properties of LILE, HFSE and Rare Earth Elements.

Types of bonding of atoms of elements in minerals.

Chemical composition and unit cell content.

Unit II: Mineralogy

Principles of ionic substitution in minerals.

Isomorphism.Solid solution and different types of polymorphic transformations.

Silicate structure.

Phase diagram.

Development of intergrowths, zoning and twinning.

Crystallography and elements of symmetry.

Mineral Optics: Behaviour of light in isotropic, uniaxial and biaxial crystals, study of crystal under parallel and convergent polarised light, Interference figures. Universal stage.

Introduction to spectroscopic study of minerals.Application of X-ray, Diffraction, EPMA and SEM-EDX.Calculation of mineral formula from chemical analysis.

Unit III: Nature, Origin, and Classification of Igneous Rock

Classification Schemes: Irvine- Baragar Classification, QAPF Classification for volcanic and plutonic rocks, Concept of Norm and Mode in Igneous rocks.

Granites, Pegmatites, Alkaline rocks, Anorthosites, Lamprophyres, Ultramafic and layered rocks, Carbonatites, Kimberlites, and Lunar rocks.

Unit IV: Igneous Processes

Crystallization of magma and their evolution through phase diagrams (binary and ternary system)

Partial melting, fractional crystallization, contamination and assimilation.

Geochemical characteristics of igneous rocks as Petrogenetic indicators.

Isotope systematic of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous rocks

Geological controls and application of major, trace and rare earth elements in petrogenesis.Quantitative approach to partial melting and fractional crystallization using different types of trace elements.

Concept of mantle metasomatism and role of fluids in magma generation.

Magmatism in Global Tectonic Scenario.Magmatism in (a) Constructive Plate Margins, (b) Destructive Plate Margins, (c) Within Plate Magmatism.

Archaean& Proterozoic Crustal Evolution.TTG Suites and their significance.

Essential readings:

1. Nesse W., 2012. Introduction to Optical Mineralogy.Oxford University Press.
2. Frost, B. Ronald and Frost, Carol D. 2014 Essentials of igneous and metamorphic petrology. Cambridge University Press
3. Gill, Robin, 2010, Igneous rocks and processes-A practical guide.Wiley-Blackwell
4. Deer, W. A., Howie, R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication,1962-1963.
5. Winter, JD, 2001. An introduction to Igneous and Metamorphic petrology, Prentice
6. Philpotts, AR and Ague, JJ. 2009. Principles of Igneous and Metamorphic Petrology. Cambridge University Press.
7. Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1993.The Interpretation of Igneous Rocks. Chapman & Hall
8. Wilson, M., 1989. Igneous Petrogenesis: a Global Tectonic Approach. London (Unwin Hyman)

Suggested readings:

1. Putnis, Andrew, 1992. Introduction to Mineral Sciences.Cambridge University Press.
2. Walter BorchardtOtt, 2012. Crystallography: An Introduction. Springer.Perkins Dexter (2014) Mineralogy Third Edition Pearson New International Edition
3. Rollinson, H. R. (1993). Using geochemical data: Evaluation, presentation, interpretation.Longman Scientific & Technical.
4. LeMaitre R.W., 2002. Igneous Rocks: A Classification and Glossary of Terms. Cambridge University Press.

Sedimentary Geology

GEOL-PG-C102

Unit I: Sedimentary Rocks: Texture, composition and structure

Nature and origin of sedimentary rocks composition and classification Earth surface processes.

Sedimentary structures and their genetic significance.

Biogenic structures. Diagenesis.

Palaeocurrent analysis.

Unit II: Classification of siliciclastic rocks

Classification of conglomerates, sandstones and shales. Texture of sediments, provenance and their deductions from composition of sedimentary rocks,

Sediment transport in different systems.

Unit III: Non Marine Sedimentary Environment

Concepts of sedimentary environment Environmental parameters and controls. Classification of environments, Glacial environment, Alluvial environment (Braided, Meandering), Aeolian Environment.

Deltaic models (Fluvial, wave), coastal (interdeltaic) model – barrier islands and lagoons, tidal channels, tidal deltas and Estuaries.

Unit IV: Marine Sedimentary Environment

Marginal marine and neritic environment.

Deep marine sedimentation: Slope and Basin-floor fans (Point and Line source).

Carbonate sedimentation model. Geometry of carbonate platforms; ramp, rimmed shelves, isolated platform, reefs.

Cyclic sediments: allokinetic and autokinetic controls, turbidites and Bouma sequence

facies model and environmental reconstruction.

Role of environmental analysis in petroleum exploration.

Essential readings:

1. Sam Boggs, 1995. Principles of Sedimentology and Stratigraphy. Printice Hall.
2. Nichols, G., 2009.Sedimentology and Stratigraphy Second Edition.Wiley Blackwell.
3. Maurice E. Tucker, 2006. Sedimentary Petrology.Blackwell Publishing.
4. Miall Andrew D. 1990. Principles of Sedimentary Basin Analysis. Springer-Verlag.
5. Reading H.G., 1996. Sedimentary Environments: Processes, Facies and Stratigraphy. Blackwell.
6. Gerald Einsele (2000), Sedimentary Basins.Springer.

Suggested readings:

1. M.E. Tucker and V.P. Wright (1990) Carbonate Sedimentology. Blackwell.
2. Collinson, J.D. and Thompson, D.B., 1988. Sedimentary structures.Unwin-Hyman.
3. Lindholm, R.C., 1987.A practical approach to sedimentology. Allen and Unwin, London
4. Pettijohn, F.J., 1975. Sedimentary rocks. Harper and Row Publ. New Delhi
5. Bastia, R., and Radhakrishna, M. 2012. Basin evolution and petroleum prospectivity of the Continental margins of India (Vol. 59). Newnes Publisher.

Atmospheric and Oceanic Sciences

GEOL-PG-C103

Unit I Atmospheric Sciences I

Structure and composition of the atmosphere, Energy Budget, Weather and Climate, Fundamental Forces – Equations of motion on a rotating earth and winds.

Hydrostatic Balance, Air Parcel Concept, Adiabatic Lapse Rate, Stability in the atmosphere, Cloud formation and their classification, Equation of state for the atmosphere, Rotating frame of reference, Geostrophic and Hydrostatic approximations, Quasi Geostrophic Motion, Gravity waves, Rossby waves, Boundary Layers

Unit II Atmospheric Sciences II

Atmospheric Chemistry and Air pollution, Natural Removal Processes in the Atmosphere, Geological processes and climate change, Green House effect, Ozone depletion.Atmospheric Hazards, SMOG and Haze.

ENSO Cycle, Indian summer monsoon (ISM). Jet streams, tornados, typhoon and tropical cyclones.

Unit III Oceanic Sciences I

T-S diagrams, mixing processes in the oceans, characteristics of important water masses.

Wind generated waves in the oceans, refraction and reflection of waves. Wave spectrum, principles of wave forecasting.

Tide-producing forces and their magnitudes, tides and tidal currents in shallow seas, estuaries and rivers.

Factors influencing coastal processes, transformation of waves in shallow water, phenomena of wave reflection, refraction and diffraction, breakers and surf, littoral currents; wave action on sediments, beach stability, tsunami, interaction of waves and structure.

Coastal pollution, coastal zone management.

UNIT-IV Oceanic Sciences II

The global wind system,action of wind on ocean surface, Ekman’s theory, Sverdrup, Stommel and Munk’s theories, divergences and convergences, geostrophic motion,barotropic and baroclinic conditions, relationship between density, pressure and dynamic topography, Wind driven coastal currents

Formation of subtropical gyres, western boundary currents, equatorial current systems, El Nino, monsoonal winds and currents over the North Indian Ocean, Somali current.

Chemical Oceanography: Composition of seawater chemical exchanges across interfaces and residence times in seawater.

Chemical and biological interactions, air-sea exchange of important biogenic dissolved gases,carbon dioxide-carbonate system, alkalinity and control of pH, abiotic and biotic controls of trace elements in the ocean, biological pump and controls on atmospheric composition; biogeochemical processes in aerobic and anaerobic environments, water column-denitrification and emission of greenhouse gases.

Oceans and atmosphere: their compositions, evolution, steady state, and global mass balance.

Rock-water interaction: Debye-Huckel theory.

Biological Oceanography**:** Classification of the marine environment and marine organisms.

Physio-chemical factors affecting marine life.

Factors controlling phytoplankton and zooplankton abundance and diversity, coastal marine communities and ecology.

Energy flow and mineral cycling – energy transfer and transfer efficiencies through different trophic levels; food webs including the microbial loop; role of bacteria in biogeochemical cycling.

Human impacts on marine communities; impacts of climate change on marine biodiversity.

Impact of pollution on marine environments including fisheries.

Essential readings:

1. An Introduction to Atmospheric Physics, Second Edition, David G. Andrews, Cambridge University Press, 2010.
2. Wallace and Hobbs, 2006. Introduction to Atmosphere: An Introductory Survey. (Elsevier).
3. Atmospheric Processes and Systems by R. D. Thompson Publisher: Routeledge
4. Gross, M.G., 1977. Oceanography: A view of the Earth, Prentice Hall.
5. Garrison, Tom S.,2011. Essentials of Oceanography. Cengage Learning.

Suggested readings:

1. Boundary Layer Meteorology by R. B. Stull
2. Physics and Chemistry of Atmosphere by Sienfeld and Pandis
3. Fundamentals of Atmospheric Modelling by Mark Jacobson, Pub: Cambridge University Press
4. Fundamentals of physics and chemistry of the atmosphere, by Guido Visconti. Pub: Springer
5. Energy and the atmosphere: a physical-chemical approach by Campbell. Pub: John wiley
6. Millero, Frank J., 2013. Chemical Oceanography, Fourth Edition. CRC Press.
7. Dijkstra, Henk A.,2008. Dynamical Oceanography. Springer.

Structural Geology

GEOL-PG-C104

Unit I: Introduction to Rock Mechanics

Stress at a point in a solid body: 3-D stress tensor; Homogeneous and heterogeneous stress: stress functions.

Mohr diagrams for stress and strain and their use.

Behaviour of rocks under stress: elastic, plastic, viscous and visco-elastic responses and their geological significance.

Mechanics of rock fracturing: fracture initiation and propagation.

Coulomb's criterion and Griffith's theory; Crack linkage and their importance.

Effect of strength anisotropy on fracturing; Role of fluid in rock fracturing.

Unit II: Deformational Structures

Concept of deformation: distortion, rotation, dilatation etc.

Analysis of homogeneous deformation: strain ellipses of different types and their geological significance.

Petrofabric analysis and diagrams.

Concept of stress-strain compatibility.

Unit III: Geological structures

Folds, fold interference and superposed folds.

Strain distribution in a folded layer and its significance.

Evolution of axial planar and transacted cleavages with folds, fold-related lineations, Constructions of folds.

Faults and Joints: Mechanics of faulting: Anderson's theory and its limitations.

Complex geometry of normal, strike slip and thrust faults with natural examples. Palaeostress analysis using fault-slip data.

Unit IV: Shear zone and Structural analysis

Ductile Shear Zones & their significance in continental crustal evolution and metallogeny

Shear/fault zone rocks: mylonite, cataclasite and pseudotachylyte.

Kinematics of flow in a shear zone.

Microstructures associated with Shear zones.

Dislocation and diffusion creep, strain hardening and softening mechanisms, lattice preferred orientation and superplasticity.

Crustal deformation: Deformation behaviour of quartzo-feldspathic rocks.

Brittle-plastic transition and seismic behaviour of the upper crust.

Essential readings

1. Fossen, H., Price, N.J, & Cosgrove, J.W.1990. Analysis of Geological Structures.Cambridge University Press.
2. Ghosh, S.K., 1993. Structural Geology: Fundamentals and modern developments, Pergamon Press.
3. Twiss, R.J. and Moores, E.M. 1992.Structural Geology. W. H. Freeman & Co.
4. Passhier, C. and Trouw, RAJ, 2005. Microtectonics. Springer, Berlin.
5. Leyson, P.R. and Lisle, R.J., 1996. Stereographic projection techniques in structural Geology, Cambridge University Press.

Suggested readings

1. Ramsay, J.G. and Huber, M.I., 1983. Techniques of Modern Structural Geology: Vol. I & II. Academic Press
2. Pollard, D.D. and Fletcher, R.C., 2005.Fundamentals of structural geology, Cambridge University Press.
3. Van der Pluijm, B.A. and Marshak, S., 2004. Earth structure: an introduction to structural geology and tectonics, W.W. Norton & Company Ltd.
4. Bayly, B., 1992.Mechanics in Structural Geology, Springer.
5. Weijermars, R. 1997. Structural Geology and Map Interpretation, Alboran Science Publisher.
6. Rowland, S.M., Duebendorier, E. and Schiefelbein, I.M., 2007. Structural analysis and synthesis: a laboratory course in structural geology, Blackwell Pub.

Core Practical Paper

GEOL-PG-P109 Practical I

Unit I: Exercises on Mineralogy

Field based exercises for sample/Data collection and in-situ study.

Study of major rock forming silicate minerals using polarizing microscope.

Calculation of mineral formulae and CIPW Norm.

Powder XRD analysis of minerals and determination of unit cell parameters and identification of unknown minerals by search-match methods.

Unit II: Exercises on Igneous Petrology

Field based exercises for sample/Data collection and in-situ study.

Study of igneous rocks and textures using polarizing microscope.

Exercises related to partial melting and fractional crystallization.

Estimation of [values, model ages and plotting of isochrons of the various data suites.Plotting and interpretation of trace element and REE characteristics of igneous rocks.

Unit III: Exercises on Sedimentary Geology & Basin Analysis

Field based practical for sample/data collection and in-situ study.

Identification and study of sedimentary and Digenetic rocks in hand specimen and thin sections.

Analysis of Sedimentary structures and determination of paleocurrent directions.

Preparation of Fence diagram, Panel diagram, Interpretation.

Preparation of isopach and paleocurrent maps and basin analysis

Problems on porosity and burial depth determination.

Unit IV: Exercises on Structural Geology

Field based exercises for data collection for structural measurement and analysis.

Analysis and interpretation of geological maps of various complexities.

Problems related to practical strain measurement (Rf-ö method, Fry method etc.) Construction of balanced cross-sections.

Stereographic techniques: orientation analyses of foliation and lineation data for regional structural geometry.

Essential Readings:

1. Nesse W., 2012. Introduction to Optical Mineralogy. Oxford University Press.
2. Deer, W. A., Howie, R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication,1962-1963.
3. Bennison, G.M. and Moseley, K.A., 2011. An introduction to geological structures and maps: Apractical guide, Hodder education.
4. Vernon R. H., 2004. A Practical Guide to Rock Microstructure.Cambridge University Press.
5. Lindholm, R.C., 1987. A practical approach to sedimentology. Allen and Unwin, London
6. Collinson, J.D. and Thompson, D.B., 1988. Sedimentary structures.Unwin-Hyman, London,
7. LISLE, RICHARD J. 2004 Geological Structures and Maps A PRACTICAL GUIDE Elsevier Butterworth-Heinemann
8. Leyson, P.R. and Lisle, R.J., 1996. Stereographic projection techniques in structural Geology, Cambridge University Press.
9. Rowland, S.M., Duebendorier, E. and Schiefelbein, I.M., 2007. Structural analysis and synthesis: a laboratory course in structural geology, Blackwell Pub.

Suggested readings:

1. Klein C., 1994. Minerals and Rocks-Exercises in Crystallography, Mineralogy and Hand Specimen Petrology. John Wiley.
2. Putnis, Andrew, 1992. Introduction to Mineral Sciences. Cambridge University Press.
3. Weijermars, R. 1997. Structural Geology and Map Interpretation, Alboran Science Publisher.

Semester II

Core Theory Papers

Stratigraphy of India and Palaeontology

GEOL-PG-C201

Unit I: Principles of Stratigraphy

Stratigraphy Principles of Stratigraphy : History and Development of Stratigraphy, Stratigraphic procedures (Surface and Subsurface), Concept of Lithofacies and Biofacies, Stratigraphic Correlation (Litho, Bio- and Chronostratigraphic Correlation), Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic and Chronostratigraphic), Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy, Nomenclature and the modern stratigraphic code.

Radioisotopes and measuring geological time: Geological time-scale.Stratigraphic procedures of correlation of unfossiliferous rocks.

Unit II: Indian Stratigraphy

Precambrian stratigraphy of India**:** Archaean stratigraphy: tectonic framework, geological history and evolution of ArcheanCratons and Mobile Belts.

Proterozoic stratigraphy: tectonic framework, geological history and evolution of Proterozoic basins of India.

Palaeozoic stratigraphy: Palaeozoic formations of India with special reference to type localities, history of sedimentation, fossil content.

Mesozoic stratigraphy: Mesozoic formations of India with special reference to type localities, history of sedimentation, fossil content. Gondwana Supergroup and Gondwanaland Deccan volcanics.

Cenozoic stratigraphy: Cenozoic formations of India, Rise of the Himalayas and evolution of Siwalik basin.

Quaternary stratigraphy: Rocks record, palaeoclimates and palaeogeography.

Stratigraphic boundaries: Stratigraphic boundary problems in Indian geology.

Unit III: Invertebrate and Vertebrate Palaeontology

Theories on origin of life: Organic evolution and astrobiology

Various invertebrate fossils.Significance and distribution of Mollusca, Trilobites, Brachiopods, Graptolites, Foraminifera and Ammonoids. Modes of preservation of fossils and taphonomicconsiderations. Important invertebrate fossils in Indian stratigraphy.Major extinction events across stratigraphic boundaries and their causes. Application of fossils in age determination and correlation

Vertebrate Palaeontology: Characteristic features of vertebrates **-** Skeletal elements of their fossil remarks. Origin of vertebrates and their general evolutionary patterns; outline classification of vertebrates. Classification and divisions of the vertebrates; Agnathans, Fishes, Amphibia, Reptilia, Aves and Mammalia.

Evolution of mammalian dentition: Phyllogeny of Equids, Proboscids and Hominids.

Unit IV: Paleobotany, Palynology and Micropalaeontology

Introduction to various groups of microfossils: Techniques of separation of microfossils from different types of sedimentary rocks.Foraminifera and Ostracoda - their morphology, orientations, growth, reproduction, ecology and palaeoecology, classification, evolutionary trends and stratigraphic distribution.Conodonts - Morphology, classification, biological affinity and stratigraphic distribution.Application of micropaleontology in hydrocarbon exploration. Oxygen and Carbon isotope studies of microfossils and their use in paleoceanographic and paleoclimatic interpretation.

Evolution of Plant life in the Geological History, Gondwana Paleobotany and Palynology, Indian Gondwana Basins: Plant fossils and Palynomorphs, Paleoecology, Life habitats and various ecosystems.

Paleobiogeography: Reconstruction of Gondwana super continent and global correlation.

Important plant fossils in the Indian stratigraphy.

Essential readings:

1. Naqvi, S.M.2005. Geology and Evolution of Indian Plate. Capital Publishing Company, New Delhi.
2. Ramkrishnan and Vaidhyanadhan: Geology of India, Volume I and II, Geological Society of India, Bangalore
3. Wadia, D.N., 1998. Geology of India. Tata McGraw Hill, India.
4. Khadg Singh Valdiya, 2010. The Making of India: Geodynamic Evolution. Macmillan Publishers India.
5. Braiser, M.D., 1980. Microfossils. Allen and Unwin Publisher.
6. Benton, M.J. 2005.Vertebrate palaeontology (3rd edition). Blackwell Scientific, Oxford.
7. Clarkson, E.N.K.1998. Invertebrate Palaeontology and Evolution. George Allen &Unwin.

Suggested Readings:

1. Naqvi, S. M., and Rogers, J. J. W., 1987. Precambrian Geology of India. Oxford University Press, New York.
2. Kumar, Ravindra, 1988. Fundamentals of Historical Geology and Stratigraphy of India. Wiley.
3. Krishnan, M.S., (1949).Geology of India and Burma.CBS Publishers & Distributors.
4. Kumar, P.S. and Srinivasan, M.S., 2016. Micropaleontology: Principles and Application. Springer.
5. Arnold, C.A.1947. An introduction to Paleobotany. McGraw Hill.
6. Brenchley, P. J., and Harper, D. A. T. 1998.Palaeoecology: Ecosystems, Environments and Evolution. Chapman and Hall.

Metamorphic Petrology

GEOL-PG-C202

Unit I: Fundamentals of Metamorphic Processes

Nature and scope of metamorphism.

Types of metamorphism.Metamorphic textures.

Fundamentals of thermodynamics.

Nucleation and crystal growth in metamorphism.

Metamorphic paragenesis.

Unit II: Compositional Plots and Projective analysis

Construction and interpretation of ACF, AKF and AFM diagrams.

Schrienmaker's rule and construction of petrogenetic grid.

Compositional Space, P-T diagrams, Psuedosections.

Unit III: Concept of Facies

Advantages and limitations of Metamorphicfacies classification.

Mineralogical changes during progressive metamorphism of pelitic, calcareous and mafic rocks

Control of bulk composition on metamorphic assemblages.

Role of fluids in metamorphism.

Metasomatism, Granitization, Migmatities, Paired Metamorphic zones,Inverted Metamorphic sequences.

Unit IV: Tectonics and Metamorphism

Orogenic processes and metamorphism.

Relationship between deformation and metamorphism.

Global Tectonic Context of Metamorphism

Ultra-high temperature and Ultra-high pressure metamorphism.

Time-scales of metamorphism and implications on thermal history of the crust.

Metamorphic differentiation, geothermobarometery, compositional zoning and P-T-t paths, and their tectonic significance.

Essential readings:

1. Winter J. D., 2001. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
2. Philpotts, A.R. & Ague, J.J., 2009.Principles of igneous and metamorphic petrology.Cambridge University Press.
3. Vernon R. H., 2004. A Practical Guide to Rock Microstructure.Cambridge University Press.
4. Bucher K. and Martin F., 2002.Petrogenesis of metamorphic rocks. Springer-Verlag Publication.

Open Paper

GEOL-PG-O 203 Remote Sensing & GIS

Unit I Principles of Remote Sensing and GIS

Introduction, Energy Sources and Radiation Principles, Energy Interactions in the Atmosphere , Energy Interactions with Earth Surface Features, Data Acquisition and Digital Image Concepts, The Global Positioning System and Other Global Navigation Satellite Systems, Characteristics of Remote Sensing.

Geographical Information System (GIS): Introduction and Definitions Technology and concepts; Components of GIS; Developments in GIS

Unit II Elements Basic Principles of Photogrammetry

Development in aerial photography.Geometry and types of aerial photographs. Scale of photographs. Types of aerial cameras, films, and filters. Panchromatic, colour and infra-red films. Multiband photography. Tilt and height displacement. Vertical exaggeration, Elements of photo interpretation: tone, texture, pattern, drainage and lineaments. Spectral signatures. Land forms. Structural and lithological interpretation.

Unit III Digital Image Analysis

Pre-processing of Images, Image Enhancement, Contrast Manipulation, Spatial Feature Manipulation and Multi-Image Manipulation, Image Classification: Supervised Classification, Unsupervised Classification and Hybrid Classification

Unit IV Applications of Remote Sensing

Land Use/Land Cover Mapping, Geologic and Soil Mapping, Agricultural Applications, Forestry Applications, Rangeland Applications Water, Resource Applications, Snow and Ice Applications, Environmental Assessment and Protection, Natural Disaster Assessment, Principles of Landform Identification and Evaluation.

Essential reading:

1. Thomas M Lillesand, and Rralph W Kiefer; “Remote sensing and Image Interpretation”, JohnWiley& Sons, 1994, 3rd edition.
2. Michael F. Worboys 1995. “GIS: A Computing Perspective”, Taylor & Francis Ltd.
3. Campbell, J. B. (1996) Introduction to Remote Sensing.
4. Drury, S.A. 1987. Image interpretation in Geology. Chapman and Hall.

Suggested reading:

1. Avery, T.U. and Berlin, G.L. 1992 Fundamentals of remote sensing and air photo interpretation. McMillion Publishing Co., New York.
2. Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag
3. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory &Practice,Springer Wien New York.
4. Rajiv Gupta &Mukesh Kumar Rohil, 2006. Computing Aspects of Geographical Information Systems.

Core Practical Paper

GEOL-PG-P209 Practical II

Unit I: Exercises on Metamorphic Petrology

Introduction to interpretation of metamorphic assemblages textures in relation to fabric elements.

Introduction to relevant softwares.(PerpleX, Thermocalc etc.).

Cation calculation using excel spreadsheet.

Construction of petrogenetic grid and compositional plots

Construction of Schreinemakers bundles in non-degenerate and degenerate 3-component systems.

Geothermobarometric calculations.

Unit II: Exercises on Palaeontology

Microscopic studies of different groups of microfossils.

Techniques of separation of microfossils from matrix.

Morphological study of important micro, Vertebrate, Invertebrate and plant fossils.

Unit-III: Exercises on Sequence Stratigraphy and Evolution

Exercise on construction of Lithostratigraphy.

Exercise on construction of BiostratigraphyandIchnostratigraphy.

Exercise on construction of Magnetostratigraphy.

Exercise on construction of Chemostratigraphy and Seismic Stratigraphy.

Exercise on construction of Sequence Stratigraphy.

Unit IV: Exercises on Geospatial Analysis

Exercises based on Remote Sensing and GIS softwares.

Essential reading:

1. Barker,A. J., 1998. Introduction to Metamorphic Textures and Microstructures.Springer.
2. Mukherjee, Soumyajit, 2013. Deformation Microstructures in Rocks.Springer Berlin.
3. Vernon R. H., 2004. A Practical Guide to Rock Microstructure. Cambridge University Press.
4. Yardley B. W. D., MacKenzie W. S., Guilford C., 1990. Atlas of Metamorphic Rocks and Their Textures. Longman Scientific and Technical.
5. Brasier, M.D., 1980. Microfossils. George Allen and Unwin, London, 193p.
6. Taylor, T.N., Taylor, E.L., Krings Michel. Paleobotany: The Biology and Evolution of Fossils. Elsevier.
7. Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag
8. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory &Practice,Springer Wien New York.
9. Catuneanu, Octavian,2006. Principles of Sequence Stratigraphy. Elsevier.

Core Field Training

GEOL-PG-F210 Field Training I

Identification and study of Igneous, Sedimentary and Metamorphic rocks in the field. Identification and study of geological structures in the field and analysis.

Study of different aspects of environmental geology.

Note: Field Training of minimum two weeks will be carried out in winter vacation and evaluated in this semester. The students have to submit their field diary and field report at the time of examination. The field diary and field report will be evaluated and there will be an open presentation and viva-voce.

Semester III

Core Theory Papers

GEOL-PG-C301 Ore Geology

Unit I: Fundamentals of Ore Geology

Ore Minerals: Development of ore minerals in open space and polycrystalline aggregates.

Endogenous, Exogenous processes and Transformation Processes of Ore formation.

Crustal evolution and metallogenesis.

Metallogenic epochs and provinces.

Unit II: Ore microscopy

Introduction to ore microscopy.Optical properties of ore minerals.

Ore texture and structure.

Fluid inclusions and their applications.

Unit III: Petrological Ore Association - I

Petrological ore association-consideration with reference to distinct ore types

Ore associated with ultramafic and related mafic plutonic rocks: Sudbury-type Fe-Ni-Cu sulphides, apatite rich and Ti-V bearing migmatites, Fe-Ti oxides and anorthosites.

Ores associated with felsic plutonic rock: porphyry deposit of Cu, Mo, Greisen &Skarn deposit of W and Sn, Various Pegmatoiddeposit,IOCG deposits.

Ores associated with acid/mafic volcanic rocks, including those in greenstone belts: Kambalda type, Kuroko type and Cyprus Types of ores.

Unit IV: Petrological Ore Association - II

Stratabound ore deposit associated with nonvolcanic, Meta Sedimentary rocks, Kupferschiefer, Rhodesia Katanga, Broken Hill.

McArthur, Mississippi valley type, Witwatersrand type, Bog iron manganese ores ironstone, Banded iron formation.

Manganeseores: Orthoquartzite-clay association, Jaspillite and volcanic association, metamorphosed manganese ores. Colorado Plateau type U-V ores,Surficial deposits.

Lateritoid and Karst deposit of Fe, Mn, Al, and Ni.

Placer deposit of Gold, Tin, Tungsten, monazite. Oxidation and supergene enrichment, sulphide enrichment.

Ocean floor deposit of Mn, Ni-Cu-Co.

Indian Mineral Deposits: Occurrence and Distribution.

Essential Readings:

1. Lawrence, Robb, 2005. Introduction to ore forming processes. Blackwell Publishing
2. Evans, A.M., 1993. Ore Geology and Industrial Minerals, Blackwell.
3. Gokhale, K.V.G.K. and Rao, T.C.1978 Ore deposits of India their distribution and processing,Tata-McGraw Hill, New Delhi.
4. Sarkar, S.C. and Gupta, A. 2014. Crustal Evolution and Metallogeny in India. CambridgePublications.
5. Sinha, R.K. and Sharma, N.L., 1989. Mineral economics.Oxford and IBH Publishing.

Suggested readings:

1. Haldar, SK, 2013. Mineral Exploration - Principles and Applications.Elsevier.
2. Guilbert, J.M. and Park, Jr. C.F., 1986. The Geology of Ore Deposits. Freeman.
3. Craig J.R. and Vaughan, D.J. 1994. Ore Microscopy and Ore Petrography
4. Misra, K. C., 2000.Understanding mineral deposits. Springer Netherlands
5. Prasad, Umeshwar, 2000. Economic Geology. CBS Publishers& Distributors Pvt. Ltd.

Fuel Geology

GEOL-PG-C302

Unit I: Coal Geology

Coal and its properties

Different varieties and ranks of coal. Origin of coal.

Type of depositional processes. Coalification process and its causes.

Sediments closely associated with coal (coal balls, tonsteins, seat-earths, under-clays, fire-clays and soils).

Coal Petrography: Lithotypes, microlithotypes and macerals: their physical, chemical and optical properties. Applications of coal petrography.

Maceral analysis of coal: Mineral and organic matter in coal.

Proximate and ultimate analyses.

Industrial evaluation of coal characteristics with reference to coal classification.

Methods of coal prospecting and estimation of coal reserves.

Geology and coal petrography of different coalfields of India.

Uses of coal for various industries e.g. carbonization, liquefaction, power generation, gasification and coal-bed methane production.

Unit II: Petroleum Geology

Origin of petroleum.

Petroleum: its different states of natural occurrence.

Basic concepts of petroleum geochemistry.Maturation of kerogen; Biogenic and Thermal effect.

Distribution of Petroleum in space and time.

Introduction to migration of oil and gas: geologic framework of migration, short and long distance migration, primary and secondary migration, geologic factors controlling hydrocarbon migration, forces responsible for migration, migration routes and barriers.

Unit III: Reservoir Studies

Reservoir rocks: general attributes and petrophysical properties.

Classification & Characterization of reservoir rocks - Clastic and Carbonate reservoirs.

Hydrocarbon traps: definition, classification of hydrocarbon traps - structural, stratigraphic and combination, time of trap formation and time of hydrocarbon accumulation.

Cap rocks - definition and general properties.

Oil field water- characters and classifications.

Petroleum Geology of important Indian basins.

Introduction to oil and gas exploration.

Unit IV: Coal Bed Methane and Gas Hydrates

Coal bed methane: Biogenic and thermogenic methane, Coal bed methane generation and accumulation.

Geological and petrographic influences on coal, Pore geometry, Micropore, Mesopore and macropore and cleat system.

Sorption – principles, sorption isotherms – types and interpretation.

CO_2, CH_4 and N_2 adsorption – desorption, hysteresis, Langmuir isotherm. Carbon dioxide sequestration.

Swelling of coal matrix isotherm construction.

CH_4 content determination in coal seams.

Potential coal bed basins and production, hydraulic fracturing of coal seams.

CBM exploration.

Non-conventional fossil fuels: Underground Coal gasification, shale gas, Gas Hydrates.

Essential readings:

1. Larry Thomas, (2002), Coal Geology: Wiley and Sons.
2. SomermierE.E. (2008), Coal: It's composition, analysis, utilisation and valuation: McGrawHill
3. R.C. Shelley (1998) Elements of Petroleum Geology, Academic Press
4. Bjorlykke, K. 1989. Sedimentology and petroleum geology. Springer-Verlag.
5. Bastia, R., &Radhakrishna, M. 2012. Basin evolution and petroleum prospectivity of thecontinental margins of India (Vol. 59). Newnes Publisher.

Suggested Readings:

1. North, F.K.1986. Petroleum Geology. Allen and Unwin
2. Tissot B.P. and Welte D.H. 1978. Petroleum Formation and Occurrence. Springer-Verlag
3. Dickie, P.A. 1986. Petroleum Development Geology. Pennwell Publisher.
4. KDMIPE, ONGC, 1986.Petroliferous Basins of India.

Open Paper

Hydrogeology

GEOL-PG-O303

Unit I: Fundamentals of Hydrogeology

Origin of Water, Hydrologic cycle and its components.

Surface water and groundwater interaction.

Classification of aquifers.

Hydrological properties of rocks - specific yield, specific retention, porosity, hydraulic conductivity, transmissivity, storage coefficient.Darcy’s law and flow in continuous media, Dupuit’s equation.

Unconfined, confined, steady, unsteady and radial flow conditions. Pumping tests. Flow nets. Water table fluctuations - causative factors, concept of barometric and tidal efficiencies.Evaluation of aquifer parameters using Thiem, Thesis, Jacob and Walton methods.

