Scheme of Instruction

2014 - 15

Biology

Semester I (AUG)

UB 101 and UB 101L (2:1)

UB 101: Introductory Biology- I (Organismal Biology and the Molecular Basis of Life)

Introduction to the world of living organisms; levels of biological organisation; diversity of life on earth; history and evolution of life on earth; mechanisms of evolution; genetic basis of natural selection; measuring the rate of natural selection; organisms and their environment; adaptation; behaviour and ecology; biological species diversity; environmental degradation, conservation and management; the future of life on earth.

Concepts of pH/pKa, structures of water, amino acids, peptides and proteins; chemistry of DNA, RNA, proteins, lipids and carbohydrates; elementary enzymology and molecular biology; Introduction to various model organisms. Cell as a unit of living organisms, cellular organelles: Structure and function, organization of cytoskeleton and nuclei, ER-Golgi modifications, Vesicle-mediated protein transport, endocytosis and exocytosis, mitochondria and respiration.

UB 101L

Methods of describing, observing, counting and estimating the abundance, diversity and behaviour of living organisms. Light Microscopy, sample preparation and examination, identification of microorganisms, staining techniques, fluorescence microscopy to examine intracellular compartments, Cell fractionation and centrifugation methods, isolation of intracellular compartments by differential centrifugation techniques, nuclei, mitochondria, RER etc. Basics of cell culture methods: cell counting, culture media preparation. Titration of amino acids, estimations of reducing non-reducing sugars, proteins, DNA, RNA, lipids, paper chromatography/ TLC, SDS-PAGE, isoelectric focusing, DNA melting curves.

Raghavendra Gadagkar, Dipankar Chatterji

Carson, R. *Silent Spring*, Fawcett World Library, New York, 1967.

Dawkins, R. *The Blind Watchmaker*, Longman Scientific & Technical, England, 1986.

R. Gadagkar, *Survival Strategies – Cooperation and Conflict in Animal Societies*, Harvard University Press and Universities Press, Cambridge, Massachusetts, USA and Hyderabad, India, 1997, 1998.

D. Sadava, D. M. Hillis, H. Craig Heller, M. Berenbaum, *Life, the science of biology*, W. H. Freeman, 9th edition, 2009.

Wilson, E. O. *The Future of Life*, Alfred A. Knopf, 2002.

Wilson, E.O. Life on Earth. Freely available at: http://eowilsonfoundation.org/e-o-wilson-s-life-on-earth

H. Lodish, A. Berk, C. A. Kreiger, M. P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira, *Molecular cell biology*, W.H. Freeman, 6th edition, 2008.

J. E. Krebs, E. S. Goldstein & S. T. Kilpatrick, *Lewin's Genes X* , Jones and Bartlett Publishers, 10th edition, 2011.

D. L. Nelson, M. M. Cox, *Lehninger Principles of Biochemistry*, W.H.Freeman, 5th edition, 2009.

J. M. Berg, J. L. Tymoczko, L. Styrer, *Biochemistry*, W.H.Freeman & Co., 6th edition, 2006.

D. Voet, J. G. Voet, *Biochemistry,* Wiley, 4rd edition, 2010.

Semester 2 (JAN)

UB 102 and UB 102L (2:1)

UB 102: Introductory Biology- II (Microbiology, Molecular Biology and Genetics)

Introduction to the microbial world and its diversity; importance of microbes in exploration of basic principles of biology; bacterial growth and its modulation by nutrient availability in the medium; structure and function of a bacterial cell; structure of cell wall; isolation of auxotrophs; life cycles of temperate and lytic bacteriophages, structure and function of extra-chromosomal elements and their applications in molecular microbiology. Molecular biology (central dogma, replication, transcription, genetic code and translation); examples of post-transcriptional and post-translational modifications; genetic methods of gene transfer in bacteria; Mendelian genetics (segregation and independent assortment); introduction to polytene and lampbrush chromosomes; sex determination and sex linkage in diploids; cytoplasmic inheritance; pedigrees, markers, mapping and genetic disorders; gene frequencies and Hardy-Weinberg principle, and introduction to various model organisms.

UB 102L

Light microscopy, identification of microorganisms, staining techniques (Gram's, acid fast), bacterial plating, tests for antibiotic resistance, M13 infection, plaque assay, preparation of bacterial competent cells, transformation, transduction, conjugation, β-galactosidase assay, Drosophila crosses using red eye and white eye mutants, observation of Barr body in buccal mucosa cells, preparation of mitotic/polytene chromosomes from Drosophila larvae, and karyotyping using human metaphase plate photos.

Umesh Varshney, Arun Kumar

J. M. Berg, J. L. Tymoczko, L. Styrer, *Biochemistry*, W. H. Freeman & Co., 6th edition, 2006.

R. Y. Stanier, E. A. Adelberg, J. L. Ingraham, *General Microbiology*, MacMillan Press, 5th edition, 2007.

M.W. Strickberger, *Genetics*, Prentice-Hall, India, 3rd edition, 2008.

Daniel Hartl, *Essential Genetics: A genomics perspective*, Jones & Bartlett 3rd edition, 2002

T. Strachan, A.P. Read, *Human Molecular Genetics*, Garland Science, 3rd edition, 2004.

Semester 3 (AUG)

UB 201 and UB 201L (2:1)

UB 201: Introductory Biology-III (Cell Biology, Immunology and Neurobiology)

Eukaryotic cells and organelles, cell membranes and cell function. Introduction to animal viruses with examples, life cycle and host-virus interactions. Introduction to the immune system – the players and mechanisms, innate immunity, adaptive responses, B cell receptor and immunoglobulins, T cell activation and differentiation and Major Histocompatibility Complex encoded molecules. Overview of the nervous system (from neuron to brain), ionic basis of resting membrane potential and action potentials, neurotransmitters, neuromodulators and second messengers, motor systems, neural basis of cognition: attention, and language and disorders of the brain.

UB 201L

Animal cell culture and microscopy, Immune organs and isolation of cells from lymph node, spleen and thymus. Lymphocyte and macrophage activation studies, nitrite detection, ELISA and cell cycle analysis. Gross anatomy of the human brain; staining of mouse brain sections; generation of action-potential; psychophysical and cognitive neurobiology experiments.

Dipankar Nandi, Saumitra Das, Shyamala Mani

Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira, *Molecular Cell Biology*, W. H. Freeman; 6th edition, 2007.

Bruce Alberts, *Molecular Biology of the Cell*, Garland Science, 5th edition, 2008

T. Kindt, R. Goldsby, B. A. Osborne, *Kuby Immunology*, W. H. Freeman, 6th edition, 2006.

David M. Knipe, Peter Howley, *Fields Virology*, Lippincott Williams & Wilkins, 6th edition, 2013.

M. Bear, B. Connors, M. Paradiso, *Neuroscience: exploring the brain*, Lippincott Williams & Wilkins, 3rd edition, 2006.

Semester 4 (JAN)

UB 207: General Biochemistry (2:0) (Core course for BIO major and minor)

Basic concepts of enzymes and enzyme kinetics, allosteric proteins, catalytic strategies, regulatory strategies of enzymes, basic concepts of metabolism and its design, catabolism and anabolism, energy generation and storage, glycolysis, citric acid cycle, oxidative phosphorylation, pentose phosphate pathway, gluconeogenesis, glycogen metabolism, fatty acid metabolism, amino acid degradation and urea cycle, biosynthesis of membrane lipids and steroids, biosynthesis of amino acids and heme, biosynthesis of nucleotides, integration of metabolism, photosynthesis.

D. N. Rao and Siddhartha Sarma

D. Voet, J. G. Voet, *Biochemistry,* Wiley, 4rd edition, 2010.

J. M. Berg, J. L. Tymoczko, L. Styrer, *Biochemistry*, W. H. Freeman & Co., 6th edition, 2006.

UB 203: Introductory structural biology (3:0) (Core course for BIO major)

Structure and function in biology, small and large molecules of living cells, molecular conformation, Stereochemistry of peptides, basics of globular protein structure and folding, Hierarchical organization of protein structures, solvent accessibility and hydrophobicity. Comprehension and analysis of protein structures, evolution of protein structures, protein folding and stability, membrane proteins, nucleic acid structure and organization.

M. R. N. Murthy and N. Srinivasan

A. Liljas, L. Liljas, J. Piskur, G. Lindblom, P. Nissen, M. Kjeldgaard, *Textbook Of Structural Biology*, World Scientific Publishing Company, 2009.

UB 205: Introductory Physiology (2:0) (Core course for BIO major)

Mammalian physiology: Introduction to physiology, internal environment, control of internal environment by feedback systems, renal physiology, body fluids and kidneys, urine formation by the kidneys, cell signalling and endocrine regulation, hormonal regulation of energy metabolism, hormonal regulation of calcium metabolism, hormonal control of reproduction in males and females, pregnancy and lactation. *Plant physiology*: plant cell structure and cell wall, water uptake, photosynthesis and photorespiration, secondary metabolites, phytochrome and light signaling, hormone signaling in plants, control of flowering, stress physiology.

Rajan Dighe, C. Jayabhaskaran, R. Medhamurthy

J. E. Hall, *Guyton and Hall Textbook of Medical Physiology*, Elsevier, 12th edition, 2011.

J. L. Jameson, L. J. De Groot, *Endocrinology*, Elsevier, 6th Edition, 2010.

L. Taiz, E. Zeiger, *Plant Physiology*, Sinauer Associates, 5th edition, 2010.

UB 206L: Experiments in Biochemistry and Physiology (0:2) (Core course for BIO major)

Expression of recombinant proteins, purification and characterization. Isolation and characterization of proteins, quantitation of proteins using biochemical assays and physico-chemical characterization of proteins. Purification of Immunoglobulin G from rabbit antiserum. Characterization of antibodies by immunoasays: solid phase, liquid phase and Western blotting. Enzyme assays and determining specific activity of enzymes.

Anjali Karande and Rajan Dighe

UB 208: Basic Molecular Biology (2:0)

Genes as carriers of heredity, gene-enzyme relation, spontaneous versus adaptive mutations: origins of bacterial genetics, the transforming principle and the chemical identity of the gene, DNA and heredity, biochemistry of DNA, Chargaff's rule, early models of DNA structure, the double helix and the origins of molecular biology, alternative structures of DNA, unidirectional flow of genetic information - The Central Dogma, the coding problem - elucidation of the genetic code, confirmation of DNA as the genetic material, models for replication of DNA. Gene organization in bacteria: operons and regulons, structure of bacterial promoters, RNA polymerase and initiation of transcription, repressors and activators, restriction-modification systems in bacteria, DNA topology and its homeostasis, DNA repair mechanisms, developmental systems in prokaryotes - lysogeny and sporulation. Chromosome organization in eukaryotes: histones and nucleosomes, gene regulation in eukaryotes:

transcription factors and enhancers, histone modification and epigenetics, gene expression during development, regulation mediated by RNA, molecular evolution, genomics.

S. Mahadevan

James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, *Molecular Biology of the Gene*, 7th edition, Benjamin-Cummings Publishing Company, 2013

G. Stent and R. Calendar, *Molecular Genetics: An Introductory Narrative*, 2nd edition, W H Freeman & Co, 1978

Semester 5 (AUG)

UB 301L: Experiments in Microbiology and Ecology (0:2) (Core course for BIO major)

There are two sets of hand on experiments for Biology majors: In the first part, students will get a hands-on experience in understanding the basic concepts in microbiology. The topics include the microbial growth curve, microbial nutritional requirements, genetic engineering techniques, plasmid isolation, creation of genetic knock out in bacteria, bacterial infection in cell culture system, estimation of infection by colony forming unit (CFU) analysis and fluorescence technique.

In the second part, students will explore key concepts in Ecology, Evolution and Behavior through field observations, manipulative experiments and computer simulations. Topics will include diversity and distributions of organisms, competition and predation, species interactions, mate choice, optimal foraging theory, plant and animal communication, learning and memory, evolutionary evidence and the fossil record, variation and heritability, natural and sexual selection, genetic drift.

Dipshikha Chakravortty and Maria Thaker

UB305 and UB305L (2:1)

UB305 GENETICS

Evolution of genetics: genes to genomics; an overview of model systems; Mendelism; extensions of Mendelism; evolution of the concept of gene; an overview of genetic chemistry; transcriptional, post-transcriptional and translational regulation in prokaryotes and eukaryotes; genetic recombination and repair; mobile genetic elements in prokaryotes and eukaryotes; epigenetics; molecular basis of sex determination and dosage compensation in Caenorhabditis, Drosophila and human; population genetics; DNA recombination technology; genome genetics.

UB305L

Practicals with genetic stocks of Drosophila. (1) Genetics of mutants: a) Drosophila (b) Zebra fish (c) Arabidopsis. (2) Chromatographic analysis of eye pigments in the mutants of Drosophila (3) Mitotic (human), meiotic (mouse/grasshopper) and polytene chromosomes (Drosophila) (4) Collection of Drosophila species from wild/nature to study sympatric diversity of species and pattern of genetic variability. (5) Experiments to demonstrate different patterns of inheritance: genetic crosses and analysis of P1, P2, F1, F2 & test cross progeny: (6) Generation of New mutations in Drosophila – this will go till the end of Course – students need to characterize a mutation based on what they learn in theory and practical classes. (7) Experiments on natural selection and genetic drift (8) Quantitative characters: acrostichals and sternopleurals bristles in Drosophila: mean, standard deviation, t-test (9) Experiments with genome - nucleic acids: isolation of genomic DNA, restriction digestion profiles, PCR

H. A. Ranganath

Griffiths A.J.F., Wessler S.R., Carroll S.B. and Doebley J. 2012. Introduction to Genetic Analysis, W.H. Freeman and Company.