Theory of groundwater flow, Bernoulli’s equation and its applications.

Hydraulic head.Potentiometric surface and potential surface.

Unit II: Groundwater Exploration

Geological, Meterological and Geophysical methods.

Application of remote sensing in ground water exploration.

Hydrogeomorphic mapping.

Types of wells. Well development and design.

Groundwater quality: physical and chemical properties of water, Hill and Piper and Durov diagrams and Chebotareb sequence.

Unit III: Application of Hydrology

Rain water harvesting and Artificial recharge methods.

Groundwater contamination and saline water intrusion (Ghyben-Herzberg Principle) in coastal and other aquifers and its prevention.

Ground water problems and management related to mining, foundation work of canals,tunnels.

Problems of over-exploitation.

Conjunctive use of ground water and surface water.

Hydrogeology of arid Zones of India.

Ground water provinces of India - their aquifer characteristics.

Unit IV: Applications

Deciphering of hydro-geological boundaries on water table contour maps.

Groundwater quality study using Trilinear (Hill-Piper), C-S diagrams etc.

Problems on radial flow to a well in confined and unconfined aquifers.

Exercises on step drawdown test.

Determination of aquifer parameters using Theis and Jacob's methods.

Calculation of salt water encroachment in coastal aquifers.

Electrical resistivity surveys for aquifer delineation.

Analysis of Hydrographs.

Essential readings

1. Fetter, C.W., 2001, Applied Hydrogeology, Prentice Hall.
2. Raghunath, H.M., 2007, Ground Water, New Age International Publishers, New Delhi.
3. Todd D.K , Mays , L W. 2004,Groundwater Hydrology, 3rd Edition Wiley
4. Braja M. Das. 2014. Principles of Geotechnical Engineering. Publishers: Cengage Learning

Suggested readings:

1. N.J. Fitts, C.R., 2006. Groundwater Science, Academic Press.
2. Mansell, M.G., 2003. Rural and Urban Hydrogeology, Thomas and Telford
3. Bryirely, G and Fryirs, K. 2005. Geomorphology and river management.Blackwell Pub.
4. Todd D.K , 1995 Groundwater Hydrology. Wiley
5. Karanth , K.R.1989 Hydrogeology Tata McGraw-Hill Publishing

Elective (Special) Papers

Geophysics and Geodynamics

GEOL-PG-E304

Unit I: Introduction to Geophysical Methods

Geophysical Properties of Earth and its layers.

Gravity method: Basis for gravity exploration, concept of geoid, international gravity formula, unit of gravity. Gravimeters: Spring-mass system as basic gravimeters, principles of working of unstable gravimeters, zero length spring, La-Coste-Romberg and Worden gravimeters.

Corrections of Gravity anomaly. Gravity effect due to buried sphere, use of gravity survey in buried high density mineral deposits.

Seismic Method:Generation and propagation of seismic waves, seismic energy sources, geometry of refraction and reflection, interpretation of travel time curves for two layered earth,horizontal and dipping interface, field procedure-profile and broad side shooting, fan shooting, end on and split spread arrangements.

Principles of Seismometry, Seismograms as signals, Earthquakes and source theory: Green's function and the moment tensor, Earthquake faults, radiation pattern and beach balls, Stress drop, earthquake b-value, Finite slip model, the heat flow paradox, Seismology and Tectonics. Continental tectonics and intraplate earthquakes.

Unit II Introduction to Geophysical Methods-II

Magnetic method: Magnetic susceptibility of rocks and their ranges, elements of earth magnetic field; Magnetometers: Fluxgate and Proton Precession Magnetometers Diurnal Correction; Magnetic effect due to isolated pole.

Resistivity Method: Resistivities of common rocks and minerals, True and apparent resistivity, Electrode configurations-Schlumberger and Wenner, Electrical profiling and Vertical Electrical Sounding,Interpretation of two layered VES curves.

Unit III: Geodynamics and strain in Rocks

Strain analysis: Kinematics, Pure and Simple Shear deformation. Kinematic vorticity.

Strain distributions in the crust: Strain associated with folds, thrust, cleavage and shear zones.

Strain ellipse and its classification.

Geological structures in »1- »2-»3 space.

Deformation of the crust in tectonic and strain domains.

Lithosphere and asthenosphere.

Detailed structures of core, mantle and crust, including their geophysical properties and composition.

Isostasy and gravity anomalies.

Unit IV: Plate Tectonics

Introduction to plate tectonics and earlier hypotheses of orogenesis, continental drift, Palaeomagnetic evidences and sea-floor spreading.

Diastrophism: Epeiorogeny and Orogeny.

Stages in the evolution of ocean basins. Wilson Cycle.

Plate geometry and Triple junctions.

Different types of continental margins and their characters.

Plates in velocity space. Spherical coordinates and reference frame.

Cartesian coordinates. Finding Euler's pole. Velocity due to rotation about an Euler's pole.

Angular velocity vectors.

Mechanisms of plate motion: mantle plume model, convection model, viscous drag and buoyancy model.

Different types of tectonic settings: extensional, compressional and strike-slip.

Transpressional and Transtensional tectonics: Indian and global examples.

Configuration of the Indian plate and origin of the Himalayas.

Orogeny through time: Global orogeny and their origin.

How correct is the theory of plate tectonics?

Introduction to Neotectonics and active tectonics.

Essential readings:

1. Fowler, C.M.R. 2005.The Solid Earth: An Introduction to Global Geophysics. Cambridge University Press.
2. Telford W.M., Geldart L.P. and Sheriff R.E., 2007.Applied Geophysics by Cambridge University Press.
3. Turcotte, D. L. and Schubert, G., Geodynamics: 2nd Ed, John Wiley & Sons, NY, 2002.
4. Moore and Twiss (2014) Tectonics, Wavel and PrInc;
5. Shearer, Peter M., 2009.Introduction to Seismology.Cambridge University Press.
6. Burbank, W.B., and Anderson, R.S., 2001. Tectonic Geomorphology, Blackwell Science.

Suggested Reading:

1. Lowrie Richard, 2007. Fundamentals of Geophysics. Cambridge University Press.
2. Schlumberger Log: Interpretations, Principles/Applications 1989, Schlumberger.
3. Lay, T. and Wallace, T., 1995. Modern Global Seismology.Academic Press.
4. Dobrin, M. B., 1976. Introduction to geophysical prospecting: McGraw-Hill.
5. Bull, W.B., 2007. Tectonic Geomorphology of Mountains, Blackwell Publishing.

Applied River Science

GEOL-PG-E305

Unit I: Basic stream hydrology

Physical properties of water, sediment and channel flow, River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis, Flood frequency analysis.

Unit II: River Basin Analysis

River basin: Sediment source and catchment erosion processes, Sediment load and sediment yield, Sediment transport process in rivers, Erosion and sedimentation processes in channel.

Drainage network, Quantitative analysis of network organization – Slope analysis, morphometry, Random Topology (RT) model and fractal analysis, Role of drainage network in flux transfer, Evolution of drainage network in geological time scale.

Unit III: River Diversity

River diversity in space patterns of alluvial rivers - braided, meandering and branching channels.

Dynamics of alluvial rivers, Channel patterns in stratigraphic sequences.

Different classification approaches in fluvial geomorphology and its applications.

River linking projects case studies.

Unit IV: Neotectonics and Stream Flow

Bedrock channels, Bedrock incision process, River response to climate, tectonics and human disturbance, Bedrock channel processes and evolution of fluvial landscapes.

Fluvial hazards, integrated approach to stream management,

Introduction to river ecology.

Techniques of artificial stream modification for the control of water flow, mitigation of floods and erosion.

Essential readings:

1. Davie, T., 2008.Fundamentals of hydrology. Routledge Publications.
2. Knighton, D., 1998. Fluvial forms and processes: A new perspective. Arnold Pubs.
3. Richards. K., 2004. Rivers: Forms and processes in alluvial channels. Balckburn Press.
4. Schumm, S.A. and Holbrook, 2000. Active Tectonic and Alluvial Rivers, Cambridge University Press.
5. Robert, A., 2003. River Processes: An introduction to fluvial dynamics. Arnold Publications.

Suggested readings:

1. Bryirely and Fryirs, 2005.Geomorphology and river management.Blackwell Pub.,

2. Julien, P.Y., 2002. River Mechanics.Cambridge University Press.

3. Vanoni, V.A., 2006. Sedimentation Engineering.ASCE Manual, Published by American Society of Civil Engineering.

4. Tinkler, K.J., Wohl, E.E. (eds.) 1998.Rivers over rock.American Geophysical Union Monograph, Washington, DC.

5. Bull, W.B., 2007. Tectonic Geomorphology of Mountains, Blackwell Publishing.

6. Burbank, W.B., and Anderson, R.S., 2001. Tectonic Geomorphology, Blackwell Science.

Isotope Geology

GEOL-PG-E306

Unit I: Fundamentals of Isotope Geology

Fundamentals of radioactivity, Stable and radiogenic isotopes.

Nuclear structure, atomic weights, nuclear stability and abundance.

Theory and mechanism of decay.

Abundances of unstable nuclides in earth, core, mantle, crust, oceans and different rock types and their decay schemes.

Radioactive elements as major elements, minor elements and trace elements and their geochemical behaviour.

Unit II: Isotopic Analysis

Mass spectrometer: Instrumentation, chemical separation, isotope dilution and ratio analysis.

Methods of dating: Isochron method, model/mineral ages, concordia–discordia method.

Fission track, ^{40}Ar-^{39}Ar, U and Th disequilibrium.

Application of ^{14}C, Be and Al isotopes.

Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in petrological applications.

Interpretation and geological significance of ages.

Unit III: Stable Isotopes

Stable isotopes of oxygen and hydrogen, carbon, nitrogen and sulphur.

Fractionation of stable isotopes in lithosphere, hydrosphere and atmosphere.

Stable isotope geothermometry and geobarometry.

Environmental, sedimentological and chemostratigraphic studies using stable isotopes systematics.

Unit IV: Applied Isotope Geology

Isotopes in mineral exploration.

Petroleum exploration, Paleo-climate evaluation, health and environmental aspects.

Introduction to software: ISOPLOT etc.

Case study, data analysis and interpretation.

Essential readings

1. Gunter F. and Mensing, Teresa M., 2004. Isotopes: Principles and Applications. Wiley
2. Faure, G., 1986. Principles of Isotope Geology. John Wiley.

3. Allegre, C. J.,2008. Isotope Geology. Cambridge University Press.
4. Dickin, A.P., 2005. Radiogenic Isotope Geology, Cambridge University Press
5. Sharp, Z., 2006.Principle of stable isotope Geochemistry. Prentice Hall.
6. Hoefs, J., 2009. Stable Isotope Geochemistry. Springer

Suggested readings

1. Doe, B.R.,1970.Lead isotopes. Springer Verlag.
2. Faure, G. and Powell, J.L., 1972. Strontium Isotope Geology. Springer Verlag.

Core Practical Paper

Practical III

GEOL-PG-P309

Unit I: Exercises on Fuel Geology

Megascopic identification of different varieties of coal.

Identification of macerals and minerals under transmitted light and reflected light. Reflectance measurements and rank determination of coal.

Location of coalfields on geographical maps with comments about quality of coal, seam formation curve.

Estimation of coal reserve.

Interpretation of geologic structures from surface geological maps and bore hole data; Preparation of structure contour and isopach maps of reservoir facies and drawing oil/water contact from bore hole data.

Calculation of oil reserves in defined structure.

Unit II: Exercises on Hydrology

Determination of permeability.

Applications of hydrological software: Aquachem, Rockworks, modflow, etc.

Graphical representation of water chemistry.

Unit III: Exercises on Ore Geology-I

Study of important ores in hand specimen.

Unit IV: Exercises on Ore Geology-II

Ore microscopic study of important oxide minerals and complex minerals.

Ore microscopic study of important sulfide minerals.

Textural and micro-structural features of ore mineral assemblages.

Determination of Paragenetic order of the ore minerals.

Characterization of Fluid Inclusions.

Essential readings:

1. Davie, T., 2008.Fundamentals of hydrology. Routledge Publications.
2. Larry Thomas, (2002), Coal Geology: Wiley and Sons.
3. R.C. Shelley (1998) Elements of petroleum Geology, Academic press
4. Craig J.R. and Vaughan, D.J., 1994. Ore Microscopy and Ore Petrography.
5. Gokhale, K.V.G.K. and Rao, T.C., 1978. Ore deposits of India their distribution and processing,Tata-McGraw Hill, New Delhi.
6. Sarkar, S.C. and Gupta, A., 2014. Crustal Evolution and Metallogeny in India. CambridgePublications.

Semester IV

Elective (Special) Papers

Exploration Geology

GEOL-PG-E401

Unit I: Geological Prospecting and Exploration

Introduction and methods of prospecting and exploration.

Sampling: theory and methods; Geological plans and sections for ore body evaluation; Exploration drilling, drill core logging and sampling.

Cut-off grade concepts and applications; Resources and Reserves.

Estimation of reserves – methods and practice.

Unit II: Geochemical Exploration

Geochemical cycle, geochemical mobility and association of elements. Pathfinder and target elements for geochemical exploration. Primary and secondary dispersions of elements.Determination of background, and geochemical anomalies.

Application of Geomorphological, remote sensing techniques, Geobotanical and Geophysical methods. Geostatistical techniques in Mineral Exploration.

Indian case studies.

Unit III: Introduction to mining

Elements of mining, definitions and explanation of different mining terms.

Introduction and classification of opencast mining, stripping ratio, bench heights and haulway design.

Introduction to underground mining, room and pillar method, Longwall method, cut and fill method.

Unit IV: Mineral Economics

Classifications of mineral resources– UNFC,JORC, IMM, SAMERC and ISP schemes.National Mineral Policy and National Mineral exploration Policy.NELP.

World resources of minerals and production of important mineral.

Concepts of Strategic Minerals.

Monopolies and Cartel, Trade restriction and production incentives.

Basic pattern of Mineral economy and changing mineral requirements.

Marine mineral resources and Law of Sea. Exclusive economic Zones.

Essential readings:

1. Haldar, SK, 2013. Mineral Exploration - Principles and Applications.Elsevier.
2. Evans, A.M. 1993. Ore Geology and Industrial Minerals. Blackwell SciPubl.
3. Sinha, R.K. and Sharma, N.L., 1989. Mineral economics.Oxford and IBH Publishing.
4. Gokhale, K.V.G.K. and Rao, T.C. 1978. Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.

Suggested readings:

1. Guilbert, J.M. and Park Jr., C.F. 1986. The Geology of Ore deposits.Freeman & Co.
2. Bateman, A.M. and Jensen, M.L. 1990.Economic Mineral Deposits. John Wiley
3. Deb, S. 1980. Industrial minerals and rocks of India. Allied Publishers
4. Singh, R.D. Principles and Practices of Modern Coal Mining. 1997 New Age International
5. Hartmann H.L., Introductory Mining Engineering. Wiley

Sequence Stratigraphy and Basin Evolution

GEOL-PG-E402

Unit I: Introduction to Sequence Stratigraphy

Sequence Stratigraphy: Historical developments, definitions and key concepts, base level changes, transgressions and regressions, Stratigraphic surfaces: Stratal terminations, sequence stratigraphic surfaces, Unconformity and correlative conformity

Unit II: Transgressive and Regressive sequences

Systems Tracts: Lowstand, Transgressive, Highstand, Falling stage. Shelf-margin system tract (SMST)

Unconformities: Type I, Type II surfaces.

Sequence Models: Depositional sequence, Genetic stratigraphic sequence, Transgressive-Regressive sequence.

Hierarchy of sequences and bounding surfaces.

Basin Correlations using sequence stratigraphy.

Unit III

Sequence stratigraphy and its relation with seismic and magnetostratigraphy.

Examples of sequence stratigraphy from petroliferous basins.

Unit IV: Basin Evolution

Tectonic Classification of Sedimentary Basins,

Basin analysis and its scope.

Sequence Stratigraphy and correlation of Sedimentary Basins.

Basin mapping methods: structure and isopach contouring, lithofacies maps.

Geohistoryanalysis.Thermal history, Porosity and Burial depth.

Subsidence of Sedimentary Basins.

Evolution of Indian Sedimentary basins.

Essential readings:

1. Catuneanu, O., (2006) Principles of sequence stratigraphy. Elsevier
2. Miall, A.D (1999), Principles of sedimentary basin analysis: Springer
3. Posamentier, H.W. and Walker., R. G. (2006)Facies Models revisited, SEPM
4. Reading.H.G. 1996 Sedimentary Environments: Processes, Facies and Stratigraphy: Blackwell Publishers.

Suggested readings:

1. EinseleGerhard2000. Sedimentary Basins: Evolution, Facies, and Sediment Budget. Springer Science & Business.

Environmental and Engineering Geology

GEOL-PG- E403

Unit I: Introduction to Environmental Geology

Changes in the environment caused by geological activities of man.

Inorganic and organic contaminants.

Drinking water standards. Surface and ground water pollution. Acid rain

Geochemistry of toxic elements in natural waters.

Environmental problems connected with exploitation of minerals and energy resources.

Acid mine drainage.

Land use and land degradation due to mining.

Study of surface geological processes, earthquakes and volcanism and GLOF with reference to their impact on environment.

Soils, erosion and conservation.

Geological solutions to environmental problems.

Role of geology in nuclear waste disposal, Global warming, Climate change and Mitigation.Environmental planning, management and economics (EMP and EIA).

Unit II: Rock Mechanics

Engineering classification of geological materials.

Introduction to rock mechanics: Rock properties:density, hardness, abrasion, slake durability, permeability. Strength of rocks: tensile, compressive and shear strength, determination of elastic moduli, Physico-mechanical properties of building stones and aggregate, alkali aggregate reaction.

Rock mass classification systems – RQD, Q system, RMR and SMR classification.

Laboratory measurements of rock strength, Uniaxial and triaxial tests, Stress-strain relationships. Determination of principal stresses.

Unit III: Soil Mechanics

Engineering classification of Soils, Particle size analysis.

Atterberg limits (plastic and liquid limits) Consolidation parameters, Swelling/Shrinking Index, Void Ratio, Effective stress concepts in soil: Total, neutral and effective stress distribution in soil,Permeability, Darcy's Law, Permeability measurement in the laboratory – quick sand condition, Seepage, Laplace Equation, Liquifaction and Condensation.

Measurement of shear strength, direct shear, Triaxial compression, UCC and Vane shear tests.

Types of shear tests, Drained and undrained behaviour of clay and sand.

Stress path for conventional triaxial test, cyclic shear test.

Unit IV: Geotechnical site Investigations

Geotechnical investigation for dam site, reservoir site; geotechnical study for road alignment, geotechnical evaluation of tunnel alignment, methods of tunnelling.

Geotechnical investigations for bridge foundation and building foundation.

Mass movements, slope stability problems, their predictions and optimum design of slope (natural slope, benches in mines, mine dumps).

Earthquakes and seismicity, seismic zones of India, soil liquefaction, and earthquake resistance design of building. Influence of geological condition of foundation and design of buildings. Shoreline engineering geology.

Essential readings:

1. Bell, F.G, 2006. Basic Environmental and Engineering Geology. Whittles Publishing.
2. Brady and Brown, 1993. Rock Mechanics for Underground Mining. Chapman and Hall.
3. Bieniawski, 1989.Engineering Rock Mass Classifications. Wiley.
4. GopalRanjan and Rao A.S.R., 2000. Basic and applied soil mechanics. New Age International Publishers, New Delhi.

Suggested readings:

1. Punmia P.C., “Soil Mechanics and Foundations”, Laximi Publications Pvt. Ltd., New Delhi,1995.
2. Krynin, D.P. and Judd W.R. 1957.Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
3. Johnson, R.B. and DeGraf, J.V. 1988. Principles of Engineering Geology, John Wiley & Sons, N.Y.
4. Goodman, R.E., 1993. Engineering Geology: Rock in engineering constructions. Jonh Wiley & Sons, N.Y.
5. Waltham, T., 2009.Foundations of Engineering Geology (3rd Edn.) Taylor & Francis

Cryospheric Science

GEOL-PG-E404

Unit I: Fundamentals of Cryospheric Sciences

Introduction to Cryosphere Sciences.

Quaternary glaciations in India.

Climate change in Quaternary – Case studies from Himalaya (Ladakh, Uttarakhand, Western UP, and Sikkim), Rajasthan and Ganga plains, correlation with Guliya and Greenland ice core, glacier types, dry and wet based glaciers and factors responsible, sediment transport and deposition by glaciers, techniques employed for the dating of glaciogenic deposits and their limitations, physics of glacier ice and snow.

Unit II: Glaciology

Movement of glacier, surface and subsurface features of glacier.

Mechanisms of glacier flow.

Meterological parameters vis-a-vis glacier, effect of debris/aerosols on glacier surface, energy balance, mass balance study of glaciers, various methods of mass balance study, isotope study of glacier ice and snow vis-à-vis climate change, chemistry of snow/ice, sediment discharge by melt water and chemistry of melt water, snout monitoring techniques, remote sensing and GIS application in the study of glaciers.

Impact of global warming on Himalayan glaciers.

Unit III: Mass Movements in Permafrost Regions

Characteristics of permafrost areas, rock and soil characters in cryosphere.

Mass movement in permafrost areas- causes and mitigation.

Snow avalanches – snow packages and density, avalanche types, characteristics of avalanche, avalanche prone areas and their mitigation.

Unit IV: Case Studies

Brief history of glaciological studies on Indian Himalayan glaciers.Case study of Himalayan glaciers**.**

Case study of Glaciers in Sikkim.Rathong, Talong, Chamgme-Khangpu and Zemu glaciers, Arctic, Antarctic and Alpine glaciers.

Essential readings

1. Roger Berry and Thian Yew Gan, the Global Cryosphere. Cambridge University Press.
2. Olav Slaymaker, Richard Kelly, 2006. The Cryosphere and Global Environmental Change. Wiley-Blackwell.
3. Marco Tedesco, 2014. Remote Sensing of the Cryosphere. Wiley
4. Raina ,V.K., Glaciers The Rivers of Ice 2005. Geological Society of India.
5. Raina, V.K. and Srivastava, D. "Glacier Atlas of India, 2008, Geological Society of India.

Suggested readings

1. Maher and Thompson 2000 Quaternary climates, environments and magnetism. Cambridge Univ. Press.
2. Williams, D. et al. 1998 Quaternary Environments. Wiley & Sons.
3. IPCC Reports.

Micropaleontology

GEOL-PG-E405

Unit I: Introduction to Micropaleontology

Global record of earliest microfossils.Classification and evolution of the microfossil groups.Prokaryotic and Eukaryotic diversification of microorganisms, multicellularity.

Ediacaran Metazoans and Metaphytes.Radiation of AcanthomorphicAcritarchs in Neoproterozoic.

Taphonomy of microfossil groups.

Unit II: Calcareous Microfossils

Foraminifera: Planktic Foraminifera, their modern biogeography, coiling, surface ultrastructure, outline of morphology. Benthic foraminifera, their brief morphology. Larger Foraminifera, their outline of morphology, application in oceanography.

Calcareous nanofossils: Outline of morphology, modern biogeography, application in Oceanography; outline morphology and wall structure of ostracoda, significance of ostracoda in Quaternary paleoceanographic and paleoclimatic studies.

Unit III: Siliceous and Phosphatic Microfossils

Outline morphology, modern biogeography of radiolarian, diatoms and silicoflagellates, their application in interpreting SST and palaeoclimates

Phosphatic Microfossils- Outline morphology, Paleo-ecology and environmental significance of conodonts.

Unit IV: Applied Micropalaeontology

Organic Walled Microfossils.

Environmental significance of Acritarchs, Dianoflagellates and Foraminifera.

Palynology: Outline of morphology of Pollens and Spores. Pollens and Spores in marine realm. Environmental application of Pollen and Spores.

Application of Micropaleontology and palynology in Petroleum and coal exploration.

Essential Readings:

1. Bignot, G., 1985. Elements of micropalaeontology; Microfossils, their geological and palaeobiological applications, Graham &Trotman, London, United Kingdom.
2. Braiser, M.D., 1980. Microfossils, Geogrge Allen and Unwin Publisher.
3. Hasllett, S.K., 2002. Quaternary Environmental Micropalaeontology, Oxford University Press, New York.
4. Jones, R.W., 1996. Micropaleontology in Petroleum exploration, Clarendon Press Oxford.

Suggested Readings:

1. Sinha, D.K., 2007. Micropaleontology: Application in Stratigraphy and Paleoceanography, Alpha Science International, Oxford &Narosa Publishing House Pvt. Ltd. Delhi.
2. Kennett and Srinivasan, 1983.Neogene Planktonic Foraminifera: A phylogenetic Atlas, Hutchinson Ross.

Oceanography

GEOL-PG-E406

Unit I: Physical Oceanography

Methods of measuring properties of sea water.Molecular structure of water.Temperature and salinity distribution in surface of the ocean.Salt composition and residence time.Dissolved gases in seawater. Carbon dioxide and carbonate cycle.

Ocean circulation: The Ocean Conveyor belt and its role in controlling world's climate. Surface circulation; concept of mixed layer, thermocline and pycnocline, Coriolis force and Ekman Spiral, Upwelling, El Nino. Processes affecting biological productivity of ocean margin waters. Deep Ocean Circulation, concept of thermohaline circulation, formation of bottom waters; water masses of the world oceans.Oxygen minimum layer in the ocean.Major currents of the world's ocean.

Unit II: Deep-Sea Sediments and Processes

Deep-sea sediments and their relation to oceanic processes such as solution, productivity, and dilution. Sediment distributions in time and space as related to tectonic models. Deep Sea hiatuses and their causes.Calcite and Aragonite Compensation depth and significance.

Ocean Resources: Mineral resources of the ocean including polymetalic nodules. Marine Gas Hydrates and their economic potential.

Unit III: Marine Pollution

Marine Pollution emphasizing geochemical aspects of the sources, transport, and fate of pollutants in the coastal marine environment.Interpreting marine pollution with the help of microfossils during Quaternary.

Paleoceanography: Ocean Floor Morphology, Oceanic Crust and Ocean Margins. Approaches to Paleoceanographicreconstructions. Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change.Deep Sea Drilling Project (DSDP); Ocean Drilling Program (ODP) and Joint Global Ocean Flux Studies (JGOFS) and their major accomplishments.Integrated Ocean Drilling Program (IODP) and its aims and objectives.

Unit IV: Evolution of Oceans in the Cenozoic

Ocean Gateways of the Cenozoic and their role in controlling global climates. Sea level changes during Quaternary with special reference to India. Application of stable isotopes (Oxygen and Carbon) in Paleoceanography and Paleoclimatology. Paleoclimatic reconstructions from ice cores.Marine Stratigraphy, correlation and chronology.

Essential Readings:

1. Gross, M.G., 1977. Oceanography: A view of the Earth, Prentice Hall.
2. Millero, Frank J., 2013. Chemical Oceanography, Fourth Edition. CRC Press.
3. Garrison, Tom S.,2011. Essentials of Oceanography. Cengage Learning.
4. Dijkstra, Henk A.,2008. Dynamical Oceanography. Springer.
5. Tolmazin, D., 1985. Elements of Dynamic Oceanography, Allen and Unwin.

Suggested Readings:

1. Siddhartha, K. Oceanography: A Brief Introduction. Kisalaya Publications.
2. Fischer, G. and Wefer, G., 1999. Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer.
3. Haq and Boersma, 1978.Introduction to Marine Micropaleontology, Elsevier.

Geology of Hydrocarbon Reservoirs

GEOL-PG-E407

Unit-I: Introduction to Oil Well Drilling

Types oil wells and geotechnical order.

Methods of Oil well drilling: Cable tool drilling and rotary drilling

Components of rotary drilling system.

Monitoring of drilling process i.e. depth ROP, WOB, sampling.

Concept of Subsurface pressure.

Types of Drilling Rigs: Onshore and offshore rigs.

Controlled Directional Rotary Drilling, Horizontal Drilling.

Drilling Mud: Mud hydraulics, uses and functions of drilling mud.

Coring: Introduction, Techniques and Applications of Coring in Petroleum Geology.

Unit-II: Formation Evaluation

Well logging- Techniques- Principles and instrumentation of electrical, radioactive,

sonic, caliper logging techniques interpretation of logs.

Wire line logs: Introduction Basic Principles, tools of SP, gamma ray, Neutron,Density,

Caliper, Dipmeter, Temperature and Sonic Logs and their interpretation.

Mud logging: Principle, techniques and tools of mud logging.

Interpretation of gas,drilling and mud parameters.

MWD (Measurement While Drilling)/LWD (Logging While Drilling):

Principle and tools of MWD/LWD, data analysis and interpretation.

Formation (Drillstem) Testing: Introduction, Tools and Techniques of DST.

Unit-III: Reservoir Engineering

Petrophysical properties of reservoir rocks: porosity, permeability, fluid saturation.

Fluid flow through porous media.

Reservoir fluid properties.Reservoir fluid sampling and PVT studies.

Material Balance, Reservoir energies & drives - Water influx; Gas, condensate and oil reservoirs.

Thermodynamics of fluid system - Phase behaviour of single and multiphase systems, Decline curve analysis.

Well performance: productivity index, IPR. Water and gas coning, Open flow potential for gas wells.

Applications of horizontal wells, ERD and multi-laterals.

Oil & Gas field development: Principles, rationale and economics of development plan. Well spacing and patterns, Economics of field development.

Unit-IV: Applications

Description and identification of well cuttings based on physical properties.

Calcimetryand fluorescence using calcimeter and UV lamp.

Percentage lithology and Master log preparation.

Gas curve identification and gas ratio plotting.

Description of core samples.

Wire line log interpretation.

Well hydraulic calculations such as annular volume, lag time calculations.

Calculations of Shale factor and shale density.

Essential readings:

1. Shelly R. C. 2014. Elements of Petroleum geology. Academic Press.
2. R.E. Chapman (1983) Petroleum Geology, Elsevier.
3. DjebbarTiab, Erle C. Donaldson (2015) Petrophysics: Theory and Practice of Measuring Reservoir Rock and Fluid. Fourth Edition, Elsevier.
4. Benjamin Cole Craft, Murray Free Hawkins, Ronald E. (1991) Terry Applied Petroleum Reservoir Engineering, Prentice Hall.
5. S.J. Mazzullo, H.H. Rieke, G.V. Chilingarian Edited, (1996) Carbonate Reservoir Characterization: A Geologic-Engineering Analysis.

Suggested Readings:

1. Petroliferous basins of India: Publisher: KDMIPE, ONGC, 1986.
2. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.

Atmospheric Processes

GEOL-PG-E408

Unit I: Physical Meteorology

Thermal structure of the atmosphere and its composition. Radiation: basin Laws - Rayleigh and Mie scattering, multiple scattering, radiation from the sun, solar constant, effect of clouds, surface and planetary albedo. Emission and absorption of terrestrial radiation, radiation windows, radiative transfer, Greenhouse effect, net radiation budget; Thermodynamics of dry and moist air: specific gas constant, Adiabatic and isoentropic processes, entropy and enthalpy, Moisture variables, virtual temperature; Clausius – Clapeyron equation, adiabatic process of moist air; thermodynamic diagrams: Hydrostatic equilibrium: Hydrostatic equation, variation of pressure with height, geopotential, standard atmosphere, altimetry. Vertical stability of the atmosphere: Dry and moist air parcel and slice methods. Tropical convection.

Unit II: Climatology:

Fundamental principles of climatology. Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance. Air masses, monsoon, Jet streams, tropical cyclones, and ENSO.Classification of climates – Koppen's and Thornthwaite's scheme of classification.Climate change.

Unit III: Cloud Physics:

Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron, Findeisen process, coalescence process – Precipitation of warm and mixed clouds, artificial precipitation, hail suppression, fog and cloud – dissipation, radar observation of clouds and precipitation, radar equation, rain drop spectra, radar echoes of hail storm and tornadoes, radar observation of hurricanes, measurements of rainfall by radar.

Unit IV: Dynamic Meteorology:

Basic equations and fundamental forces: Pressure, gravity, centripetal and Corolis forces, continuity equation in Cartesian and isobaric coordinates. Momentum equation Cartesian and spherical coordinates; scale analysis, inertial flow, geostrophic and gradient winds, thermal wind. Divergence and vertical motion Rossby, Richardson, Reynolds and Froude numbers. Circulation, vorticity and divergence; Bjerknese circulation theorem and applications, vorticity and divergence equations, scale analysis, potential vorticity, stream function and velocity potential. Atmospheric turbulence: Mixing length theory, planetary boundary layer equations, surface layer, Ekman layer, eddy transport of here, moisture and momentum, Richardson criterion; Linear Perturbation Theory: Internal and external gravity waves, inertia waves, gravity waves, Rossby waves, wave motion in the tropics, barotropic and baroclinic instabilities. Atmospheric Energetics: Kinetic, potential and internal energies – conversion of potential and internal energies into kinetic energy, available potential energy.

Essential readings:

1. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology.Pearson Publisher.

2. An Introduction to Atmospheric Physics, Second Edition, David G. Andrews, Cambridge University Press, 2010.

3. Wallace and Hobbs, 2006. Introduction to Atmosphere: An Introductory Survey. (Elsevier).
4. Atmospheric Processes and Systems by R. D. Thompson Publisher: Routeledge.
5. Reist, Parker C., 1984. Introduction to aerosol science. MacMillan Publishers.

Suggested readings:

1. Rudiman, W.F., 2001. Earth's climate: past and future. Freeman Publisher.
2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt.
3. Aguado, E., and Burt, J., 2009. Understanding weather.
4. Fundamentals of Atmospheric Modelling by Mark Jacobson. Cambridge University Press.