Pierce BA 2012 Genetics: A Conceptual Approach. W.H. Freeman Palgrave MacMillan.

Semester 6 (JAN)

UB 302 (formerly UB 204): Developmental Biology (2:0) (Core course for BIO major)

Introduction, history and concepts of developmental biology; the current understanding on the mechanisms of development using model organisms including invertebrates, vertebrates and plants; general principles for the making of a complex, multicellular organism from a single cell; the creation of multicellularity (cellularization, cleavage), reorganization into germ layers (gastrulation), cell type determination; creation of specific organs, (organogenesis); molecular mechanisms underlying morphogenetic movements, differentiation, and interactions during development; fundamental differences between animal and plant development; embryogenesis in plant – classical and modern views; axis specification and pattern formation in angiosperm embryos; organization and homeostasis in the shoot and root meristems; patterning in vegetative and flower meristems; growth and tissue differentiation in plants; stem cells and regeneration; evolution of developmental mechanisms.

Usha Vijayraghavan, Upendra Nongthomba, Utpal Nath

L. Wolpert, C. Tickle, *Principles of development*, Oxford University Press, 4^{th} edition, 2010.

S. F. Gilbert, *Developmental Biology*, Sinauer Associates, 9^{th} edition, 2010.

J. M. W. Slack, *Essential Developmental Biology*, John Wiley & Sons, 3^{rd} edition, 2012.

Leyser, S. Day, *Mechanisms in Plant Development*, Willey-Blackwell, 2003.

L. Taiz, E. Zeiger, *Plant Physiology*, Sinauer Associates, 5^{th} edition, 2010.

Bruce Alberts, *Molecular Biology of the Cell*, Garland Science, 5^{th} edition, 2008.

UB 303L: Experiments in Molecular Biophysics (0:1) (Core course for BIO major)

UV spectroscopy of proteins (quantitation and determination of extinction coefficient). Fluorescence spectroscopy of proteins. UV spectroscopy of DNA (determination of melting temperature and influence of buffer composition). CD spectroscopy of proteins and calculation of helical contents. CD spectroscopy of DNA and monitoring conversion of B-form DNA [poly(dG-dC)] to Z-form DNA in high salt. Mass spectroscopy of proteins (determination of mass and MS-MS analysis). Study of protein oligomerization by dynamic light scattering. Estimation of free sulfhydryl groups in proteins by DTNB titration and its validation by mass spectroscopy and iodoacetamide labeling.

Dipankar Chatterji and Siddhartha Sarma

UB 304L: Experiments in Neurobiology (0:1)

The vertebrate nervous system and its organization. Theory and demonstration of stereotactic surgery in rodents. Demonstration of tissue sectioning techniques. Preparation of primary neuronal cultures and imaging neurons. Theory and demonstration of neuronal activity. Introduction to behavioral measurements and statistical analysis.

Prerequisite: NS201 (AUG) 3:0

Vijayalakshmi Ravindranath and Shymala Mani

Semester 8 (JAN)

UB 401: Research Project (0:16)

An independent research project will be performed by all UG-Biology major students under the supervision of faculty. It is recommended that students initiate laboratory work during the summer break post completion of the sixth semester. The progress of the project will be monitored at the end of the seventh semester. The submitted project report will be graded before the end of the eight semester as follows: faculty assessment (30% marks), independent referee (30% marks) and presentation (40%). Based on the student's performance, the final grade will be determined.

Faculty members in the Division of Biological Sciences, IISc

ADDITIONAL COURSES IN SEMESTERS 5, 6, 7 and 8:

CHEMISTRY

Semester 1 (AUG)

UC 101: Physical Principles of Chemistry (2:1)

Bohr theory, Wave Particle Duality, Uncertainty principle, Schrödinger equation, H-atom and atomic orbitals, electron spin, Pauli principle and many electron atoms. Chemical bonding: covalent and ionic bonding, valance bond theory, hybridization and resonance; molecular orbital theory. Homonuclear and heteronuclear diatomics, potential energy curves and intermolecular interactions; elements of spectroscopy, van der Waals equation of state; theory of chemical reactions.

K L Sebastian, A Srinivasan and Ambili Menon

D.A. McQuarrie and J.D. Simon, Physical Chemistry, Viva Books.

H.B. Gray, Electrons and Chemical Bonding, W.A. Benjamin Inc. (1965).

Elements of Physical Chemistry by Peter Atkins & Julio De Paula, 5/E, Oxford University Press, Indian Edition.

Physical Chemistry by Ira N. Levine, 2008 (Tata McGraw Hill).

Physical Chemistry by Gordon M Barrow, 2007 (McGraw Hill).

Semester 2 (JAN)

UC 103: Basic Inorganic Chemistry (2:1)

Multi-electron atoms–periodic trends; chemical bonding: ionic solids, CFT: d-orbital splitting, tetrahedral, square planar, cubic and octahedral crystal fields, covalent bonding; Lewis model (2 Dim); VSEPR (3 Dim) hybridization; molecular orbital theory: heteronuclear diatomics, triatomics; shapes of main group compounds; acid-base chemistry: concepts, measures of acid-base strength, HSAB.

P S Mukherjee, Ambili Menon and A Srinivasan

Concise Inorganic Chemistry by J. D. Lee, 5/E, Oxford University Press, Indian Edition.

Pearson Inorganic Chemistry Third Edition by Gary L. Miessler, Donald A. Tarr.

Inorganic Chemistry by Duward F. Shriver, P.W. Atkins, C.H. Langford, Oxford University Press.

Inorganic Chemistry by J. E. Huheey, E. A. Keiter, R. L. Keiter, 4/E, Pearson Education Asia.

Semester 3 (AUG)

UC 206: Basic Organic Chemistry (2:1)

Nomenclature of organic compounds: alkanes, alkenes and alkynes; structure and reactivity. Concept of aromaticity; organic reactions – Addition reactions; Elimination reactions; substitution reactions and rearrangements. Organic reaction mechanisms; reaction intermediates and their characterization. Introduction to stereochemistry.

Mrinmoy De, T K Chakraborty and Anuradha Mukherjee

Organic Chemistry by Solomons, T. W. G. and Fryhle, C., John Wiley & Sons, (2009).

Organic Chemistry by McMurry, J. E., 7th Ed., Thomson, (2007).

Organic Chemistry by Paula Y. Bruice, 6th Edition, Pearson.

Semester 4 (JAN)

UC 202: Thermodynamics and Electrochemistry (2:0) (Core for majors)

Intermolecular forces, van der Waal's interactions, Leonard-Jones potentials, hydrogen bonding. Laws of thermodynamics, state functions, thermodynamic properties of liquids and solids, state equations, phase change, thermodynamic description of mixtures, reversible and irreversible processes, colligative properties and chemical equilibrium, thermodynamic cycles. Activity and activity coefficients, Debye-Hückel law, Arrhenius theory, cells, Nernst equation, EMF and free energy, concentration cells, conductivity, electrode processes, Fick's laws, Electrochemical techniques.

Anshu Pandey

McQuarrie and Simon, Physical Chemistry – A Molecular approach.

R. Holze, Experimental Electrochemistry.

Electroanalytical techniques, Southampton electrochemistry group, Li, Peat, Peter and Pletcher.

J M Seddon and Gale J D, Thermodynamics and Statistical Mechanics, Royal Society of Chemistry.

S. Glasstone, Thermodynamics for Chemists, Affiliated East West Press.

E. Fermi, Thermodynamics, Dover Publications.

Berry, Rice and Ross: Physical Chemistry, Oxford University Press.

UC 207: Instrumental Methods of Chemical Analysis (2:1) (Core for majors and minors)

Propagation of errors in measurement, statistical analysis of data, etc. Separation Techniques: Extraction and separation, principles of chromatography. Electroanalytical Techniques: Voltammetry and its variants, ion selective electrodes and electrochemical techniques for analysis Spectroscopic Techniques: Atomic absorption/ emission, Electronic, Fluoresecence, and Vibrational (IR and Raman) Spectroscopy: basic principles, operation and application to chemical problems. NMR Spectroscopy: Basic principles and operation, application of one dimensional NMR for identification of chemicals. Mass Spectrometry: Principles and Applications.

P K Das, S Ramakrishnan and Anuradha Mukherjee

Fundamentals of Analytical Chemistry by Skoog, West, Holler and Crouch; Eighth edition.

UC 204: Inorganic Chemistry: Chemistry of Elements (2:0) (Core for majors)

Chemistry of d-block elements: structure – coordination numbers, isomerism, chelate effect; bonding: VBT, CFT, MOT; descriptive chemistry of metals: periodic trends, chemistry of various oxidation states of transition metals, oxidation states and EMFs of groups; organometallic chemistry: 18 electron rule, metal carbonyls, metal cyclopentadienyl and arene compounds, industrial catalysts; bioinorganic chemistry: metals in biological systems, heme and non-heme proteins, metalloenzymes; main group chemistry: carbon group elements (electron precise compounds); Noble gas compounds; Chemistry of f-block elements.

A R Chakravarty

Inorganic Chemistry by Shriver, D.F. Atkins, P.W. ELBS; 4th Edition.

Inorganic Chemistry by James E. Huheey , Ellen Lieter, Keith Leiter; Harper International Edition.

Chemistry of Elements Greenwood and Earnshaw; Maxwell Macmillan.

Advanced Inorganic Chemistry Cottton and Wilkinson; Wiley International.

UC 205: Basic Organic Reactions (2:0) (Core for majors)

Acids and bases: definitions, pKa, pKaH, effect of structure on acid/base strength, kinetic & thermodynamic acidity, general & specific acid/base catalysis; Reactions of alkenes and alkynes: addition of halogens, hydrogen halides & interhalogen compounds, halolactonization – Baldwin's rule & Thorpe-Ingold effect, hydration, epoxidation, dihydroxylation, ozonolysis, diol cleavage, carbenes and their reactions with olefins, hydrogenation; Reactions of carbonyl compounds: addition to carbonyls, reductions, rearrangements & their applications, oxidations, C–C bond forming reactions involving carbonyls, Cram's rule, Felkin-Anh model; Introduction to pericyclic reactions: cycloadditions, elctrocyclic reactions, FMO theory and Woodward-Hoffmann rules.

Santanu Mukherjee

Norman, R. O. C. and Coxon, J. M.; Principles of Organic Synthesis, 3rd Ed., (1993).

Carruthers, W. and Coldham, I.; Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press, (2004).

Clayden, J.; Greeves, N.; Warren, S. And Wothers, P.; Organic Chemistry, Oxford University Press, (2000).

Carey, F. A. and Sundberg, R. J.; Advanced Organic Chemistry, Part A & Part B, 5th Ed., Springer, (2007).

Semester 5 (AUG)

CD 211: Physical Chemistry I - Quantum Chemistry and Group Theory (3:0) (Core for majors)

Postulates of Quantum Mechanics and introduction to operators; Exactly solvable problems Perturbational and Variational Methods, Hückel model, Many electron Atoms, Slater determinants, Hartree-Fock Variational Method for atoms; Molecular Quantum Mechanics, Symmetry and Group theory, Point Groups, Reducible and Irreducible Representations (IR), Great Orthogonality theorem, Projection operators, Applications to molecular orbitals and normal modes of vibration and selection rules in spectroscopy

S Ramasesha

I. Levine, Quantum Chemistry.

D. Griffiths, Introduction to Quantum Mechanics.

R.H. Dicke and J.P. Wittke, Introduction to Quantum Mechanics.

F. A. Cotton, Chemical Applications of Group Theory.

M. Tinkham, Group Theory and Quantum Mechanics.

CD 212: Inorganic Chemistry -Main group and Coordination Chemistry (3:0) (Core for majors)

Main group: hydrogen and its compounds -ionic, covalent, and metallic hydrides, hydrogen bonding; chemistry of lithium, beryllium, boron, nitrogen, oxygen and halogen groups; chains, rings, and cage compounds; Coordination chemistry: bonding theories (revision and extension), spectral and magnetic properties; inorganic reactions and mechanisms: hydrolysis reactions, substitution reactions trans-effect; isomerization reactions, redox reactions; metal-metal bonding and clusters; mixed valence systems; chemistry of lanthanides and actinide elements.

E D Jemmis and P Thilagar

Shriver and Atkins' Inorganic Chemistry by: Atkins, Overton, Rourke, Weller and Armstrong, Fifth Edition. South Asia Edition (paper back), Oxford University Press, 2010.

Advanced Inorganic Chemistry, 6th edition, by: Manfred Bochmann, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murilla Wiley Student Edition, NY, 2007.

Inorganic Chemistry, Principles of Structure and Reactivity, 4th Edition, by: James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, Pearson, 2006.

CD 213: Organic Chemistry - Structure and Reactivity (3:0) (Core for majors)

Kinetics and reaction mechanism, primary and secondary isotope effects, Nucleophilic substitution, stereochemistry and conformation.

U Maitra and Mrinmoy De

Carey, F. A. and Sundberg, R. J.; Advanced Organic Chemistry, Part 8, s" Ed., Springer, (2007).

Lowry, T. M. and Richardson, K. S.; Mechanism and Theory in Organic Chemistry, 3rd Ed., Addison-Wesley, (1987).

Smith, M. B. and March, J.; March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, John Wiley & Sons, (2007).

Anslyn, E. V. And Dougherty, D. A.; Modern Physical Organic Chemistry, University Science Books, (2005).

UC 301: Organic & Inorganic Chemistry Laboratory (0:1) (Core for majors)

Common organic transformations such as esterification, Diels-Alder reaction, oxidation-reduction, Grignard reaction, etc. Isolation and purification of products by chromatographic techniques, characterization of purified products by IR and NMR spectroscopy. Synthesis of coordination complexes, preparation of compounds of main group elements, synthesis of organometallic complexes. Physico-chemical characterization of these compounds by analytical and spectroscopic techniques.

N Jayaraman, K R Prabhu, P Thilagar, S Natarajan, A Srinivasan

Semester 6 (JAN)

CD 221: Physical Chemistry II: Statistical Mechanics (3:0) (Core for majors)

Review of thermodynamics, foundations of statistical mechanics, ensembles, partition functions, averages, distributions, and non-interacting systems. Applications to rotational and vibrational problems, specific heats of solids, classical fluids, and phase transitions.

Govardhan Reddy

H.B.Callen, Thermodynamics and Introduction to Thermostatistics.

D. A. MacQuarrie Statistical Mechanics.

D. Chandler Introduction to Modern Statistical Mechanics.

CD 222: Material Chemistry (3:0) (Core for majors)

Structure of solids, symmetry concepts, crystal structure. Preparative methods and characterization of inorganic solids. Crystal defects and non-stoichiometry. Interpretation of phase diagrams, phase transitions. Kinetics of phase transformations, structure property correlations in ceramics, glasses, polymers. Composites and nano-materials. Basics of magnetic, electrical, optical, thermal and mechanical properties of solids.

Bikramjit Basu, K K Nanda and Prabeer Barpanda

A.R. West, Solid State Chemistry and its Applications John Wiley and Sons, 1984.

J.F. Shackelford, Introduction to Materials Science for Engineers, MacMillan, 1988.

W. D. Callister and D. G. Rethwisch; Fundamentals of Materials Science and Engineering: An Integrated Approach; John Wiley & Sons; 2012.

B. Basu and Kantesh Balani; Advanced Structural Ceramics; John Wiley & Sons; 2011.

CD 223: Organic Synthesis (3:0) (Core for majors)

Principles of selectivity and reactivity in the use of reagents for oxidation, reduction and bond forming reaction. Planning a synthesis, antithetic analysis, synthons, linear and convergent synthesis.

N Jayaraman and T K Chakraborty

Warren S., Designing Organic Synthesis, 1978

Carruthers W. S., Some Modern Methods of Organic Synthesis, 3rd edition, Cambridge University Press, 1986.

Carery, F. A. and Sundberg, R. J., Advanced organic chemistry, Part B, 2nd ed., Plenum, 1984

House, Modern Synthetic Reactions, 1972.

Fuhrhop J. and Penzilin G., Organic Synthesis -Concepts, Methods, Starting Materials, Verlog Chemie 1983.

UC 302: Physical and Analytical Chemistry Laboratory (0:1) (Core for majors)

Chemical kinetics. Langmuir adsorption, chemical analysis by potentiometric and conductometric methods, cyclic voltametry, flame photometry, electronic states by UV-Visible spectroscopy, IR spectroscopy, solid state chemistry -synthesis of solids and chemical analysis. Thermogravimetry. X-ray diffraction, electrical and magnetic properties of solids. Vacuum techniques in preparative chemistry.

S Sampath, Aninda Bhattacharya, C Shivakumar

Vogel, A.I, Vogel's text book of quantitative chemical analysis Longman 1989.

Semester 7 (AUG)

UC 401: Basic Organometallic Chemistry (3:0) (Core for majors)

Structure and bonding in organo-metallic compounds – isolobal analogies, metal carbonyls, carbenes and NHC complexes, olefin and acetylene complexes, alkyls and allyl complexes, metallocenes. Major reaction types –

oxidative addition, reductive elimination, insertion, isomerization and rearrangement reactions. Catalytic reactions: metathesis, hydrogenation, allylic activation, C-C coupling reactions, C-X coupling.

A G Samuelson and B R Jagirdar

Elschenbroich, Ch. Organometallics, 3rd edition, Wiley-VCH, Weinheim, 2005.

Gupta, B. D.; Elias, A. J. Basic Organometallic Chemistry: Concepts, Syntheses and Applications (second edition), 2013.

UC 402: Molecular Spectroscopy, Dynamics and Photochemistry (3:0) (Core for majors)

Energy levels of molecules and their symmetry. Polyatomic rotations and normal mode vibrations. Electronic energy states and conical intersections; time-dependent perturbation theory and selection rules; microwave, infrared and Raman, electronic spectroscopy; energy transfer by collisions, both inter and intra-molecular. Unimolecular and bimolecular reactions and relations between molecularity and order of reactions, rate laws; temperature and energy dependence of rate constants, collision theory and transition state theory, RRKM and other statistical theories; photochemistry, quantum yield, photochemical reactions, chemiluminescence, bioluminescence, kinetics and photophysics.

E Arunan

Molecular Spectroscopy by I. N. Levine.

Molecular Spectroscopy by J. L. McHale.

Chemical Kinetics and Dynamics by J. I. Steinfeld, J. S. Fransisco and W. L. Hase.

Chemical Kinetics by K. J. Laidler.

Electives to be offered to UG Students in the 7th and 8th Semesters

Inorganic and Physical Chemistry

IP 203 (AUG) 3:0
Group Theory and Molecular Spectroscopy
Sai G Ramesh

IP 211 (AUG) 3:0
Physical Chemistry – I Thermodynamics, Kinetics and Electrochemistry
N Munichandraiah and Atanu Bhattacharya

IP 214 (AUG) 2:1
Crystallography for Chemists
M Nethaji

IP 311 (AUG) 3:0
Bio & Medicinal Inorganic Chemistry
G Mugesh

IP 313 (JAN) 3:0
Electrochemical Energy Conversion and Storage
N Munichandraiah, S Sampath and P. Barpanda

IP 312 (JAN) 3:0
Advanced Organometallic Chemistry
B R Jagirdar

IP 322 (JAN) 3:0
Polymer Chemistry
S Ramakrishnan

IP 323 (JAN) 3:0
Topics in Basic and Applied Electrochemistry
S Sampath

IP 324 (JAN) 3:0
Photophysics and Photochemistry: Fundamentals and Applications
S Umapathy

Solid State and Structural Chemistry Unit

SS 201 (AUG) 3:0
Thermodynamics and Statistical Mechanics
B Bagchi and S Yashonath

SS 202 (AUG) 3:0
Quantum Chemistry
S Ramasesha

CD 204 (AUG) 3:0
Chemistry of Materials
S. Natarajan (SSCU) and S Vasudevan (IPC/SSCU)

SS 205 (AUG) 3:0
Symmetry and Structure in the Solid State
T N Guru Row

SS 207 (AUG) 3:0
Non-equilibrium Statistical Mechanics: Applications to Biological Systems
B Bagchi

SS 304 (AUG) 3:0
Solar Energy: Advanced Materials and Devices
S Patil and A Pandey

SS 206 (JAN) 3:0
Statistical Mechanics of Liquids & Simple Systems
B Bagchi

SS 301 (JAN) 2:1
Topics in Solid State Chemistry
Faculty

SS 303 (JAN) 3:0
Functional Molecular Materials: Theory and Applications
A J Bhattacharya and S A Patil

Organic Chemistry

OC 301 (AUG) 3:0
Advanced Organic Synthesis
Kavirayani R Prasad

OC 302 (AUG) 3:0
Asymmetric Catalysis: From Fundamentals to Frontiers
Santanu Mukherjee

OC 232 (JAN) 2:0
Graduate Colloquium
Santanu Mukherjee and K R Prabhu

Materials Research Centre

BE 201 (AUG) 3:0
Fundamental of Biomaterials and Living Matter
Bikramjit Basu

Engineering

Semester 1 (AUG)

UE 101: Algorithms and Programming (2:1)
Notions of algorithms and data structures. Introduction to C programming. Importance of algorithms and data structures in programming. Notion of complexity of algorithms and the big Oh notation. Iteration and Recursion. Algorithm analysis techniques. Arrays and common algorithms with arrays. Linked lists and common algorithms with linked lists. Searching with hash tables and binary search trees. Pattern search algorithms. Sorting algorithms including quick-sort, heap-sort, and merge-sort. Graphs: shortest path algorithms, minimal spanning tree algorithms, depth first and breadth first search. Algorithm design techniques including greedy, divide and conquer, and dynamic programming.

Y. N. Srikant

Brian W. Kerninghan and Dennis M. Ritchie, The C Programming Language. Prentice Hall of India, New Delhi, 2009.
R.G. Dromey, How to Solve it by Computer. Pearson Education India. 2006.
Robert L. Kruse, Data Structures and Program Design in C. Prentice Hall of India, New Delhi, 2006.
Steven S. Skiena, The Algorithm Design Manual. Springer, Second Edition, 2008.

Semester 2 (JAN)

UE 102: Introduction to Electrical and Electronics Engineering (2:1)
Ohms law, KVL, KCL, Resistors and their characteristics, Categories of resistors, series parallel resistor networks. Capacitors and their characteristics, Simple capacitor networks, Simple RC Circuit and differential equation analysis, Frequency domain analysis and concepts of transfer function, magnitude and phase response, poles. Inductors and their characteristics, a simple LR circuit and differential equation analysis, frequency domain transfer function and time constant, LRC circuit and second order differential equation, frequency domain analysis, resonance and Quality factor. Introduction to Faraday's and Lenz's laws, magnetic coupling and transformer action for step up and step down. Steady State AC analysis and introduction to phasor concept, lead

and lag of phases in inductors and capacitors, Concept of single phase and three phase circuits. Semiconductor concepts, electrons & holes, PN junction concept, built-in potential, forward and reverse current equations, diode operation and rectification, Zener diodes, Simple Diode circuits like half wave rectifier and full-wave rectifier. NPN and PNP bipolar transistor action, current equations, common emitter amplifier design, biasing and theory of operation. MOSFET as a switch, introduction to PMOS and NMOS. Introduction to Opamp concept, Characterisitics of an ideal opamp a simple realisation of opamp using transistors, Various OPAMP based circuits for basic operations like summing, a mplification, integration and differentiation, Introduction to feedback concept LAB: Design of 3 transistor opamp and its characterisation. Simple OPAMP applications using 741. MOSFET circuits for some simple gates, simple combinational functions. Basic flip-flop operation and clocks in digital design, Introduction to A/D conversion, Introduction to 8051 microcontroller and assembly language programming.

M K Gunasekaran

Art of Electronics, Second Edition, by Horowitz and Hill.

Semester 3 (AUG)

UE200: Introduction to Earth and its Environment (2:0)

Evolution of earth as habitable planet; evolution of continents, oceans and landforms; evolution of life through geological times. Exploring the earth's interior; thermal and chemical structure; origin of gravitational and magnetic fields. Plate tectonics; how it works and shapes the earth. Internal Geosystems; earthquakes; volcanoes; climatic excursions through time. Basic Geological processes; igneous, sedimentation and metamorphic processes. Geology of groundwater occurrence.

Groundwater occurrence and recharge process, Groundwater movement, Groundwater discharge and catchment hydrology, Groundwater as a resource, Natural groundwater quality and contamination, Modeling and managing groundwater systems.

Engineering and sustainable development; population and urbanization, toxic chemicals and finite resources, water scarcity and conflict. Environmental risk; risk assessment and characterization, hazard assessment, exposure assessment. Water chemistry; chemistry in aqueous media, environmental chemistry of some important elements. Air resources engineering; introduction to atmospheric composition and behavior, atmospheric photochemistry. Solid waste management; Solids waste characterization, management concepts.

Kusala Rajendran, Ashok Raichur, M. Sekhar

John Grotzinger and Thomas H. Jordan (2010) Understanding Earth, Sixth Edition, W. H. Freeman, 672 pp

Younger, P L (2007) Groundwater in the environment: An introduction, Blackwell Publishing, 317pp

Mihelcic, J. R., Zimmerman, J. B. (2010) Environmental Engineering: Fundamentals, Sustainability & Design, Wiley, NJ, 695 pp

UE202: Introduction to Materials Science (2:0)

Bonding, types of materials, basics of crystal structures and crystallography. Thermodynamics, thermochemistry, unary systems, methods of structural characterization. Thermodynamics of solid solutions, phase diagrams, defects, diffusion. Solidification. Solid-solid phase transformations. Mechanical behaviour: elasticity, plasticity, fracture. Electrochemistry and corrosion. Band structure, electrical, magnetic and optical materials. Classes of practical materials systems: metallic alloys, ceramics, semiconductors,composites.

Kaushik Chatterjee

W.D. Callister: Materials Science and Engineering, Wiley India (2007)

Semesters 4, 5 and 6

The students can take courses within the following pool.
Pool of Elective Courses
UE 201: Introduction to Scientific Computing (2:1) (Semester 4/6) (JAN)
Number representation, stability and convergence and error analysis; Interpolation: Lagrange, Newton's Divided Difference, Neville; Root finding: Bisection, Newton-Raphson, Secant, Regula falsi, Ridders, Steffensen; Data analysis and fitting: Goodness of fit, Chi-Square test; Numerical integration and differentiation: Newton-Cotes, Gaussian quadrature, Romberg integration, Importance sampling; Numerical solution of ODEs: Euler and Runge-Kutta methods; Fourier Series and Fourier Transforms, Basics of Sampling Theory, DFT and FFT; Simple computer implementation exercises.