Core Practical Paper

Practical IV

GEOL-PG- P409

Unit I: Exercises on Exploration Geology

Reserve estimation: Principles of reverse estimation, density and bulk density, factors affecting reliability of reserve estimation, reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks) regular and irregular grid patterns, statistics and error estimation.

Grade Tenor and Tonnage calculations.

Preparation of cross-sections, LV sections.

Borehole data correlation and ore body geometry.

Unit II: Exercises on Well logging

SP log, Natural Gamma Ray log, Formation Water resistivity Logs, Porosity.

Log, Neutron Log, Lithology-Porosity Logs, resistivity Logs, Induction Logging, Electromagnetic Propagation Logs and Well bore Seismic Logging.

Applications of well logging in exploration and geotechnical site, Investigation.

Unit III: Exercises on Environmental and Engineering Geology

Field based practical for sample/data collection and in-situ study. Grain Size Analysis.

Density Determination.

Atterbergs Limit Tests Compaction Test Consolidation Test.

Direct and Triaxial Shear Test Compressive Strength Test Abrasion and slake durability test Permeability Test.

Selection of sites using topographic maps for dams, tunnels, bridges, highways and similar civil structures.

Computation of reservoir area, catchment area, reservoir capacity and reservoir life, discharges and sedimentation rates.

Use of softwares for solving various geotechnical problems.

Unit IV: Exercises on Micropaleontology

Techniques of separation of microfossils from matrix.

Types of microfossils: Calcareous, Siliceous, Phosphatic and organic walled microfossils

Study of important planktic foraminifera useful in surface water paleoceanography and biostratigraphy.

Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India.

Study of modern surface water mass assemblages of planktic foraminifera from Indian, Atlantic and Pacific Ocean.

Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemblages

Identification of benthic for aminifera characteristic of various deep sea environment Identification of planktic foraminifera characteristic of Warm Mixed Layer, Thermocline and deep surface waters of the modern oceans.

Identification of modern and ancient surface water mass with the help of planktic foraminifera.

Essential readings:

1. Bell, F.G, 2006. Basic Environmental and Engineering Geology. Whittles Publishing.
2. Haldar, SK, 2013. Mineral Exploration - Principles and Applications. Elsevier.
3. R.C. Shelley (1998) Elements of petroleum Geology. Academic press
4. P.A. Dickie, (1986), Petroleum Development Geology: Publisher: Pennwell Publishing, Tulsa, Oklahoma
5. Sinha, D.K., 2007. Micropaleontology: Application in Stratigraphy and Paleoceanography, Alpha Science International, Oxford &Narosa Publishing House Pvt. Ltd. Delhi.
6. Bignot, G., 1985. Elements of micropalaeontology; Microfossils, their geological and palaeobiological applications, Graham &Trotman, London, United Kingdom.

Core Field Training

Field Training II

GEOL-PG-F410

Field training in the type area of economic deposits to study the geological aspects

Visit of Mines/industry for geological study and exploitation techniques.

Study of aspects of the environmental geology

Note: Field Training of minimum two weeks will be carried out in winter vacation and evaluated in this semester. The students have to submit their field diary and field report at the time of examination. The field diary and field report will be evaluated and there will be an open presentation and viva-voce.

Dissertation Paper

Dissertation

GEOL-PG-D411

The students have to submit their dissertation by the end of the fourth semester. There will be an open presentation and viva-voce.

DEPARTMENT OF GEOLOGY

Ph.D Course Work Syllabus

Course	Title of Course	Credit	Marks
GEO-RS-C101	Research Methodology	4	100
GEO-RS-C102	Research Proposal Preparation	4	100
GEO-RS-E103	Advances in Structural Geology	4	100
GEO-RS-E104	Advance Techniques in Mineral Exploration	4	100
GEO-RS-E105	Advances in Hydrology	4	100
GEO-RS-E106	Advances in Igneous Petrogenesis	4	100
GEO-RS-E107	Advances in Metamorphic Geology	4	100
GEO-RS-E108	Analytical Geochemistry	4	100
GEO-RS-E109	Atmospheric Processes	4	100
GEO-RS-E110	Clastic and Carbonate Sedimentology	4	100
GEO-RS-E111	Cryospheric Science	4	100
GEO-RS-E112	Environmental Geochemistry	4	100
GEO-RS-E113	Environmental Geology and Hazard Management	4	100
GEO-RS-E114	Geochronology and Isotope Geology	4	100
GEO-RS-E115	Geodynamics and Neotectonics	4	100
GEO-RS-E116	Geology of Eastern Himalayas	4	100
GEO-RS-E117	Invertebrate-Vertebrate Palaeontology and Paleobotany	4	100
GEO-RS-E118	Micropaleontology and Astrobiology	4	100
GEO-RS-E119	Ore Geology and Metallogenesis	4	100
GEO-RS-E120	Paleoclimatology	4	100
GEO-RS-E121	Developments in Hydrocarbon Exploration	4	100
GEO-RS-E122	Basin Analysis and Sequence Stratigraphy	4	100

Course Contents

Compulsory Courses

Course: GEOL-RS-C101 **Credits: 4**

Research Methodology

Module I

Defining the Research problem: objectives, approaches, planning or design, process/ methods of research; literature survey.Basics of Research, Fundamental questions like definition of research, logical and systematized applications of the fundamentals of science and scientific techniques, necessity of research in science. Importance of research, generalizations of new theories,outlet for new ideas and insights.

Probability distributions and their properties, Sampling, Correlation and Covariance Multivariate and Factor Analysis.

Module II

Identification of geological research problem, Formulating work plan, Dos and Don'ts for selecting a research problem.

Importance of problem in National and International scenario, how to conduct research survey (books, journals, electronic search engines like Google, SCOPUS, Wikipedia Research-gate, IGCP Project Data Base, etc.).

Research Methodology and techniques used in the field and laboratory for geological samples, Field and Lab, Developing hypothesis, Collection of primary data from the field, Execution of project, Data analysis, Interpretations of field and lab data, Dissemination of research results through conferences, workshops, synthesis of data, report writing and publication of research paper.

Module III

Research Methodology is an art of scientific investigations, Geological questions and new insights of an geological event or phenomenon (For Example, Climate Change Impacts andmelting of glaciers, Cretaceous – Tertiary Mass Extinction, India – Asia collision and formation of the Himalaya, Tectonic Geo-morphological aspects of River Systems, Mineralisation associated with Lesser and Greater Himalayan Sequences etc).

Planning, Selection, Formulation and Execution of research project, Thrust area of the project, Objectives of the project and the Course of action (work plan), Conceptual and Empirical literature review. Status of research on international and national level

Module IV

Methods of sampling, and analytical techniques: Collection of air, water, soil and rock samples, Preparation of samples for microscopic examination and chemical analysis, Analytical Techniques viz. AAS, XRF, ICP, EPMA, Mass Spectrometryand Portable analytical techniques, Geospatial and Remote Sensing Techniques.

Fundamentals of Geoscientific Writing and relevant softwares, Research Ethics, Intellectual Property Rights (IPR) and Plagiarism.

Suggested Readings:

1. Research Methodology: A Hand Book – Geological Survey of India, M. Ramakrishna.
2. Research Methodology: A Hand Book by R.P. Mishra.
3. Research Methodology in Geology by Arnold LuwangUsham.
4. Handbook of research on Methodology and Techniques: B.K. Daniel.
5. Research Methodology by C.R. Kothari.

Course: GEOL-RS-C102 **Credits: 4**

Research Proposal Preparation

This is a non lecture paper in which the respective teacher will explain the student about how to prepare synopsis or research proposal. At the end of the semester students will give a presentation and a write up. Students will be evaluated on the basis of that.

Module I

Literature Review, Identification of problem, Presentation.

Module II

Research Project Formulation, Understanding the proposal preparation for various funding agencies viz. DST, MoES, CSIR, UGC, BRNS, IGCP, ISRO and Sikkim University.

Module III

Performa for the submission of the Research Project, Format for the Quarterly Progress Report, Format for Technical Report.

Module IV

Project Proposal Preparation and Presentation (Oral/Poster/Video Conferencing, Webcasting).

Optional Papers

Course: GEOL-RS-E103 **Credit 4**

Advances in Structural Geology

Module-I

Stress at a point in a solid body: 3-D Stress Tensor; Homogeneous and heterogeneous stress: stress functions, Application of Continuum Mechanics in Structural Geology, Rheological Behaviour of rocks under stress, Analysis of homogeneous deformation, Mechanics of rock fracturing: fracture initiation and propagation, Mohr diagrams for stress and strain and their use.

Module-II

Microstructures associated with deformational and metamorphic events, Thrust Tectonics in Orogenic Belts, Introduction to Experimental Structural Geology, Introduction to Finite element Analysis.

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module-IV

Exercises related to Strain Analysis. Micro structural Studies on Thin Sections.

Problems related to Continuum Mechanics and Finite element Analysis.

Suggested Readings:

1. Dubey, A. 2014, Understanding an Orogenic Belt Structural Evolution of the Himalaya, Springer; 2014 edition, ISBN-13: 978-3319055879
2. Ramsay, J.G. and Huber, M.I., 1983. Techniques of Modern Structural Geology: Vol. I & II. Academic Press
3. Ramsay, J.G. and Lisle, R., 2000. Techniques of Modern Structural Geology: Vol. III. Applications of Continuum Mechanics in Structural Geology. Academic Press.
4. Fossen, H. Structural Geology 2010. Cambridge University Press.
5. Vernon, R., 2004, A Practical Guide to Rock Microstructure 1st Edition. Cambridge University Press
6. Ragan, D.M., STRUCTURAL GEOLOGY: An Introduction to Geometrical Techniques. 2009. IVthEdition Cambridge University Press.
7. Ghosh, S.K., 1993. Structural Geology: Fundamentals and modern developments, Pergamon Press.
8. Bayly, B., 1992. Mechanics in Structural Geology, Springer.
9. Davis, G.H. and Reynolds, S.J., 1996. Structural Geology of rocks and regions, John Wiley & Sons.
10. Leyson, P.R. and Lisle, R.J., 1996. Stereographic projection techniques in structural Geology, Cambridge University Press.

11. Passhier, C. and Trouw, RAJ, 2005. Microtectonics. Springer, Berlin.
12. Pollard, D.D. and Fletcher, R.C., 2005. Fundamentals of structural geology, Cambridge University Press.
13. Rowland, S.M., Duebendorier, E. and Schiefelbein, I.M., 2007. Structural analysis and synthesis: a laboratory course in structural geology, Balckwell Pub.
14. Suppe, J., The Principles of Structural Geology, Prentice-Hall, Inc., New Jersey, 1985.
15. Twiss, R.J. and Moores, E.M., 2007. Structural Geology. Freeman.
16. Van der Pluijm, B.A. and Marshak, S., 2004. Earth structure: an introduction to structural geology and tectonics, W.W. Norton & Company Ltd.

Course: GEOL-RS-E104 **Credit 4**

Advance Techniques in Mineral Exploration

Module-I

Advances in mineral exploration concepts. Concept-based exploration. Application of remote sensing, geophysical, geochemical, and drilling techniques in mineral exploration.

Module-II

Resources classification and Reserves Estimation Methods, Elements of Classical Statistics and Probability distribution and their applications in Ore Evaluation, Geo-statistical Concepts and Theories: Regionalized Variable Theory, Geo-statistical Semi-variogram Analysis: Definition, Characteristics, Properties, Relation with Covariogram, SemivariogramModels with Sill and Models without Sill, Nested Models and Trend Models.

Module-III

Review of recent publications and case studies, Synthesis and presentation of major findings and discussion.

Module-IV

Preparation of Sections and plans for ore evaluation, Ore microscopic studies; Studies on fluid inclusions, Geospatial analysis for Mineral Deposits, Geophysical Data processing for identifying deposits, Conventional and Geo-statistical methods of ore evaluation.

Suggested Readings:

1. Clark, Isobel and Harper, Bill.Practical Geostatistics 2000/2010. Geostokos (Ecosse) Limited
2. Clark, Isobel., Practical Geostatistics 1979 Elsevier Applied Science
3. Craig J.R. and Vaughan, D.J. 1994. Ore Microscopy and Ore Petrography
4. Essentials of Medical Geology Impacts of the Natural Environment on Public Health: Editor OlleSelinus, 2005, Elsevier Academic Press. PP: 826
5. Evans, A.M. 1993. Ore Geology and Industrial Minerals. Blackwell ScLPubl. Guilbert, J.M. and Park Jr., C.F. 1986. The Geology of Ore deposits. Freeman & Co. Bateman, A.M. and Jensen, M.L. 1990. Economic Mineral Deposits. John Wiley
6. Mookherjee, A., 2000. Ore Genesis – A Holistic Approach. Allied Publisher.
7. Sahu, B.K. Satistical Models in Earth Sciences, BS Publications
8. Sharma, D.D..Geostatistics with Applications in Earth Sciences'. Springer, 2005
9. Stanton, R.L., 1972. Ore Petrology, McGraw Hill.
10. Trosset, 1Michael W. An Introduction to Statistical Inference and Data Analysis
11. Webster Richard & Oliver Margaret A. Geostatistics for Environmental Scientists Second Edition 2007, John Wiley & Sons PP333.

Course: GEOL-RS-E105 **Credit 4**

Advances in Hydrology

Module I

Hydrologic cycle and Climate change, Change in temperatures and sea water levels, Surface and subsurface water distribution and interaction, Geological classification of aquifers and properties, Hydrological laws and application and validity, Geothermal Springs, Water quality: Physical, chemical, biological properties, Effects of geological environment on groundwater quality, Water- Rock interaction, Anthropogenic activities and Water Pollution, Sea water intrusion in coastal aquifers.

Module II

Ground water exploration: Geological, Meteorological and Geophysical methods, Application of Remote sensing in ground water exploration, Hydro-geomorphic mapping, Types of wells, Well development and design, Rain Water Harvesting, Radioisotopes in hydro-geological studies.

Module III

Review of recent publications and case studies, Synthesis and presentation of major findings and discussion.

Module IV

1. Field based practical for sample/data collection and in-situ study.
2. Deciphering of hydro-geological boundaries on water table contour maps
3. Analysis of Hydrographs
4. Determination of permeability.
5. Groundwater quality study using Trilinear (Hill-Piper), C-S diagrams etc.
6. Problems on radial flow to a well in confined and unconfined aquifers.
7. Exercises on step drawdown test.
8. Determination of aquifer parameters using Theis and Jacob’s methods
9. Calculation of salt water encroachment in coastal aquifers
10. Electrical resistivity surveys for aquifer delineation.
11. Use of Handheld water quality monitors.
12. Application of hydrological softwares.

Suggested Readings:

1. Bryirely, G and Fryirs, K. 2005. Geomorphology and river management. Blackwell Pub.Vanoni, V.A., 2006. Sedimentation Engineering, ASCE, Manual.
2. Davie, T., 2008. Fundamentals of hydrology. Routledge Publications.

3. Fetter, C.W., 2001, Applied Hydrogeology, Prentice Hall Inc., N.J., U.S.A.
4. Fitts, C.R., 2006. Groundwater Science, Academic Press.
5. Freeze, R.A. and Cherry, J.A., 1979. Groundwater, Englewood Cliffs, New Jersey: Prentice- Hall.
6. Julien, P.Y., 2002. River Mechanics. Cambridge University Press.
7. Knighton, D., 1998. Fluvial forms and processes: A new perspective. Arnold Pubs.
8. Mansell, M.G., 2003. Rural and Urban Hydrogeology, Thomas and Telford
9. Raghunath, H.M., 2007, Third Edition, Ground Water, New Age International Publishers, New Delhi.
10. Richards. K., 2004. Rivers: Forms and processes in alluvial channels. Balckburn Press.
11. Todd, D.K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.

Course: GEOL-RS-E106 **Credit 4**

Advances in Igneous Petrogenesis.

Module-I

Petrological-geochemical characters of magmas in diverse tectonic settings. Magmatism and global orogenic events.

Mineralization associated with large igneous provinces and different tectonic settings. Application of Geochemistry, geochronology and Mineral Chemistry to infer igneous processes.

Module-II

Petrogeneticmodeling of crystallization and melting processes using geochemical data. Evolution of Magmatic Processes through Geological Time.

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion.

Module-IV

Geochemical Modelling of data.

Plotting and interpretation ofIsochrons. Estimating model ages and • (epsilon) ratios. Textures and Microstructures of Igneous Rocks.

Suggested Readings:

1. Cox, KG, Bell, JD and Pankhurst, RJ, 1993. The Interpretation of Igneous Rocks. Chapman & Hall, London
2. Dickin, A.P. (2005). Radiogenic Isotope Geology, Cambridge University Press, 512p
3. Gill, R, 2010, Igneous Rocks and Processes: A Practical Guide, Wiley-Blackwell; 1 edition
4. Philpotts, AR and Ague, JJ. 2009. Principles of Igneous and Metamorphic Petrology. 2nd Edition
5. Rollinson, HR 2007. Using geochemical data-evaluation, presentation and interpretation. 2nd edition. Longman Scientific & Technical
6. Vernon, R., 2004, A Practical Guide to Rock Microstructure 1st Edition. Cambridge University Press
7. Wilson, M, 1989. Igneous Petrogenesis. Wiley
8. Winter, JD, 2001. An introduction to Igneous and Metamorphic petrology, Prentice Hall

Course: GEOL-RS-E107 **Credit 4**

Advances in Metamorphic Geology

Module-I

Facies concept, reaction isograds and Bathozones.

Geothermometry and geobarometry in metamorphic rocks. Mineral chemistry and thermodynamics.

Kinetics of metamorphic reactions.

Module-II

Phase equilibrium studies. Characterisation of fluid composition through mineral equilibria. Metamorphism in Himalayas. Inverted metamorphic sequences.Ultra High Pressure metamorphic rocks. Mineralisation associated with metamorphic belts.

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion.

Module-IV

Microstructural study of metamorphic rocks. Schreinemakers analysis and petrogenetic grid.

Construction of P-T, T-X, and P-X diagrams. Pseudobinary sections.

Suggested Readings:

1. Bucher K. and Martin F. 2002. Petrogenesis of Metamorphic rocks. Springer-Verlag Publication.
2. Bucher, K, Grapes,R. 2010 Petrogenesis of Metamorphic Rocks, Springer
3. John D. Winter 2001. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall Inc
4. Passchier, C.W., Myres, J.S., Kroner, A. 1990 Field Geology of High-Grade Gneiss Terrains. Perfect Paperback Springer
5. Philpotts, A.R. & Ague, J.J. 2009. Principles of igneous and metamorphic petrology. Cambridge University Press.
6. Spears F. 1993. Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths. AGU publication
7. Vernon R. H. and Clarke G. L. 2008. Principles of metamorphic Petrology. Cambridge publication.
8. Vernon, R., 2004, A Practical Guide to Rock Microstructure 1st Edition. Cambridge University Press

Course: GEOL-RS-E108 **Credit 4**

Analytical Geochemistry

Module-1

Analytical Instrumentation in Geology, Sample preparation and Geological Reference materials, Portable analytical instruments, Optical Emission /Absorption Spectroscopy (spectrophotometry, UV- VIS), flame photometry, F-AAS, GF-AAS and ICP-AES, Microwave Plasma Atomic Emission Spectrometry (MP-AES).

Infrared and Raman Spectroscopy; Thermoluminescene and Optically Stimulated Luminescence technique (FTIR); Low Temperature Thermochronology, Mossbauer Spectroscopy; Electron Spin Resonance (ESR), X-ray techniques: XRD, XRF, SEM-EDX, Microbeam techniques: EPMA, SEM, TEM, SIMS, Nano-SIMS and SHRIMP.

Module-II

CHNS-O analyser, Chromatographic techniques viz, GCMS, HPLC, Neutron activation analysis, Mass spectrometric techniques ICP-MS, LA-ICPMS, TIMS, Isotope ratio techniques and Accelerator Mass Spectrometry (AMS), Atomic Force Microscope, Techniques for Speciation studies

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion.

Module-IV

Geochemical Sample preparation and Geochemical Analysis of various media using various instruments.

Suggested Reading:

1. Aitken, M. J., An Introduction to Optical Dating : The Dating of Quaternary Sediments by the Use of Photon-stimulated Luminescence, Oxford University Press, Oxford,1998.
2. BANWELL Colin and MC CASH Elaine, Fundamentals of Molecular Spectroscopy, Mc

   Graw-Hill, 1994.
3. Beran, A and Libowitzky, E. (ed), Spectroscopic methods in Mineralogy. European Mineralogical Union Notes in Mineralogy. Vol 6, 2004.
4. Braun, R. D., Introduction to Instrumental Analysis, McGraw-Hill, Singapore, 1987
5. Hawthorne, F. C. (ed.), Spectroscopic Methods in Mineralogy and Geology, Reviews in Mineralogy, Mineralogical Society of America, 18, 1988.
6. King, P. L. Ramsey, M. S. and Swayse, G. A. (Eds.) Infrared Spectroscopy in Geochemistry, Exploration Geochemistry and Remote Sensing, Mineralogical Association of Canada, short course series, V 33, 2004.
7. Marfunin, A. S. Spectroscopy, Luminescence and Radiation centers in Minerals, Springer- Verlag, Berlin, 1979.
8. Mendham, J., Denney, R.C. , Barnes, J. D., Thomas, M.J.K.. 2000 Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall
9. Reiners, P. W. and Ehlers, T. A. Low-Temperature Thermochronology: Techniques, Interpretations and Applications. Reviews in Mineralogy and Geochemistry, V 58. 2005.
10. Willard, H.H., Merit L.L., Dean J.A Seattle F.L., Instrumental Methods of Analysis, CBS publishing and Distribution, 1995

Course: GEOL-RS-E109 **Credits: 4**

Atmospheric Process

Module I

Structure and composition of the atmosphere, weather elements, Stability in the atmosphere, Clouds and their classification, Fundamental Forces – Equations of motion on a rotating earth and winds, Turbulent diffusion equation – Eddy transport of heat, mass and momentum. Bjerknes' circulation theorem and applications, Particle size distributions, Fluid properties, Aerosol charging mechanisms, coagulation of particles. Optical properties of aerosols. Cloud seeding and artificial Rains.

Mountain Meteorology. Effects of Meteorological parameters on Transport and Diffusion, Influence of Topography on Transport and Diffusion. Equation of state and conversion of concentrations, Principles of Turbulence and Diffusion.

Module II

Air Pollution Climatology, Meteorology and Air Pollution, Atmospheric chemistry and Air pollution. Natural Removal Processes in the Atmosphere, Geological processes and climate change, Green House effect, Ozone depletion. Atmospheric Hazards, SMOG and Haze.

ENSO Cycle, Indian Summer monsoon (ISM). Jet streams, tornados, typhoon and tropical cyclones. Climate models, Weather Prediction and Doppler Radar systems,

Module III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module IV

Aerosol and green house gases sampling and analysis. Meteorological data collection, processing and modelling.

Suggested Readings:

1. Introduction to Atmosphere by Wallace and Hobbs;
2. Boundary Layer Meteorology by R. B. Stull
3. Meteorology by Holton
4. Physics and Chemistry of Atmosphere by Sienfeld and Pandis
5. Atmospheric Processes and Systems by R. D. Thompson Publisher: Routeledge
6. Fundamentals of Atmospheric Modelling by Mark Jacobson, Pub: Cambridge University Press
7. Fundamentals of physics and chemistry of the atmosphere, by Guido Visconti. Pub: Springer
8. Energy and the atmosphere: a physical-chemical approach by Campbell. Pub: John wiley

Course: GEOL-RS-E110 **Credit: 4**

Clastic and Carbonate Sedimentology

Module I:

Sedimentary Environments and Facies, Alluvial fans: Geomorphology, Sedimentology and dynamics.Source to sink relation from sediments.

Tectonics and Sedimentation. Clasticsedimentation. KT boundary sedimentation. Application of Geochemical data in identification of Provenance.

Recent developments in Sedimentary Petrography and Clay Mineralogy. Heavy mineral analysis.

Shallow marine and deep marine sedimentation (eg. Polymetallic Nodules and crust). Geometry of carbonate platforms, carbonate ramps, rimmed shelves, reefs and algal buildups.

Module II:

Carbonate rocks, controls of carbonate deposition. Sedimentary environments and carbonate facies. Continental carbonate deposits.Diagenesis of carbonate rocks.

Tectonics and Carbonate sedimentation.

Biogenic chert and siliceous sediments, phosphorites, carbonaceous sediments, iron rich sediments and evaporites.

Microbial (biogenic) ancient and modern carbonate sedimentation. Geological distribution, environment and isotope and biogeochemistry of the biogenic carbonates.

Olistoliths and their origin.

Snow Ball Earth and Glacial carbonates and their global distribution.

Terrestrial deposits (Speleothems), and their implication in Paleoclimate, Paleomonsoon and ITCZ reconstruction.

Module- III:

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module- IV

Exercises on

1) Sedimentary facies identification and correlation vertical as well as lateral.

2) Palaeocurrent Analysis

3) Petrographic Analysis of thin sections.

4) Heavy mineral Analysis.

5) Study of carbonate sedimentary successions, sedimentary structures,stromatolites, speleothems and other microbial buildups.

6) Petrography of carbonates and microfacies identifications

7) Interpreting Major, Minor, Trace, REE, PGE data for Provence studies and Boundary problems.

8) Use of Stable isotope ratio to infer paleoclimate.

Suggested Reading:

1. Boggs, Sam,2006. Principles of Sedimentology and Stratigraphy, Prentice Hall
2. Einsele, G., 2000. Sedimentary Basins: Springer
3. Harris, P.M., Saller, A.H., and Simo, J.A., 1999. Advances in carbonate sequence stratigraphy. Soc. Econ. And Min. Spl. Publ. . 63, 421pp.
4. Leeder, M. R., 1982. Sedimentology. Process and Product. xv + 344 pp., London, : George Allen & Unwin.
5. Nichols, G 2009. Sedimentology and Stratigraphy:), Wiley-Blackwell
6. Posamentier, H.W. and Walker R. G. 2006, Facies Models revisited: SEPM
7. Reading.H.G. 1996Sedimentary Environments: Processes, Facies and Stratigraphy: Blackwell Publishers
8. Scoffin, T.P., 1987. An Introduction to carbonate sediments and diagenesis , 482pp. Blackwells, Oxford.
9. Tewari, V.C. and Seckbach, J. .2011. Interaction of Microbes with Sediments. COLE Volume 18, Springer Verlag, Heidelberg, Germany, 745 pages
10. Tucker , M.E. and Wright, V.P., 1990. Carbonate Sedimentology and Diagenesis. ,482 pp. Blackwell Oxford.

Course: GEOL-RS-E111 **Credit: 4**

Cryospheric Science

Module-I

Glaciers –Classification,GlacialLand System,GlacialGeomorphology,Glacial deposits and palaeoglaciationstudies, Lichenometry, Quaternaryglaciations, Glaciatedregime, environmental interaction and Himalayan ecosystem,Glacier Inventory

Module-II

Mass balance studies ,Heat Balance in glacier regime – Climatic changes,Hydrometry of glacierisedbasin,Suspended sediment transport in glacierised stream, Snow cover assessment study,Snow melt and its estimation,Winter snow melt its estimation and forecasting, Effect of debris/aerosols on glacier surface Chemical and isotopic studies of snow / ice,Glacier movement studies,Geophysics in glacial studies

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module-IV

Surveying techniques in glaciological studies.Mass Balance estimation-Ablation measurements,Snoutmonitoring,Melt water discharge measurement,Suspended sediment transport tudies,Meteorologicalmeasurements,Thickness estimation-GPR applications,Application of RS in glaciological studies.Age determination by isotopic methods, Snout monitoring with remote sensing and GIS application, Case study of Glaciers in Sikkim.

Suggested Readings

1. Jonathan L. Barmer and Antony J Payne, Mass Balance of Crosphere; Observation and Modelling.
2. Marco Tedesco, Remote Sensing of Cryosphere
3. Marshel S. J, The Cryosphere
4. Christian Hoggel, Mark Cary &Jhon J. ClagueThe High Mountain Cryosphere
5. Maher and Thompson 2000 Quaternary climates, environments and magnetism. Cambridge Univ. Press
6. Williams, D. 1998 Quaternary Environments. Wiley & Sons.

Course: GEOL-RS-E112 **Credit: 4**

Environmental Geochemistry

Module 1

Natural and anthropogenic inputs, Geochemistry and Chemical composition of Environmental materials, Introduction to Medical Geology, Water-rock interaction and solubility of minerals, Mass balance approach to weathering, Clay mineralogy.

Module II

Geological aspects of pollution, Pollution of water and land by agricultural practice, mining activities and industries, Acid mine drainage, Heavy Metal Pollution. Trace metals, speciation and toxicity, Development of materials for removal of Toxic materials, Radioactive pollution; nuclear waste disposal, Impacts of anthropogenic activities on Coastal and ocean environments, Biodegradable and Non-biodegradable waste especially plastic in oceans and land, Application of geochemical data for EIA and EMP.

Module III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module IV (Practical)

1. Analysis of various media and interpretation of results.
2. Statistical tools for environmental data analyses.
3. Development of models.

Suggested Readings:

1. Apello, C.A.J. and Postma, D. Geochemistry, Groundwater and Pollution. Balkema, 2005.
2. Drever, J.I. Geochemistry of Natural waters. Prentice Hall, 1997.
3. Essentials of Medical Geology Impacts of the Natural Environment on Public Health: Editor OlleSelinus, 2005, Elsevier Academic Press. PP: 826
4. Faure, G. 1991 Principles and Applications of Inorganic Geochemistry: A Comprehensive Textbook for Geology Students McmillanCollDiv
5. Faure, G. 1998 Principles and Applications of Geochemistry Prentice Hall
6. Langmuir, D, Aqueous Environmental Geochemistry. Prentice Hall, 1997.
7. ValdiyaK.S., 2013 Environmental Geology: Ecology, Resource and Hazard Management, McGraw Hill Education

Course: GEOL-RS-E113 **Credit: 4**

Environmental Geology and Hazard Management

Module-I

Geological aspects of pollution, Pollution of water and land by agricultural practice, mining activities and industries, Acid mine drainage, Heavy Metal Pollution. Trace metals, speciation and toxicity, Development of materials for removal of Toxic materials, Radioactive pollution; nuclear waste disposal, Impacts of anthropogenic activities on Coastal and ocean environments, Biodegradable and Non-biodegradable waste especially plastic in oceans and land, Application of geochemical data for EIA and EMP.

Module-II

Lithosperic Hazards: Types and Mechanisms, Earthquake Hazards and Mitigation. Soil Liquefaction. Seismic zonation map of India.Tectonics and Climate, Landslides, Types of slope failure, Slope Mass Rating (SMR) classification, Causative factors, Landslide Hazard Zonation, Factor of Safety analysis, Slope stabilization measures, Volcanic Hazard: Origin and Types, Products and Hazards, Monitoring, Risk Evaluation and Prediciton. Meteorite Impacts, Atmospheric Hazards: Cyclones and Anticyclones, Thunderstorms and Lightning, Hail, Flash Flooding,Cloud burst. Drought, Hydrospheric Hazards: Fluvial hazards: Flooding, channel migration, bank erosion, catchment erosion. GLOF. Snow avalanches – snow packages and density, avalanche types, characteristics of avalanche, avalanche prone areas and their mitigation, Coastal Hazards: Tsunamis,Sea Level fluctuation, sea water intrusion and Oil spill. Impact of mining and drilling on coastal regions.

Module III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module IV

Application of softwares for Hazard assessment and Risk Management. Case Studies related various Disasters

Suggested Readings:

1. Bell, F.G., 1999. Geological Hazards, Routledge, London.
2. Bryant, E., 1985. Natural Hazards, Cambridge University Press.
3. Clark, Isobel and Harper, Bill. Practical Geostatistics 2000/2010. Geostokos (Ecosse) Limited
4. Clark, Isobel., Practical Geostatistics 1979 Elsevier Applied Science
5. Edward A.K. and Robert H.B.Natural Hazards-Earth’s Processes as Hazards, Disater, and Catastrophes, Second Edition 2008, Prentice Hall (Pearson).
6. Essentials of Medical Geology Impacts of the Natural Environment on Public Health: Editor OlleSelinus, 2005, Elsevier Academic Press. PP: 826
7. Patwardhan, A.M., 1999. The Dynamic Earth System. Prentice Hall.
8. Sahu, B.K. Satistical Models in Earth Sciences, BS Publications

9. Sharma, D.D..Geostatistics with Applications in Earth Sciences'. Springer, 2005

10. Smith, K., 1992. Environmental Hazards. Routledge, London.

11. Todd, D.K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.

12. Trosset, 1Michael W. An Introduction to Statistical Inference and Data Analysis

13. ValdiyaK.S., 2013 Environmental Geology: Ecology, Resource and Hazard Management, McGraw Hill Education

14. Webster Richard & Oliver Margaret A. Geostatistics for Environmental Scientists Second Edition 2007, John Wiley & Sons PP333.

Course: GEOL-RS-E114 **Credit: 4**

Geochronology and Isotope Geology

Module-I

Principles and applications of Radiogenic, Stable, Cosmogenic and Anthropogenic Isotope geochemistry, Sample processing and analytical techniques for isotope analysis.

Module-II

Isotope geochemistry of magamatic and metamorphic minerals, waters, sediments and the oceans. Zirconology and crustal evolution. Thermochronology.

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion.

Module-IV

Plotting and interpreting Geochronological and Isotopic data.

Suggested Reading:

1. Dickin, A.P. (2005). Radiogenic Isotope Geology, Cambridge University Press, 512p
2. Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.
3. Faure, G. 1991 Principles and Applications of Inorganic Geochemistry: A Comprehensive Textbook for Geology Students McmillanCollDiv
4. Faure, G. 1998 Principles and Applications of Geochemistry Prentice Hall
5. Faure, G and Mensing T.M., 2005 Isotopes Principles and Applications. Wiley
6. Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p.
7. Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology. Springer Verlag, 188p
8. Faure, Gunter. 2001 Origin of Igneous Rocks: The isotpoisc evidence. Springer Verlag.
9. Rollinson, H.R. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.

Course: GEOL-RS-E115 **Credit: 4**

Geotechnical and Engineering Geology

Module-I

Geotechnical classification of geological materials, Geotechnical behavior of Earth Materials, Relationship between Stress and Strain and their measurement in rock mass. Mohr circles and Failure criterions, Rock mass classification, NGI – Q Index, RMR, SMR, GSI and other Classification schemes.

Module-II

Structural geology with special reference to engineering geology, Anisotropy and heterogeneity in deformed rocks, Geometric analysis of folds, faults, joints and rock cleavages, Structural evaluation of sites of construction, Rock Slope Engineering, Environmental Geotechnology.

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion. Geotechnical case studies of dams, tunnels and underground space, Analyzing geotechnical aspects of Natural Disasters.

Module-IV

Compressive Strength tests for rocks.

Use of GPR to locate shallow structures. Exercises on Mohr's criteria.

Determination of physical and engineering properties of soils.

Analysis of Fracture and Lineament array. Structural Geometry by stereographic projection. Exercises on RQD and rock mass quality determination.

Analysis of slope stability problems.

Exercises on Plane, Wedge and Circular failure analysis.

Use of software for solutions on Rock slope stability

Suggested Readings:

1. Engineering Rock Mass Classifications by Bieniawski; Wiley, 1989.
2. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. Jonh Wiley & Sons, N.Y.
3. Gopal Ranjan and Rao A.S.R., "Basic and applied soil mechanics", New Age International Publishers, New Delhi, 2000.
4. Johnson, R.B. and DeGraf, J.V. 1988. Principles of Engineering Geology, John Wiley & Sons, N.Y.
5. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGrawHill (CBS Publ).
6. Punmia P.C., "Soil Mechanics and Foundations", Laximi Publications Pvt. Ltd., New Delhi, 1995.
7. Rock Mechanics by Fairhurst
8. Rock Mechanics for Underground Mining by Brady and Brown; Chapman and Hall, 1993.
9. Waltham, T., 2009. Foundations of Engineering Geology (3rdEdn.) Taylor & Francis.

Course: GEOL-RS-E115 **Credit: 4**

Geodynamics and Neotectonics

Module-I

Internal structure of the earth. Variation of physical properties in the earth, Detailed structures of core, mantle and crust, including their geophysical properties and composition, Geodynamic evolution of Earth and its components, Distribution of tectonically active zones, Configuration of the Indian plate and origin of the Himalayas.

Module-II

Introduction to Neotectonics and active tectonics, Thrust and fold belts, Active faults: concepts and methods, Geomorphic markers of tectonic deformation, Active tectonics and alluvial rivers, Tectonics and erosion. Landscape response to active tectonics, Tectonic- climate interaction, GPS geodesy and its applications to lithospheric deformation, Rate of deformation and seismicity. Introduction to paleoseisomology, Application of isotopic and fission-track data for uplift-erosion-incision relationships.

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module-IV

Acquiring Total Station, GPR, DGPS and satellite data and interpretation. Geodesic Data analysis and interpretation.

Analysis of isotopic and fission-track data and interpretation.

Suggested Reading:

1. Allen, P.A., 1997. Earth Surface Processes, Blackwell publishing.
2. Bloom, A.L., 1998. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education.
3. Bridge, J.S. and Demicco, R.V., 2008. Earth Surface Processes, Landforms and Sediment Deposits, Cambridge University Press.
4. Bull, W.B., 1991. Geomorphic Response to Climate Change, Oxford University Press.
5. Bull, W.B., 2007. Tectonic Geomorphology of Mountains, Blackwell Publishing.
6. Burbank, W.B., and Anderson, R.S., 2001. Tectonic Geomorphology, Blackwell Science.
7. Easterbrook, D.J., 1992. Surface Processes and Landforms, MacMillan Publ.
8. Kale, V.S. and Gupta, A., 2001. Introduction to Geomorphology, Orient Longman Ltd.
9. Keller, E.A. and Pinter N., 2001. Active Tectonics: Earthquakes, Uplift, and Landscape, Prentice Hall.
10. McCalpin, J., 1998. Paleoseismology, Academic Press.
11. Schubert, G., Turcotte, D. L. and P. Olson Mantle Convection in the Earth and Planets, , Cambridge University Press, 2001.
12. Schumm, S.A. and Holbrook, 2000. Active Tectonic and Alluvial Rivers, Cambridge University Press.
13. Turcotte, D. L. and Schubert, G., 2002.Geodynamics: 2nd Ed, John Wiley & Sons, NY,
14. Wilcock, P.R., Iverson, R.M. (2003) Prediction in geomorphology, AGU Publication

Course: GEOL-RS-E116 **Credit: 4**

Geology of Eastern Himalayas

Module I

Geology of Sub , Lesser , Greater/ Higher and Tethyan Eastern Himalaya (Sikkim- Darjeeling , Arunachal), Indo Myanmar Ranges in Nagaland and Manipur and Shillong Plateau, Meghalaya, Tectonostratigraphy of the Eastern Himalaya and Eastern Syntaxial belt, Proterozoic Daling - Buxa-Miri geology of the Sikkim – Darjeeling and Arunachal Lesser Himalaya. Higher grade gneisses (Darjeeling – Sikkim Group and Lingtse Granite Gneiss), Rangpo- Bhutang sulphide mineralization, Paleozoic – Mesozoic Gondwana- Rishi Group in Sikkim (Namchi Formation and paleoglacialRanjit Pebble Slate) and Arunachal Himalaya. Geology of Tethyan Group rocks,

(Everest Limestone , Lachi and ChhoLahmo Formation), Major Tectonic units, Main Boundary Thrust (MBT) and Main Central Thrust (MCT) in the Eastern Himalaya.

Module II

Geodynamic evolution of the Eastern Himalaya, eastern syntaxial belt and Indo – Myanmar orogenic ranges, Collision of Indian and Asian and Indo – Myanmar Plates, Manipur Nagaland Ophiolite belt, subduction and olistostromes. Chromite and PGE mineralisation, Development of Foreland basins (Siwaliks) , neotectonic activity in Teesata valley, climate and tectonic relationship, Lesser Himalayan stromatoliticcarbonate platforms and siliciclastic shallow water sedimentation, Gondwana coal formation in the Namchi(Sikkim) and Arunachal Himalaya and Tertiary oil formation in the Assam – Arakan basins, Development of the eastern Tethyanrealm , extension of western Tethys in the eastern India in Meghalaya, High resolution Cretaceous – Tertiary Boundary mass extinction and stable isotope chemostratigraphy in the Shillong Plateau, Paleogeography and northward flight of India during Late Cretaceous and - Paleocene time and birth of Himalaya-Alpine mountains, Quaternary Geology and Glaciers of Sikkim (LachenChhu, LachungChhu, Zemu, Changmekhampu, Kanchengayo).

Module III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module IV

a. Section Measurement and collection of samples and field data.

b. Litholog correlation of various sections.

c. Study of thin sections from various formations.

Suggested Readings:

1. Acharyya, S.K., 1978. Stratigraphy and the Tectonics of the Eastern Himalaya. In : P.S. Saklani, (Editior), Stratigraphy and Geology of the Himalaya. Today and Tomorrow Publications, 243- 269.
2. Basu, S. K, 2013. Geology of Sikkim State and Darjiling district of West Bengal. Geological Society of India , Bangalore , 2013.
3. Earth Science Review, Volume 76, p,1- 131.

4. Geology and Mineral Resources of Sikkim, 2012, Miscellaneous Publication Number 30 Part XIX Geological Survey of India.

5. Geology, Mineral and Water Resources of Sikkim, 2009 Special Publication No. 93: Geological Survey of India.

6. Mukul, M. AND Martin, M., 2005. Tectonics of the Himalayan Mountain Front, Darjiling Himalaya , India., In: Mucclik, M., Rigguzi, F. and Mukhopadhya , D., 2009.(Editors), Estimates of motion and strain rates across active faults in the frontal part of Eastern Himalaya in north Bengal from GPS measurements. Terra Nova , .Volume, 21(5), p.410-415.

7. Sinha Roy,S. 1982, Himalaya, MCT and implication for Himalayan inverted metamorphism., Tectonophysics, Volume 84, 197- 224.

8. Tewari, V.C. and Seckbach, J. .2011. Interaction of Microbes with Sediments. Springer Verlag, Heidelberg, Germany, 745 pages.

9. Valdiya, K.S. DyanamicHimalaya ,, University Press (India) Limited, Hyderabad, 178 pages.

10. Yin, A., 2006. Cenozoic tectonic evolution of the Himalayan Orogen as constrained by along strike variations of structural geometry , exhumation history and foreland sedimentation .

Course: GEOL-RS-E117 **Credit: 4**

Invertebrate-Vertebrate Palaeontology and Paleobotany

Module: I

Origin and evolution of Invertebrate and Vertebrate fossils, Precambrian to Cenozoic life & events, Major invertebrate and vertebrate fossil groups, Important type areas of fossil localities of India and the world, Body and trace fossils, fossilization process andmode of preservation, methods of description and fossil identification, Stromatolites their classification scheme, microstructures and global distribution in Proterozoic sedimentary basins and correlation, Principles of biostratigraphy, biozonation, fossil assemblages, correlation, Paleobotany (Palynology and significance of Gondwana flora), Quaternary climate and Dendrochronolgy, Application of fossils in paleoenvironment and paleogeograpgy.

Module II

Major steps in diversification and extinction of Invertebrate and Vertebrate animals,Global biotic events across the Precambrian- Cambrian , Permian Triassic and Cretaceous – Tertiary boundaries, evolution and extinction of dinosaurs, Paleoecology and paleoclimatic implications of the fossils and chemostratigraphy, Detailed study and significance of the Ediacaran soft bodied animals, trace fossils Mollusca, trilobites, brachiopods, graptolites and ammonoids, Biostratigraphic significance of the fossils including Gondwana plant fossils in the Northeastern Himalaya with special focus on the Sikkim Himalaya.

Module III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module IV

Field / Laboratory Practicals and Case studies

a. Field based study of fossils, plant fossils ,stromatolites and collection of fossils.

b. Identification, systematic description, thin section study and processing of samples in the lab for various investigaions.

c. Use of research techniques and preparation of biostratigraphicfossil distribution charts etc.

Suggested Readings:

1. S.K. Shah. Elements of Paleontology. 2013. Text Book Series, Geological Society of India. 144 Pages.
2. Shrock, R.R. and Twenhofel,W. H., 1987. Principles of Invertebrate Paleontology . CBS Publishers and Distributers, Pvt. Ltd., New Delhi.
3. Romer, A.S. 1966. Vertebrate Paleontology , University of Chicago Press. ,USA.
4. Nield, E,W and Tucker, V.C.T. , 1985., Paleontology – An Introduction.Pregamon Press. Oxford.
5. Colbert, E.H., 1980. Evolution of the Vertebrats. John Wiley and Sons Inc. .USA.
6. Arnold, C.R., 1978. An Introduction to Paleobotany. John Wiley and Sons, Inc. USA
7. Clarkson, E.N.K. 1998. Invertebrate Palentology and Evolution. Blackwell Series, UK.
8. Milsom, C. and Rigby .S. 2010. Fossils at a Glance. Wiley- Blackwell, , West Succex ,UK.

Course: GEOL-RS-E118 **Credit: 4**

Micropaleontology and Astrobiology

Module I

Basics and Fundamentals of Micropaleontology& Astrobiology, Prokaryotic , eukaryotic, planktonic and benthic microfossils and their classifications, taxonomy, systematics andbiostratigraphic significance, Unicellular to multicellular evolution of microorganisms, Application of microfossils in the hydrocarbon generation, paleoenvironment and paleotemperature, Theories of Origin, evolution , diversification and extinction of life on Earth and Astrobiology, Global evidences of early life on Earth, India and special reference to Himalaya, Systematic study offossilstromatolites , three dimensional reconstructions, microstructures and paleoenvironmental / paleoclimatic interpretations. Stromatolite biostratigraphy and microbiallymediated sedimentary structures, Study ofmicrostromatolites , organic walled microfossils, paleobiology and unicellular to multicellular evolution of organisms and their Astrobiological implications, Geomicrobiology and Molecular biological (DNA and RNA), Study of the speleothems.

Module II

Taxonomic diversity in Prokaryotic and eukaryotic bacteria, benthic and planktic foraminifera and radiolarians, Paleoclimatic and paleoceanographic significance of foraminifera, algal microfossils

,dinoflagellates,coccoliths and palynomorphs etc., Stable isotope chemostratigraphy of the microfossil yielding carbonate sequences and paleoclimate, Past life on Earth and recentsearch for life and methane on Mars by ISRO and NASA.Future space research on Europa, Titan and other planets of the Solar system for Astrobiological aspects. Laser Raman Spectroscopic and Confocal Laser Scanning Microscopic studies of earliest microfossils on Earth, Atomic Force Microscopy , stable isotopic and biogeochemistry of microfossils, Possible life evidences from meteorites from Mars recovered from Antarctica, India Australia and elsewhere, Study of amino acids and other organic compounds in meteorites, Microbially Induced Sedimentary Structures on Mars and Earth, Fluvial , paleo lake and glacial deposits on Mars, Carbon and Sulphur cycles on Mars and other planets, Glacial lakes in the Himalaya and permafrost conditions on Earth like Antarctica and Arctic regions and their comparison with and Martian analogues.

Module III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module IV

Field / Laboratory Practicals

a. Collection of fossiliferous carbonates for microfossil recovery in the laboratory and thin section study.

b. Laser Raman spectroscopic, CLSM, AFM , SEM ,IPMA, and isotopic analysis of the microfossils. PCR (DNA) sequencing of speleothems (in collaboration).

c. Systematic stromatolite and speleothem sampling from the Proterozoic and Phanerozoic successions

d. Identification of microfossils and their Astrobiological implications

e. Meteorite samples for possible search of biomolecules and micro/ nannofossils.

Suggested Readings

1. Schopf, J. W. 1983, Earth's Earliest Biosphere, Its Origin and Evolution - Princeton University Press, Princeton
2. Valdiya, K. S., &Tewari, V. C. 1989, Stromatolites and Stromatolitic Deposits, Himalayan Geology (Volume 13) - Wadia Institute of Himalayan Geology, Dehradun, India
3. Schopf, J.W & Klein, C. ,1992. The Proterozoic Biosphere: A Multidisciplinary Study - (1992), Cambridge University Press, New York
4. Knoll, A. H. (2003), Life on a Young Planet: The First Three Billion Years of Evolution on Earth - Princeton University Press, Princeton
5. Konhauser, K. (2007), Introduction to Geomicrobiology -Blackwell, Malden
6. Tewari, V.C. and Seckbach, J. .2011. Interaction of Microbes with Sediments. COLE Volume 18, Springer Verlag, Heidelberg, Germany, 745 pages
7. Seckbach J. & Walsh, M. (2009). From Fossils to Astrobiology: Record of Life on Earth and the Search for ExtraterrestrialBiosignatures - Seckbach J. & Walsh, M. (2009), Springer, COLE Volume, 12
8. Chela-Flores, J. (2011) .The Science of Astrobiology -), Springer, COLE, Volume 20
9. Amstrong, H. and Brasier, M.D., Microfossils, John Wiley and Sons. Inc.
10. Bignot, G., 1985. Elements of Micropaleontology, Springer.

Course: GEOL-RS-E119 **Credit: 4**

Ore Geology and Metallogenesis

Module-I

Ore Genetic Processes. Ore textures and their origin, Important mineral associations in different genetic groups, Tectonic Controls on Mineralisation, Growth and growth structures of crystalline phases in open space and polycrystalline aggregates. Structures due to annealing and deformation, Pathfinders and tracers associated with ore deposits, Geochemical characteristic of groundwater in ore province, Application of Geobotanicalstudies for identifying ore deposits.

Module-II

Paragenetic studies and Phase diagrams, Analytical Techniques in Ore Geology with special reference to portable techniques, Fluid inclusion studies for geothermobarometry and recognition of fluid components, Mineral analysis and phase relationships, Isotopes studies for discriminating deposit potential, Isotope studies for dating and identifying ore deposit relationships.

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion.

Module-IV

Study of Ore Textures, micro structures and establishing paragenetic sequence.

Characterization of Fluid Inclusions.

Themobarometric calculations of oxide and sulphide phases.

Suggested Readings:

1. Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
2. Barnes, H.L., 1979. Geochemistry of Hydrothermal Ore Deposits, John Wiley.
3. Chatterjee, K.K. 2008 An Introduction To Mineral Economics
4. Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
5. Craig J.R. and Vaughan, D.J. 1994. Ore Microscopy and Ore Petrography
6. Evans, A.M., 1993. Ore Geology and Industrial Minerals, Blackwell.
7. Guilbert, J.M. and Park, Jr. C.F., 1986. The Geology of Ore Deposits. Freeman.
8. Klemm, D.D. and Schneider, H.J., 1977. Time and Strata Bound Ore Deposits. Springer Verlag.
9. McKinstry, H.E. 1962. Mining Geology (2nd Ed.) Asia Publishing House.
10. Mookherjee, A., 2000. Ore Genesis – A Holistic Approach. Allied Publisher.
11. Stanton, R.L., 1972. Ore Petrology, McGraw Hill.

Course: GEOL-RS-E120 **Credit: 4**

Paleoclimatology

Module I:

Fundamentals and Basics of Paleoclimatology, Paleoclimate change on Earth since Proterozoic to recent geological past, Paleoclimate proxies (geological, biological, historical) , glacial deposits, periglacial features, aeolian and lacustrine sediments, speleothems, (age and stable isotope composition), Tree rings, pollen, corals, diatoms, plant microfossils, and planktonic and benthic microfossils and their oxygen isotope composition, Numerical models of the paleoclimate system, Milankovitchcycle , orbital variations of earth and solar radiation. Past global warming and cooling cycles, Interaction of climate system (atmosphere, ocean, biosphere, land surface and cryosphere), Alpine-Himalayan mountain glaciers, and continental ice sheets (northern and southern polar ice caps).Last Glacial Maxima (LGM) and Little Ice Age (LIA), Glacial- interglacial cycles during Quaternary Period, Uplift of Tibetan Plateau and rise of Himalaya, and onset of Indian Summer Monsoon, El Nino Southern Oscillation (ENSO) and La Ninas , Intertropical Convergence Zone (ITCZ), speleothem and sea level variation, thermohaline circulation of the oceans , Heinrich and Daansgard events, Geochemical Tools for identifying climate change. Application of Redox sensitive elements Co, Mn, Fe, Ce, and Pt in climate change studies, Radiocarbon, Uranium Series, Luminescence,Thermoluminescence(TL/ OSL) and Radioisotopic methods for dating of climate events, Biological dating methods (Amino acid dating, Lichenometry, Dendrochronology), dating of ice cores, tree line fluctuations , pollen analysis, Paleoclimate models and Intergovernmental Project on Climate Change (IPCC).

Module 2

Paleoglaciations during Proterozoic , Snow Ball Earth (Neoproterozoic glaciation), ice albedo, low latitude glaciations, Post EdiacaranLowerPaleozoic (Ordovician, Silurian , Carboniferous – Permian glaciations) and their equivalent glacial paleoclimatic events in the Lesser and Tethyan Himalaya and Gondwanaland. Paleoclimatic reconstructions, carbon isotope chemostratigraphy ,paleomagnetic and RodiniaSupercontinental reconstruction, Blainian glaciation (Blaini Boulder Bed) of the Garhwal Lesser Himalaya , Lower Gondwana glaciation of the Sikkim and Arunachal Lesser Himalaya (Ranjit Boulder Slate), Global Mesozoic – Tertiary warm and cool climatic fluctuations , Cretaceous –

Tertiary cool climate and Paleocene – Eocene Thermal Events and their records in the Indian subcontinent, Global temperature and sea level rise, increase ingreen house gases in atmosphere, Global warming and melting of ice sheets in the northern and southern hemispheres including the third pole Himalayan glaciers from NW in Kashmir to Sikkim in the east, Pleistocene glaciation and Last Glacial Maxima and Little Ice Age and its evidence from the Indian subcontinent, Mountain Meteorology and Glacial Lake Outburst Flood (GLOF).

Module III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module IV

Field / Lab. / Case History:

1. Field study of the paleoglaciers , collection of tilloid, diamictites , glacial carbonates for lab analysis.
2. Reconstructions of the paleopositions of the continents showing paloclimatic zones.

3. Preparation of report / dissertation / case histories of the past climates

Suggested Readings

1. J. P.Parrish. Interpreting Pre Quaternary Climate
2. M.L. Bender, Paleoclimate. Princeton University Press.
3. Margaret Leinen and Michel Sarnthein, 2012. Paleoclimatology and Paleometerology : Modern and Past.
4. Raymond S. Bradley, 1999. Paleoclimatology: Reconstructing Climate of the Quaternary. Elsevier Academic Press.

Course: GEOL-RS-E121 **Credit: 4**

Developments in Hydrocarbon Exploration

Module- I

Origin, Migration and Accumulation of Petroleum, Reservoir rocks, Reservoir traps and Cap rocks, Hydrocarbon traps, Petroleum system and prospect evaluation, Petroliferous basins of India, Developments in petroleum exploration: Sequence, Seismic and Biostratigraphy, Micropaleontological applications in Hydrocarbon exploration, Petroleum geochemistry, Seismic Data acquisition and processing, Petrophysical properties of rocks, Oil well drilling, Casing and Coring, Formation evaluation, Mud logging, Well logging and reservoir parameters,

Module-II

New technologies and Techniques used in shale gas exploration and production, Shale Gas: Introduction of shale gas, Early Shale Plays, Recent and Emerging shale Plays, Gas Hydrate: Gas hydrate, occurrence and origin; Structure of gas hydrate, Types of gas hydrate; Geological setting of Hydrate; Stability of gas hydrates; Gas hydrate reservoir; Geological and geophysical exploration of gas hydrate.CBM.

Module- III-

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion.

Module –IV

Practical

1) Interpretation of geologic structures from surface geological maps and bore hole data.
2) Preparation of structure contour and isopach maps of reservoir facies and drawing oil/water contact from bore hole data.
3) Interpretation of Seismic data for identification of subsurface structure.
4) Micropaleontological zonation exercises.
5) Calculation of oil reserves in defined structure.
6) Interpretation of well logs.

Suggested Readings:

1. Petroleum Geology: F.K.North, 1986, Allen and Unwin
2. Petroleum Formation and Occurrence: B.P.Tissot and D.H.Welte 1978, Publisher: Springer- Verlag
3. Elements of petroleum Geology: R.C.Shelley 1998, Academic press
4. Petroleum Development Geology: P.A.Dickie, 1986, Publisher: Pennwell Publishing, Tulsa, Oklahoma
5. Petroliferous basins of India: Publisher: KDMIPE, ONGC, 1986.

Course: GEOL-RS-E122 **Credit: 4**

Sequence Stratigraphy and Basin Analysis

Module-I

Sequence Stratigraphy: Historical developments, definitions and key concepts, base level changes, transgressions and regressions, Stratigraphic surfaces: Stratal terminations, sequence stratigraphic surfaces, Unconformity and correlative conformity, Systems Tracts: Lowstand, Transgressive, Highstand, Falling stage. Shelf-margin system tract (SMST) Unconformities: Type I, Type II and Type III, Sequence Models: Depositional sequence, Genetic stratigraphic sequence, Transgressive- Regressive sequence. Hierarchy of sequences and bounding surfaces.

Module-II

Basin Analysis: Definition and scope of basin analysis. Stratigraphy and sedimentology of Sedimentary basin: Introduction, Stratigraphic- sedimentologic database, startigraphic correlation, Facies analysis, Basin- Mapping Methods. Global control on sedimentary basin developments.

Module-III

Review of recent publications and case studies. Synthesis and presentation of major findings and discussion

Module-IV Practical

1) Exercise on Construction of lithostratigraphy and
2) biostratigraphy
3) Exercise on Construction of Magnetostratigraphy
4) Exercise on Ichnostratigraphy.
5) Exercise on Construction of Chemostratigraphy and
6) Exercise on Seismic Stratigraphy
7) Exercise on Construction of Sequence Stratigraphy.

Suggested Readings:

1. Catuneanu, O., 2002 Sequence stratigraphy of clastic system: concept, merits and pitfalls. Journal of African Earth Sciences, v. 35, pp. 1-43
2. Miall, A.D (1999), Principles of sedimentary basin analysis: Springer
3. Posamentier, H.W. and Walker., R. G. (2006Facies Models revisited:), SEPM
4. Reading.H.G. 1996 Sedimentary Environments: Processes, Facies and Stratigraphy: Blackwell Publishers

DEPARTMENT OF MATHEMATICS

M.Sc. Syllabus

Subject Code	Paper Name	Credits	L-T-P
Semester I			
MTH-PG-C101	Analysis-I	4	4-0-0
MTH-PG-C102	Linear Algebra	4	4-0-0
MTH-PG-C103	Combinatorics and Elementary Number Theory	4	4-0-0
MTH-PG-C104	Differential Equations	4	4-0-0
Semester II			
MTH-PG-C201	Analysis-II	4	4-0-0
MTH-PG-C202	Complex Function Theory	4	4-0-0
MTH-PG-C203	Algebra	4	4-0-0
MTH-PG-O204	Numerical Analysis (Open Elective)	4	4-0-0
Semester III			
MTH-PG-C301	Topology	4	4-0-0
MTH-PG-O302	A) Optimization Technique B) Nonlinear Dynamics (Open Elective)	4	4-0-0
MTH-PG-E303	Cryptography	4	4-0-0
MTH-PG-E304	Field Theory	4	4-0-0
MTH-PG-E305	Measure Theory	4	4-0-0
Semester IV			
MTH-PG-E401	Algebraic Topology	4	4-0-0
MTH-PG-E402	Commutative Algebra	4	4-0-0
MTH-PG-E403	Differential Geometry	4	4-0-0
MTH-PG-E404	Functional Analysis	4	4-0-0
MTH-PG-E405	Operator Theory	4	4-0-0
MTH-PG-E406	Algebraic Geometry	4	4-0-0
MTH-PG-E-407	Advanced Complex Analysis	4	4-0-0
MTH-PG-P404	Dissertation/Project Work	4	

ANALYSIS-I

MTH-PG-C101 **Credit: 4**

Unit I: Real Numbers

Relations and functions, Finite and infinite sets, countable and uncountable sets, least upper bound property, the field of real numbers, Archimedean property, density of rational numbers, existence of nth root of positive real numbers, exponential and logarithm, the extended real number system.

Unit II: Numerical Sequences and Series

Numerical sequences and their convergence, bounded sequences, Cauchy sequences, construction of real numbers using Cauchy sequences; limit supremum and limit infimum, Bolzano-Weierstrass' threorem for sequences of real number, series of nonnegative terms, the number e, tests of convergence of series, power series, absolute convergence, addition and multiplication of series, rearrangements (statement only).

Unit III: Topology of R^n

Euclidean spaces, open and closed sets, limit points, interior points, compact subsets of R^n, nested interval theorem, Heine-Borel theorem, and Bolzano-Weierstrass' threorem.

Limits of functions, continuous functions, continuity and compactness, uniform continuity, connected sets, connected subsets of real numbers, continuity and connectedness, intermediate value theorem; discontinuities and their classifications, monotonic functions, infinite limits and limits at infinity.

Unit IV: Differentiation & Integration

Differentiation of real-valued functions and its elementary properties; mean value theorem; Taylor's theorem; elementary properties of Riemann integral, Fundamental theorem of Calculus, mean value theorem, convergence of improper integrals.

Textbooks:

1. Rudin, W. (2013) *Principles of Mathematical Analysis* (3rd Edition), Tata McGraw Hill Education.

Reference books:

1. Apostol, T. (2000) *Mathematical Analysis* (2nd edition) Narosa Book Distributers Pvt. Ltd.
2. Bartle, R.G. and Sherbert D. R. (2000) *Introduction to Real Analysis* (3rd edition) John Wiley & Sons, Inc., New York.
3. Fraleigh, J. B. (2002) *A First Course in Abstract* Algebra (4th edition) Narosa Publishing House, New Delhi.
4. Gallian, J. A. (1999) *Contemporary Abstract Algebra* (4th edition) –Narosa Publishing House, New Delhi.

LINEAR ALGEBRA

MTH-PG-C102 **Credit: 4**

Unit I: Vector Space

Vector spaces, linear independence; linear transformations, matrix representation of a linear transformation; isomorphism between the algebra of linear transformations and that of matrices;

Unit II: Eigenvalues and Eigenvectors

Similarity of matrices and linear transformations; trace of matrices and linear transformations, characteristic roots and characteristic vectors, characteristic polynomials, relation between characteristic polynomial and minimal polynomial; Cayley-Hamilton theorem (statement and illustrations only); diagonalizability, necessary and sufficient condition for diagonalizability;

Unit III: Canonical Forms

Projections and their relation with direct sum decomposition of vector spaces; invariant subspaces; primary decomposition theorem, cyclic subspaces; companion matrices; a proof of Cayley-Hamilton theorem; triangulability; canonical forms of nilpotent transformations; Jordan canonical forms; rational canonical forms.

Unit IV: Inner Product Spaces

Inner product spaces, properties of inner products and norms, Cauchy-Schwarz inequality; orthogonality and orthogonal complements, orthonormal basis, Gram-Schmidt process; adjoint of a linear transformation; Hermitian, unitary and normal transformations and their diagonalizations.

Textbooks:

1. Hoffman, K., Kunze, R. (2000) *Linear Algebra* (2nd edition) Prentice Hall of India Pvt. Ltd., New Delhi.
2. Bhattacharya, P. B. Jain, S. K. and Nagpal, S. R. (2000) *First Course in Linear Algebra*, Wiley Eastern Ltd., New Delhi.

Reference books:

1. Herstein, I. N. (2003) *Topics in Algebra* (4th edition), Wiley Eastern Limited, New Delhi.
2. Shilov, G. E. (1998) *Linear Algebra*, Prentice Hall Inc.
3. Halmos, P. R. (1965) *Finite Dimensional Vector Spaces*, D.VanNostrand Company Inc.
4. Finkbeiner, D. T. (2011) *Introduction to Matrices and Linear Transformations* (3rd edition) Dover Publications.
5. Kumaresan,S. (2001) *Linear Algebra: A Geometric Approach*, Prentice-Hall of India Pvt. Ltd., New Delhi.

COMBINATORICS AND ELEMENTARY NUMBER THEORY

MTH-PG-C103 **Credit: 4**

Unit I: Theory of Numbers

Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem; Euler's phi-function.

Unit II: Congruences

Congruence modulo powers of prime; primitive roots and their existence; quadratic residues; Legendre symbol, Gauss' lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol.

Unit III: Diophantine Equations

Solutions of $ax + by = c$, $x2 + y2 = z2$, $x4 + y4 = z2$; properties of Pythagorean triples; sums of two, four and five squares; assorted examples of diophantine equations.

Unit IV: Generating Functions and Recurrence Relations

Generating Function Models, Calculating coefficient of generating functions, Partitions, Exponential Generating Functions, A Summation Method. Recurrence Relations: Recurrence Relation Models, Divide and conquer Relations, Solution of Linear, Recurrence Relations, Solution of Inhomogeneous Recurrence Relations, Solutions with Generating Functions.

Textbooks:

1. Niven, I., Zuckerman, H. S. and Montegomery, H. L. (2003) *An Introduction to the Theory of Numbers* (6th edition) John Wiley and sons, Inc., New York.
2. Burton, D. M. (2002) *Elementary Number Theory* (4th edition) Universal Book Stall, New Delhi.
3. Balakrishnan, V. K. (1994) *Schaum's Outline of Theory and Problems of Combinatorics Including Concepts of Graph Theory*, Schaum's Outline.
4. Balakrishnan,V. K. (1996) *Introductory Discrete Mathematics*, Dover Publications.

Reference books:

1. Dickson, L. E. (1971) *History of the Theory of Numbers* (Vol. II, Diophantine Analysis) Chelsea Publishing Company, New York.
2. Hardy, G.H. and Wright, E. M.(1998) *An Introduction to the Theory of Numbers* (6th edition),The English Language Society and Oxford University Press.
3. Niven, I. and. Zuckerman, H. S. (1993) *An Introduction to the Theory of Numbers* (3rd edition), Wiley Eastern Ltd., New Delhi.

DIFFERENTIAL EQUATIONS

MTH-PG-C104 **Credit: 4**

Unit I: Initial Value Problems

Existence and uniqueness of solutions of IVP: method of successive approximations, system of first order approximations, Picards theorem, Continuous dependence of the solution on initial data, general theory of system of first order equations. Linear systems: Homogenous and nonhomogenous linear systems with constant coefficients.

Unit II: Series Solution

Power series solution, second order equations, ordinary points, regular points and singular points, special functions, Hermite polynomials, Chebychev polynomials, Legendre polynomials, Bessel functions, Gamma functions.