S Raha

Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edn., John Wiley & Sons, 2011

W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B.P. Flannery, Numerical Recipes: The Art of Scientific Computing, 3rd Edn., Cambridge Univ. Press, 2007

F. B. Hildebrand, Introduction to Numerical Analysis, 2nd Edn., Dover Publications, 1987 (First South-Asian Edition – 2008)

R. L. Burden and J. D.Faires, Numerical Analysis: Theory and Applications, India Edition, Cengage Brooks-Cole Publishers, 2010.

UE204: Elements of solid mechanics (3:0) (Semester 4/6) (JAN)
Elastic bodies. Axial and shear stresses. Hookes law. Stress resultants. Axially loaded members. Torsion of circular bars. Shear force, bending moment, and axial thrust. Theory of simple bending. Bending and shear stress distribution in beams. Two dimensional state of stress. Principal stresses and strains. Mohrs diagram. Pressure vessels. Combined states of stress and failure theories. De.ection of beams. Statically indeterminate beams. Unsymmetrical bending. Shear centre. Buckling of columns. Energy methods. Principle of virtual work. Castiglianos theorems and applications.

C S Jog, Ananth Ramaswamy, C S Manohar.

J M Gere, and S P Timoshenko, 1984, Mechanics of materials, 2nd Edition, CBS Publishers, New Delhi.

E P Popov, 1990, Engineering mechanics of solids, Prentice Hall, New Jersey.

S Utku, C H Norris, and J B Wilbur, 1991, Elementary structural analysis, McGraw-Hill, New York

S H Crandall, and N C Dahl, 1959, An Introduction to mechanics of solids, McGraw-Hill, New York.

Division of Mechanical Sciences

Department of Materials Engineering

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
UMT 203	Materials Thermodynamics	3:0	Jan	None	No limit
MT 271	Introduction to Biomaterials	3:0	Aug	None	No limit
MT 253	Science and Engineering Mechanical Behaviour of materials	3:0	Aug	MT 250/PD 205/	No limit
MT 260/CH237	Polymer Science Engineering	3:0	Aug	None	No limit

Department of Mechanical Engineering

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
ME 201	Fluid Mechanics	3:0	Aug(5th Sem)	UP 101 UP 202	20
ME 228	Materials & Structure Property Correlations	3:0	Aug(5th Sem)	None	15
ME 240	Dynamics & Control of Mechanical Systems	3:0	Aug	None	10
ME 271	Thermodyamics	3:0	Aug(7th Sem)	UC 202	
ME 256	Variational Methods & Structural Optimization	3:0	Jan(6th Sem)	None	Max 15 UG Students
ME 251	Biomechanics	3:0			Check with instructor
UE 204	Elements of Solid Mechanics	3:0	Jan		No limit

Department of Aerospace Engineering

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
AE 221	Flight vehicle structures	3:0	Aug	None	Max 10 UG students
AE 224	Analysis & design of Composite structures	3:0	Aug/Jan	None	Max 10 UG students
AE 227	Multi-body dynamics using	3:0	Aug	None	Max 10 UG students
AE 259	Symbolic manipulators Navigation, Guidance & Control	3:0	Aug	None	Max 10 UG students
AE 266	Introduction to Neural Network and Engineering Applications	3:0	Aug/Jan	None	Max 10 UG students
AE 262	Guidance Theory & Applications	3:0	Jan	None	Max 10 UG students
AE 281	Introduction to Helicopters	3:0	Jan	None	Max 10 UG students

Centre for Atmospheric and Oceanic Sciences

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
Number	**Title**				
AS 230	Atmos Thermodynamics	3:0	Aug	Physics	No limit
AS 211	Observational Techniques	2:1	Aug	None	2
AS 209	Mathematical methods in Cli Sci	3:0	Aug	None	No limit
UES 307	Introduction to solid earth	3:0	Jan	None	No limit
UES 204	Fundamentals of Climate Science	3:0	Jan	None	No limit
AS 202	GeoPhys Flu. Dyn.	3:0	Jan	Diff. equations	No limit

Department of Chemical Engineering

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
CH 201	Chemical Engg Mathematics	3:0	Aug	None	Check with instructor
CH 202	Numerical Methods	3:0	Aug	None	No limit
CH 203	Transport Processes	3:0	Aug	None	Check with instructor
CH 204	Thermodynamics	3:0	Aug	None	Check with instructor
CH 237/MT260	Polymer Science and Engineering	3:0	Aug	None	No limit
CH 205	Chemical Reaction Engineering	3:0	Jan	None	Check with instructor

Centre for Product Design and Manufacturing

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
PD 201	Elements of Design	Aug	2:1		Check with instructor
PD 202	Elements of Solid and Fluid Mechanics	Aug	2:1		Check with instructor
PD 203	Creative Engineering Design		2:1		Check with instructor
PD 212	Computer Aided Design	Jan	2:1		Max No. of UGs 15
PD216	Design of automotive systems				Check with instructor
PD 217	CAE in Product Design	Aug	2:1	Strength of Materials, Numerical Methods	Max No. of UGs 15
PD 214	Advanced Materials & Manufacturing	Jan	3:0	Materials Science	Max No. of UGs 15
PD 215	Mechatronics	Jan	2:1	Control Systems	Max No. of UGs 15

Centre for Sustainable Technologies

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
ST 202	Energy Systems and Sustainability	3:0	Aug	None	Max 20 UG students
ST 201	Thermochemical & biological energy recovery from biomass	3:0	Jan	None	Max 20 UG students

Scientific computing

Only one of CH 202/SE 288/ SE 289/UE 203 can be taken, as they are equivalent courses

Materials Science and Engineering

Only one of UMT200/MT 250, PD 205, or ME 228 can be taken, as they are equivalent courses

Division of Electrical Sciences

Department of Computer Science and Automation

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
E0 251	Data Structures & Algorithms	3:1	Aug	A or S in UG 101 Algorithms & Programming A or S in all Mathematics Course in the UG Programme	Only fifth term or later; Max number:10
E0 222	Automata Theory & Computability	3:1	Aug	A or S in UG 101 Algorithms & Programming A or S in all Mathematics Courses in the UG Programme	Only fifth term or later; Max number:10
E0 220	Graph Theory & Combinatorics	3:1	Aug	A or S in UG 101 Algorithms & Programming A or S in all Mathematics Courses in the UG Programme	Only fifth term or later; Max number:10
E0 231	Algorithmic Algebra	3:1	Jan	A or S in UG 101 Algorithms & Programming A or S in all Mathematics Courses in the UG Programme	Only sixth term or later; Max number:10
EI 254	Game Theory	3:1	Jan	A or S in UG 101 Algorithms & Programming A or S in all Mathematics Courses in the UG Programme	Only sixth term or later; Max number:10

Department of Electrical Engineering

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
E1 251	Linear and Nonlinear Optimisation	3:0	5th or 7th Sem	Multivariate calculus, matrices & linear algebra	max 15 UGs
E9 201	Digital Signal Processing	3:0	5th or 7th Sem	A basic orientation in Signals and Systems	max 25 UGs

Department of Electrical Communication Engineering

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
E3 238	Analog VLSI Circuits	2:1	Aug	UE 102	Max 10 UG students
E7 213	Introduction to Photonics	3:0	Aug	3rd yr or 4th yr UG standing	No cap

SERC

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
SE 301	Bioinformatics	2:0	Aug		Check with instructor

Additional courses from this division that are allowed but require explicit consent of the instructor

E0 224	Computational Complexity Theory	3:1
E0 229	Foundations of Data Science	
E0 235	Cryptography	3:1
E1 213	Pattern Recognition and Neural Networks	3:1
E1 216	Computer Vision	3:1
E1 254	Game Theory	3:1
E2 201	Information Theory	3:0
E3 214	Microsensor Technologies	3:0
E3 222	Micromachining for MEMS Technology	2:1
E3 253	Industrial Instrumentation	
E3 267/IN 222	Microcontroller Applications	
E9 213	Time-Frequency Analysis	3:0
E9 282	Neural signal processing	3:0

Interdisciplinary Programme

BioEngineering

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
BE 201	Fundamentals of Biomaterials and Living Matter	3:0	Aug		No Cap

Center for Nanoscience

Course Number	Course Title	Credits	Semester	Prerequisites	Comments
NE 327	Nanoelectronics Device Technology	3:1	Aug		Check with instructor
NE 231	Microfluidics	3:0	Aug		Check with instructor
NE 201	Micro and Nano Characterization Methods	2:1	Aug		Check with instructor

Environmental Science

Semester 4 (JAN)

UES 202: Introduction to Earth Systems (2:1, Core course for Env. Sci. major)
Earth Surface features, concept of Geomorphology, Weathering phenomena, Physics and chemistry of Earth's interior, Internal processes, tectonics through time, Geological time scale, Bio-stratigraphy, Early Earth, Rock formation, Rock classification, mineralogy, Basics of crystal symmetry, Composition of Atmosphere and origin of atmosphere, Earth like planetary bodies, Evidence of life in other planet, basics of hydrosphere and its

component, physical property of water, Elementary Oceanography, chemical composition of ocean, Evolution of life and its diversification.

Prosenjit Ghosh

Patwardhan PHI, The Dynamic Earth System, Learning Private Limited , New Delhi . ISBN -978-81-203-1496-2

Kump, Kasting and Crane, The Earth System, Prentice Hall, ISBN 0-13-142059-3

G.R. Thompson and J. Turk, Modern Physical Geology, Saunder College Publishing

UES 206: Experimental Methods in Environmental Chemistry (1:2, Core course for Env. Sci. major)

Characterization of Water Quality - Electrical conductivity, pH, Chlorides, Sulphates, Alkalinity, Hardness.
Characterization of pollutants in water - Estimation using spectroscopic and chromatographic techniques.
Determination of dissolved and suspended solids in water samples, Determination of turbidity of water samples. Determination of chlorine in bleaching powder, Determine the optimum dosage of coagulant for coagulation of suspended solids in water sample. Estimation of total coliforms by MPN and Membrane Filtration Method. Soil surface sorption properties - Cation exchange capacity, Organic content, Grain size distribution, Pore water salinity.
Sampling and measurement techniques in air quality - gaseous pollutants and particulates, air quality standards, Instrumental techniques for gas analysis.

Sudhakar Rao, P. Raghuveer Rao

APHA, Standard methods for the examination of water and wastewater. American Public Health Association, 20th edition, Washington DC, (1999).

SP 36 : Part 1 : 1987 Compendium of Indian standards on soil engineering: Part 1- Laboratory testing of soils for civil engineering purposes

UES 204: Fundamentals of Climate Science (3: 0, Core course for Env. Sci. major)

Atmospheric structure and composition, Observations and theory of the general circulation of the atmosphere, Global energy balance, Radiative processes in the atmosphere, the greenhouse effect, natural and anthropogenic climate change, waves in the atmosphere, clouds, weather systems, tropical dynamics and monsoons, ocean circulation

G. Bala, Arindam Chakraborty

Dennis L. Hartmann, Global Physical Climatology, Academic Press, 1994.

Wallace J.M. and Hobbs, P.V., Aytmospheric Sciences: An Introductory survey, Academic Press

Peixoto J.P and Oort, A.H., Physcs of Climate. American Institute of Physics, New York.

Semester 5 (AUG)

UES 301: Environmental Hydrology (3:0, Core course for Env. Sci. major)

Basic concepts, definition and scope of environmental hydrology, Hydrological cycle and energy budget, Hydro-meteorological processes, Watershed hydrology; Hydrology of forests, wetlands and urban areas, Climate change, Hydrological impacts of environmental change; Hydrogeology, Water quality issues in surface and groundwater.

V. V. Srinivas

Andy D. Ward and Stanley W. Trimble, Environmental Hydrology, Lewis Publishers, 2004.

Singh, V.P. (Ed.), Environmental Hydrology, Water Science and Technology Library, Vol. 15, 1995.

Chow,V. T., David R. Maidment, Larry W. Mays, Applied Hydrology, Tata McGraw-Hill Edition, 2010.

UES 302: Design Principles in Environmental Engineering (2:0, Core course for Env. Sci. major)

Laws of conservation: mass, energy and momentum balances.
Fundamentals of chemical reaction engineering: thermodynamics, stoichiometry and kinetics of chemical reactions, chemical reactors – stirred tank and plug flow reactors,

Design for waste water treatment processes: physical unit operations such as sedimentation and filtration, chemical and biological treatment processes.
Design for air pollution control: gas-liquid interactions, absorption and adsorption processes, particulate emission control

Jayant M. Modak

Mackenzie Davis and Susan Masten, Principles of Environmental Engineering, McGraw Hill, 2004.

Mackenzie Davis and David Cornwell, Introduction to Environmental Engineering, McGraw Hill, 2006.