Unit III: Boundary Value Problem

Boundary value problem, Green function, Sturm-Liouville Theory, eigenvalues and eigenfunctions, qualitative properties of solutions, Sturm comparison theorem, Sturm separation theorem

Unit IV: Partial Differential Equations

First order equations, Cauchy Kowlewski theorem, classification of second order PDE, canonical form second order linear equations with constant co-efficients, method of separation of variables. Characteristics and uniqueness theorem for hyperbolic theorems with initial boundary conditions. Elliptic and Parabolic partial differential equations

Text Book:

1. Ross, S. L. (1984) *Differential Equations* (3rd edition), John Wiley & Sons.
2. Coddington, E. A. *An Introduction to Ordinary Differential Equations*, Prentice-Hall.
3. Sneddon, I.N. (1957) *Elements of Partial Differential Equations*, McGraw Hill.

References:

1. G. F. Simmons, *Differential Equations with Applications and Historical Notes*, McGraw HillEducation.
2. Fritz John (1982) *Partial Differential Equations*, Springer-Verlag, New York Inc.
3. Coddington, E. A. and Levinson, N. (1955) *Theory of Ordinary Differential equations*, TMH Education.
4. Cronin, J. (1994) *Differential Equations: Introduction and Qualitative Theory*, Marcel Dekker.
5. Hirsch, M.W. Smale, S. and Devaney, R.L. (2004) *Differential Equations, Dynamical Systems and an Introduction to Chaos*, Elsevier.

ANALYSIS II

MTH-PG-C201 **Credit: 4**

Unit I: Sequences & Functions

Sequences of functions, pointwise and uniform convergence, uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, Weierstrass' approximation theorem.

Unit II: Differentiability of Functions of Several Variables

Directional derivatives and differentiability of functions of several variables and their interrelationship, chain rule, mean value theorem; higher order partial derivatives, equality of mixed partial derivatives, Taylor's theorem.

Unit III: Inverse & Implicit Function Theorem

Injective mapping theorem, surjective mapping theorem, inverse function theorem and implicit function theorem of functions of two and three (for analogy) variables, extremum problems with and without constraints of functions of two and three (for analogy) variables.

Unit IV: Multiple Integrals

Multiple integrals, repeated integrals, interchange of order of integrations, change of variable theorem, mean-value theorems for multiple integrals, line integral and Green's theorem, Convergence of improper integrals

Textbooks:

1. Rudin, W. (2013) *Principles of Mathematical Analysis* (3rd Edition), Tata McGraw Hill Education.
2. Apostol, T. (2000) *Mathematical Analysis* (2nd edition) Narosa Book Distributers Pvt. Ltd.
3. Bartle, R.G. (1994) *The Elements of Real Analysis* (3rd edition), Wiley International Edition.
4. Joel R. Hass, Christopher E.Heil, Maurice D. Weir, Thomas Calculus (14^{th} Edition) Pearson

Reference books:

1. Buck, R. C. &Buck, E. F. (1999) *Advanced Calculus* (4th Edition), McGraw Hill, New York.
2. Simmons, G. F.(2003) *Introduction to Topology and Modern Analysis* (4th edition), McGraw Hill.
3. Bartle, R. G. and Sherbert, D. R. (2000) *Introduction to Real Analysis* (3rd edition), John Wiley & Sons, Inc., New York.
4. Tom M.Apostol, Calculus Volume –II (2^{nd} Edition), Wiley and Sons

COMPLEX FUNCTION THEORY

MTH-PG-C202 **Credit: 4**

Unit I: Holomorphic Functions

Holomorphic Functions, Cauchy-Riemman equations and its applications, Formal power series, radius of convergence of power series, exponential, cosine and sine, logarithm functions introduced as power series, their elementary properties.

Unit II: Complex Integration

Integration of complex-valued functions and differential 1-forms along a piecewise differentiable path, primitive, local primitive and primitive along a path of a differential 1-form, Index of a closed path, Cauchy's theorem for convex regions.

Cauchy's integral formula, Taylor's expansion of holomorphic functions, Cauchy's estimate; Liouville's theorem; fundamental theorem of algebra; zeros of an analytic function and related results; maximum modulus theorem; Schwarz' lemma.

Unit III: Singularities and Residues

Laurent expansion of a holomorphic function in an annulus, singularities of a function, removable singularities, poles and essential singularities; extended plane and stereographic projection, residues, calculus of residues; evaluation of definite integrals; argument principle; Rouche's Theorem.

Unit IV: Conformal Mapping

Complex form of equations of straight lines, half planes, circles, etc., analytic (holomorphic) function as mappings; conformal maps; Mobius transformation; cross ratio; symmetry and orientation principle; examples of images of regions under elementary analytic function.

Textbooks:

1. Sarason, D. (2008) *Complex Function Theory, Texts and Readings in Mathematics*, Hindustan Book Agency, New Delhi.

Reference books:

1. Ahlfors, L. V. (1990) *Complex Analysis* (2nd Edition), McGraw-Hill International Student Edition.
2. Conway, J. B. (2000) *Functions of one complex variable,* Springer International Student edition, Narosa Publishing House, New Delhi.
3. Churchill, R. V. (1996) *Complex Variables and applications,* McGraw-Hill.
4. Copson, E. T. (1995) *An Introduction to the Theory of functions of a complex Variable,* Oxford University Press.
5. Shastri, A. R. (2003) *An Introduction To Complex Analysis*, Macmillan India Ltd.

ALGEBRA

MTH-PG-C203 **Credit: 4**

Unit I: Basic Concepts of Groups

A brief review of groups, their elementary properties and examples, subgroups, cyclic groups, homomorphism of groups and Lagrange's theorem; permutation groups, permutations as products of cycles, even and odd permutations, normal subgroups, quotient groups; isomorphism theorems, correspondence theorem;

Unit II: Sylow's Theorem

Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary properties; orbit decomposition; counting formula; class equation, consequences for p-groups; Sylow's theorems (proofs using group actions). Applications of Sylow's theorems, conjugacy classes in Sn and An, simplicity of An. Direct product; structure theorem for finite abelian groups; invariants of a finite abelian group (Statements only)

Unit III: Rings

Basic properties and examples of ring, domain, division ring and field; direct products of rings; characteristic of a domain; field of fractions of an integral domain; ring homomorphisms (always unitary); ideals; factor rings; prime and maximal ideals, principal ideal domain; Euclidean domain; unique factorization domain.

Unit IV: Polynomial Rings

A brief review of polynomial rings over a field; reducible and irreducible polynomials, Gauss' theorem for reducibility of *f*(x) Z x ; Eisenstein's criterion for irreducibility of *f*(x) Z x over Q, roots of polynomials; finite fields of orders 4, 8, 9 and 27 using irreducible polynomials over Z2 and Z3 .

Textbooks:

1. Bhattacharya,P.B., Jain, S. K. and Nagpal S. R. (2000) *Basic Abstract Algebra* (3rd edition), Cambridge University Press.
2. Jacobson, N. (2002) *Basic Algebra I* (3rd edition), Hindustan Publishing Corporation, New Delhi.
3. Gallian, J. A. (1999) *Contemporary Abstract Algebra* (4th edition), Narosa Publishing House, New Delhi.

Reference books:

1. Herstein, I. N. (2003) *Topics in Algebra* (4th edition), Wiley Eastern Limited, New Delhi.
2. Fraleigh, J. B. (2002) *A First Course in Abstract Algebra* (4th edition), Narosa Publishing House, New Delhi.
3. Dummit, D.S. and Foote, R.M (2003) *Abstract Algebra*, John Wiley & Sons.

NUMERICAL ANALYSIS

MTH-PG-O204 **Credit: 4**

Unit I: Non- linear system of equations and linear system of algebraic equations

System of non-linear equations: Fixed point iteration method for the system x = g(x), sufficient condition for convergence, Newton's method for nonlinear systems

Solution of Linear equations: Direct methods: Gaussian elimination, LU and Cholesky factorizations. Operational counts for all these direct methods. Iterative methods: General framework for iterative methods, Jacobi and Gauss Seidel methods, Necessary and sufficient conditions for convergence, order of convergence, successive relaxation method.

Unit II: Eigenvalue Problem

Gershgorin theorem, Power and inverse power method, QR method. Jacobi, Givens and Householder's methods for symmetric eigenvalue problem

Unit III: Finite Difference Methods

Finite difference methods for two point boundary value problems, convergence and stability. Finite difference methods for parabolic, hyperbolic and elliptic partial differential equations: Discretization error, Idea of convergence and stability, Explicit and Crank-Nicolson implicit method of solution of one dimensional heat conduction equation: convergence and stability. Standard and diagonal five point formula for solving Laplace and Poisson equations, Explicit and Implicit method of solving Cauchy problem of one-dimensional wave equation, CFL conditions of stability and convergence, Finite difference approximations in polar coordinates.

Unit IV: Practical

1. Gauss-Jordan method
2. LU and Cholesky factorization methods
3. Inverse of a matrix
4. S.O.R. / S.U.R. method
5. Relaxation method
6. Power and inverse power methods
7. Jacobi, Givens and Householder's methods
8. Solution of one dimensional heat conduction equation by i) Explicit and
   ii) Crank-Nicolson implicit method
9. Solution of Laplace equation
10. Solution of Poisson equation
11. Solution of one-dimensional wave equation

Textbooks:

1. K. E. Atkinson, K. E. (1989) *Introduction to Numerical Analysis*, John Wiley.
2. Smith, G. D. (1986) *Numerical Solution of Partial Differential Equations*, Oxford University Press.

TOPOLOGY

MTH-PG-C301 **Credit: 4**

Unit I: Topology

Definition and examples of topological spaces; basis and sub basis; order topology; subspace topology.Continuity and related concepts; product topology; quotient topology; countability axioms; Lindelof spaces and separable spaces.

Unit II: Connectedness

Connected spaces, generation of connected sets; component, path component; local connectedness, local path-connectedness.

Unit III: Compactness

Compact spaces; limit point compact and sequentially compact spaces; locally compact spaces; one point compactification; finite product of compact spaces, statement of Tychonoff's theorem (Proof of finite product only).

Unit IV: Separability & Countability

Separation axioms; Urysohn's lemma; Tietze's extension theorem; Urysohn's embedding lemma and Urysohn's metrization theorem for second countable spaces.

Textbooks:

1. Munkres, J. R. (2000) *Topology: a First Course*, Prentice-Hall of India Ltd., New Delhi.

Reference books:

1. J. Dugundji (1990) *General Topology*, Universal Book Stall, New Delhi.
2. Pervin, W. J. (1964) *Foundations of General Topology*, Academic Press, New York.
3. Willard, S. (1970) *General Topology*, Addison-Wesley Publishing Company, Massachusetts.
4. Armstrong, M. A. (2005) *Basic Topology*, Springer International Ed.
5. Kelley, J. L. (1990) *General Topology*, Springer Verlag, New York.
6. Joshi, K. D. (2002) *An Introduction to General Topology* (2nd edition), Wiley Eastern Ltd., New Delhi.

OPTIMIZATION TECHNIQUE

MTH-PG-O302A **Credit: 4**

Unit I: Introduction

Nature and Features of Operations Research (O.R, Convex set, Polyhedral Convex Set-Linear Programming (L.P), Mathematical Formulation of the Problem, Graphical Solution Method,Some Exceptional Cases, General Linear Programming Problem (General L.P.P)

Unit II: Linear Programming Problem

Slack and Surplus Variable, Reformulation of the General L.P.P., Simplex Method- Matrix Notation, Duality (Statement only of Property without Proof), Initial Simplex Tableau, Pivot,Calculating the new Simplex Tableau, Terminal Simplex Tableau, Algorithm of the Simplex Method.

Unit III: Games and Strategies

Introduction, Two- person Zero-sum games, Pay-off Matrix , some basic terms, the Maximum Minimal Principle, Theorem on Maximum and Minimal Values of the Game,Saddle Point and Value of the Game, Rule for determining a Saddle Point, Games without Saddle Points, Mixed Strategies, Graphic solution of 2 x n and m x 2 games, Dominance Property- General rule for Dominance, Modified Dominance Property.

Unit IV: Integer Programming

Travelling Salesman Problem, Transport and Assignment Problem, Max flow-Min cut problem, Minimal spanning tree, shortest path problem.

Text Book:

1. Hadley, G. (1966) *Linear Programming*, Addison.
2. Gale, D. (1989) *The Theory of Linear Economic Model*, University of Chicago Press.
3. Swarup, K, Gupta, P. K. and Mohan, M. (2002) *Operations Research*, Sultan Chand & Sons, New Delhi.

Reference Books:

1. Friderick S. H. and Gerald J. L. (1974) *Operations Research*, Holden-Day Inc, San Fransisco.
2. Hamdy A. T. (2002) *Operation Research: An Introduction*, Prentice-Hall of India Pvt. Ltd., New Delhi.

NON-LINEAR DYNAMICS

MTH-PG-O302A **Credit: 4**

Unit I: Linear Systems

System of linear ordinary differential equations; Fundamentals of linear systems; Linear Systems in R^2; Stability theory, phase portraits in R^2.

Unit II: Non-Linear Systems

System of nonlinear ordinary differential equations; Fundamental existence-uniqueness theorem, dependence on initial conditions and parameters; flow defined by differential equations; linearization; Hartman-Grobman theorem; Stability and Lyapunov functions.

Unit III: Stable Points

Stable manifold theorem, Center manifold theorem; Elementary bifurcations- Saddle-node, Transcritical, Pitch-fork, Hopf bifurcation.

Unit IV: Attractors

Limit sets and attractors, periodic orbits and limit cycles, stable manifold theorem for periodic orbits, Lienard systems, Bendixon's Criteria, global bifurcation of systems in R^2 .

Text Books:

1. Perko, L. (2001) *Differential Equations and Dynamical Systems*, Springer.
2. Jordan, D. W. and Smith, P. (1999) *Nonlinear Ordinary Differential Equations: An Introduction to Dynamical Systems*, Oxford University Press.

CRYPTOGRAPHY

MTH-PG-E301 **Credit: 4**

Unit I: Number Theory and Time estimates required for Cryptography

The big Oh notation, time estimates for doing addition, subtraction, multiplication, division. Euclidean Algorithm and the time estimate to find the greatest common divisor of two integers, extended Euclidean algorithm. Properties of congruences: addition, multiplication, subtraction and division; solution of linear congruences, modular exponentiation by repeated squaring method.

Unit II: Fundamental Theorems

Fermat's little theorem, Euler's totient function, Euler's theorem, Primitive roots. Finite fields: Primitive polynomials, Irreducible polynomials, Time estimations for doing arithmetic operations in finite fields, Construction of finite fields.

Unit III: Classical Cryptosystems

Shift cipher, Affine cipher, Substitution cipher, Vigenere cipher, Hill cipher, permutation cipher. Public Key cryptography: One way function, Trap door functions, Concept of public key cryptography, RSA, Digital signature scheme.

Unit IV: Primality Testing and Integer Factorization

Primality testing: pseudo primes, Rabin Miller probabilistic primality test, Carmichael numbers.

Factoring algorithms: Pollard's rho method, Pollard's p-1 method, Fermat's factorization method.Discrete logarithm, Diffie-Hellman Key exchange protocol, El Gamal cryptosystem over prime field and finite fields, El Gamal digital signature scheme.

(Note: A basic introduction to Elliptic curve cryptography should be taught for the benefit of the students but it should not be included for examination purpose).

Text book:

1. Koblitz, N. (1994) *A course in Number Theory and Cryptography*, (Second Ed.), Springer-Verlag.

Reference books:

1. Stinson, D. R. (1995) *Cryptography: Theory and Practice*, CRC Press series on Discrete Mathematics and its applications.
2. Yan, S. Y. (2003) *Primality Testing and Integer Factorization in Public-Key Cryptography*, Springer

FIELD THEORY

MTH-PG-E302 **Credit: 4**

Unit I: Field Theory

Extension fields, finite extensions; algebraic and transcendental elements, adjunction of algebraic elements, Kronecker theorem, algebraic extensions, splitting fields – existence and uniqueness; extension of base field isomorphism to splitting fields;

Unit II: Polynomials

Simple and multiple roots of polynomials, criterion for simple roots, separable and inseparable polynomials; perfect fields; separable and inseparable extensions, finite fields; prime fields and their relation to splitting fields; Frobeniusendomorphisms; roots of unity and cyclotomic polynomials.

Unit III: Galois group

Algebraically closed fields and algebraic closures, primitive element theorem; normal extensions; automorphism groups and fixed fields; Galois pairing; determination of Galois groups, fundamental theorem of Galois theory, abelian and cyclic extensions.

Unit IV: Solvability

Normal and subnormal series, composition series, Jordan-Holder theorem (statement only); solvable groups, Sovability by radicals; solvability of algebraic equations; symmetric functions; ruler and compass constructions, fundamental theorem of algebra.

Textbooks:

1. T. I. F. R. *Mathematical pamphlets*, No. 3, (1965) Galois Theory.
2. Artin, E. (1997) *Galois Theory*, Edited by Arthur N. Milgram, Dover Publications.

Reference books:

1. Herstein, I. N. (2003) *Topics in Algebra* (4th edition), Wiley Eastern Limited, New Delhi.
2. Bhattacharya, P. B., Jain, S. K. and Nagpal, S. R. (2000) *Basic Abstract Algebra* (3rd edition), Cambridge University Press.
3. Jacobson, N. (2002) *Basic Algebra I* (3rd edition), Hindustan Publishing Corporation, New Delhi.
4. Fraleigh, J. B. (2002) *A First Course in Abstract Algebra* (4th edition), Narosa Publishing House, New Delhi.

MEASURE THEORY

MTH-PG-E303 **Credit: 4**

Unit I: Measures

Algebras, sigma-algebras, monotone classes; outer measures and Caratheodory's extension theorem; existence of Lebesgue measure and of non-measurble sets.

Unit II: Integration

Measurable functions, monotone approximability by simple functions, integrability and Lebesgue integration; standard limit theorems: Fatou's lemma, monotone convergence and dominated convergence theorems; almost everywhere considerations.

Unit III: Random Variables & Distributions

Probability, random variables and their distributions, joint distributions and independence, Borel-Cantelli lemma and Kolmogorov's zero-one law, Some of the more standard distributions - both discrete (Bernouilli, Binomial, Poisson, etc.) and continuous (Uniform, Normal, etc.); a brief introduction to conditional expectations and probabilities.

Unit IV: Measures on Product Spaces

Product measures, theorems of Tonelli and Fubini, independence and product measures, infinite products and finite state Markov Chains, Kolmogorov consistency theorem. Characteristic funcions, modes of convergence.

Text book:

1. Athreya, S. R. and Sunder, V.S. (2008) *Probability and Measure*, Universities Press, India.

Reference:

1. Rana, I.K. (2002) *An Introduction to Measure and Integration*, American Math. Soc. 2. Chung, k. L. (2001) *A Course in Probability Theory*, Academic Press.

ALGEBRAIC TOPOLOGY

MTH-PG-E401 **Credit: 4**

Unit I: The fundamental group

Homotopy of paths, fundamental group of a topological space, fundamental group functor, homotopy of maps of topological spaces; homotopy equivalence; contractible and simply connected spaces; Calculation of fundamental groups of n (n > 1) using Van Kampen's theorem (special case); fundamental group of a topological group; Brouwer's fixed point theorem; fundamental theorem of algebra; vector fields, Frobenius theorem on eigenvalues of 3 x 3 matrices.

Unit II: Covering spaces

Covering spaces, unique lifting theorem, path-lifting theorem, covering homotopy theorem, fundamental group of 1, 1 x 1 etc., degree of maps of 1 andapplications; criterion of lifting of maps in terms of fundamental groups; universal coverings and its existence; special cases of manifolds and topological groups.

Unit III: Homology

Category and Functors, Singular homology, relative homology, Eilenberg-Steenrod axioms (without proof), Reduced homology, relation between Ï1 and H1;.

Unit IV: Applications

Calculations of homology of n; Brouwer's fixed point theorem and its applications to spheres and vector fields; Meyer-Vietoris sequence and its application.

Textbooks:

1. Munkres, J. R. (2000) *Topology: A First Course*, Prentice-Hall of India Ltd., New Delhi.
2. Greenberg, M. J. and Harper, J. R. (1997) *Algebraic Topology: A First Course* (2nd edition), Addison-Wesley Publishing Co.
3. Hatcher, A. (2002) *Algebraic Topology*, Cambridge University Press.

Reference:

1. Armstrong , M. A. (2000) *Basic Topology*, UTM Spinger
2. Spanier, E. H. (2000) *Algebraic Topology* (2nd edition), Springer-Verlag, New York.
3. Rotman, J. J. (2004) *An Introduction to Algebraic Topology*, *Text in Mathematics*, No. 119, Springer, New York.

COMMUTATIVE ALGEBRA

MTH-PG-E402 **Credit: 4**

Unit I: Rings and Ideals

A brief review of rings, ideals and homomorphisms, Operations on ideals, Extension and contraction of ideals, Nil radical and Jacobson radical.

Unit II: Modules

Modules, sub modules, homomorphism, direct sum and products of modules, exact sequences

Tensor product of modules and algebras and basic properties

Unit III: Modules of Fractions and Primary Decomposition

Rings and modules of fractions, Primary decomposition,

Unit IV: Integral Dependence and Valuation Rings

Integral dependence, Going up and going down theorems, Valuation rings; Noetherian rings, Artin rings

Text Books:

1. M. F. Atiyah & I. G. Macdonald, *Introduction to Commutative Rings*, Addison Wesley
2. Zarinski and P. Samuel, *Commutative Algebra with a view towards Algebraic Geometry*, Springer

Reference Books:

1. Irving Kapalansky– *Commutative Rings*
2. N. S. Gopalakrishnan – *Commutative Algebra*, Oxonian Press

DIFFERENTIAL GEOMETRY

MTH-PG-E403 **Credit: 4**

Unit I: Vectors

Vectors in R3; tangent vectors; tangent spaces; tangent vector fields; derivative mappings; translations; affine transformations and rigid motions (isometries); exterior derivatives.

Unit II: Space Curves

Space curves; arc length; tangent vectors and vector fields on a curve; curvature and torsion; Serret-Frenet formulas; osculating plane; osculating circle; osculating sphere; fundamental theorem of local theory of space curves (existence and uniqueness theorems).

Unit III: Surfaces

Surfaces and their (local) parametrization on coordinate systems; change of parameters; parametrized surfaces; curves on surfaces; tangent and normal vectors; tangent and normal vector fields on a surface; first, second and third fundamental forms of a surface at a point; Gauss mapping.

Unit IV: Curvature

Normal sections and normal curvature of a surface at a point; Meusnier's theorem; elliptic, hyperbolic, parabolic and planar points; Dupin indicatrix; principal directions; principal curvatures of a surface at a point; Mean curvature and Gaussian curvature of a surface at a point. Line of curvature; asymptotic curves; conjugate directions; fundamental equations of the local theory of surfaces; statement of Bonnet's fundamental theorem of local theory of surfaces.

Textbook:

1. Hsiung, C. C. (1997) *A first Course in Differential Geometry*, International Press, University of Michigan.

Reference:

1. Eissenhart, P. (1960) *A Treatise on the Differential Geometry of Curves and Surfaces*, Dover Publications, Inc., New York.
2. Weatherburn, C. R. (1964) *Differential Geometry of Three Dimensions*, The English Language Book Society and Cambridge University Press.
3. Willmore, T. S. (1979) *An Introduction to Differential Geometry*, Clarendon Press, Oxford.
4. Klingenberg, V. (1978) *A Course in Differential Geometry*, Graduate Texts in Mathematics 51, Springer-Verlag.
5. Pressley, A. (2005) *Elementary Differential Geometry*, Springer International Edition.

FUNCTIONAL ANALYSIS

MTH-PG-E404 **Credit: 4**

Unit I: Normed Linear Spaces and Banach Spaces

Bounded Linear Operators, Duals, Hahn-Banach theorem, Uniform boundedness principle.

Unit II: Open mappings and closed graph theorems

Some applications, dual spaces, computing duals of and C 0, 1 , reflexive spaces;

Unit III: Weak and weak* topologies

BanachAlaoglu theorem, Hilbert Spaces-orthogonal sets, projection theorem, Riesz representation theorem

Unit IV: Adjoint operator

Self-adjoint, normal and unitary operators; Projections, spectrum and spectral radius, spectral theorem for compact operators

Text Book:

1. G.F. Simmons- *Topology and Modern Analysis* (Ch. 9, 10, 11,12), TMH
2. J.B. Conway- *A first course in Functional Analysis*, Springer

Reference Books:

1. W. Rudin- *Real and Complex Analysis*, TMH
2. Erwin Kreyszig – Introductory Functional Analysis with Applications.

OPERATOR THEORY

MTH-PG-E405 **Credit: 4**

Unit I: Compact operators on Hilbert spaces

Fredholm theory, index

Unit II: C^* algebra

Non-commutative states and representations, Gelfand-Neumark representation theorem.

Unit III: Von-Neumann Algebras

Projections, Double communtant theorem

Unit IV: L^∞ Functional Calculus

Toeplitz operators

Text Books:

1. W. Arveson- *An Invitation to C* algebras*, GTM(39), Springer-Verlag

2. V.S. Sunder- *An invitation to von Neuman algebras,* Springer-Verlag

References:

1. N.Dunford and J.T. Schwarz- *Linear Operators*, Part-II: spectral theory.

ALGEBRAIC GEOMETRY

MTH-PG-E406 **Credit: 4**

Unit I: Affine algebraic sets

Affine spaces and algebraic sets, Noetherian rings, Hilbert basis theorem, affine algebraic sets as finite intersection of hypersurfaces; Ideal of a set of points, coordinate ring, morphism between algebraic sets, isomorphism. Integral extensions, Noether's normalization lemma

Unit II: Hilbert's Nullstellensatz and applications

Correspondence between radical ideals and algebraic sets, prime ideals and irreducible algebraic sets, maximal ideals and points, contrapositive equivalence between affine algebras with algebra homomorphisms and algebraic sets with morphisms, between affine domains and irreducible algebraic sets, decomposition of an algebraic set into irreducible components. Zariski topology on affine spaces, algebraic subsets of the plane.

Unit III: Projective spaces

Homogeneous coordinates, hyperplane at infinity, projective algebraic sets, homogeneous ideals and projective Nullstellensatz; Zariski topology on projective spaces. Twisted cubic in P_3(k). Local properties of plane curves: multiple points and tangent lines, multiplicity and local rings, intersection numbers; projective plane curves: Linear systems of curves, intersections of projective curves: Bezout's theorem and applications; group structure on a cubic

Unit IV: Introduction to sheaves of affine varieties

Examples of presheaves and sheaves, stalks, sheafification of a presheaf, sections, structure sheaf, generic stalk and function fields, rational functions and local rings, Affine tangent spaces; Projective varieties and morphisms; Hausdorff axiom. Prime spectrum of a ring: Zariski topology, structiureaheaf, affine schemes, morphism of affine schemes. Elementary Dimension Theory, Fibres of a morphism, complete varieties, nonsingularity and regular local rings, Jacobian criterion, nonsingular curves and DVR's.

Text Books:

1. W.Fulton *Algebraic Curves: An introduction to algebraic geometry*
2. C. G. Gibson – *Elementary Geometry of Algebraic Curves*, CUP,
3. D. S. Dummitt and R. M. Foote – *Abstract Algebra*, Wiley, Ch. 15

Reference Books:

1. J. Harris *Algebraic Geometry, A first course*, Springer
2. M. Reid *Undergraduate algebraic geometry*, LMS 12, CUP
3. K. Kendig – *Elementary Algebraic Geometry*, Springer
4. D. Mumford – *The Red Book of Varieties and Schemes*, Springer
5. I. R. Shafarevich – *Basic Algebraic Geometry*, Springer

ADVANCED COMPLEX ANALYSIS

MTH-PG-E407 **Credit: 4**

Unit I: Harmonic functions and their properties:

Harmonic functions, Relation with analytic functions, Characterisation of Harmonic functions by mean-value property, Properties of Harmonic functions, Poisson's integral formula, Dirichlet problem for a disc.

Unit II: Weierstrass Elliptic function:

Doubly periodic functions, Weierstrass Elliptic function.

Unit III: Preliminaries of Nevanlinna Theory:

Entire functions, $M(r, f)$ and its properties (statements only), Meromorphic functions and their expansions, Definition of the functions $m(r, a)$, $N(r,a)$ and $T(r,f)$.

Nevanlinna's first fundamental theorem, Cartan's identity and convexity theorems, Orders of growth, Order of a meromorphic function, Comparative growth of log $M(r)$ and $T(r)$, Nevanlinna's second fundamental theorem, Estimation of $S(r)$ (Statement only), Nevanlinna's theorem on deficient functions. Nevanlinna's five-point uniqueness theorem, Milloux theorem.

Unit IV: Introduction to several complex variables:

Functions of several complex variables, Power series in several complex variables, Region of convergence of power series, Associated radii of convergence, Analytic functions, Cauchy-Riemann equations, Cauchy's integral formula, Taylor's expansion, Cauchy's inequalities, Zeros and Singularities of analytic functions, Weierstrass preparation theorem (statement only).

Text Books:

1. A. I. Markushevich - Theory of Functions of a Complex Variable, (Vol. I, II, III).

2. E. T. Copson - An Introduction to the Theory of Functions of a Complex Variable.

3. E. C. Titehmarsh The Theory of Functions.

4. W. K. Hayman - Meromorphic Functions.

5. L. Yang - Value Distribution Theory.

6. R. C. Gunning and H. Rossi - Analytic Functions of Several Complex Variables.

7. Bochner and Martin - Several Complex Variables.

8. B. A. Fuks - An Introduction to the Theory of Analytic Functions of Several Complex Variables.

DEPARTMENT OF MATHEMATICS

M. Phil/Ph.D Course Work Syllabus

Course Code	Course Name	Credits	Marks
MAT-RS-C501	Research Methodology	4	100
MAT-RS-O502	Research Proposal and Preparation	4	100
MAT-RS-E503	Differential Quadrature methods and Applications	4	100
MAT-RS-E504	Mesh-free methods and Applications	4	100
MAT-RS-E505	Computational method for PDE	4	100
MAT-RS-E506	Commutative Rings	4	100
MAT-RS-E507	Value Distribution Theory	4	100
MAT-RS-E508	Advanced Linear Algebra	4	100
MAT-RS-E509	Advanced Functional Analysis	4	100
MAT-RS-E510	Numerical Linear Algebra	4	100

Research Methodology and Advanced Mathematics

MAT-RS-C501

UNIT I: Used of computer/Programming

LaTex and Beamer typing

Concept of computer language-Fortran 90 programming,

Matlab, Mathematica, CoCoa software, Origin

UNIT II, III &IV : Quantitative method & Problem solving in Mathematics

Problem solving in Algebra and Number Theory, Problem Solving in Analysis and Differential Equations, Problem Solving in Topology and Complex Function Theory.

Research Proposal and Preparation

MAT-RS-C502

Unit I & II: Review of a scientific research paper

Studying a research paper and writing a review of the same, identifying any new problem, question, and direction emanating from the paper.

Unit III & IV: Research proposal

The students will write a detailed proposal of their research including a thorough review of literature on a topic of their choice and present the same in a seminar at least 10 days before the End-Semester examination.

Differential Quadrature Methods and its Applications

MAT-RS-E503

Unit-I: Introduction to Differential Quadrature

Introduction, differential quadrature, analysis of linear vector space, properties of linear vector space, solutions of partial differential equations and function approximations, Fourier series expansion, general functions, even functions, odd functions.

Unit-II: Polynomial based differential quadrature (PDQ)

Computation of weighting coefficients of the first order derivative, Bellman's approaches, Quan and Chang's approach, Shu's general approach.Computation of weighting coefficients for the second and higher order derivatives, Shu's recurrence formulation for higher order derivatives.Matrix multiplication approach.

Unit-III: Fourier expansion based differential quadrature (FDQ)

Cosine expansion based differential quadrature (CDQ) for even functions, Sine expansion based differential quadrature (SDQ) for odd functions, Fourier expansion based differential quadrature (FDQ) for general functions.

Unit-IV: Solution techniques for differential quadrature (DQ) resultant equations

Solution techniques for differential quadrature of ordinary differential equations (ODEs),

Implementations of boundary conditions.Sample applications of DQ method to Burgers' equation,

Two-dimensional Poisson equation and Helmholtz eigenvalue problems.

Text Book:

1. C. Shu, Differential Quadrature and its application in Engineering, Springer-Verlag London Ltd., Great Britain, 2000.
2. Zhi Zong and Yingyan Zhang, Advanced Differential Quadrature Methods, CRC press, London, 2009.

Mesh-free methods and Applications

MAT-RS-E504

Unit I: Overview of meshfree methods

Why Meshfree methods, Definition of Meshfree methods, Solution procedure of MFree methods, Categories of Meshfree methods, Classification according to the formulation procedures-Meshfree methods based on weak-forms-Meshfree methods based on collocation techniques-Meshfree methods based on the combination of weakformand collocation techniques.

Unit II: Meshfree methods based on the moving least squaresapproximation

Moving least squares shape functions, Formulation of MLS shape functions, Choice of the weight function, Properties of MLS shape functions, Examples of MLS shape functions, Interpolation error using Meshfree shape functions, Fitting of a planar surface, Fitting of a complicated surface.

Unit III: Element Free Galerkin Method

EFG Formulation with Lagrange Multipliers, EFG with Penalty Method, Some simple applications.

Unit IV: Meshless Local Petrov–Galerkin Method

MLPG Formulation, The Idea of MLPG, Formulation of MLPG, Types of Domains, Application to some simple problems**.**

Text Books:

1. G.R. LIU, Y.T. GU, AN INTRODUCTION TO MESHFREE METHODS AND THEIR PROGRAMMING, Springer -2005.
2. G.R. LIU, MeshFree methods: moving beyond finite element methods, CRC Press London, 2003.

COMPUTATIONAL METHODS FOR THE PDE

MAT-RS-E505

Unit – I: Partial Differential Equations

Introduction, Difference methods, Routh Hurwitz Criterion, Domain of dependence of hyperbolic equations

Uni t – II: Difference methods in Parabolic PDEs

Introduction, One space dimension, Two space dimensions, variable coefficients problems, spherical and cylindrical coordinate systems

Unit –III: Difference methods for hyperbolic PDEs

Introduction, One space dimension, Two space dimensions, first order equations, systems of first order equations

Unit – IV: Numerical methods for elliptic PDEs

Difference methods for linear BVPs, General second order linear equations, quasilinear elliptic equations

Text Book:

1. Williams F Ames, Numerical Methods in PDE, Academic Press, New York, 1977.
2. Paul Duchateau and David W Zachmann, Partial Differential Equations – Schaum's Outline Series, McGraw-Hill, 1986

COMMUTATIVE RINGS

MAT-RS-E506

UNIT I: Prime Ideals and applications

Prime ideals, G-domains, G-ideals, Hilbert rings, Hilbert Nullstellensatz

UNIT II: Localization and Integral Extension

Localization, Prime ideals in polynomial rings,Integralextensions,Going-up and Going-down theorems, Valuation domains, Prufer domains and Bezout domains.

UNIT III: Noetherian Rings & Factorization

Noetherian rings, Hilbert basis theorem, Krull's intersection theorem,

Nakayama lemma, Zero divisors, Discrete valuation rings, Dedekind domains, Krull domains.

UNIT IV: Cohen Macaulay & Regular Rings

R-sequences, Cohen-Macaulay rings, Principal ideal theorem, Generalised principal ideal theorem, Regular rings.

Text book:

1. Commutative Rings by Irving Kaplansky, Chicago universitypress,1968.

Reference Books:

1. Commutative Ring Theory by Hideyuki Matsumura, Cambridge studies in advanced mathematics 8, Cambridge universitypress,Cambridge,1989.
2. Introduction to Commutative Algebra by M.F.Atiyah andI.G. Macdonald, Addison- Wesley Publ. Company, 1969.
3. Local Algebra by Jean-Pierre Serre(translated from theFrench by CheeWhye Chin), Springer,1999.

VALUE DISTRIBUTION THEORY

MAT-RS-E507

Unit – I: Review of general theory of entire and meromorphic functions

Harmonic functions and their relations with analytic functions, Poisson-Jensen's formula, Elliptic function, Nevanlinna's characteristic function and related results.

Unit – II: Growth properties of entire and meromorphic functions

Growth indicators of functions, order, hyper-order, basic properties and related results.

Unit – III: Deficiencies of meromorphic functions and their generalizations

Various types of deficiencies of different functions at some given point, their inter-relations and relevant results.

Unit – IV: Uniqueness of entire and meromorphic functions sharing values

Basic uniqueness theorems on analytic functions and their counterparts for meromorphic functions, value sharing, uniqueness results under value sharing.

Texts/References Books:

1. W. K. Hayman: Meromorphic Functions, The Clarendon Press, Oxford, (1964).
2. C. C. Yang and H. X. Yi: Uniqueness Theory of Meromorphic Functions, Science Press, Beijing (2003).
3. A. I. Markushevich, Theory of Functions of a Complex Variable, (Vol. I, II, III).
4. L. Yang, Value Distribution Theory.
5. A. S. B. Holland: Introduction to the theory of Entire Functions, Academic Press, New York (1973).

ADVANCED LINEAR ALGEBRA

MAT-RS-E508

Unit I: Eigenvalues, Eigenvectors and Canonical forms

Eigenvalues and eigenvectors, diagonalization, invariant subspaces and triangularization, minimal

polynomial, Jordan canonical form with applications, rational canonical form.

Unit II: Inner Product Spaces

Hermitian, normal and unitary matrices, Schur's theorem - real and complex versions. Spectral theorems for normal and Hermitian matrices - real and complex versions. Positive definite matrices, characterizations of definiteness. Congruence and simultaneous diagonalization. Singular value decomposition, polar decomposition.

Unit III: Hermitian and Symmetric Matrices

Variational characterizations of eigenvalues of Hermitian matrices, Rayleigh-Ritz theorem, Courant-

Fischer theorem, Weyl theorem, Cauchy interlacing theorem, Inertia and congruence, Sylvester's law of inertia.

Unit IV: Localization and perturbation of eigenvalues

Matrix norms, spectral radius formula, relationships between matrix norms. Gerschgorin discs, perturbation theorems and other inclusion regions. Functions of matrices via spectral decompositions.

Texts/References:

1. R. A. Horn and C. R. Johnson, Matrix Analysis, CUP, 1985.
2. S. Axler, Linear Algebra Done Right, 2nd Edition, UTM, Springer, Indian Edition, 2010.
3. P. Lancaster and M. Tismenetsky, The Theory of Matrices, Second edition, Academic Press, 1985.
4. F. R. Gantmacher, The Theory of Matrices, Vol-I, Chelsea, 1959.

ADVANCED FUNCTIONAL ANALYSIS

MAT-RS-E509

Unit I: Bounded linear operators on Banach spaces

Banach spaces, bounded linear operators, open mapping theorem, closed graph theorem, uniform

boundedness principle.

Unit II: Weak and weak* topologies

Dual spaces, Hahn-Banach theorem, transpose of a bounded linear operator, weak and weak* topologies, Alaoglu theorem.

Unit III: Bounded operators on Hilbert spaces

Hilbert spaces, orthonormal bases, Riesz representation theorem. Adjoint of a bounded linear operator, orthogonal projection, projection theorem, self-adjoint, normal and unitary operators.

Unit IV: Spectral Theory

Spectrum of a bounded linear operator, Gelfand-Mazur Theorem, Compact operators, Riesz theory for compact operators, spectral theory of compact self-adjoint/normal operators.

Texts/References:

1. J. B. Conway: A Course in Functional Analysis, 2nd edition (Springer low price edition)
2. B. V. Limaye: Functional Analysis, 3rd edition (New Age Publishers)
3. G.F. Simmons: Introduction to Topology and Modern Analysis (McGraw Hill Education)

NUMERICAL LINEAR ALGEBRA

MAT-RS-E510

Unit I: Linear systems

LU decompositions, Gaussian elimination with partial pivoting, banded systems, positive definite systems, Cholesky decomposition.

Unit II: Sensitivity of Linear Systems

Floating point computations, IEEE floating point arithmetic, analysis of roundoff errors; Sensitivity analysis linear and condition numbers, sensitivity analysis of linear systems, stability of Gaussian elimination..

Unit III: The Least Squares Problem

Householder transformation, Givens rotations; QR factorization, stability of QR factorization.

Solution of linear least squares problems, normal equations, singular value decomposition(SVD), Moore-Penrose inverse. Sensitivity analysis of least-squares problems.

Unit IV: Eigenvalue Problems

Eigenvalues, eigenvectors, Schur decomposition, reduction to Hessenberg and tridiagonal forms. Power, inverse power and Rayleigh quotient iterations. Explicit and implicit QR algorithms for symmetric and nonsymmetric matrices, sensitivity analysis of eigenvalues. Reduction to bidiagonal form, Golub- Kahan algorithm for computing SVD.

Texts/ References:

1. D. S. Watkins, Fundamentals of Matrix Computations, 2nd Ed., John Wiley, 2002.
2. L. N. Trefethen and D. Bau, Numerical Linear Algebra, SIAM, 1997.
3. G. H. Golub and C. F. Van Loan, Matrix Computations, 3rd Ed., John Hopkins University Press, 1996.

DEPARTMENT OF PHYSICS

M.Sc. Syllabus

Semester	Code	Name of the Paper	Credit	Marks
I	PHY-PG-C101	Classical Mechanics	4	100
	PHY-PG-C102	Quantum Mechanics	4	100
	PHY-PG-C103	Mathematical Physics	4	100
	PHY-PG-C104	Practical I	4	100
II	PHY-PG-C201	Electromagnetic Theory	4	100
	PHY-PG-C202	Statistical Physics	4	100
	PHY-PG-	Open Elective I	4	100
	PHY-PG-C204	Practical II	4	100
III	PHY-PG-C301	Solid State Physics	4	100
	PHY-PG-C302	Advanced Quantum Mechanics and EMT	4	100
	PHY-PG-	Open Elective II	4	100
	PHY-PG-C304	Practical III	4	100
IV	PHY-PG-C401	Nuclear & Particle Physics	4	100
	PHY-PG-E402	Elective I	4	100
	PHY-PG-E403	Elective II	4	100
	PHY-PG-C404	Project Work	4	100

SEMESTER I

CLASSICAL MECHANICS

PHY-PG-C101

Unit I: Lagrangian & Hamiltonian Formalism

Hamilton principle-derivation of Lagrange equations. Simple applications of Lagrangian formulation, generalized momenta, cyclic coordinates, Routh's procedure, symmetry properties and conversation laws.

Hamilton equations of motion, preservation of phase volume under Hamilton flow (Liouville theorem), canonical transformations, generating functions, Poisson brackets, applications to simple problems.

Unit II: Applications

Hamilton-Jacobi equation, harmonic oscillator problem as an example, separation of variables in the Hamilton-Jacobi equation, action-angle variable, Solving Kepler's problem by HJ method.

Central force problem, Kepler's problem, inverse square law of forces, scattering in central force field, Rutherford formula, Virial theorem.

Unit III: Rigid Bodies

The kinematics of rigid body motion, Euler angles, infinitesimal rotations, the Coriolis force, rigid body equations of motion.

Unit IV: Small Oscillations & Chaos

Theory of small oscillations, normal modes of the system.

Non-linear equation of motions; phase diagram, simple examples like Duffing and van der Pol oscillators

Basic idea of chaotic solutions; fixed points and attractors; bifurcations; strange attractors; logistic maps, fractal dimensions and Lyapunov exponent.

Reference Books:

1. H. Goldstein, C. Poole and J. Safko: Classical Mechanics, 3rd Ed, Pearson Education (2002).
2. J. B. Marion: Classical Mechanics of Particles and Systems, Academic Press, (1999)
3. Rana and Joag: Classical Mechanics, Tata Mcgraw Hill, (1991)
4. A.K. Raychaudhuri: Classical Mechanics: A Course of Lectures, OUP, India 1983
5. MG Calkin, Lagrangian and Hamiltonian Mechanics; World Scientific Publishing Co Pte Ltd (18 March 1999)

Quantum Mechanics

PHY-PG-C102

Unit I: Exactly Solvable Problems

One dimension: Postulates of Quantum Mechanics. Free particle, position space and momentum space wave function, Heisenberg uncertainty relation, expectation values. Schrodinger equations, equation of continuity. Particle in a box, simple harmonic oscillator (ladder operator and wave functions), Ehrenfest theorem. classical limit.

Three dimension: Rotational Invariance and angular momentum, eigenstates and eigenvalues of angular momentum operators. Separation of variables, spherical harmonics. Particle in central force, free particle in spherical polar coordinate, hydrogen atom.

Unit II: Approximation Methods

Time independent perturbation theory, non-degenerate and degenerate cases, fine structure and Zeeman Effect (without spin), Stark effect, Fine structure, hyperfine structure, Lamb shift.

Approximation methods: WKB approximation, validity of WKB approximation, alpha emission. Variational method, ground state of helium atom.

Unit III: Interaction with radiation and identical particle

Time dependent Perturbation Theory: Heisenberg and Interaction pictures. Two state problem. First order perturbation, constant and periodic perturbation, sudden and adiabatic perturbation. Higher order perturbation. Transition rate, Fermi's Golden rule.

Dipole approximation, photoelectric effect, Absorption and stimulated emission, spontaneous emission, Einstein's A and B coefficient.

Identical Particles and Spins: Indistinguishability, symmetric and anti-symmetric wave functions, Pauli exclusion principle, electron spin functions, the helium atom, Spin angular momentum, Addition of angular momenta, Clebsch-Gordon coefficients, LS and JJ couplings.

Hartee-Fock method and self-consistent field.

Unit IV: Scattering Theory

One dimensional scattering by barrier, reflection and transmission coefficient. Three dimensional scattering, Lippman-Schwinger equation, Born approximation, optical theorem. Higher order Born approximation.Plane wave vs. spherical wave, method of partial wave analysis, scattering by hard sphere, attractive well and repulsive barrier potential. Low energy scattering and bound states, resonances. Coulomb scattering.

Text Books:

1. E. Merzbacher: Quantum Mechanics, 3rd Edition, John Wiley & Sons (2003)
2. J. J. Sakurai: Modern Quantum Mechanics, Pearson Education, Reprint(1967)
3. R. Shankar: Principles of Quantum Mechanics, Springer, 2ndedn. (1994).

4. P. T. Mathews and S. Venkatesan: Textbook on Quantum Mechanics, McGraw Hill (2002)
5. David J Griffiths, Introduction to Quantum Mechanics, Pearson Education, second edition, 2015

Reference Books:

1. L. I. Schiff: Quantum Mechanics, 3rd Edition, Mc Graw Hill Intl. Edition (1988)
2. J. M. Ziman: Elements of Advanced Quantum Theory, Cambridge University Press.(1975).
3. J. Powell and B. Crasemann: Quantum Mechanics, Narosa Publishing House, (1998).
4. R. Eisberg and R. Rensick: Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles (2nd Ed), John Wiley & Sons, (2003).
5. A. Ghatak and S. Lokanathan: Quantum Mechanics (Theory and Application) (4th Ed), Macmillan (2003).
6. L. D. Landau and L. M. Lifshitz: Quantum Mechanics: Non-relativistic Theory, Butterworth-Heinemann, 3rdEdn. (1981)..
7. K. Thankappan: Quantum Mechanics, New Age Intl. Pub (1996)
8. S. Gasiorowiz: Quantum Mechanics, Wiley (1995)
9. P. A. M. Dirac: Principles of Quantum Mechanics, Dover Publications
10. R. P. Feynman,: Feynman lectures on physics - volume III, Pearson
11. F. Schwabl: Quantum Mechanics, Narosa Pub. House (1998).

MATHEMATICAL PHYSICS

PHY-PG-C103

Unit I: Complex Analysis

Geometrical representation of complex numbers. Functions of complex variables, differentiation. Properties of analytical functions, Cauchey-Riemann conditions. Contours and contour Integration in complex plane, Cauchy theorem, Cauchy integral Formula. Taylor and Laurent series representation, Features of singular points, poles. Residues, Cauchy residue theorem. Applications of the residue theorem.

Unit II: Linear Algebra

Vector Spaces, linear independence, spanning set and basis, Linear operators, representations of vectors and linear operators with respect to bases and change of basis,.Inner Product space (Field of C-No.), Hermitian operators. Eigen values and eigenvectors and their determination, diagonalization of linear operators and matrices.

Unit III: Integral Transforms & Special Functions

Fourier transforms, Laplace transforms.Fuch's theorem, Frobenius method of series solution.

Bessel's, Legendre's, Hermite's and Laguerre's differential equations and solutions: Generating function, Rodrigue's formula, orthogonality. recurrence Associated Legendre and Laguerre polynomials, Green's function

Unit IV: Group Theory

Definitions and examples of physically important finite groups. Multiplication table, Homomorphism and Isomorphism. Subgroups, Cyclic groups, Center. Classes, Cosets, Factor groups. Representation, reducible and irreducible representation, Character table. Simple applications. Introduction to Lie groups.

Text Books:

1. H.J. Weber and G. B. Arfken: Mathematical Methods for Physicists,Academic Press6th Ed. (2005). ISBN-10: 0120598760 ISBN-13: 978-0120598762
2. Murray R. Spiegel: Complex Variables, Mc Graw Hill (1964). ASIN: B000LC6GMS
3. R. V. Churchill: Complex Variables & Applications, Mc Graw Hill Inc. 2nd Edn. (1960). ISBN-10: 0070108536 ISBN- 13: 978-0070108530 1.
4. Lipschutz-Lipson: Schaum's outline of theory and problems of linear algebra: Tata McGraw Hill
5. S. Sternberg: Group Theory and Physics, Cambridge Univ. Press, (1994).

Reference Books:

1. P. Dennery and A. Kryzywicki: Mathematics for Physicists, Dover Publications, (1996).
2. K. F. Riley: Mathematical Methods for Physics and Engineering, CUP, New York (2002)
3. B. D. Gupta: Mathematical Physics, Vikas Pub. House, New Delhi (2004).
4. C. Harper : Introduction to Mathematical Physics, Prentice HallText Books:

5. J Mathews and R L Walker, Mathematical Methods for Physics, Addison-Wesley publishing company Inc. 1973
6. R. R. Halmos: Finite-Dimensional Vector Spaces, Springer, (1993).
7. C. Birkhoff and G.C. Rota, Ordinary Differential Equations (4^{th} Ed), John Wiley &Sons, 2003.
8. Forsythe : A Treatise on Differential Equations, CBS(1995)
9. R. L. Rabenstein: Ordinary differential equations, Cambridge University Press, (2004)
10. G. Stephenson: Partial Differential Equation for Scientists and Engineers, World Scientific Publishing Company, (1996).
11. M. Hamermesh: Group Theory and its Application to Physical Problems, Addison-Wesley Publishing Company, (1962).

PRACTICAL I

PHY-PG-C104

[Minimum 5 experiments from Electronics Lab to be performed. Another minimum of 5 problems are to be solved in the computational lab.]

Electronics Lab:

There should be few lectures covering the relevant topics for the working of the following listed experiments.

1. Clipping and Clamping Circuits
2. Wien's Bridge Oscillator
3. F.E.T
4. Op-Amp (741)
5. Multivibrators
6. Zener Diode
7. Rectifier
8. Multiplexer and Seven Segment Display
9. J-K flip-flop and Up Down Counters
10. Adder/Substractor and Decoders

Computational Lab:

The purpose of this lab session is to train the students to solve the real life physical problems computationally. There will be few lectures covering the following topics:

Representing numbers in a computer, machine precision, Errors and approximations. Concept of computer language.

Fortran 90, Program structure, Data Types, Arithmatic Operators, Intrinsic functions, I/O, Arrays, Control Statements, Formatted I/O, File processing, Subprograms, Subroutines.

Introduction toMatlab, Mathematical functions, Basic plotting, Matrix generation, Array equations and Linear equations, Programming in Matlab, Script files, Function files, Control flow and operators, Saving output to a file

Introduction to Mathematica, Symbolic expressions, simple plot, Matrices as list, Logical expressions, Functions and programming.

The students will require to make programmes to solve the real life applications. The course instructor will provide the relevant problems.

References:

Electronics Lab:

1. A. S. Sedra and K. C. Smith, Electronics Circuits, (6thEdn), Oxford University Press (2009)
2. R. Gaekwad, Op-Amps and Linear Integrated Circuits, (4^{th}Edn) Prentice Hall of India (2002).
3. Millman&Halkias, Integrated Electronics: Analog & digital circuits systems, Mc Graw Hill, 1972.
4. D. P. Leach, A. P. Malvino and G. Saha, Digital Principles and Applications (6^{th}Edn), Tata McGraw Hill (2007)
5. H. S. Kalsi, Electronic Instrumentation, Tata McGraw Hill Education, 2012.

Computational Lab

1. W. H. Press, B. P. Flannery, S. A. Teukolsky, W. T. Vetterling: Numerical Recipe in Fortran, Cambridge University Press India Ltd (2000)
2. G. Lindfield and J. Penny: Numerical Methods: using Matalab, Academic Press (2012)
3. R. Pratap: Getting Started with MATLAB 7, Oxford University Press, 2006.
4. S. Wolfram, Mathematica: A System for doing mathematics by Computer, Addison. Wesely, 1991
5. V. Rajaraman: Computer based Numerical Methods , Prentice Hall India, 1980,
6. N. Boccara: Essentials of Mathematica, Springer, 2009.
7. S. Attaway: MATLAB: A Practical Approach, Elseiver, 2009.
8. A. Gilat: MATLAB: an Introduction with applications, John Wiley Sons, 2004.

Semester II

ELECTROMAGNETIC THEORY

PHY-PG-C201

Unit I: Electrostatics

Equations of electrostatics in differential and integral forms. Potential and field due to point charges and continuous charge distributions. Boundary value problems and their solutions by separation of variables, method of images and Green's functions. Multipole expansion: Electric dipole and quadrupole moments.

Electrostatics and dielectrics: Polarization and bound charge, displacement field, Poisson's equation in a uniform linear dielectric. Boundary value problems with dielectrics.

Unit II: Magnetostatics

Electric Current as a source of magnetic field, Equations of magnetostatics in differential and integral forms, Vector potential, magnetic dipole, multipole expansion of vector potential

Magnetic fields and matter: magnetization and bound currents, Amperes law for free currents and H, Boundary Conditions, magnetic scalar potential.

Unit III: Time varying fields & Maxwell's equations

Electromotive force, Faraday's Law of induction. Maxwell's displacement current and Maxwell's equations, covariant formulation of Maxwell's equations, Boundary conditions, Electromagnetic field energy, vector and scalar potentials, Wave equations, Gauge transformations, Poynting's theorem, Conservation laws.

Unit IV: Plane electromagnetic waves

Properties of the electromagnetic wave equations in different media (vacuum, conductor, plasma and waveguides). Rectangular waveguides and resonant cavities. Reflection and refraction of electromagnetic waves at the interface of non-conducting media.

Text Books:

1. D. J. Griffiths: Introduction to Electrodynamics (3rd Ed.), Pearson Edn., (2002)
2. J. D. Jackson: Classical Electrodynamics ,Wiley Eastern, (2003)
3. G. L. Pollack, D. Stump and D. R. Stump: Electromagnetism, Addison-Wesley (2001).
4. W. H. Hayt, Jr. J. A. Buck: Engineering Electromagnetics, The McGraw-Hill (2001).

STATISTICAL PHYSICS

PHY-PG-C202

Unit I: Thermodynamic laws and functions

Entropy, Free energy, Internal Energy, Enthalpy, Chemical Potential, Systems with large number of degrees of freedom, Micro and macro states, Phase space of a classical system, Density of states, Liouville's Theorem.

Unit II: Basic principles of ensembles

Micro-canonical, Canonical and GrandCanonical ensembles, Concept of ensemble average, Equation of state, specific heat and entropy of a classical ideal gas, Gibb's paradox and its resolution, Energy and Density fluctuations, Virial and equipartition theorems, Partition function, Determination of translational, rotational and vibrational motions to the partition functions of an ideal diatomic gas.

Unit III: Quantum Statistics

Inadequacy of classical theory, Quantum mechanical ensemble theory, density matrix, Ensembles in quantum statistical mechanics, Ensembles of ideal Boltzman, Bose-Einstein and Fermi gas, Identical particles, quantum distribution functions, Bose-Einstein and Fermi-Dirac statistics, Grand partition function for ideal Bose and Fermi gas.

Unit IV: Ideal Bose & Fermi Systems

Thermodynamics of Black body radiation, Stefan-Boltzman law, Wien's Displacement Law, Ideal Bose System: Thermodynamic behaviour of ideal Bose gas, Bose-Einstein condensation

Thermodynamic behaviour of an ideal Fermi Gas, Degenerate Fermi Gas, Fermi Energy and Mean Energy, Fermi Temperature, Fermi Velocity of a particle of a degenerate gas, Compact stars.

Text Books:

1. R. K. Patharia: Statistical Mechanics (2^{nd} Ed) Butterworth Heinman, Elsevier (2005)
2. K. Huang: Statistical Mechanics (2^{nd} Ed) John Wiley & Sons (2002)
3. K. Huang, Introduction to Statistical Physics, Taylor & Francis (2001).
4. F. Reif: Statistical and Thermal Physics, McGraw Hill (1985).
5. T. Guenault: Statistical Physics (2^{nd} Ed), Kluwer Academic (1995).
6. S. Lokanathan and R.S. Gambhir, Statistical and Thermal Physics, Prentice Hall, (2000).

Reference Books:

1. B. B. Laud: Fundamentals of Statistical Mechanics, New Age Intl. Publishers (1998)
2. L. D. Landau and E. M. Lifshitz: Statistical Physics, Part I & II, Butterworth and Heinman, (1980).
3. E.M. Lifshitz and L.P. Pitaevskii, Statistical Physics (Part 2), Butterworth-Heinemann (1980).

PRACTICAL II

PHY-PG-C204

[Minimum 10 experiments to be performed from the following list]

1. Fibre Optics
2. Fresnel Diffraction
3. Photoconductivity
4. Stefan’s Law
5. Dielectric Constant
6. Ultrasonic Diffraction
7. Hall Effect
8. Planck’s Constant
9. Michelson Interferometer
10. Susceptibility of Paramagnetic Solution
11. Hydrogen Spectrum and Rydberg Constant
12. Single Slit, Double Slit, Grating and Thin Wire Diffraction
13. Foaming and Foam Stability

SEMESTER III

SOLID STATE PHYSICS

PHY-PG-C301

Unit I: Crystal Structure

Simple crystal structures, atomic scattering factor, Structure factor, Bragg's law, Direct and reciprocal lattice, Laue diffraction, neutron diffraction, electron diffraction, crystal structure determination by Laue, powder and rotating crystal methods. Concept of point groups and space groups, Influence of symmetry on physical properties.

Unit II: Defects and Lattice Vibrations

Defects in Solids, Grain and twin boundaries, Point Defects, line defects and planar defects or dislocations and their effects on solid state properties, colour centres. Lattice vibrations, phonons and dispersion relations for acoustical and optical lattice vibrations in crystals (mono and diatomic linear lattice), phonons, normal and Umklapp processes, anharmonic vibrations, thermal expansions and thermal conductivity. Bloch theorem, Brillouin zones for simple lattices, crystal momentum, effective mass of electrons and holes, ideas of Fermi surfaces, band structure of simple elements.

Unit III: Electric polarization and Band Structure

Electric polarization, Static dielectric constant, complex dielectric constant, dielectric loss, dielectric relaxation, Debye equations, classical theory of electronic polarization, ferroelectricity, ferroelectric domains, anti-ferroelectricity. Electronic band structure calculations: Tight-binding method, pseudo potentials and Augmented Plane Wave (APW) methods, nearly free electron approximation, OPW, Fermi surfaces (FS), effects of electric and magnetic field on FS, de Haas van Alfen effect, Cyclotron resonance, anomalous skin effect.

Unit IV: Magnetism and Superconductivity

Magnetism, Diamagnetism; Paramagnetism (Quantum treatment); Crystal-field effects; John-Teller effects; Adiabatic demagnetization; Molecular field theory of ferromagnetism; Heisenberg-exchange interaction; Spin Waves; Ginzburg-Landau theory of the ferromagnetism; Shape, Origin and observation of ferromagnetic domains; Dynamic Phenomena : Linear Response Theory, Hall effect, quantum Hall effect.

Superconductivity: Phenomenological thermodynamic treatment, intermediate state, London's equations and penetration depth, Type I & II superconductivity, quantized flux, coherence length. Ginzburg-Landau theory, variation of the order parameter and the energy gap with magnetic field, isotope effect; Energy gap and its measurement; electron-phonon interaction and Cooper pairs,

B.C.S. theory, dc and ac Josephson effects, critical currents of type-II superconductors.

Text Books:

1. C. Kittel: Introduction to Solid State Physics, 7th Ed. Wiley (1996)
2. N. W. Ashcroft & N.D. Mermin: Solid State Physics, Harcourt Asia, 1st ed. (2001)
3. J. Dekker: Solid State Physics, Macmillan (2003).

4. L. V. Azaroff: Introduction to Solids, Tata McGraw-Hill (2002).
5. DG Pettifor: Bonding and Structure of Molecules and Solids, Oxford University Press; First Edition edition (December 7, 1995)
6. C Kittel, Quantum Theory of Solids,: Wiley 1987
7. H Ibach and H Luth, Solid-State Physics: An Introduction to Principles of Materials Science: 4^{th} Ed. Springer 2009
8. S Blundell: Magnetism in Condensed Matter, OUP Oxford (4 October 2001)
9. James Patterson and Bernard Bailey, Solid-State Physics: Introduction to the Theory, Springer; 2nd ed. 2010 edition (January 11, 2011)

ADVANCED QUANTUM MECHANICS and EMT

PHY-PG-302

Unit I: Relativistic Quantum Mechanics

Klein-Gordon equation, probability density and probability current density, solution of free particle Klein-Gordon equation in momentum representation. Dirac equation, solution of free particle. Interpretation of negative probability density and negative energy solutions. Interaction with em field. Inadequacy of Relativistic Quantum Mechanics, requirement of Field theory.

Unit II: Quantisation of Fields

Classical field theory, Lagrangian and Hamiltonian formulations. Real and Complex scalar and Dirac fields. Symmetry and conservation, Noethers theorem.

Quantisations of scalar field, creation, annihilation and number operators, Fock space, momentum and Hamiltonian operator, time ordering, Green's functions, Feynman propagator. Quantisation of Dirac field, anti commutation, propagators.

Unit III: Radiating fields

Retarded potentials, Lienard-Wiechert potentials. Radiation from a moving point charge, oscillating electric and magnetic dipoles. Multipole expansion for radiation fields, radiation from antennas. Dispersion, Lorentz's dispersion equation. Transformations of electromagnetic fields under Lorentz transformations, Covariant formalism of Maxwell's equations.

Unit IV: Waves in plasma

Introduction to plasma, criteria for plasma, Debye's screening. Single particle motions, magnetic mirrors. Magnetohydrodynamics and fluid equations of motion. Plasma oscillations, electron plasma waves, Langmuir waves and ion sound waves, Alfven waves, magnetosonic waves. Nonlinear phenomena in plasma.

Text Books:

1. R. Shankar: Principles of Quantum Mechanics, Springer, 2^{nd} edn. (1994).
2. J. S. Townsend: Modern Approach to Quantum Mechanics, University Science Books, California (2000)
3. J. J. Sakurai: Advanced Quantum Mechanics, Pearson Education, Reprint(1967).
4. M. Peskin and D. V. Schroeder: Introduction to Quantum Field Theory (Frontiers in Physics), Westview Press, (1995).
5. D. J. Griffiths: Introduction to Electrodynamics (3^{rd} Ed.), Pearson Edn., (2002)
6. J. D. Jackson: Classical Electrodynamics,Wiley Eastern, (2003)
7. G. L. Pollack, D. Stump and D. R. Stump: Electromagnetism, Addison-Wesley (2001).
8. F. F. Chen: Introduction to Plasma Physics and Controlled Fusion, vol. I: plasma physics, 2^{nd} edition, Springer, 1984.
9. R. J. Goldston and P. H. Rutherford: Introduction to Plasma Physics, Institute of Physics, London, 1995.

Reference Books:

1. James D. Bjorken and Sidney D. Drell, Relativistic Quantum Mechanics, McGraw Hill Education, Edition 1 (2013).
2. James D. Bjorken and Sidney D. Drell, Relativistic Quantum Fields, Dover Publications Inc., (2013).
3. Steven Weinberg, Quantum Theory of Fields, Cambridge University Press, 2008.
4. T-Y Wu and W-Y P. Hwang: Relativistic Quantum Mechanics and Quantum Field,World Scientific Publishing Co., (1991).
5. Claude Itzykson & Jean Bernard Zuber: Quantum Field Theory, Dover publications Inc. (2006).
6. Sylvan S. Schweber, An Introduction to Relativistic Quantum Field Theory, Dover Publications Inc. , (2005).
7. Franz Mandl and Graham Shaw, Quantum Field Theory, Wiley-Blackwell; 2nd Revised edition edition (9 April 2010)
8. Lewis H. Ryder, Quantum Field Theory, Cambridge University Press (2008)

PRACTICAL III

PHY-PG-C304

[Minimum 10 experiments to be performed from the following list]

1. Four Probe
2. Electron Spin Resonance (ESR)
3. Converters: (A to D) & (D to A)
4. Automation
5. Knife edge and Polarisation (QW plate, Half wave plate)
6. Ionization potential
7. Specific heat of solids
8. Zeeman Effect
9. Raman effect
10. Emission and absorption
11. Laser Doppler Anemometry
12. Microprocessor
13. Faraday Rotation

SEMESTER IV

NUCLEAR & PARTICLE PHYSICS

PHY-PG-C401

Unit I: Nuclear Physics

Properties of nuclear forces-deuteron problem, n-p scattering. Nuclear models, liquid drop model, shell model and collective Model.

Radioactivity, Alpha Decay, Beta Decay. Fermi Theory, Gamma Decay and internal Conversion, selection rules.

Unit II: Elementary Particles

Elementary particles, their quantum numbers. Weak, strong and electromagnetic interactions, quarks and leptons, quark model of hadrons, standard model.

Relativistic kinematics; Symmetries and conservation laws; P,C and T discrete symmetries; CP violation.

Unit III: Quantum Electrodynamics

Lagrangian formulation of relativistic theory: Dirac equation and trace theorems. Perturbation expansion of correlation functions, Wick's theorem, Feynman diagrams. Cross sections and S-matrices, Feynman rules for QED, elementary processes.

Unit IV: Gauge Theory

Gauge symmetry, local gauge invariance, Yang-Mills theory, Spontaneous symmetry breaking, Higgs mechanism. One loop structure, renormalization prescriptions, Ward identities.