James Mihelcic and Julie Beth Zimmerman, Environmental Engineering: Fundamentals, sustainability and Design, John Wiley, 2010

Frank R. Spellman and Nancy E. Whiting, Environmental Engineer's Mathematics Handbook, CRC Press, 2005

UES 303: Introduction to Geochemistry: (2:1, Elective)

Geochemical Fundamentals/Chemistry Review , The Elements; basic principles of inorganic chemistry, periodic properties, Thermodynamics and chemical reactions, solubility , Aquatic Chemistry, pH-pE, Biology and redox , Organic Chemistry.
High temperature geochemistry - Planetary geochemistry , Age and Origin of the Solar System., Planet formation, differentiation of the Earth, igneous processes, Radiogenic isotope geology/Geochronology.
Low temperature geochemistry - The hydrologic cycle and Sedimentary geochemistry, Chemical Processes, Photosynthesis/respiration, Aquatic Microbial Biochemistry in rain, rivers, lakes, estuaries, Chemical weathering, soil formation, geochemistry of clays, The oceans, marine chemistry, primary productivity, Gaia, Marine Sediments: a record of environmental global history, light isotope geochemistry, Global Climate: Present and Future, atmospheric CO.
Lab component: will involve exposure to instrumental methods which include a) titration b) chromatography using liquid and gas columns c) analyses of cation and anion using Ion Chromatography, towards chemical analysis of rock samples, measurement of soil moisture contents, geo-chemical characterization of rock samples and determination of CO2 concentrations in air.

Prosenjit Ghosh

John Victor Walther, Essentials of Geochemistry, Jones and Bartlett Publishers 2nd Edition, 2009.

R. Gill, Chemical Fundamentals of Geology, Springer; 2nd edition, 1995.

UES 304: Introduction to Basic Geology (2:1, Elective)

Classification of rocks; Geology of southern India: tectonic concepts; The earth structures and its significance; Shear/suture zones-identification, interpretation and implications, Fluid influence in shear zones; Petrological, geochemical and geochronological: methods, approaches and inferences, origin-exhumation-weathering: the rock cycle, landforms, element mobility and interactions; Linking rocks/mineral chemistry to tectonics with Indian examples.
Laboratory component: Sample preparation of rock specimens, Petrological observation of rock and mineral thin sections

Sajeev K

Ron H. Vernon & Geoffrey Clarke, Principles of Metamorphic Petrology

Cambridge University Press, 2008.

Ron H. Vernon, A Practical Guide to Rock Microstructure, Cambridge University Press, 2004.

Using Geochemical Data: Evaluation, Presentation, Interpretation , by Hugh R. Rollinson, Longman Publishing Group, 1993.

Kent C. Condie, Earth as an Evolving Planetary System, Academic Press; 1st edition, 2004.

Earth Structure: An Introduction to Structural Geology and Tectonics by Ben A. Van Der Pluijm & Stephen Marshak, W W Norton & Co Inc.; 2 edition, 2003.

Anthony R. Philpotts, Petrography of Igneous and Metamorphic Rocks, Waveland Pr Inc, 2003.

UES 310: Experimental Methods in Solid Waste Management (1:2, Elective)

Solid waste characterization - Water leach test, Toxicity Characteristic Leach Procedure.
Pollutant sorption capacity characterization – Kinetics & adsorption isotherms, Distribution coefficients.

Pollutant transport – Column experiments to evaluate transport and partitioning in vadose and saturated zones, Diffusion coefficients.
Laboratory determination of soil permeability for contaminant flow.
Chemical solidification of contaminated wastes-Lime and cement stabilization, Leaching and compressive strength measurements.

Sudhakar Rao, P. Raghuveer Rao

US EPA publication SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, 1996.

BIS Compendium on Engineering Properties of Soils

Semester 6 (JAN)

UES 306: Surface and Groundwater Quality (3:0, Core course for Env. Sci. major)

Hydrologic Cycle, Water and chemical budgets; Sources and types of water pollution, Water quality standards, Fate and transport in aquatic systems, Rivers and streams, Lakes & Reservoirs, Wetlands, Estuaries. Groundwater flow and geologic controls on flow, Vadose zone hydrology, Contaminant transport in groundwater, Modeling environment.

M. Sekhar

Chin, D. A., Water quality engineering in natural systems. Willey InterScience, 2006.

Bedient, P.B., Rifai, H.S.,Newell, C.J., Ground Water Contamination: Transport and Remediation. Prentice Hall, Englewood Cliffs, NJ, USA. 1994.

UES 307: Introduction to Solid Earth (3:0, Elective)

History of the Earth: Introduction to Earth history, origin of the Earth and solar system; origin and evolution of life, mass extinctions, interpretation of the geological record of Earth history; measurement of geological time, historical development of concepts.
The dynamic Earth: Introduction to the dynamic Earth, Gravity and Magnetic fields, thermal structure and heat flow, Radioactivity, internal structure of the earth. Continental drift and plate tectonics, earthquakes, volcanoes, mountain-building processes; igneous and metamorphic processes; surface processes, erosion, soil, and sediment formation, important morphological features on the earth, interactions among the lithospheric, hydrospheric, atmospheric, and biospheric systems.

Kusala Rajendran

1.C.M.R. Fowler, The solid earth: An introduction to Global Geophysics, Cambridge University Press, 2005.

Philip Keary and Frederick Vine, Global Tectonics, Blackwell Science, 1996.

Raymond Siever, John Grotzinger, and Tom Jordan, W. H. Freeman; Understanding Earth, Frank Press, Fourth Edition, 2003.

UES 308: Landfill Engineering (3:0, Elective)

Physico-chemical and engineering properties of soil, Ground water flow and contaminant transport, Criteria for landfill site location, Design of landfill components such as liners, covers, leachate collection and removal, Gas generation and management, Principles and methods of monitoring ground water quality and quantity, End uses of landfill sites, Risk assessment approaches, Contaminated site characterization and remediation technologies, Environmental laws and regulations.

G. L. Siva kumar Babu

Rowe, R. Kerry, Quigley, Robert M., Brachman, Richard W. I., and Booker, John R. Barrier Systems for Waste Disposal Facilities , 2nd ed., Spon Press, Taylor & Francis Group, London, 2004.

Sharma, H.D., and Reddy, K.R., Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.

Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management - Engineering Principles and Management Issues, McGraw Hill 1993.

UES 309: Wastewater Treatment (3:0, Elective)

Wastewater generation patterns /sources - quantification and quality issues, Pathogens and microbiological risks from wastewater.

Pollution Indicators - physical, chemical, biological and microbiological.

Water Testing - Physico-chemical properties, Biological and microbiological characteristics.

Microbial Metabolism with respect to waste water remediation and water treatment,

Organic Matter Removal-Anaerobic and Aerobic methods, Modeling activated sludge processes.

Nitrogen, Phosphorus and Pathogen removal from wastewater, Aquatic and water Toxicity and toxicology, Physico-chemical basis and processes for aeration, mixing, settling, microbial killing processes.

Sludge physical properties, settling properties, characterization, remediation, treatment and disposal.

Membrane Bio-reactors, Anaerobic Wastewater Treatment reactor designs, Hybrid reactors, Biofilm Reactors, Anaerobic biofilm reactors.

Micro-biological and Phyto-remediation techniques.

Grey and black water recycling, needs, Ground water pollution, sources and mechanisms, sustainability issues, in-situ and ex-situ bioremediation.

Hoysall Chanakya

APHA, Standard methods for the examination of water and wastewater. American Public Health Association, 20th edition, Washington DC, 1999.

Metcalf & Eddy Incorporation, Wastewater engineering, treatment and re-use. Revised by George Tchobanoglous, Franklin, L. Burton and H. David Stensel, Tata McGraw-Hill Publishing Company limited, New Delhi., 2003.

Relevant papers from current literature.

Semester 7 (AUG)

UES 401 Natural Hazards and Their Mitigation (3:0, Core)

Definitions and basic concepts, different kinds of hazards and their causes, Geologic Hazards: Earthquakes, causes of earthquakes and their effects, plate tectonics, seismic waves, measures of size of earthquakes, earthquake resistant design concepts; Slope instability and landslides, causes of landslides, principles of stability analysis, remedial and corrective measures for slope stabilisation, Climatic Hazards: Floods, causes of flooding, regional flood frequency analysis, flood control measures, flood routing, flood forecasting and warning systems; Droughts, causes and types of droughts, effects of drought, hazard assessment and decision making; Use of GIS in natural hazard assessment, mitigation and management.

Donald Hyndman and David Hyndman, Natural Hazards and Disasters, Brooks/Cole Cengage Learning, 2008

Edward Bryant, Natural Hazards, Cambridge University Press, 2005

J Michael Duncan and Stephan G Wright, Soil Strength and Slope Stability, John Wiley & Sons, Inc, 2005.

Amr S Elnashai and Luigi Di Sarno, Fundamentals of Earthquake Engineering, John Wiley & Sons, Inc, 2008

K. S. Nanjunda Rao, V. V. Srinivas

UES 402 Green Chemistry (2:0, Elective)

Introduction and principles of green chemistry, Tools of green chemistry-alternative starting material, alternative target/product, Process analytical chemistry, Evaluation of methods to design safer chemicals, Reaction types, yield and atom economy, Examples of green chemistry, Solid acids and bases as catalysts, Organocatalysis, Catalysis and Green chemistry, Catalysis in novel reaction media, Enatoselective catalysis, Future trends in green chemistry.

Paul T. Anastas and John C. Warner, Green Chemistry: Theory and Practice. Oxford University Press, 2000.

William McDonough and Michael Braungart, Cradle to Cradle: Remaking the Way We Make Things. New York: North Point Press, 2002.

Paul T. Anastas and John C. Warner, Green Chemistry: Theory and

Practice. Oxford University Press, 2000.
William McDonough and Michael Braungart, Cradle to Cradle: Remaking the Way We Make Things. New York: North Point Press, 2002.
Roger A. Sheldon, Isabel Arends, and Ulf Hansfeld, Green Chemistry and Catalysis.Wiley-VCJ Verlag GmbH & Co. KGaA. Weinreim, Germany, 2007

K. R. Prabhu

Semester 8 (JAN)

UES 403 Solid Waste Management (3:0, Elective)

Classification and characterization of solid wastes, The RCR (recover, recycle and reuse) principle, Handling and treatment of MSW (municipal solid waste), Biological treatment, Thermal treatment, Landfill, Integrated waste management, Sludge generation from treatment of industrial waste waters, Physico-chemical characterization of sludge, Sludge handling, treatment and disposal options, Siting, operation and maintenance of Toxic Substances Disposal Facilities (TSDFs), Surface and ground water control, Closure and post closure care of land-fills, Treatment of hazardous wastes: Air stripping, Soil vapour extraction, Carbon absorption, Steam stripping, Stabilization and solidification, Thermal methods – combustion, liquid injection incinerators, Biological methods – conventional treatment, In-situ bio-remediation
Toxicology and risk assessment: Toxic effects, dose-response relationships, carcinogens, ecotoxicology, risk, exposure and toxicity assessment, risk characterization, ecological risk assessment.
Environmental, legal and public health aspects of solid waste management

F.McDougall, P.White, M.Franke and P.Hindle, Integrated Solid Waste Management- Life Cycle inventory, Blackwell Publishing, 2001.
Charles A.Wentz, Hazardous Waste Management, McGraw-Hill International Editions, Singapur, 1989
G.Kiely, Environmental Engineering, Mc-Graw Hill International Edition, 1998.
Dawson and Mercer,Hazardous Waste Management –John Wiley, 1981
Lagrega M.D., Buckingham P.L., and Evans J.C., Hazardous Waste Management , McGraw Hill International Edition. (1994)

J.R.Mudakavi

HUMANITIES

Semester 1 (AUG)

UH-101: Ways of Knowing (2:0)
Prof. S.V. Srinivas

Module 1: Ethnographic methods: What is culture? How are cultural practices and patterns reproduced and carried forward in time? Questions such as these can be explored with the help of qualitative ethnographic methods. Originating in cultural anthropology, these are now widely used across the human sciences. Typically, ethnography collects empirical data about human societies, using fieldwork, participant observation, questionnaires, interviews, chain sampling, etc. to understand how social meanings are created. Of special interest to science students would be the reflexive and interpretive emphasis of ethnography, since it has a bearing on how to read and write up scientific findings. The module will expose students to some key debates in this area through short readings and documentary films.

Module 2: Historical analysis: How do we assemble and examine data from the past? What are the problems we might encounter in verifying the accuracy of this data? Although the discipline of History pioneered archival work in relation to societies with written documents, almost every branch of social sciences and humanities uses methods that in different ways take up and discuss historical examples. This is true of the natural sciences as well. This module will briefly introduce students to historical research and then examine the issues confronting researchers in this field of knowledge production. The focus of the module is on the relationship between the past and present. It encourages students to engage with the problem of how a researcher located in the present might access or reconstruct the past. The module, while discussing these issues, will also touch upon some of the challenges to conventional history-writing.

Module 3: Textual analysis: This module introduces student to key concepts and issues in textual analysis, a method adopted by students of literature but also History and other disciplines. It begins with the discussion of what a text is and the relationship of the writer to the text written by him or her. It then goes on to discuss how meaning is produced from a text and who produces it. It then returns to the problem of interpretation, discussed in the earlier modules, to focus on the reader's role in interpreting texts and generating meaning, examine how texts are. What is the role of the reader in interpreting textual meaning? Students will be introduced in this module to methods of close reading drawn from literary criticism and cultural studies.

Humanities Lab: **Writing workshop:** Conducted by the course instructor, with inputs from visiting lecturers. This workshop will expose students to modes of analytical writing, report writing, etc.

Raymond Williams, "The Analysis of Culture". In John Storey ed. *Cultural Theory and Popular Culture: A Reader*.

Clifford Geertz, "Thick Description" and "Notes on the Balinese Cockfight," in *The Interpretation of Cultures.*

Lata Mani, "Contentious Traditions: The Debate on Sati in Colonial India," in Kumkum Sangari and Sudesh Vaid, eds., *Recasting Women: Essays in Colonial History*.

Michel Foucault, "What is an Author?" in Paul Rabinow ed., *The Foucault Reader*.