Text Books:

1. S N Ghoshal: Nuclear Physics, S. Chand and Co. Ltd
2. R. Roy and B.P. Nigam: Nuclear Physics (Theory & Experiment), New Age Intl., (1967).
3. D. J. Griffiths: Introduction to Elementary Particles, John Wiley & Sons (1987).
4. Francis Halzene & Alan D. Martin: Quarks & Leptons: An introductory course in modern particle physics, Wiley, (2008)
5. Ta Pei Cheng & Ling-Fong: Gauge theory of elementary particle physics, Oxford University Press, (1984)
6. Ian J R Aitchison & Anthony J G Hey: Gauge theories in particle physics: A practical introduction, CRC Press, (2013)
7. M. Peskin and D. V. Schroeder: Introduction to Quantum Field Theory (Frontiers in Physics), Westview Press, (1995).

Reference Books:

1. S. Krane: Introductory Nuclear Physics, John Wiley, (1988).
2. Emilio. Segre: Nuclei and Particles: An introduction to nuclear and subnuclear physics, Dover, (2013).
3. W. E. Burcham: Elements of Nuclear Physics, Longman, (1986).
4. W. N. Cottingham and D. A. Greenwood: An Introduction to Nuclear Physics. Cambridge University Press, 2^{nd} Edn. (2001).
5. W. Greiner and A. Schafer, Quantum Chromodynamics, Springer-Verlag, (1994).
6. F. J. Yndurain: The Theory of Quarks & Gluon Interactions, Springer-Verlag, (1999).
7. M. K. Pal, Theory of Nuclear Structure, Affiliated East-West, 1982
8. P. Marmier and E. Sheldon: Physics of Nuclei and Particles, Vol.I & II, Academic Press, (1969).

PROJECT WORK

PHY-PG-C404

A student's project work should be a guided study of an advanced topic not covered in the curriculum. It is expected that the student learns and applies some of the techniques and knowledge taught in the class through this Project Work. The main objective of the Project Work is to provide students with skill and knowledge in conducting research in fundamental and application aspects of physics/allied fields. Proper acknowledgement and permission of unavoidable earlier published work must be given in the thesis. If any kind of plagiarism is practised by the student, his/her dissertation or project work shall be liable to be rejected.

The Project Work will be evaluated at the end of the semester by an evaluation committee consisting of the following four members: Head of the Department, the Supervisor, an Internal Examiner and an External Examiner.

OPEN ELECTIVE PAPERS OPEN ELECTIVE I FOR SEMESTER II

NANO AND SOFT MATERIALS

PHY-PG-OE203A

Unit-I Nanomaterials and their properties

Introduction to nanotechnology. Various kinds of Nanostructures-Carbon fullerenes and nanotubes, Metal and metal oxide nanowires, Self-assembly of Nanostructures, Core-shell nanostructures, Nanocomposites. Thermodynamics of Nanomaterials. Physical Properties of nanomaterials - Photocatalytic, Dielectric, Magnetic, Optical, Mechanical.

Unit-II Synthesis of Nanomaterials

Bottom up and top down approaches. Synthetic methodologies including Sol-gel, Micromulsion, CVD,PVD,Molecular beam epitaxy, Vapor (solution)-liquid-solid growth, (VLS or SLS), Spray Pyrolysis, Template based synthesis, Lithography, Laser ablation.

Unit-III Characterization Techniques and Applications

Absorption and PL spectroscopy, Electron Microscopic techniques, X-ray and electron diffraction, AFM, Auger Electron Spectroscopy, X- ray Photoelectron Spectroscopy. Applications of Nanomaterials.

Unit IV: Soft Materials

Introduction to Soft Condensed Materials and their properties: Plastic and Liquid Crystals, Thermotropic (Nematic, Smectic and Discotic) and Lyotropic Liquid Crystals; Surfactants and Polymers; Colloids: Foams, Gels and Microemulsions; Biomaterials; Applications of Soft Materials

References:

1. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press 2004.
2. T. Pradeep, Nano: The Essentials Understanding nanoscience and nanotechnology, Tata McGraw- Hill Publishing Company Limited NEW DELHI, 2007.
3. Nanomaterials Synthesis, Properties and Applications Edited by A S Edelstein and R C Cammarata, IOP Publishing Ltd 1996.
4. Chaikin and Lubensky, Principles of Condensed Matter Physics, Cambridge University Press 1995.
5. P-G de Gennes, J Prost, The Physics of Liquid Crystals, , Oxford University Press, 1994.

RENEWABLE ENERGIES (SOLAR AND HYDROGEN)

PHY-PG-OE203B

Unit I: Solar Energy

Fundamentals of photovoltaic energy conversion Physics and material properties basic to photovoltaic energy conversion: optical properties of solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Unit II: Types of Solar Cells

p-n junction solar cell, transport equation, current density, open circuit voltage and short circuit current, brief descriptions of single crystal silicon and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g. tandem solar cells. Solid liquid junction solar cells, nature of Semiconductor, electrolyte junction, principles of photo electrochemical solar cells.

Unit III: Hydrogen Energy & Production

Relevance in relation to depletion of fossil fuels and environment considerations. Solar Hydrogen through photo electrolysis and photo catalytic process. Physics of material characteristics for production of solar hydrogen.

Unit IV: Storage and Safety

Brief discussion of various storage processes, special features of solid state hydrogen storage materials, structural and electronic characteristics of storage materials. New Storage Modes. Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular Transport, Hydrogen for Electricity Generation, Fuel Cells, Elementary concepts of other Hydrogen Based devices such as Air Conditioners and Hydrides Batteries.

Text Books:

1. GD. Raj: Solar energy utilization, Khanna Publishers, New Delhi, 2005.
2. H.P. Garg and J Prakash: Solar Energy: Fundamental and Applications, Tata McGraw Hill, 2000.
3. Charles E.: Solar cells, IEEE Press, 1976.
4. K. L. Chopra and S. Ranjan Das: Thin film solar cells, Plenum, New York, 1983.

NUMERICAL METHODS AND COMPUTATIONAL PHYSICS

PHY-PG-OE203C

Unit I: Roots of Equations:

Roots of Nonlinear Equations: Bisection, Newton-Raphson, secant method. System of Nonlinear equations, Newton's method for Nonlinear systems. Applications in Physics problems.

Solution of linear systems: Gauss, Gauss-Jordan elimination, matrix inversion and LU decomposition. Eigenvalues and Eigenvectors. Applications.

Unit II: Interpolation and Curve fitting:

Introduction to interpolation, Lagrange approximation, Newton and Chebyshev polynomials. Least square fitting, linear and nonlinear. Applications in Physics problems.

Unit III Numerical Differentiation & Integration:

Approximating the derivative, numerical differentiation formulas, Numerical Integration: Quadrature Formula, trapezoidal and Simpson's rule, Gauss-Legendre integration. Applications.

Unit IV: Solution of ODE:

Initial value and boundary value problems, Euler's and Runge-Kutta methods, Finite difference method. Applications in Chaotic dynamics, Schrodinger equations. Solution of PDE: Hyperbolic, Parabolic, and Elliptic Equations by finite difference. Application to 2-dimensional Electrostatic Field problems.

Text Books:

1. K. E. Atkinson, Numerical Analysis, John Wiley (Asia) (2004).
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill (2002).
3. R.J. Schilling and S.L. Harries, Applied Numerical Methods for Engineers using MATLAB and C, Thomson Brooks/Cole, (2006).
4. S.S. Sastry, Introductory methods of Numerical analysis, Prentice Hall India,(2012).

References:

1. J. H. Mathews, Numerical Methods for Mathematics, Science, and Engineering, Prentice Hall of India (1998).
2. S. S. M. Wong, Computational Methods in Physics, World Scientific (1992).
3. W. H. Press, B. P. Flannery, S. A. Teukolsky, W. T. Vetterling: Numerical Recipe in C, Cambridge University Press India Ltd (2007)
4. W. H. Press, B. P. Flannery, S. A. Teukolsky, and W. T. Vetterling: Numerical Recipe in Fortran ,Cambridge University Press India Ltd (2000)
5. G. Lindfield and J. Penny: Numerical Methods: using Matalab, Academic Pres (2012)
6. S. Wolfram, Mathematica: A System for doing mathematics by Computer, Addison. Wesely, (1991).

OPEN ELECTIVE II FOR SEMESTER III

Space Physics

PHY-PG-OE303A

Unit I: Motion of plasma particles and models

Characteristics of a plasma, Plasmas in space. Particle orbit theory: particles in constant external fields, guiding centre drifts, nonuniform magnetic fields, gradient and curvature drifts, magnetic bottling. Adiabatic invariatns. Models to study plasma: kinetic, fluid and MHD models, Boltzmann equation, Vlasov equation, Fokker-Planck equation. Ideal MHD.

Unit II: Waves in Plasmas

Linearized MHD equations. Magnetohydrodynamic waves: Alfven waves, magneto-sonic waves, MHD waves oblique to the field. Electrostatic waves in non-magnetic plasmas: plasma oscillations, Langmuir waves, ion-acoustic waves. Electrostatic waves in magnetized plasmas: upper hybrid frequency, lower hybrid frequency, ion cyclotron waves. Electromagnetic waves in non- magnetized and magnetized plasmas.

Unit III: Space Plasmas

Sun and Solar Wind: Structure of the Sun, Solar neutrinos, solar atmospheres, coronal magnetic field. Solar wind model. Coronal heating and solar wind acceleration, A simple model of the solar cycle. Stellar activity. Flares and coronal mass ejections. Interplanetary shocks. Energetic particles in the heliosphere. Turbulence and stochastic acceleration. Interplanetary magnetic field. Plasma waves in interplanetary space. Planetary magnetospheres and their comparisons.

Unit IV: Sun-Earth Connection and Instrumentation

Terrestrial Magnetosphere: Geomagnetic field, Structure of the Magnetosphere. Interaction of the solar wind with the terrestrial magnetic field. Formation of aurora. Magnetospheric currents. Magnetic activity and substorms. Solar activity and its effect to climate and culture. Energetic particles and the atmosphere.

Instruments to measure fields and waves. Plasma instruments. Energetic particle instruments. Supplementary ground-based observations

Text Books:

1. May-Britt Kallenrode: Space Physics: An Introduction to plasmas and Particles in the Heliosphere and Magnetospheres, 3^{rd} Ed. Springer, 2004.
2. Tamas I. Gombosi: Physics of the Space Environment, Cambridge University Press, 1998.
3. J. T. Houghton: The Physics of Atmosphere, Cambridge University Press, 3^{rd} Edn. (2001).
4. Margaret G. Kivelson Christopher T. Russell: Introduction to Space Physics, Cambridge University Press, 1996.
5. George K. Parks: Physics of Space Plasmas: An Introduction, 2^{nd} Ed., Westview Press, 2004.
6. Thomas E. Cravens: Physics of Solar System Plasmas, Cambridge University Press, 2004.

BIOPHYSICAL TECHNIQUES

PHY-PG-OE303B

Unit I: Light scattering and Electron Microscopy

Elastic and inelastic scattering, light scattering by macromolecules, dynamic light scattering, radius of gyration and molecular mass. Transmission and scanning microscopy, negative staining, cryo-electron microscopy.

Unit II: Chromatography and Mass spectrometry

Electrospray MS, MALDI, applications. Paper Chromatography, TLC, column, gas-liquid, ion-exchange, size-exclusion and affinity chromatographies, HPLC and FPLC, applications to macromolecules.

Unit: III: IR and Raman spectroscopy

Rotational and vibrational spectra, oscillator, molecular symmetry, optical density, investigations of molecular structure, hydrogen bonding. Examples and comparison of IR and Raman spectra, resonance Raman spectroscopy

Unit IV: Absorption, Fluorescence and NMR Spectroscopy

UV and Visible spectra, chromophores, Circular Dichroism and Optical Rotatory Dispersion, cotton effect, applications to proteins and nucleic acids, Frank-condon principle, classical picture, resonance condition, Bloch condition, relaxation phenomenon, Fourier transform technique. NMR, chemical shifts, coupling constraints, Karplus equation, analysis of simple NMR spectra, Nuclear Overhauser Effect, proton magnetic resonance, 13C and 31P spectra.

Text Books:

1. K.Wilson and K. H. Gouldberg: Principles and Techniques of Bochemistry, Edward Arnold (Publishers) Ltd, London, UK, (1986).
2. K. E. van Holde: Physical Biochemistry, Prentice-Hall Inc., New Jersey, USA, (1971)
3. D. Freifelder: Physical Biochemistry, W.H.Freeman and Company, NewYork, USA, (1982).

Reference Books:

1. C. R. Cantor and P. Schimmel: Biophysicsal Chemistry, Vol 1, W. H. Freeman and Company, NewYork, USA. (1985).
2. L. Stryer: Biochemistry. W.H.Freeman and Company, NewYork, USA, (1995).

COGNITIVE SCIENCE

PHY-PG-OE303C

Unit I: Introduction and Cognitive Psychology

Historical overview, Analyzing Information processes at several levels, Interdisciplinary nature of cognitive science, Application related system in the Cognitive Science.

Nature of cognitive psychology, notion of cognitive architecture, propositional and schematic representation, cognitive processes: working memory and attention, mental images, reasoning. automatic and controlled processes, acquisition of skills.

Unit II: Artificial Intelligence and Neuroscience

History and background of Artificial Intelligence, Knowledge representation, Human information processing and problem solving: Search, Control and Learning

Introduction to nervous system, organisation of nervous system, neural representation, computational neuroscience, neural network and distributed information processing, neural network models of cognitive processes, strategies for brain mapping.

Unit III: Cognitive Modelling

Different types of Cognitive Models: Symbolic Model, Connectionist Model etc. and their implications to Memory, Learning, Reasoning, Attention, Mood Detection, Visual Perception, Pattern recognition, Mental Imagery.

Vector and Matrix Algebra, Rigid Body Geometric transformations, Spatial Filtering, Convolution, Frequency Filtering, Fourier Transform.

Unit IV: Biomedical Imaging Techniques

An overview of X-ray, CT scan, PET scan, MRI scan, fMRI, EEG, MEG. Fundamental concepts of Image acquisition / Signal acquisition, Spatial Normalization, Affine and Non-linear Image Registration, Spatial resolution, Temporal resolution, Contrast resolution, Image representation, Image Database, Image Data Communication and Data Compression, Image visualization such as various types of 2D and 3D rendering techniques.

Text Books:

1. D. Kolak et. al.: Cognitive Science: An Introduction to Mind and Brain, Routledge, 2006.
2. J.L. Bermudez: Cognitive Science, Cambridge University Press, 2010.
3. Neil A. Stilings et al.: Cognitive Science; an Introduction, A Bradford Book, 1998
4. David Papineau, Thinking about Consciousness, Oxford University Press, 2002.
5. J. Copeland: Artificial Intelligence: A Philosophical Introduction, Oxford Blackwell, 1993.
6. H. van Oostendorp, Cognition in a digital world, Lawrence Erlbaum Associates, Publishers: Mahwah, N.J. 2003.
7. M. Felix Goodson,.: The evolution and function of cognition, Lawrence Erlbaum Associates, Publishers: Mahwah, N.J. 2003.
8. Cornelius T. Leondes: Image Processing and Pattern Recognition, Academic Press, London, 1998.
9. N. Bankman, Handbook of Medical Image Processing and Analysis, Elsevier, 2009
10. Konar Amit: Artificial Intelligence and Soft Computing – Behavioural and Cognitive Modelling of the Human Brain, CRC Press, Florida, 2000.

Electives for Semester IV
(Any Two to be Chosen)

COSMOLOGY

PHY-PG-E402/3-A

Unit I: Expansion of universe

GTR: Equivalence principle, metric tensor, covariant derivative, curvature tensor. Currents and conservation law, energy momentum tensor, Einstein's equation.

Robertson-Walker metric, cosmological redshift, Hubble constant. Cosmic distance ladder. Dynamics of expansion.

Unit II: CMBR & Early Universe

Discovery of cosmic microwave background radiation, Equilibrium era, Recombination and last scattering, dipole anisotropy, primary fluctuations. Thermal history, Nucleosynthesis, Baryosynthesis, Leptosynthesis, cold dark matter.

Unit III: Inflation

Flatness, horizons, monopoles; slow roll inflation, chaotic inflation, eternal inflation. Perturbed Ricci and EM tensor, scalar, vector and tensor modes; Fourier decomposition, choice of gauge.

Unit IV: Cosmological Fluctuations & CMBR Anisotropy

Scalar perturbation: kinetic theory, hydrodynamic limit, long and short wavelength. Tensor perturbation. General formula for temperature fluctuation, temperature multipole coefficients, vector and tensor modes, polarisations.

Text Books:

1. Steven. Wineberg: Cosmology, Oxford University Press, 2008. Hermann Bondi and I W Roxburgh, Cosmology, Dover Publications Inc. 2009,
2. Marc Lachieze-Rey, John Simons, Cosmology: A first course, Cambridge University Press,
3. Fred Hoyle and J V Narlikar, Introduction to Cosmology, Cambridge University Press, 1993Andrei Linde, Particle Physics and Inflation, CRC Press, 1999, Kindle Edition

ASTROPHYSICS

PHY-PG-E402/3-B

Unit I:

Telescopes: basic optics, optical telescopes, radio telescopes, IR, UV, X-ray and Gamma-ray Astronomy, all-sky surveys and virtual observatoriesOverview of major contents of universe, Black body radiation, specific intensity, flux density, luminosity, Basics of radiative transfer (Emission/absorption coefficients, source functions), Magnitudes, distance modulus, Color index, Extinction, Color temperature, effective temperature, Brightness temperature, bolometric magnitude/luminosity, Excitation temperature, kinetic temperature, Utility of stellar spectrum, basic knowledge of stellar atmospheres

Unit II

HR diagram, a discussion on the variety of stellar phenomena. Stellar Structure, stellar opacities, stellar polytropes, Energy Generation in Stars: Calculation of thermonuclear reaction rates for non-resonant and beta-decay reactions, The various reaction chains: pp-I, II, III, CNO, He-burning, C-burning, Si-burning, photo-dissociation . Neutrino emission from Stars: The solar neutrino “problem” and its solution, terrestrial detection of stellar neutrinos - solar and supernovae (Arnett, Bahcall). Stellar degeneracy and Equations of State: Stellar degeneracy (Clayton), Chandrasekhar mass, EoS of matter at near-nuclear and nuclear densities (Shapiro &Teukolsky).

Unit III

Final stages of stellar evolution: Supernovae and neutron stars - a basic knowledge of NS structure, the problems associated with determining a unique equation of state for NS, various manifestations of NS. Binaries, variable stars, clusters, open and globular clusters, Laws of planetary motion, Motions and Distances of Stars, Statistical and moving cluster parallax, Velocity Dispersion, Compact objects (BH-systems, Accretion rate/efficiency, Eddington luminosity),

Unit IV

Shape, size and contents of our galaxy, Normal and active galaxies, High energy physics (introduction to X-ray and Gamma-ray radiation processes), Newtonian cosmology, microwave background, early universe.

Text Books:

1. William K. Rose: Atrophysic, Dover Publications, (2010).
2. Padmanabhan, T., Theoretical Astrophysics, Vols.1-3, Cambridge University Press, 2005.
3. BadyanathBasu: An introduction to Astrophysics, Prentice Hall of India, (2003).
4. D. D. Clayton: Principle of Stellar evolution and nucleosynthesis, University Chicago Press, (1984).
5. R. Kippenhahn and A.Weigert: Stellar structure and evolution (Astronomy and Astrophysics Library), Springer, (1994).
6. K. D. Abhayankar: The Physics of Stars and Galaxies
7. H. L. Duorah and KalpanaDuorah.: Introduction to Astrophysics

8. Frank H. Shu: The Physical Universe: An Introduction to Astronomy, University Science Books, California, (1982).

9. Bradley W. Ostlie and Dale A. Carrol: An introduction to Modern Astrophysics, Addision-Wesley, (1996).

References

1. Harwit, M., Astrophysical Concepts, 3rd ed, Springer-verlag, 2006.

2. Erika Bohm-Vitense, Introduction to Stellar Astrophysics, Vol. 3 : Stellar structure and evolution

3. Shapiro &Teukolsky,Black Holes, White Dwarfs & Neutron stars.

QUANTUM FIELD THEORY

PHY-PG-E402/3-C

UnitI: Scalar and Spinor Fields

Need for Field Theoretic description, Klein-Gordon Field: Lagrangian formulation, symmetries and conservation laws, canonical quantization, propagators, Feynman diagrams

Dirac Field: Canonical quantization, propagators, Symmetries: Gauge Symmetries, Gauge Field: Elementary realization of BRST symmetry and gauge fixing.

Unit II: Interactions

Hamiltonian formulation, S-matrix, Interacting Fields and Feynman Diagrams, Yukawa Theory, Elementary processes of Quantum Electrodynamics, radiative corrections.

Unit III: Renormalization

Functional Methods, Systematics of Renormalization, Renormalization and Symmetry, Renormalization Group, Critical Exponents. Wilsonian renormalization.

Unit IV: Non-Abelian Gauge Field

Non-AbelianGauge invariances,Quantizations, Quantum Chromodynamics, Operator products, effective vertices, Gauge theory with spontaneous symmetry breaking, Higgs mechanism.

Text Books

1. M. E. Peskin, D. V. Schroeder: An Introduction to Quantum Field Theory, Addison-Wesley, 1995.
2. F. Mandl and G. Shaw: Quantum Field Theory, John Wiley, 1992.
3. S. Weinberg, The Quantum Theory of Fields, Vol. I and II, Cambridge University Press, 2005
4. C. Itzyksion and J B Zuber, Quantum Field Theory, Dover Publications, 2006

Reference Books:

1. T. P. Cheng and L.-F. Li: Gauge Theory of Elementary Particle Physics, Oxford University Press, 1984.
2. S. Pokorski: Gauge Field Theories, Cambridge University Press, 2000.
3. L. H. Ryder: Quantum Field Theory, Cambridge University Press, 1996.
4. D. Bailin and A. Love: Introduction to Gauge Field Theory, IOP Publishing, Graduate Student Series in Physics, 1986.
5. P. B. Pal and A. Lahiri: A First Book of Quantum Field Theory, CRC Press, 2001.
6. A . Zee, Quantum Field Theory in a nutshell, Princeton University Press, 2010

ADVANCED ELECTRONICS

PHY-PG-E402/3-D

Unit I

Modulation & Demodulation: Modulation, types (AM, FM and PM), mathematical analysis of Amplitude Modulated and Frequency modulated carrier wave, AM signal detection using diode detector & transistor detector, FM detection using quadrature detector, basic concept of vestigial side band modulation.

Unit II

Optical Fibre Communication: Introduction, advantages & disadvantages over transmission lines, classification of optical fibres, light propagation through optical fibres: Snell's law, total internal reflection, acceptance angle and numerical aperture, block diagrammatic description of fibre- optic communication system, Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM), Losses in optical fibres.

Unit III

Satellite communications: Introduction to digital communication techniques, satellite orbits, satellite orbital patterns, Geo- synchronous satellites, Satellite system link models: Uplink model, transponders & downlink model (Block diagrammatic description only).

Unit IV

Cellular communication: Introduction to cellular telephone service, evolution of cellular telephone, fundamental concepts, frequency re-use, interference (co-channel and adjacent channel)

Text Books:

1. Simon Haykin: Communication Systems : 4th Ed., John-Wiley & Sons (2000)
2. W. Tomasi: Advanced Electronic Communication Systems, 6th Ed., P.H.I. (2005)
3. Martin S. Roden: Analog & Digital Communication Systems, 3rd Ed., PHI (2005)
4. B. P. Lathi: Modern digital and Analog Communication Systems, Oxford University Press, 3rd ed., (1998).
5. Das, Mallik and Jain:Communication Systems.

ADVANCED STATISTICAL PHYSICS AND ATOMIC

PHY-PG-E402/3-E

Unit I: Statistical Mechanics of Interacting System

Imperfect gases at low temperature: Method of pseudopotential: two body problem, N-body problem, imperfect Bose gas, Fermi gas. Cluster expansion: classical gas, quantum mechanical system; Virial coefficients.

Phase transitions: Formulation of the problem; Theory of Yang and Lee; Lattice gas, binary alloy, Ising model in one and two dimensions, liquid Helium.

Unit II: Fluctuations

Thermodynamic fluctuations, spatial correlations in fluid; Brownian motion, Einstein-Smoluchowski theory, Langevin theory; Fokker- Planck equation, Spectral analysis, fluctuation-dissipation theorem, Onsagar relations.

Unit III: Interaction of Atoms with Radiation

Perturbation by an oscillating electric field, The rotating-wave approximation, Interaction with monochromatic radiation, The concepts of ð-pulses and ð/2-pulses, The Bloch vector and Bloch sphere, Ramsey fringes, Radiative damping, The damping of a classical dipole, The optical Bloch equations, The optical absorption cross-section, Cross-section for pure radiative broadening, The saturation intensity, Power broadening, The a.c. Stark effect or light shift. Doppler free spectroscopy.

Unit IV: Non-linear Optical Susceptibility

Introduction, Schrödinger calculation of non-linear optical susceptibility, Perturbation solution of the Density matrix equation of motion, density matrix calculation of the Linear and second order susceptibility, Electromagnetic Induced transparency, Intensity dependent refractive Index. Experimental evidences: Optical Cooling and Trapping of Atoms, Magnetic trapping of neutral atoms, quantum information processing of the trapped ions.

Text Books:

1. R. K. Patharia: Statistical Mechanics (2^{nd} Ed) Butterworth Heinman, Elsevier (2005)
2. K. Huang: Statistical Mechanics (2^{nd} Ed) John Wiley & Sons (2002)
3. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules, Longman,1996.
4. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill, 1994.
5. Atomic Physics- C J Foot, Oxford master series in Physics
6. Wolfgang Demtröder- Laser Spectroscopy Vol. 1: Basic Principles(4th edition)- Springer (2008)
7. Rober Boyd- Nonlinear Optics – 3rd edn. – Elsevier (2008)
8. H Metcalf and P V der Straton, Laser cooling and Trapping, 1994, Springer)
9. K Thyagarajan and Ajoy Ghatak, Lasers: Fundamentals and Applications, Springer, 2011, 2^{nd} edition.

Reference Books:

1. G. K. Woodgate, Elementary Atomic Structure, Clarendon Press, 1989.
2. F. L. Pilar, Elementary Quantum Chemistry, McGraw Hill, 1990.
3. H. E. White, Introduction to Atomic Spectra, Tata McGraw Hill, 1934.
4. J. M. Hollas, Modern Spectroscopy, John Wiley & Sons, 2004.
5. R.J. Abraham and J. Fishe and P. Loftus, Introduction to NMR Spectroscopy, John Wiley & Sons. 1994.
6. J. A. Weil, J.R. Balton & J.E. Wertz, Electron Paramagnetic Resonance: Elementary Theory and Practical Applications. John Wiley and Sons, 1994.

X-RAY CRYSTALLOGRAPHY AND MOLECULAR BIOPHYSICS

PHY-PG-E402/3-F

Unit I

The Crystalline state of solids:

The crystalline and amorphous state, covalent solids, ionic solids, hydrogen bonded solids and metals.

Space lattice, unit cell, Bravais lattices, crystal planes and Miller indices, spacing of planes in crystal lattices, symmetry operations, point groups and crystal classes, screw axis and glide planes, space groups.

Unit II

Origin of X-rays, Continuous and Characteristics spectra, Absorption of X-rays, Absorption edge, filters, production of X-rays, modern X-ray generator.Scattering of X-rays by an electron, an atom and a unit cell, atomic scattering factors, Diffraction of X-rays, the Bragg's law.

Unit III

Diffraction methods- Laue method, powder method, precision determination of lattice parameters, x-ray diffractometer. Reciprocal lattice, sphere of reflection, rotating crystal method, use of oscillation photograph, determination of lattice parameter from oscillation photograph. Integrated intensity and their measurement, Lorentz polarization correction, Debye-Waller temperature factor.Structure analysis by Fourier Synthesis.

Unit IV ‘

Bio molecules: chemistry of monomers and polymers, amino acids, lipids, nucleic acids, proteins, DNA, RNA, Protein crystallization, X-ray diffraction from Protein crystals, crystals structures of some protein molecules, Fibre diffraction , interpretation of fibre-pattern x-ray diffraction.

Text Books:

1. B. D. Culity: Elements of X-ray diffraction, Addison-Wesley, 3rd Printing, (1967).
2. Henry, M. F. M.Lipson, W.A. Wooster, Henry: Interpretation of x-ray diffraction Photograph. Macmillan, London, (1961)
3. Harold, P. Klug and E. L. Alexender: X-ray diffraction procedures for polycrystalline and Amorphous Materials. Wiley-Interscience, 2nd Edn. (1974).
4. Wolfram Saenger: Principle of Nucleic Acid Structure. Springer, (1988).
5. J. M. Berg, J. L, Lubert Stryer: Bio Chemistry. W. H. Freeman, 5th Edn. (2002).

DEPARTMENT OF PHYSICS

M.Phil./Ph.D. Course Work Syllabus

Code	Course Name	Credits	Marks
PHY-RS-C501	Research Methodology and computational techniques	4	100
PHY-RS-C502	Research Proposal and Preparation	4	100
PHY-RS-E503	Atomic, Molecular and Optical Physics	4	100
PHY-RS-E504	Solid state Spectroscopy	4	100
PHY-RS-E505	High Energy Physics	4	100
PHY-RS-E506	Semiconductor Physics and Devices	4	100
PHY-RS-E507	Quantum Optics & Quantum Information Processing	4	100
PHY-RS-E508	Nonlinear Science: Solitons And Chaos	4	100
PHY-RS-E509	Magnetism and Superconductivity	4	100
PHY-RS-E510	Semiconductor Laser Physics	4	100
PHY-RS-E511	Solar Energy and its Utilization	4	100
PHY-RS-E512	Physics of Nanomaterials and Devices	4	100
PHY-RS-E513	Plasma Physics	4	100
PHY-RS-E514	Thin Film Technology	4	100
PHY-RS-E515	Quantum Field Theory	4	100
PHY-RS-E516	General Relativity and Cosmology	4	100

Physics M.Phil/Ph.D. Syllabus

Research Methodology and Computational Techniques

PHY-RS-C501

Unit I: Computational Techniques

Representing numbers in a computer – machine precision – errors and approximations – concept of computer language – Fortran 90 programming – Matlab syntax – Mathematica syntax, Origin Syntax .Random number generator – Monte Carlo simulation, Fast Fourier Transform.

Unit II: Numerical Techniques

Solution of polynomial and transcendental equations, ordinary differential equations with initial conditions, matrix algebra and simultaneous equations, eigenvalues and eigenvectors of a real symmetry matrix. Numerical differentiation and integration – trapezoidal rule – Simpson' rule – Gaussian quadrature formula. Numerical solution of ordinary differential equations solution by Taylor's series – Euler's method – RungeKutta method with Runge's coefficients. Numerical solution of partial differential equations using finite difference method.

Unit III: Curve Fitting

Error analysis, Importance of sampling, Curve fitting – evaluation of linear parameters – weighted least square fitting – Binomial, poission, Normal distribution, Chi-square goodness of fit test, Random Spectral data analysis.

Unit IV: Technical Writing

Language of Science and technology, Technical presentations design and delivery, Collecting materials for research, Organization of research paper/dissertation – symbols – the observations

– tables and figures – equations – the style – sentence length – word length – page and chapter format – referencing.

– tables and figures – equations – thestyle – sentence length – word length – page and chapter format – referencing.

References:

1. R.P. Mishra Research Methodology: a handbook, Concept Publishing Company, New Delhi, 2002.
2. Jonathan Anderson and M.E. Poole: Assignment & Thesis Writing, John Wiley, 2002.
3. S.D. Sharma: A Textbook on Scientific and Technical Communication Writing for Engineers and Professionals, Sarup and Sons, 2007.
4. Robert A. Dey and B. Gastel: How to Write and Publish a Scientific Paper, Cambridge, 2006
5. Thomas R. Mc Calla: Introduction to Numerical methods and Fortran programming, John Wiley & Sons, Inc. New York 1967.
6. Anthony Rabston: A First course in Numerical Analysis, McGraw Mill Co., New York 1965.
7. Evous, D.J: Software for Numerical Methods, Academic Press Inc. New York, 1974.
8. E.V. Krishnamurthy: Numerical Analysis and algorithm, Wiley Eastern, 1982.
9. S.S. Sastry: Introduction methods of Numerical analysis, Prentice Hall of India P. Ltd., 1977.
10. M.K. Jain: Numerical analysis for Scientists &Engineers, SBW Publishers, Delhi 1971.
11. Kurt Binder and D.W. Heermann: Monte Carlo Simulation in Statistical Physics: an Introduction, Springer, 2010.

Research Proposal and Preparation

PHY-RS-C502

This is a non-lecture paper in which the respective teacher will explain the student about how to prepare synopsis or research proposal. Students will also do literature survey for the relevant topic(s) that he/she is interested in. At the end of the semester he/she will give a presentation and a write-up. He/she will be evaluated on the basis of that.

PHY-RS-E503: Atomic, Molecular and Optical Physics Unit I: Introduction

Basic Optics: Fourier optics, two beam and multiple beam interference, Fabry-Perot interferometer. Interaction of radiation with matter, light amplification and gain saturation. Laser rate equations, three level and four level systems; Free electron laser, Optical

Resonators: resonator stability; modes of a spherical mirror resonator, mode selection; Q switching and mode locking in lasers.

Atomic Collisions: Types of collisions, channels, thresholds, cross-sections, potential scattering, general features, Born approximation. Phase shift analysis (low energy), Atomic collisions in solids, nuclear and electronic stopping.

Unit II: One, two and many electron atoms

Schrodinger equation, para and ortho states, Pauli Exclusion Principle, Excited states, doubly excited states, Auger effect, resonance. Central field approximation, Thomas-Fermi model, Hartee-Fock method and self-consistent field, Hund's rule, L-S and j-j coupling.

Interaction with Electromagnetic fields: Selection rules, spectra of alkalis, Helium and alkaline earths, multiplet structure, Zeeman and Stark effect, Paschen-Back effect

Unit III: Molecular Structure and spectra

Molecular Structure: General nature, Born-Oppenheimer separation, rotation and vibration ofdiatomic molecules, electronic structure of diatomic molecules, structure of polyatomic molecules.

Molecular spectra: Rotational, vibrational, electronic spectra of diatomic molecules, electronic spin and Hund's cases and nuclear spin, Raman and Infra-Red spectrums.

Unit IV: Resonance Spectroscopy

NMR: Principle, chemical shift, shielding, relaxation process, chemical & magnetic non equivalence, local dia magnetic shielding and magnetic anisotropy, spin splitting, Pascal triangle, coupling constant, mechanism of coupling, quadrupole broadening and decoupling. Effect of stereochemistry on the spectrum, shift reagent, applications.

ESR: Principle and correlation with proton magnetic resonance, derivative curves, g values, hyperfine splitting, Applications.EPR of triplet states; Structural applications to transition metal complexes.

Mössbauer Spectroscopy: Principle, Spectral parameters (Isomer shift, electric quadrupole interactions, magnetic interactions), temperature-dependent effects, structural deductions for iron and tin complexes, applications. Basic concepts of FTIR and Raman and its applications to various materials.

References:

1. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules, Longman, 1996.
2. G. K. Woodgate, Elementary Atomic Structure, Clarendon Press, 1989.
3. F. L. Pilar, Elemntary Quantum Chemistry, McGraw Hill, 1990.
4. H. E. White, Introduction to Atomic Spectra, Tata McGraw Hill, 1934.
5. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill, 1994.
6. J. M. Hollas, Modern Spectroscopy, John Wiley & Sons, 2004
7. C. N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill, 1994.
8. R.J. Abraham and J. Fishe and P. Loftus, Introduction to NMR Spectroscopy John Wiley & Sons. 1994.
9. J. A. Weil, J.R. Balton& J.E. Wertz, Electron Paramagnetic Resonance: Elementary Theory and Practical Applications. John Wiley and Sons, 1994.

Solid State Spectroscopy

PHY-RS-E504

Unit I: Atomic Spectroscopy

Free Ion: The Free-ion; free ion terms for d2 and f2 configuration; Spin-orbit Coupling; Energy level states for d2 and f2 configuration; Ground states for fN configuration; Rare earthfree-ions; Coloumb and Spin-orbit energies - Intermediate coupling.

Ligand Field: The concept of ligand field; The scope of ligand field theory; The Physicalproperties affected by ligand fields; Ligand fields and f electron systems; The magneticproperties of actinide element compounds.

Unit II: Group Theory

Sketch of Group theory; Kramer's degeneracy; Crystal field splitting - D3hsymmetry; Product of two representations - Selection rules; Examples of selection rules -D3h symmetry; Applications of theoretical results to the analysis of experimental data.

Unit III: Optical Spectra

Rare Earth Ions: Judd-Ofelt theory for the parametrization of intensities; Radiative properties; Upconversions in rare earths; Luminescent properties of Eu^{3+} and Tb^{3+} ions.

Trivalent Rare Earth Ions in Crystal Field: Introduction; Parametrization of crystal field splittings; The spin Hamiltonian; Examples of crystal field parametrization; Model description of the crystal field.

Unit IV: Optical Instruments and Spectral Analyses

Rare Earth Lasers: Introduction; Principles of laser action; Typical rare earth lasers; Nd:YAG and Nd:glass lasers; Energy level scheme of the Nd in YAG.

Spectral Analyses: Spectrographs and Spectrophotometers for UV, VIS and IR regions; Absorptionand Emission spectra; Temperature dependent spectra; Axial, Sigma and Pi polarization spectral measurements.

References

1. B.N. Figgis; Introduction to Ligand Fields, Wiley Eastern Limited, New Delhi, 1976.
2. S. Hufner, Optical Spectra of Transparent Rare Earth Compounds, Academic Press, London (1978).
3. J. W. Robinson: Atomic Spectroscopy, M Dekker, New York, 1990.
4. Joseph Sneddon et al.: Lasers in analytical atomic spectroscopy, Wiley VCH, 1997.
5. J. Michael Hollas: Modern spectroscopy, John Wiley & Sons, 2004.
6. A. W. Joshi, Elements of Group Theory for Physicist, New Age International Publishers, New Delhi, 2005.
7. Michael Tinkham: Group Theory and Quantum Mechanics, McGraw Hill, 2003.

High Energy Physics

PHY-RS-E505

Unit I: Introduction

Special theory of relativity and kinematics, Classification of fundamental interactions and elementary particles. Yukawa's proposal on meson exchange. Nother's theorem in classical mechanics, continuous space time symmetries and associated conservation laws of momentum, energy, angular momentum. Lorentz invariance.

Unit II: Symmetries and Conservation Laws

Symmetries in quantum mechanics, Discrete Symmetries, Parity, Charge conjugation and time reversal. Examples of determination of intrinsic quantum numbers, mass and spin. Charge independence of nuclear forces, isospin and strangeness. Application of isospin invariance to pion nucleaon scattering. Starngeness charm and other additive quantum numbers.Resonance and their quantum numbers with special reference to pion nucleaon scattering. Gell Mann Nishijima formula.

Violation and symmetries: Isospin violation in electromagnetaic interactions, Parity non- conservation in weak interactions, CP violations and KoKosystem.

Unit III: Theoretical Techniques I

Introduction to Gauge theory of fundamental interactions, Covariant Perturbation theory, Feynman diagrams in momentum space and its applications in QED and QCD.Lie groups: SU(2), SU(3) and SU(5) and their applications: Higgs Mechanism and Goldstone theorem and its application in gauge theories.

Unit IV: Theoretical Techniques II

Feynman Rules for spin 0 and spin ½ particles and their applications ,Parton model, Deep- Inelastic Scattering (DIS), QCD-evolution equations. Standard model of electroweak interaction, Minimal supersymmetric standard model (MSSM), neutrino masses and mixing angles.

Books:

1. T.P. Cheng and Li: Gauge theory of Elementary Particles, Oxford University Press, 2000.
2. David Griffiths, Introduction to Elementary Particles, Wiley VCH, 2008.
3. Donald Perkins, Introduction to High Energy Physics, Cambridge University Press, 2008
4. G. L. Kane: Modern Elementary Particle Physics, Addison Wesley, 1993.
5. B. Zwiebach, A first course in string theory, Cambridge University Press, 2004.
6. J. Hartle, Gravity: An introduction to Einstein's general relativity, Pearson education, 2003.
7. A. Das and T. Ferbel: Introduction to Particle & Nuclear Physics, World Scientific Publishing, 2004.

Semiconductor Physics and Devices

PHY-RS-E506

Unit I: Characterisation of Semiconductors

Review of quantum theory of semiconductors, Semiconductors in equilibrium, Carrier transport in semiconductors, Semiconductor under non-equilibrium. Hall effect: measurement of resistivity, mobility, carrier concentration, diffusivity, Hall coefficient, Haynes-Shockley experiment, mobility, diffusivity and life time of minority carriers.

Unit II: P-N Junctions-Characteristics and Devices

Junction in equilibrium, Continuity of Fermi level across the junction, Junction under forward and reverse bias, Zero bias, Builtin- potential, Electric field in depletion region, Biased junction, Space charge width under electric field, Junction capacitance, Diffusion capacitance, One sided junction, Non-uniformly doped junctions, Linearly graded, Hyper abrupt etc., Avalanche and Zener Breakdown. Zener diode, Varactor diode, Tunnel diode, Photovoltaic Cell.

Unit III: Junction Diodes and Transistors

Metal-semiconductor Junction Diode: Structure, metal semiconductor contacts, energy band diagram for different cases, barrier formation, Schottky barrier diode, Nonideal effects on barrier heights, Current voltage characteristics, Comparison of barrier diode and PN-junction diode, Metal Semiconductor Ohmic Contact, Ideal non-rectifying barriers, Heterojunction, Two dimensional electron gas.

Bipolar Junction Transistor: Structure, Basic principle of operation, Modes of operation, Carrier concentration profile in various regions in forward active mode, current gain and current gain factors, Equivalent circuit models: Ebers-Moil model, Dependence of Ebers-Moll parameters on the structure and operating point, Maximum transition current, Voltage and power rating, Transistor as a switch.

Unit IV: Semiconductor Devices

Photodiode and solar cells, Microwave Devices: IMPATT devices: Read diode, principle of operation, applications, other structures. Gunn devices: Two valley semiconductors, transferred electron mechanism, formation and drift of space charge domain, application to resonant circuit. Semiconductor optical amplifiers, LEDs and LDs: device structure and characteristics, DFB, DBR, and quantum well lasers, Laser diode arrays, Semiconductor photodetectors; PINs and APDs, CCDs and OEICs

References:

1. Adir Bar-lev: Semiconductor and electronic Devices, Prentice Hall of India, 1993.
2. Hess, K.: Advanced Theory of Semiconductor Devices, Prentice Hall of India, 2000.
3. Roy.D.K. : Physics of Semiconductor Devices, University Press, India, 2000.
4. Streetman, B.G.: Solid State Electronic Devices, Prentice Hall of India, 2000.
5. Sze, S.M.: Semiconductor Devices; Physics and Technology, Wiley Eastern Ltd. 2009.
6. Sze, S. M: Physics of Semiconductor Devices, Wiley Eastern Ltd., 2007.
7. Wang, S.: Fundamentals of Semiconductor Theory and Device Physics, Prentice Hall of India, 1989.
8. Jasprit Singh, Semiconductor Devices - Basic Principles, John Wiley &Sons, Inc., 2002.
9. Zambuto, M.: Semiconductor Devices, McGraw Hill, 1989.

Quantum Optics & Quantum Information Processing

PHY-RS-E507

Unit I: Quantum theory of radiation

Review of quantum theory of radiation; Quantization of free electromagnetic field; Fock states, Lamb shifts, Quantum beats, coherent & squeezed states of the field, Quantum distribution theory & partially coherent radition (Q-representation and Wigner- Weyle distribution).

Unit II: Quantum Field Interactions

Field- Field and Photon – Photon interferometry, First& second order Coherence; photon detection & quantum coherence functions. Photon counting & Photon statistics; Classical & Quantum description of TWO source interference, Atom-field interaction- Semiclassical& Quantum theory.

Unit III: Quantum Optics

Laser without inversion & other effects of atomic coherence &interference Resonance flurescence Quantum theory of laser- density operator approach and Heisenberg- Langevein approach, Theory of microMasers. Atom optics. EPR paradox; hidden variable & Bell’s theorem; Quantum calculation of the correlation in Bell’s theorem; Bell’s theorem without inequalities (GHZ equality). Quantum Cryptography (Bennett- Brossard protocol)Qantum Non demolition measurement.

Unit IV: Quantum Computations

Quantum circuits; Quantum search algorithm, Quantum Computers- Physical realization, Condition for quantum computation, Different implementation schemes for quantum computation; Quantum information theory (Distinguishing Quantum states, Data compression, Classical& Quantum information & noisy Quantum channels), Entanglement as physical resonance, Quantum key distribution and security of quantum key distribution.

Books:

1. M.O. Scully & M. SuhailZubairy: Quantum optics, Cambridge University Press, 2002.
2. D. F. Walls and G. J. Milburn: Quantum optics, Springer, 2008.
3. M A Nielsen & I L Chuang: Quantum Computation & Quantum Information, Cambridge University Press, 2010.
4. Rodney Loudon: The Quantum theory of light, Oxford University Press, 2003.
5. IoanBurda: Introduction to Quantum Computation, Universal Publishers, Florida, USA, 2005.

Nonlinear Science: Solitons and Chaos

PHY-RS-E508

Unit I: Introduction

Nonlinear equations in physics: an overview, Non-linear mechanics. Sensitive dependence on initial conditions. Discrete-time systems, Continuous time systems, Phase space, Poincare section, Spectral analysis of time series and power spectra, attractors, Bifurcation diagrams.

Stability: Fixed points, Lyapunov Stability, Asymptotic Stability, Poincare Stability, Lagrange Stability, Periodic and quasi-periodic motions, Logistic map-period doubling, periodic windows, Entropy and direction of time, Prediction of chaotic states-methods of analogues-linear approximation method.

Unit II: Chaotic Motion

Intermittency mechanism (Type I, II and III intermittencies), Bifurcations of homoclinic orbits, saddle point, turbulence, Fractal and fractal dimensions, self-similarity and self-affinity.

Hamiltonian theory, Duffing oscillator- Nonlinear oscillator – Standard map – integrable mapping- Non integrable mappings, Kepler's problem - order and chaos – Simple applications of chaos in physical systems - Quantum chaos-Applications.

Unit III: Solitons & Coherent Structures

Linear waves, wekly nonlinear and dispersive waves, solitonds, Kdv, NLS, Sine-Gordon systems, examples and applications in physics and engineering; Nonlinear optical phenomena second harmonic generation, parametric processes, optical solitons, soliton based all optical communications.

Unit IV: Applications

Non-linear systems, Nonlinear optics - Optical communications - Fluid dynamics - Magnetic systems – Liquidcrystals – Biomolecules - Medical physics - Plasma and Astro physics - Electrical circuits -, management systems, chaos in-earthquake dynamics - quantum physics - statistical mechanics.

References:

1. Thierry Vialar, Complex and chaotic nonlinear dynamics, Springer-Verlag, 2009.
2. Ali H. Nayfeh and B. Balachandran, Applied nonlinear Dynamics, WILEY-VCH, Verlag, 2004
3. M. Lakshmanan (Ed.,) Introduction to Solitons, Springer-Verlag, 1988.
4. M.J. Ablowitz and H. Segur, Solitons and Inverse Scattering Trasform, Philadelphia (1981).
5. P.G. Drazin and R.S. Johnson, Solitons: An Introduction, Cambridge University Press, 1989.
6. A.J. Licthenberg and M.A. Lieberman Regular and Stochastic Motion, SpingerVerlag, Berlin, (1983)
7. J.M. Thompson and H.B. Stewart, Nonlinear Dynamics and Chaos, John Wiley and Sons, 1989.
8. A.S. Davydov, Solitons in Molecular Systems, Kluwer Academic Publishers, 1991
9. A. Hasegawa and Y. Kodama, Solitons in Optical Communications, Oxford Press, 1995.

Magnetism and Superconductivity

PHY-RS-E509

Unit I: Magnetism – I

Static Phenomena : Diamagnetism; Paramagnetism; Crystal-field effects; John-Teller effects; Adiabatic demagnetization; Molecular field theory of ferromagnetism; Heisenberg-exchange interaction; Superexchange; Ruderman-Kasuya and Yosida interaction; Series-expanison and Bethe-Peierls-Weiss methods; Spin Waves; Ginzburg-Landau theory of the ferromagnetism.

Unit II: Magnetism – II

Slater-Puling Curve; Shape, magnetocrystalline and other types of anisotropy; Micromagnetics; Origin and observation of ferromag - neticdomins; Soft and hard magnetic materials; magnetic exchange bias, Different stages of magnetic ordering in alloys; Kondo, spin-glass, cluster spin- glass, inhomogeneous long-range characterization and the relevant theoretical concepts.

Applications of bulk and thin film magnetic materials and multi layers.

Dynamic Phenomena: Linear Response Theory: Magnetic response and relaxation; Generalized magnetic susceptibility; Kramers-Kronig relations.

Unit III: Superconductivity I

Basic properties of superconductors. Phenomenological thermodynamic treatment. Two fluid model; Magnetic behaviour of superconductors, intermediate state, London’s equations and penetration depth, quantized flux. Pippard’s non-local relation and coherence length.Ginzburg- Landau theory, variation of the order parameter and the energy gap with magnetic field, isotope effect; Energy gap and its measurement; magnetization, specific heat and thermal conductivity; electron-phonon interaction and cooper pairs, brief discussion of the B.C.S. theory, its results and experimental verification; (p- and d- wave pairs).

Unit IV: Superconductivity II

Tunneling in SIN and SIS sandwiches, practical details; Coherence of the electron-pair wave, Weak links; dc and ac Josephson effects, superconducting Quantum Interference Devices (SQUID).

Type II superconductivity, magnetization of type-II superconductors, mixed state, surface energy, specific heat, critical currents of type-II superconductors flux lattice, flux flow (creep). Superconducting materials (only qualitative description) conventional low temperature superconductors, High temperature superconductors, heavy fermions system, boro-carbides.

Books:

1. A. H. Morrish: Physical Principles of Magnetism, R. E. Krieger Pub. Co., 1980
2. S. Chikazumi: Physics of Magnetism, R. E. Krieger Pub. Co., 1978
3. Wolfgang Nolting, AnupuruRamakanth: Quantum Theory of Magnetism, Springer, 2009.
4. R. M. White: Quantum Theory of Magnetism, Springer, 2007
4. S. Dattagupta: Relaxation Phenomena in condensed matter , Academic Press, 198
5. M. Tinkham: Introduction to Superconductivity, McGraw Hill, 1996
6. P. G. deGennes: Superconductivity of Metals and Alloys, Advanced Book Program, Perseus Books, 1999
7. K. H. Bennemann, J. B. Ketterson: The Physics of Superconductors, Springer Verlag, 2003.

Semiconductor Laser Physics

PHY-RS-510

Unit I: Introduction

Physics of interaction between radiation and atomic systems including: stimulated emission, emission line shapes and dispersion effects. Physics of semiconducting optical materials, degenerate semiconductors and their homojunctions and hetrojunctions.Light emitting diodes (LED's), Junction lasers. Characteristics of diode laser arrays and applications.

Unit II: Double Hetero Structure & Quantum Wells

Double Hetero Structure: Materials and growth techniques – brief outlook, electronic properties of heterojunctions,optical properties of hetero-junctions, lateral mode control.

Quantum Wells: Semiconductor multi quantum wells, density of states in 2-D systems, optical transitions, gain,strained quantum wells, optical and electrical confinement, strained layer superlattices (SLS)

Unit III: Diode Laser Modelling

Rate equations of idealised diode laser, gain compression, small signal rate equations, real laser diodes: InGaAsP/InP quantum well lasers, three level rate equation models for quantum well SCH lasers.

Unit IV: Applications of Laser

Application of lasers in data storage, communication and information technology: CD players, DVDs, laser printers, bar-code scanners, and optical communication; Surface profile and dimensional measurements using diffraction and its variations; High-power laser applications: marking, drilling, cutting, welding, and hardening; laser fusion; Laser Doppler velocimetry, LIDAR, laser spectroscopy, medical applications of lasers.

Books

1. D. Sands: Diode Lasers, Institute of Physics, UK, 2005.
2. S. Hooker and C. Webb: Laser Physics, Oxford University Press, 2010.
3. W. W. Chow and S. W. Koch: Semiconductor Laser Fundamentals, Springer-Verlag, 1999.
4. C. Hammaguchi: Basic Semiconductor Physics, Springer-Verlag, 2010.
5. K. Seeger: Semiconductor Physics, Springer-Verlag, 2004.
6. L. A. Coldren and S. W. Corzine : Diode lasers and photonic integrated circuits, John Wiley & Sons, Inc., 1995.
7. Eli Kapon: Semiconductor lasers – Part – I., (Fundamentals), Academic Press, 1999.
8. P. S. Zory Jr.: Quantum Well Lasers, Academic Press 1993.

Solar Energy and Its Utilization

PHY-RS-E511

Unit I: Radiation & Energy Storage

Radiation Geometry: Basis earth sun angles - Determination of Solar time - Derived Solar angles - Day length - Solar Radiation measurements - selective surfaces - Heat balance energy lost by radiation, convection and conduction - Physical characteristics of selectives surface - Anti reflection coatings - Solar reflector materials - production methods of coatings.

Energy storage and solar applications: Types of energy storage Thermal storage Latent heat storage – Electrical storage Principle of operation of solar ponds-Non convective solar ponds – Theoretical analysis of solar pond – solar distillation – solar cooking –solar pumping.

Unit II: Fundamentals of Heat Transfer

Transfer of Heat by Conduction: Study heat flow in a slab-steady heat flow in a cylindrical shell- Heat transfer through fins – Transient heat conduction.

Thermal Radiation: Basic laws of radiation – Radiant heat transfer between two black bodies- Radiant heat transfer between grey bodies.

Conduction heat loss Evaluation of convective heat transfer co-efficient –Free convection from vertical planes and cylinders – Forced convection – Heat transfer for fully established

flow in tubes.

Unit III: Solar Thermal systems

General description of plate collector – thermal losses and efficiency of FPC –Energy balance equation – Evaluation of overall loss coefficient – Thermal analysis of flat plate collector and useful heat gained by the fluid performance of solar air heaters – Heating and drying of agricultural products Types of drier in use.

Solar concentrators and Receiver geometries – General characteristics of focusing collector systems Evaluation of optical losses – Thermal performance of focusing collectors.

Unit IV: Photovoltaics

Description of the photovoltaic effect – Electrical characteristics calibration and efficiency measurement – silicon solar energy converters – Thermal generation of recombination centers silicon.

Role of thin films in solar cells, Quantum dots, Properties of thin films for solar cells CdSe, CeTe, InP, GaAs, CdCu2, CuIn SnO2, Cd2SnO4 ZnO)- Transport properties of metal films – poly crystalline film silicon solar cells (Photovoltaic characteristics, junction analysis loss mechanisms) Amorphous silicon solar cells (Structural compositional optical and electrical properties)

Books

1. GD. Raj: Solar energy utilization, Khanna Publishers, New Delhi, 2005.
2. H.P. Garg and J Prakash: Solar Energy: Fundamental and Applications, Tata McGraw Hill, 2000.
3. Charles E.: Solar cells, IEEE Press, 1976.
4. K. L. Chopra and S. Ranjan Das: Thin film solar cells, Plenum, New York, 1983.

Physics of Nanomaterials and Devices

PHY-RS-E512

Unit I: Physics of quantum dots & wells

Introduction, quantum dots, wires, wells. Density of states in 0, 1 & 2D.Growth of quantum dots

– SK quantum dots – basics of semiconductor quantum dots –Electron photon scattering - Exciton dynamics in quantum dots – carrier relaxation inquantum dots – optical spectroscopy of single and multiple quantum dots – basics of metalquantum dots and their applications.

Infinite deep square wells – parabolic wells –triangular wells –sub-band formation in low dimensional system – occupation of sub-bands –quantum wells in hetero-structures, strained layer super-lattices – basics of tunneling transport – current and conductance – current in one dimension – current in two and three dimensions – basis of coherent transport.

Unit II: Growth of hetero-structures

Growth of hetero-structures by MBE and MOCVD method – band gap engineering by swipt heavy ion beam methods –modulation doping – 2DEG formation – Strained layers and its effect

– wire and dot formation – optical confinement – effective mass approximation in hetero- structures – photon, electron and proton beam lithography methods –methods in the nanoscale device fabrication

Unit III: Photonic devices

Metal semiconductor contacts – space charge region – schottky effect – ohmic contact –Basic microwave technology – tunnel diode – impatt diodes – transferred electron devices –quantum effect devices – light emitting diodes – basics of Solar cells – lasers and quantumwell lasers, VCSEL, Plasmons.

Unit IV: Characteristics of Nanomaterials

Spectroscopy of nanomaterials, bulk, Raman Scattering, STS, TEM, SCM, XRD, Raman spectroscopy.

References:

1. John H. Davies: The Physics of Low dimensional semiconductors, Cambridge University Press, 2000.
2. S. M. Sze: Semiconductor devices: Physics and Technology, John Wiley &Son, 2009
3. Garnett W. Bryantand Glenn Solomon: Optics of quantum dots and wires, Artech House, 2005.
4. Marius Grundmann: The Physics of Semiconductors: An Introduction including nanophysics and Applications, Springer, 2010.
5. S. L. Chuang: Physics of Photonic Devices, John Wiley & Sons, 2009.
6. Paul Harrison, Quantum Wells, Wires and Dots, John Wiley & Sons, 2005.

Plasma Physics

PHY-RS-E513

Unit I: Introduction

Introduction to plasma, definition, concept of temperature– Debye Shielding – The Plasma parameters – Criteria for Plasma.

Applications of Plasma physics (basis ideas) single – Particle motions; uniforms E and B fields – Gravitational field – Non uniform B fields – Gravitational field – Non – uniform B field – Curve B - magnetic mirrors non Uniform E filed Time – varying B field – Adiabatic Invariants.

Unit II: Fluid Models

Fluid theory in plasma, Fluid equations of motion, single fluid magneto-hydrodynamics, magnetic Reynolds number, magnetic equilibrium-the concept of beta, diffusion, resistivity and collision in plasma, Fokker-Plank equation

Waves in Fluid Plasma: Representation of waves – Group velocity – plasma Oscillations – Waves in unmagnetized plasmas – Electron Plasma waves-Langmuir waves and oscillations-ion sound waves, high frequency electromagnetic waves in unmagnetized plasma.

Unit III: Kinetic Theory & Plasma Instabilities

Kinetic Theory: Need for Kinetic theory, f (v) equations by kinetic theory, Vlaslov equations, kinetic effects on plasma waves and in a magnetic field, Landaus treatment, BGK and van Kampen modes – Experimental verification.

Plasma Instabilities: Instability in plasma; streaming instability, ion drag force induced, drift wave instability and parametric instability.

Chaos and time series analysis; Fourier theory, Liapunov exponent, Attractors, self-similarity, Hurst exponent and Fractal dimension

Unit IV: Applications

Waves in space-plasma, plasma turbulence and particle heating. Fundamentals of plasma processing. Gas discharge processes, dc discharge, rf discharge, capacitive and inductively coupled plasma systems, theory and description of different plasma production systems, Dusty plasma. Introduction to controlled thermonuclear fusion, magnetic confinement; Tokamak, Spheromak and ITER.

References

1. Francis F Chen: Introduction to plasma physics and controlled Fusion, vol. I: plasma physics, 2nd edition, Springer, 1984.
2. Robert J Goldston and Paul H Rutherford: Introduction to Plasma Physics, Institute of Physics, London, 1995.
3. U. S. Unan and U Golkowsky: Principles of Plasma Physics for Engineers and Scientist, Cambridge University Press, 2011.
4. Nocholas A Krall and Alvin W Trivelpiece: Principles of plasma physics, San Francisco Press, 1986.

5. Donald E. Gurnett and A. Battacharjee: Introduction to Plasma Physics: With Space and Laboratory Applications, Cambridge University Press, 2005.
6. M. Kono and M. M. Skoric: Nonlinear Physics of Plasmas, Springer-Verlag, 2010.
7. Alexander Piel: Introduction to Plasma Physics: An Introduction to Laboratory, Space and Fusion Plasmas, Springer-Verlac, 2010.
8. Richard Dendy: Plasma Physics: An Introductory Course, Cambridge University Press, 1996.
9. Richard H Huddlestone and Stanly Leonard: Plasma Diagnostic Techniques, Academic Press Inc., 1965.
10. R. J. Shul, S. J. Pearton, Handbook of Advanced Plasma Processing Techniques, Springer- Verlac, 2000.
11. I. H. Hutchinson: Principles of Plasma diagnostics, Cambridge University Press, 2002.
12. Francis F Chen and Jane P Chang: Lecture Notes on Principles of Plasma Processing, Kluwer Academic/ Plenum Publishers, 2003.

Thin Film Technology

PHY-RS-E514

Unit I: Introduction

Preparation: Spray pyrolytic process – characteristic feature of the spray pyrolytic process – ion plating– Vacuum evaporation – Evaporation theory – The construction and use of vapour

sources– sputtering Methods – Reactive sputtering – RF sputtering - DC planar and magnetron sputtering , atom beam/ion beam sputtering.

Thickness measurement: electrical methods – optical interference methods – multiple beam interferometry – Fizeau – FECO methods – Quartz crystal thickness monitor.

Nucleation & **growth**– Four stages of film growth incorporation of defects during growth.

Unit II: Electrical properties of metallic thin films

Sources of resistivity in metallic conductors – sheet resistance - Temperature coefficient of resistance (TCR) – influence of thickness on resistivity – Hall effect and magneto resistance

– Annealing – Agglometation and oxidation.

Unit III: Transport properties of semiconducting and insulating Films

Semiconducting films; Theoretical considerations - Experimental results – Photoconduction

– Field effect in thin films – transistors, Insulating films Dielectric properties – dielectric losses – Ohmic contacts – Metal – Insulator and Metal – metal contacts – DC and AC conduction mechanism.

Unit IV: Optical properties of thin films and thin films solar cells

Thin films optics –Theory – Optical constants of thin films – Experimental techniques – Multilayer optical system – interference filers – Antireflection coating, Thin films solar Cells, Single & multi junction solar cells, Role, Progress, and production of thin solar cells – Photovoltaic parameter, Thin film silicon (Poly crystalline) solar cells: current status of bulk silicon solar cells –Fabrication technology – Photo voltaic performance: Emerging solar cells: GaAs and CdlnSe.

References:

1. L I Maissel and R Glang: Hand book of Thin films Technology, McGraw Hill, 1970.
2. K L Chopra: Thin film Phenomena, McGraw Hill, 1970.
3. George Hass et al.: Physics of thin films, vol. 12, New York Academic Press, 1975.
4. K L Chopra and S R Das: Thin films solar cells, Plenum Press, 1983.
5. John A. Venables: Introduction to Surface and Thin films processes, Cambridge University Press, 2000.
6. L. Holland: Vacuum deposition of thin films, Chapman and Hall, 1966.
7. J C Anderson: The Use of Thin Films in Physical Investigations, New York, 1

Quantum Field Theory

PHY-RS-E515

Unit I: Introduction

Scalar Fields: Need for Field Theoretic description, Klein-Gordon Field: Lagrangian formulation, symmetries and conservation laws, canonical quantization, propagators, Feynman diagrams.

Spinor & Vector Fields: Dirac Field: Canonical quantization, propagators, Symmetries: Gauge Symmetries, Gauge Field: Elementary realization of BRST symmetry and gauge fixing.

Unit II: Interactions

Hamiltonian formulation, S-matrix, Interacting Fields and Feynman Diagrams, Yukawa Theory, elementary processes of quantum electrodynamics, radiative corrections.

Unit III: Renormalization

Functional Methods, Systematics of Renormalization, Renormalization and Symmetry, Renormalization Group, Critical Exponents.Wilsonian renormalization.

Unit IV: Non-Abelian Gauge Field

Non-Abelian Gauge invariances, Quantizations, Quantum Chromodynamics, Operator products, effective vertices, Gauge theory with spontaneous symmetry breaking, Higgs mechanism.

References

1. F. Mandl and G. Shaw: Quantum Field Theory, Wiley, 1992.
2. T. P. Cheng and L.-F. Li: Gauge Theory of Elementary Particle Physics, Oxford University Press, 1984.
3. S. Pokorski: Gauge Field Theories, Cambridge University Press, 2000.
4. L. H. Ryder: Quantum Field Theory, Cambridge University Press, 1996.
5. D. Bailin and A. Love: Introduction to Gauge Field Theory, IOP Publishing, Graduate Student Series in Physics, 1986.
6. F. Mandl and G. Shaw: Quantum Field Theory, John Wiley, 2009.
7. P. B. Pal and A. Lahiri: A First Book of Quantum Field Theory, CRC Press, 2001.
8. M. E. Peskin, D. V. Schroeder: An Introduction to Quantum Field Theory, Addison-Wesley, 1995.

General Relativity and Cosmology

PHY-RS-E516

Unit I: Tensor Analysis

Elements of tensor analysis, Affine transplantation of tensors, concept of the metric tensor and geodesics, Curvature, Reimann Tensor and its properties, Energy Momentum tensor, Ricci Tensor and Einstein tensor. Einstein Equations. Newtonian limit.

Unit II: General Relativity

Foundations of general relativity, Schwarschild solution and its consequences. Schwarzschild and Kerr space times, black hole physics, gravitational radiation, gravitational lensing, cosmological models, observational tests, the early universe, the microwave background, formation of structured dark matter and dark energy, Hawking radiation.

Unit III: Cosmology I

Galaxies and the expanding Universe; Hubble's Law; the age of the Universe; the Big Bang; cosmic microwave background (blackbody radiation); big bang nucleo-synthesis (cosmic abundances, binding energies, matter & radiation).

Unit IV: Cosmology II

Introductory cosmology (the cosmological principle, homogeneity and isotropy, Olber's paradox); cosmological models (critical density, geometry of space, the fate of the Universe); cosmological constant, dark energy and the accelerating Universe.

References

1. Steven Wienberg, Cosmology, Oxford University Press, (2008)
2. Robert M Wald, General Relativity, University of Chicago Press (1984)
3. Landau, L.D. &Lifshitz, E.M.: The Classical Theory of Fields, 2nd ed., Pergamon Press, 1995.
4. Hartle, J. B.: Gravity: Introduction to Einstein's General Relativity, Pearson Education, 2003.
5. Peebles, P.J.E.: Principles of Physical Cosmology, Princeton University Press, 1993.