Semester 2 (JAN)

UH-102: Ways of Seeing (2:0)

Prof. S.V. Srinivas

This course introduces students to a) the ways in which cultural forms and genres represent the world around us and b) how we see and understand the world as refracted by these forms. There will be three modules. In short, this is a course about seeing and interpreting the forms that show us the world. Each module discusses a particular cultural form and also focuses on one theme.

General Introduction: Reinforcement of concepts and theories introduced in Semester I: archive, text, author, reader, and interpretation.

Module1: Literature: What do we need to know in order to appreciate creative writing? How do we read and interpret literary works? Where does meaning lie? How do we 'learn' from literature? Special focus on science fiction: good science and bad science; space/distance and time/history; human and non-human; science & technology and nature.

Module 2: Visual Arts: How do paintings represent reality? Is realism more "scientific" than other ways of presenting the world? How does technology determine the evolution of art forms? What problems did artists face in the Indian context as they adopted western styles and forms? Special focus on mythology and its representation in modern Indian art.

Module 3: Film: History of cinema as a technological form, technophobic reactions to film. Audiences and spectatorship. Film as an urban, democratic form. How fiction and non-fiction films "document" reality and what they can they tell us about society; how to "read" films. Special focus on the city, as subject of cinema and site of film production and viewing.

Issac Asimov, Selections from *I, Robot*: "Introduction," "Robbie," "Runaround" and "Reason"

Satyajit Ray, "Diary of a Space Traveller" and "Bonku Babu's Friend"

Gulammohammed Sheik, "Mobile Vision: Some Synoptic Comments"
Walter Benjamin, "Work of art in the age of mechanical reproduction."
Ashish Rajadhyaksha, "Phalke Era: The Conflict of Traditional Form and Modern Technology".

Semester 3 (AUG)

UH-203: Ways of Doing (2:0)
Anshuman Manur, Sabah Siddiqui, Prof. Rajan Gurukkal, Prof. H.N. Chanakya

Module 1: The Digital Subject: What does a digital subject look like? How do digital technologies produce new interfaces for interaction and mobilisation? How do the new interfaces affect older forms of social and political movements? As globalisation consolidates itself, we see changes in the patterns of governance, of state operation, of citizen engagement and civic action. We are in the midst of major revolutions in the Middle East and North Africa, powered by digital social change, some headed by cyber-utopians specializing in Web 2.0 and social media. Phrases like 'Twitter Revolutions' and 'Facebook Protests' have become common. How do we develop integrated science-technology-society approaches to understand our technology-mediated contemporary and futures?

Module 2: Brain-Mind Divide: This module looks at contemporary debates in Cognitive Studies to show how we might require an interdisciplinary perspective, integrating insights from neurobiology, evolutionary history, biophysics, computation, cultural studies, psychology and civilizational histories, to make sense of "what makes us think". Natural sciences talk about the *brain* and humanities disciplines talk about the *mind.* Is the object of inquiry actually one and the same, and would it be better analysed through an inter-disciplinary approach?

Module 3: People and Nature: This module will approach the theme of people and nature from several natural science, social science, humanities and arts perspectives. The course will discuss the evolution of our conception of nature, our understanding of our place in nature, our understanding of how nature works and our attempts to describe, appreciate, control and manipulate nature. This module will be more multidisciplinary than interdisciplinary and will attempt to showcase the significant variation across, disciplines, historical time and geographical space, in our approach to nature, and the inevitable conflicts such variation generates.

Module 4: Sustainable Development
This module will approach the gradually evolving concepts of sustainable development from the Indian to a Global perspective and in the process bring about the various societal forces (local and global) that evolve(d) the meanings of sustainability and sustainable development, emerging debates and likely conflicts into the future. Is sustainability Science? Examining how people of natural, engineering and social sciences perceive sustainability in different perspectives /domains and the potential to integrate these perspectives for completeness, S&T in championing sustainable development. Measuring sustainability and evolving indices for sustainability.

Balibar, Etienne. "Citizen-Subject." Who Comes After the Subject. Eds Eduardo Cadava, Peter Connor and Jean-Luc Nancy. New York: Routledge, 1991.
Freud, S. A Note upon the "Mystic Writing Pad". 1925.
Gilbert F. LaFreniere, *The Decline of Nature: Environmental History and the Western Worldview*, Paper Back ed. Oak Savanna Publishing, Oregon, 2012.
Emilio F. Moran, *People and Nature: An Introduction to Human Ecological Relations*, Wiley-Blackwell, 2006.

Semester 4 (JAN)

UH-204 Seminar Course: Mapping India through the Folk Arts (1:0)

Dr. Bitasta Das
The objective of this course is to understand the seven regions of India—North, West, East South, Central,

North-East and the Islands a little better—through their folk arts. The course considers the art forms, as viewed in the discipline of Folkloristics, as means of knowing the regional cultures from "inside-out rather than outside-in". The aim of this seminar course is to provide the students a broad idea of India as a "nation", its diverse regional specificities and the relevance of the folk arts in understanding the "national" and the "regional". The students will get an oppourtunity to interact with folk artists and gain first-hand knowledge about various aspects of the folk arts to understand the synergy between artistic worldview and the contemporary social milieu. The course will be useful in recognizing how meaning is produced and expressed in folk domain and at the same time, aid the students to gain cognizance of Indian multiculturalism.

Anderson, Benedict. *Imagined Community Reflection On The Origin And The Spread Of Nationalism*. New York. Verso. 1991.

Bhabha, Homi. K (ed.). *Nation and Narration*. New York. Routledge. 1990.

Dorson, M Richard. *Folklore and Folklife*. Chicago. University of Chicago Press. 1972.

Dundes, Alan. *Interpreting Folklore*. Indiana University. 1980.

Semester 5 (AUG)

UH-301Seminar Course: Journalism for Scientists (1:0)

Amrita Shah

The Course will be useful in acquainting students with journalistic skills which they may apply in their own work to observe and communicate better for instance or to their field as future science reporters, perhaps or as individuals who might have to explain science to the lay person.
It also seeks to provoke thought on the practice of journalism, its tenets, its limitations and its influence with a view to encouraging a more critical engagement with media but also to position science within the media.

Sainath, P. "The Trickle Up Down Theory; Or, health for the millions." In *Everybody Loves a Good Drought* New Delhi: Penguin Books, 2000, pp.23-27.

Shah, Amrita. *Hype, Hypocrisy & Television in Urban India,* Vikas, New Delhi 1997.

Wolfe, Tom. "Selections". In E W Johnson; Picador (ed.) *The New Journalism,* 1990, pp.40-42.

Shah, Amrita. *Vikram Sarabhai-A Life.* Viking-Penguin, 2007.

Semester 6 (JAN)

UH-302 Seminar Course: Introduction to Governance (1:0)

Dr. Uday Balakrishnan

The Semester long programme on **Introduction to Governance** is to enable the participants to develop an appreciation of key issues and challenges to governance in India while gaining an insight into how the Government of India works and relates to the people. The Semester- long programme will be largely interactive and to facilitate this (i) **Select reading material** will be given ahead of each session (a) additionally a **selection of books** will be available for consultation in the library of the Centre for Contemporary Studies –IISc. Some if not all of the **sessions** are expected to be supplemented by experts drawn from the top echelons of public administration, the judiciary and politics. Evaluation is based on group projects and individual assignments emerging from each covering a range of contemporary issues that engage us as concerned citizens of our country.

Ivan Illich's De-schooling Society, Small is beautiful by E.F.Schumacher

An Eye to India by David Selbourne

The Economic and Political Weekly

The Economist

MATERIALS

Semester 4 (JAN)

UMT 202 Structure of Materials (2:1)

(Core for Materials majors and minors)

Elements of bonding, structures of simple metallic, ionic and covalent solids; Coordination polyhedra, projections of structures, stacking; Lattices, symmetry operations, stereographic projection; Structure and thermodynamics of point defects and solid solutions, non-stoichiometry, ordered structures; Dislocations and slip, twinning and interfaces.

N. Ravishankar, S. Karthikeyan

A. Kelly and G.W.Groves: Crystallography & Crystal Defects, Addison Wesley

C.S.Barrett and T.B.Massalski, Structure of Metals, Pergamon

A.R. West,: Introduction to solid state chemistry, John Wiley

UMT 203 Materials Thermodynamics (3:0)

(Core for Materials majors + Soft core for Materials minors)

First Law, Enthalpy, Thermochemistry; Second Law, Entropy, Statistical Interpretation; Helmholtz and Gibbs Free Energies, Chemical Potential; Solution Thermodynamics; Conditions for Equilibrium, Phase Rule, Phase Diagrams; Chemical Reactions and Equilibria; Surfaces and Interfaces.

T.A. Abinandanan

R.T. DeHoff: Thermodynamics in Materials Science, Taylor & Francis (2006)

D.R. Gaskell: Introduction to the Thermodynamics of Materials (4th Ed), Taylor & Francis (2003).

UMT 204 Electronic Properties of Materials (3:0)

(Core for Materials majors + Soft core for Materials minors)

Brief review of the fundamentals of quantum mechanics, statistical mechanics, electrostatics and electrodynamics. Energy bands in crystals, density of states, Electric conduction in metals and alloys, Thermoelectric phenomenon and applications, Semiconductors and devices, Electrical properties of polymers, ceramics, dielectric and amorphous materials, classical and quantum mechanical description of optical properties, Lasers, LEDs, photonics,Magnetic phenomenon and applications, Thermal properties of materials.

R. Ranjan

C. Kittel: Introduction to Solid State Physics, McGraw-Hill.

L. Solymar and D. Walsh, Lectures on Electrical Properties of Materials

M. Ali Omar: Elementary Solid State Physics

R.E. Hummel: Electronic Properties of Materials

Semester 5 (AUG)

UMT 301 Materials Kinetics (3:0)

(Core for Materials majors + Soft core for Materials minors)

Point defects, Fick's laws of diffusion, concept of jump frequency, activation energy, Kirkendall effect, solidification, nucleation, constitutional supercooling, sintering, interfaces, grain growth, solid state transformations, JMA theory, GP zone, Spinodal decomposition, ordering and martensitic transformations, effect of stress and electric current.

A. Paul

R.E. Reed-Hill and R. Abbaschian, Physical Metallurgy Principles, Cengage (2009)

D.A. Porter and K. E. Easterling, Phase Transformations in Metals and Alloys, Taylor and Francis (2009)

UMT 302 Introduction to Materials Processing (2:1)
(Core for Materials majors + Soft core for Materials minors)
Metals: Principles of extraction of metals, hydrometallurgy, electrometallurgy, pyrometallurgy. Solidification Processing. Ceramics: Synthesis of ceramic powders, consolidation, sintering. Polymer synthesis. Growth and processing of thin films.

S. Subramanian, P.C. Ramamurthy, S. Bose

C.B. Alcock: Principles of pyrometallurgy, Academic Press, London (1976)

S. Venkatachalam: Hydrometallurgy, Narosa, New Delhi (1998).

W.D. Kingery, H.K. Bowen, D.R. Uhlmann, Introduction to Ceramics, Wiley (1976)

D. Braun, H. Cherdron, M. Rehahn, H. Ritter and B. Voit, Polymer Synthesis: Theory and Practice: Fundamentals, Methods, Experiments , Springer (2010)

UMT 303 Mechanical Behaviour of Materials (3:0)
(Core for Materials majors + Soft core for Materials minors)
Introduction to basic concepts of Stress and Strain; Engineering stress-strain response vs. True stress-strain response, Elastic and viscoelastic behavior, dislocations, plastic flow in single crystals, strengthening mechanisms, composites, noncrystalline materials, fracture and toughening mechanisms of ceramics and polymers, creep and fatigue, environmental effects.

B. Basu

T.H. Courtney, Mechanical Behavior of Materials, 2nd edition, Tata McGraw Hill (2001).

UMT 306 Mechanical Processing Lab (0:1)
(Core for Materials majors)
Solidification, Mechanical working of materials: Rolling, Extrusion; Powder processing: Sintering; Materials Joining: Welding, Soldering.

G.S. Avadhani, S.V. Kailas, S. Suwas

Semester 6 (JAN)

UMT 304 Microstructures in Materials (3:0)
(Elective)
Structure and properties of grain boundaries, interface boundaries, and surfaces; Solidification microstructures; Phase transformations: precipitation, eutectoid, martensitic transformations; Sintering.

T.A. Abinandanan

D.A. Porter and K. E. Easterling, Phase Transformations in Metals and Alloys, Taylor and Francis (2009)

J.W. Martin, R.D. Doherty and B. Cantor, Stability of Microstructures in Metallic Systems, Cambridge University Press (1997)

UMT 305 Mechanical Properties Lab (0:1)
(Core for Materials majors)
Tensile and compression testing. Hardness tests. Fatigue. Impact testing. Creep, Dynamic properties of materials.

P. Kumar, R. Ravi, S. Suwas

Electives

An indicative list of graduate-level elective courses is given below; specific recommendations will be made at the beginning of each semester:

For the third year:

Fundamentals of Biomaterials and Living Matter (Bio-Engineering)
Introduction to Biomechanics of Solids (Bio-Engineering)
Corrosion Technology (MT)
Polymer Science and Engineering-I (MT)
Topics in Basic and Applied Electrochemistry (IPC)
Phase Transformations (MT)
Interfacial Phenomena in Materials Processing (MT)
Fracture (MT)
Solidification Processing (MT)
Defects and Materials Properties (MRC)
Functional Materials Lab (MRC)
Introduction to Biomaterials (MRC)
Thin Films, Nanomaterials and Devices: Science and Engineering (MRC)

For the fourth year:

Semiconductor Devices and Integrated Circuit Technology (CeNSE)
Crystal Growth and Thin Films (CeNSE)
Elements of Solid and Fluid Mechanics (CPDM)
Design and Selection of Materials (MT)
Defects in Materials (MT)
Modeling and Simulations in Materials Engineering (MT)
Science of Materials Processing (MT)
Introduction to Biomaterials Science and Engineering (MT)
Electron Microscopy (MRC)
Computational Modeling of Materials (MRC)
Nanostructured Materials (MRC)

MATHEMATICS

Semester 1 (AUG)

UM 101: Analysis and Linear Algebra I (3:0)

One-variable calculus: Real and Complex numbers; Convergence of sequences and series; Continuity, intermediate value theorem, existence of maxima and minima; Differentiation, mean value theorem, Taylor series; Integration, fundamental theorem of Calculus, improper integrals. Linear Algebra: Vector spaces (over real and complex numbers), basis and dimension; Linear transformations and matrices.

A. Ayyer

T M Apostol, Calculus, Volume I, 2nd. Edition, Wiley, India, 2007.
G. Strang, Linear Algebra And Its Applications, 4th Edition, Brooks/Cole, 2006.

Semester 2 (JAN)

UM 102: Analysis and Linear Algebra II (3:0)

Linear Algebra continued: Inner products and Orthogonality; Determinants; Eigenvalues and Eigenvectors;

Diagonalisation of Symmetric matrices. Multivariable calculus: Functions on R^n Partial and Total derivatives; Chain rule; Maxima, minima and saddles; Lagrange multipliers; Integration in R^n, change of variables, Fubini's theorem; Gradient, Divergence and Curl; Line and Surface integrals in R^2 and R^3; Stokes, Green's and Divergence theorems.

Introduction to Ordinary Differential Equations; Linear ODEs and Canonical forms for linear transformations.

T. Bhattacharyya

T. M. Apostol, Calculus, Volume II, 2nd. Edition, Wiley Wiley India, 2007.

G. Strang, Linear Algebra And Its Applications, 4th Edition, Brooks/Cole, 2006

M. Artin, Algebra, Prentice Hall of India, 1994.

M. Hirsch, S. Smale, R. L. Devaney, Differential Equations, Dynamical Systems, and an Introduction to Chaos, 2nd Edition, Academic Press, 2004.

Semester 3 (AUG)

UM 201: Probability and Statistics (3:0)

Basic notions of probability, conditional probability and independence, Bayes' theorem, random variables and distributions, expectation and variance, conditional expectation, moment generating functions, limit theorems. Samples and sampling distributions, estimations of parameters, testing of hypotheses, regression, correlation and analysis of variance.

S. Iyer

Sheldon Ross, A First Course in Probability, 2005, Pearson Education Inc., Delhi, Sixth Edition.

Sheldon Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier, 2010, Fourth edition.

William Feller, An Introduction to Probability Theory and Its Applications, Wiley India, 2009, Third edition.

R. V. Hogg and J. Ledolter, Engineering Statistics, 1987, Macmillan Publishing Company, New York.

Semester 4 (JAN)

UM 202: Multivariable Calculus and Complex Variables (3:0) (core course for Mathematics major and minor)

Topolgy of R^n: Notions of compact sets and connected sets, the Heine-Borel theorem, uniform continuity, Cauchy sequences and completeness. Review of total derivatives, inverse and implicit function theorems. Review of Green's theorem and Stokes' theorem. Complex linearity, the Cauchy-Riemann equations and complex-analytic functions. Möbius transformations, the Riemann sphere and the mapping properties of Möbius transformations. Some properties of complex-analytic functions, and examples.

G. Bharali

T.M. Apostol, Calculus, Volume II, 2nd. Edition, Wiley India, 2007.

T.W. Gamelin, Complex Analysis, Springer Undergraduate Texts in Mathematics, Springer International Edition, 2006

UM 203: Elementary Algebra and Number Theory (3:0) (core course for Mathematics major and minor)

Divisibility and Euclid's algorithm, Fundamental theorem of Arithmetic, Congruences, Fermat's little theorem and Euler's theorem, the ring of integers modulo n, factorisation of polynomials, Elementary symmetric functions, Eisenstein's irreducibility criteria, Formal power series, arithmetic functions, Prime residue class groups, quadratic reciprocity. Basic concepts of rings, Fields and groups. Applications to number theory.

S. Das

D. M. Burton, Elementary number theory, McGraw Hill.

Niven, H. S. Zuckerman and H. L. Montgomery, An Introduction To The Theory Of Numbers, 5th Edition, Wiley Student Editions

G. Fraleigh, A First Course in Abstract Algebra, 7th Edition, Pearson.

Semester 5 (AUG)

MA 212: Algebra (3:0) (core course for Mathematics major and minor)

Groups: Review of Groups, Subgroups, Homomorphisms, Normal subgroups, Quotient groups, Isomorphism theorems. Group actions and its applications, Sylow theorems. Structure of finitely generated abelian groups, Free groups. Rings: Review of rings, Homomorphisms, Ideals and isomorphism theorems. Prime ideals and maximal ideals. Chinese remainder theorem. Euclidean domains, Principal ideal domains, Unique factorization domains. Factorization in polynomial rings. Modules: Modules, Homomorphisms and exact sequences. Free modules. Hom and tensor products. Structure theorem for modules over PIDs.

A. Banerjee

Lang, S., Algebra, revised third editiom. Springer-Verlag, 2002 (Indian Edition Available).

Artin, M., Algebra, Prentice-Hall of India, 1994.

Dummit, D. S. and Foote, R. M., Abstract Algebra, John Wiley & Sons, 2001.

Hungerford, T. W., Algebra, Springer (India), 2004

Herstein, I. N., Topics in Algebra, John Wiley & Sons, 1995.

MA 219: Linear Algebra (3:0) (core course for Mathematics major and minor)

Vector spaces: Basis and dimension, Direct sums. Determinants: Theory of determinants, Cramer's rule. Linear transformations: Rank-nullity theorem, Algebra of linear transformations, Dual spaces. Linear operators, Eigenvalues and eigenvectors, Characteristic polynomial, Cayley- Hamilton theorem, Minimal polynomial, Algebraic and geometric multiplicities, Diagonalization, Jordan canonical Form.

Symmetry: Group of motions of the plane, Discrete groups of motion, Finite groups of S0(3).

Bilinear forms: Symmetric, skew symmetric and Hermitian forms, Sylvester's law of inertia, Spectral theorem for the Hermitian and normal operators on finite dimensional vector spaces.

Linear groups: Classical linear groups, SU2 and SL 2(R).

P. Singla

Artin, M., Algebra, Prentice-Hall of India, 1994.

Herstein, I. N., Topics in Algebra, Vikas Publications, 1972.

Strang, G., Linear Algebra and its Applications, Third Edition, Saunders, 1988.

Halmos, P., Finite dimensional vector spaces, Springer-Verlag (UTM), 1987.

MA 221: Real Analysis (3:0) (core course for Mathematics major and minor)

Review of Real and Complex numbers systems, Topology of R, Continuity and differentiability, Mean value theorem, Intermediate value theorem. The Riemann-Stieltjes integral. Introduction to functions of several variables, differentiablility, directional and total derivatives. Sequences and series of functions, uniform convergence, the Weierstrass approximation theorem.

T. Gudi

Rudin, W., Principles of Mathematical Analysis, McGraw-Hill, 1986.

Royden, H. L., Real Analysis, Macmillan, 1988.

MA 231: Topology (3:0) (core course for Mathematics major)

Open and closed sets, continuous functions, the metric topology, the product topology, the ordered topology, the quotient topology. Connectedness and path connectedness, local path connectedness. Compactness. Countability axioms. Separation axioms. Complete metric spaces, the Baire category theorem. Urysohn's embedding theorem. Function. Topological groups, orbit spaces.

B. Datta

Armstrong, M. A., Basic Topology, Springer (India), 2004.

Janich, K., Topology, Springer-Verlag (UTM), 1984.
Munkres, K. R., Topology, Pearson Education, 2005.
Simmons, G. F., Topology and Modern Analysis, McGraw-Hill, 1963.

Semester 6 (JAN)

MA 222: Measure Theory (3:0) (core course for Mathematics major)

Construction of the Lebesgue measure, measurable functions, limit theorems. Lebesgue integration. Different notions of convergence and convergence theorems. Product measures and the Radon-Nikodym theorem, change of variables, complex measures.

H. Seshadri

Hewitt, E. and Stromberg, K., Real and Abstract Analysis, Springer, 1969
Royden, H.L., Real Analysis, Macmillan, 1988.
Folland, G.B., Real Analysis: Modern Techniques and their Applications, 2nd edition, Wiley.

MA 224: Complex Analysis (3:0) (core course for Mathematics major)

Complex numbers, complex-analytic functions, Cauchy's integral formula, power series, Liouville's theorem. The maximum-modulus theorem. Isolated singularities, residue theorem, the Argument Principle, real integrals via contour integration. Mobius transformations, conformal mappings. The Schwarz lemma, automorphisms of the dis. Normal families and Montel's theorem. The Riemann mapping theorem.

S. Thangavelu

Ahlfors, L. V., Complex Analysis, McGraw-Hill, 1979.
Conway, J. B., Functions of One Complex Variable, Springer-veriag, 1978.
Gamelin, T.W., Complex Analysis, UTM, Springer, 2001.

MA 241: ODE (3:0) (core course for Mathematics major)

Basics concepts: Phase space, existence and uniquness theorems, dependence on initial conditions, flows.
Linear systems: The fundamental matrix, stability of equilibrium points. Sturm-Liouvile theory.
Nonlinear systems and their stability: The Poincare-Bendixson theorem, perturbed linear systems, Lyapunov methods.

G. Rangarajan

Coddington, E. A. and Levinson, N., Theory of Ordinary Differential Equations, Tata McGraw-Hill 1972.
Birkhoff, G. and Rota, G.-C., Ordinary Differential Equations, wiley, 1989.
Hartman, P., Ordinary Differential Equations, Birkhaeuser, 1982.

Semester 7 (AUG)

The coursework for this semester comprises five electives.
See below for the list of electives offered by the Department of Mathematics.

Semester 8 (JAN)

The work for this semester consists of one elective course and the undergraduate project.
The undergraduate project carries 13 credits.
See below for the list of electives offered by the Department of Mathematics.

List of electives offered by the Department of Mathematics

ELECTIVES OFFERED IN THE AUGUST-DECEMBER SEMESTER

MA 223: Functional Analysis (3:0)
Instructor: S. Thangavelu

MA 226: Complex Analysis II (3:0)
Instructor: Jaikrishnan J. / Gautam Bharali

MA 232: Introduction to Algebraic Topology (3:0)
Instructor: S. Gadgil

MA 242: Partial Differential Equations (3:0)
Instructor: M. K. Ghosh

MA 317: Introduction to Number Theory (3:0)
Instructor: S. Das

MA 325: Operator Theory (3:0)
Instructor: G. Misra

MA 327: Topics in Analysis (3:0)
Instructor: M. Krishnapur

MA 338: Differentiable Manifolds and Lie Groups
Instructor: H. Seshadri

ELECTIVES OFFERED IN THE JANUARY-APRIL SEMESTER

MA 210: Logic, Types and Spaces (3:0)
Instructor: S. Gadgil

MA 213: Representation Theory of Finite Groups (3:0)
Instructor: P. Singla

MA 229: Calculus on Manifolds (3:0)
Instructor: A.K. Nandakumaran

MA 312: Commutative Algebra (3:0)
Instructor: D. P. Patil

MA 315: Galois Theory (3:0)
Instructor: A. Banerjee

MA 318: Combinatorics (3:0)
Instructor: A. Ayyer

MA 347: Advanced PDE and Finite Element Method (3:0)
Instructor: T. Gudi

MA 361: Probability Theory
Instructor: M. Krishnapur

Physics

Semester 1 (AUG)

UP 101: Introductory Physics I - Mechanics, oscillations and waves (2:1)

Kinematics, laws of motion. Circular motion, Work. Kinetic and potential energy. Line integrals. Conservative forces. Friction, terminal velocity in air. Systems of particles. Conservation of linear momentum. Scattering in one and two dimensions. Angular momentum. Moment of inertia. Rotation about one axis. Precession of gyroscope. Central force. Reduction of two-body problem to one-body problem and effective one-body potential. Planetary motion and Kepler's laws. Simple pendulum, damped and forced, resonance. Coupled oscillators, normal modes. Small oscillations. Transverse waves on a string. Linear superposition, interference, beats. Fourier series. Sound waves in air. Doppler effect.

V Venkataraman, Prasad V Bhotla, K Ramesh

Kittel C, Knight W D, Ruderman M A, Helmholz A C and Moyer B J, Mechanics, Berkeley Physics Course: Volume 1, 2nd Edition (2011)

Kleppner D and Kolenkow R J, An Introduction To Mechanics (Special Indian Edition) (2007)

Semester 2 (JAN)

UP 102: Introductory Physics II – Electricity, Magnetism and Optics (2:1)

Introduction, Review of vector algebra, Vector calculus: gradient, divergence, curl, Gauss's theorem and Stokes' theorem, Laplacian etc. Coulomb's law, electric field, Electrostatic potential, Uniqueness theorem, Conductors, capacitance, Method of images, Bound charges and dipole moment density, Energy stored in electric fields. Magnetostatics: Electric currents, Biot-savart law, Ampere's law, magnetic fields of straight wires, circular loops and infinite solenoids, Vector potential, Magnetic dipole moment and bound currents. Lorentz force and Faraday's law, Inductance, Energy stored in a magnetic field. Linear dielectric and magnetic materials, Charge conservation, displacement current, Maxwell's equations and gauge invariance, Classical wave equation and plane monochromatic waves, Energy of EM waves and Poynting's theorem.

Tarun Deep Saini, Sai Gorthi, D V S Muthu

Purcell E.M., Electricity and Magnetism, Berkeley Physics Course - Volume 2, 2nd edn (Tata McGraw Hill, 2011)

Griffiths D.J., Introduction to Electrodynamics, 3rd edn (Prentice-Hall of India, 2003)

Semester 3 (AUG)

UP 201: Introductory Physics Ill - Thermal and Modern Physics (2:1)

Temperature, The First Law of Thermodynamics, Kinetic Theory of Gases and Maxwell -Boltzmann Statistics, Heat Engines, Entropy and the Second Law of Thermodynamics, Relativity, Introduction to Quantum Physics, Basics of Quantum Mechanics, Atomic , Molecular and Solid state Physics, Nuclear Physics, Particle Physics and Cosmology

H R Krishnamurthy, P S Anil Kumar, K P Ramesh

Serway and Jewitt, Physics for Scientists and Engineers (7th Edition)

Young and Friedman, University Physics (12th Edition)

Halliday, Resnick and Walker, Fundamentals of Physics, Extended (8th Edition)

Harris Benson , University Physics, Revised Edition

Kenneth Krane, Modern Physics, Second Edition

Semester 4 (JAN)

UP 202: Intermediate Mechanics, Oscillations and Waves (2:1) (Core course for Physics major)

Special theory of relativity. Lorentz transformations. Energy-momentum relation. Lorentz four-vectors. Motion in non-inertial frames. Fictitious forces. Coriolis force. Focault pendulum. Basic scattering theory. Vibrations of particles on a circle and a line. Orthonormal basis. Wave equation. Fourier transform. Phase space. Hamiltonian equations, fixed points and stability. Nonlinear equations. Chaos. Logistics map and period doubling. Fluid mechanics. Euler equation. Bernoulli's equation. Waves in fluids. Gravity waves. Viscosity. Navier-Stokes equation. Basic ideas about turbulence. Elasticity. Strain and stress tensors. Elastic modulii. Bending of rods. Waves in solids.

Biplob Bhattacharjee, K P Ramesh, R Ganesan

Kleppner D and Kolenkow R J, An Introduction To Mechanics (Special Indian Edition) (2007)

Rana, N.C., and Jog, P.S., Classical Mechanics Tata McGraw-Hill, New Delhi, 1991.

L. D. Landau and E. M. Lifshitz, Fluid Mechanics and Theory of Elasticity (Vols. 6 and 7 of Course of Theoretical Physics)

UP 203: Intermediate Electromagnetism and the Quantum Physics of Radiation (2:1) (core Course for Physics major)

Electromagnetic waves: Wave equation from Maxwell's equations, polarization, energy and momentum in EM waves, propagation in linear media, reflection and refraction, Snell's law and Fresnel's equations, Brewster angle and total internal reflection. EM waves in conductors, skin depth, simple theories for disperion of EM waves. Wave guides and coaxial cables, optical fibres Geometrical optics: Fermat's principle, Snell's law, reflection and refraction at spherical surfaces, convex and concave mirrors and lenses, real and virtual images Physical optics: Coherence, Young's two slit experiment, multiple slits, diffraction grating, wavelength resolution and fringe visibility, Newton's rings, Michelson and Fabry-Perot interferometer, difraction from rectangular and circular apertures, Airy disc and resolving power of microscopes. Quantum optics: Photons, spontaneous and stimulated emission, Einstein A and B coefficients and relation to the Planck distribution, rate equations for absorption and emission, two level and three level systems, population inversion and light amplification, optical resonators and the basic working principle of a laser, examples of lasers: Ruby, He-Ne, semiconductor etc.

Prerna Sharma, K S R Koteswara Rao and K Ramesh

Griffiths D.J., Introduction to Electrodynamics, 3rd edn (Prentice-Hall of India, 2003)

Hecht E. & Ganesan A.R., Optics, 4th edn (Pearson, 2008)

Ghatak A. and Thyagarajan K., Optical Electronics (Cambridge University Press, 1991)

UP 204: Intermediate Thermal Physics and the Physics of Materials (2:1) (core course for Physics major and minor)

Review of kinetic theory and thermodynamics, Free energies, Phases and phase transitions, Van der Walls gas and the liquid gas transition, Thermodynamics of magnetic systems, Ensembles and rules of Statistical Mechanics, The Ideal Maxwell-Boltzmann Gas, The Ideal Fermi Gas, The Ideal Bose Gas, Crystal Structure, Lattice Vibrations, Band theory of electrons in crystalline solids, Thermal properties of crystalline solids.

Chandan Dasgupta, V Venkataraman, Prasad V Bhotla

Callen, H.B., Thermodynamics and Introduction to Thermostatistics (2^{nd} edition), Wiley Student Edition

Reif, F., Statistical Physics. Berkeley Physics Course Volume 5, Tata McGraw Hill.

Kittel,C., Introduction to Solid State Physics, $5^{th}/6^{th}/7^{th}$ edition, Wiley International

Semester 5 (AUG)

PH 201: Classical Mechanics (3:0) (core course for Physics major)

Newton's laws, generalized co-ordinates. Lagrange's principle of least action and equations. Conservation laws and symmetry. Integrable problems, elastic collisions and scattering. Small oscillations including systems with many degrees of freedom, rigid body motion. Hamilton's equations. Poisson brackets. Hamilton Jacobi theory. Canonical perturbation theory, chaos, elements of special relativity. Lorentz transformations, relativistic mechanics.

Banibrata Mukhopadhyay

Goldstein, H., Classical Mechanics, Second Edn, Narosa, New Delhi, 1989.

Landau, L.D., and Lifshitz, E.M., Mechanics, Pergamon, UK, 1976.

Rana, N.C., and Jog, P.S., Classical Mechanics Tata McGraw-Hill, New Delhi, 1991.

PH 203: Quantum Mechanics I (3:0) (core course for Physics major)

Historical foundations. Wave function for a single particle. Hamiltonian. Schrodinger equation. Probability current. Wave packets. One-dimensional problems: step, barrier and delta-function potentials. Tunnelling, scattering and bound states. Harmonic oscillator, operator approach. Matrix formulation of quantum mechanics. Hermitian and unitary operators. Orthonormal basis. Momentum representation. Uncertainty relations. Postulates of quantum mechanics. Heisenberg representation. Ehrenfest's theorem. Three-dimensional problems. Rotations, angular momentum operators, commutation relations. Spherical harmonics. Hydrogen atom, its spectrum and wave functions. Symmetries and degeneracies. Spin angular momentum. Spin-1/2 and two-level systems. Addition of angular momentum. Spin-orbit and hyperfine interactions. Time-independent perturbation theory. Stark and Zeeman effects. Variational methods, ground state of helium atom.

Diptiman Sen

Cohen-Tannoudji, C., Diu, B., and Laloe, F., Quantum Mechanics Vol.1, John Wiley, 1977.

Landau, L.D., and Lifshitz E.M., Quantum Mechanics, Pergamon, NY, 1974.

R. Shankar, Principles of Quantum Mechanics, Springer, 2010

F. Schwabl, Quantum Mechanics, Springer, 1995

PH 205: Mathematical Methods of Physics (3:0) (core course for Physics major)

Linear vector spaces, linear operators and matrices, systems of linear equations. Eigen values and eigen vectors, classical orthogonal polynomials. Linear ordinary differential equations, exact and series methods of solution, special functions. Linear partial differential equations of physics, separation of variables method of solution. Complex variable theory; analytic functions. Taylor and Laurent expansions, classification of singularities, analytic continuation, contour integration, dispersion relations. Fourier and Laplace transforms.

Subroto Mukerjee

Mathews, J., and Walker, R.L., Mathematical Methods of Physics, Benjamin, Menlo Park, California, 1973.

Dennery, P., and Krzywicki, A., Mathematics for Physicists, Harper and Row, NY, 1967.

Wyld, H.W., Mathematical Methods for Physics, Benjamin, Reading, Massachusetts, 1976.

PH 211: General Physics Laboratory (0:3)

Diffraction of light by high frequency sound waves, Michelson interferometer, Hall effect, band gap of semiconductors, diode as a temperature sensor, thermal conductivity of a gas using Pirani gauge, normal modes of vibration in a box, Newton's laws of cooling, dielectric constant measurements of tri-glycerine selenate, random walk in porous medium.

Vasant Natarajan, Aveek Bid, D V S Muthu, G R Jayanth, Anindya Das

Semester 6 (JAN)

PH 202: Statistical Mechanics (3:0) (core course for Physics major)

Basic principles of statistical mechanics and its application to simple systems. Probability theory, fundamental postulate, phase space, Liouville's theorem, ergodicity, micro-canonical ensemble, connection with thermodynamics, canonical ensemble, classical ideal gas, harmonic oscillators, paramagnetism, Ising model, physical applications to polymers, biophysics. Grand canonical ensemble, thermodynamic potentials, Maxwell relations, Legendre transformation. Introduction to quantum statistical mechanics, Fermi, Bose and Boltzmann distribution, Bose condensation, photons and phonons, Fermi gas, classical gases with internal degrees of freedom, fluctuation, dissipation and linear response, Monte Carlo and molecular dynamics methods.

Arnab Rai Choudhuri

Pathria, R.K., Statistical Mechanics, Butterworth Heinemann, Second Edn, 1996.

Reif, F., Fundamentals of Statistical and Thermal Physics, McGraw Hill, 1965.

Landau, L.D., and Lifshitz E.M., Statistical Physics, Pergamon, 1980.

PH 204: Quantum Mechanics II (3:0) (core course for Physics major)

Time dependent perturbation theory. Fermi golden rule. Transitions caused by a periodic external field. Dipole transitions and selection rules. Decay of an unstable state. Born cross section for weak potential scattering. Adiabatic and sudden approximations. WKB method for bound states and tunneling. Scattering theory: partial wave analysis, low energy scattering, scattering length, Born approximation, optical theorem, Levinson's theorem, resonances, elements of formal scattering theory. Minimal coupling between radiation and matter, diamagnetism and paramagnetism of atoms, Landau levels and Aharonov- Bohm effect. Addition of angular momenta, Clebsch Gordon series, Wigner Eckart theorem, Lande's g factor. Many particle systems: identity of particles, Pauli principle, exchange interaction, bosons and fermions. Second quantization, multielectron atoms, Hund's rules. Binding of diatomic molecules. Introduction to Klein Gordon and Dirac equations, and their non-relativistic reduction, g factor of the electron.

B Ananthanarayan

Landau, L.D., and Lifshitz E.M., Quantum Mechanics, Pergamon, NY, 1974.

Cohen-Tannoudji, C., Diu, B., and Laloe, F., Quantum Mechanics (2 Vols.), John Wiley, 1977.

Optional Courses for Physics Major

Course no.	GP	Title	Faculty
PH 206	3:0	Electromagnetic Theory	Anindya Das
PH 207	1:2	Analog Digital and Microprocessor Electronics	K Rajan and M N Ramanuja
PH 208	3:0	Condensed Matter Physics-I	Manish Jain
PH 209	2:1	Analog and Digital Electronics Lab	K Rajan and M N Ramanuja
PH 212	0:3	Experiments in Condensed Matter Physics	Raghu Menon, Suja Elizabeth, D V S Muthu and Ramesh Mallik
PH 213	0:4	Advanced Experiments in Condensed Matter Physics	Arindam Ghosh, R Ganesan, K R Gunasekhar and Ambarish Ghosh
PH 217	3:0	Fundamentals of Astrophysics	Biman Nath and Tarun Saini
PH 231	0:1	Workshop practice	Vasant Natarajan
PH 320	3:0	Condensed Matter Physics II	Rahul pandit

PH 322	3:0	Molecular Simulation	Prabal K Maiti
PH 325	3:0	Advanced Statistical Physics	Vijay B Shenoy
PH 330	0:3	Advanced Independent Project	Faculty
PH 340	4:0	Quantum Statistical Field Theory	
PH 347	2:0	Bioinformatics	S Ramakumar and K Sekar
PH 350	3:0	Physics of Soft Condensed Matter	Jadeep K Basu
PH 351	3:0	Crystal Growth, Thin Films and Characterization	Suja Elizabeth and P. S. Anil Kumar
PH 352	3:0	Semiconductor Physics and Technology	K S R Koteswara Rao
PH 359	3:0	Physics at the Nanoscale	A K Sood and Arindam Ghosh
PH 362	3:0	Matter at Low Temperatures	Ambarish Ghosh
HE 215	3:0	Nuclear and Particle Physics	Sudhir Vempati
HE391	3:0	Quantum Mechanics III	Sachindeo Vaidya
HE395	3:0	Quantum Field Theory I	Chetan Krishnan
HE397	3:0	The standard model of Particle Physics	Rohini Godbole
HE316	3:0	Advanced Mathematical Methods of Physics	Apoorva Patel
HE396	3:0	Quantum Field Theory II	Aninda Sinha
HE398	3:0	General Relativity	Justin R David
AA363	2:0	Fluid mechanics and plasma physics	Prateek Sharma